1.1 Notes

2022年11月28日 18:35

1.1.1 How and why computers use binary

- Binary
  - Anything with only two possible states
  - The only way that the computer saves data
  - Data are saved by using transistors
  - Also called Base 2
- Why a computer system only process data in binary form
  - Data is processed by logic gates that only have two states (0 and 1)

1.1.2 Binary to denary conversion

- Units
  - 1 byte = 8 bits = 2 hex digit
  - 1 nibble = 4 bits = 1 hex digit

1.1.3 How and why is hexadecimal used

- Why is hexadecimal used
  - It is a shorter representation of binary, so it is easier for human to understand
- Main uses
  - Error codes
    - Refer to the memory location of the error
    - Generated automatically by the computer
  - MAC addresses
    - MAC = media access control
    - A number uniquely identifies a device on a network, referring to the network interface card which is part of the device
    - Made up of 48 bits which are shown as 6 groups of 2 hexadecimal digits
  - IPv6 addresses
    - IP = Internet Protocol
    - Address given to each device connected to a network
    - Difference between IPv4 and IPv6
      - IPv4
        - 32 bit written in denary or hexadecimal
        - Uses decimal point to connect
      - IPv6
        - 128 bits
        - Broken down into 16-bit chunks (= 4 hex digits) written in hexadecimal and uses colons
  - HTML colour codes
    - Three primary colours: red, green, blue
    - 8 bits (2 hex digit) and 256 shades of each primary colour
    - Hexadecimal is used because it uses less digits and is easier to read

1.1.4-5 Binary addition and logical binary shifts

- Overflow error
  - Occurs when 8-bit register addition results in a value larger than 255
  - All the bits required to represent the value cannot fit in the 8-bit register (a 9th bit is required) as the number is too big
- Logical shifts
  - Left: × 2
  - Right: ÷ 2
  - Rightmost digits might be lost if shifted to the right

1.1.6 Two's complement

- The most significant bit (leftmost digit) is changed to a negative value
    - 1 = negative, 0 = positive
- Will be indicated clearly when to use in exams

1.2 Notes

2022年10月1日 星期六 08:42

1.2.1 Character Sets - ASCII Code and Unicode

- Text is converted to binary to be processed by a computer
- ASCII
  - American Standard Code for Information Interchange
  - 7 bits (8 for extended) per character
  - 128 codes (256 for extended ASCII)
  - Lower to upper case: - 32 (6th digit changes from 1 to 0)
- Unicode
  - First 128 letters are the same
  - 32 bits (4 bytes) per character
  - Allows for a greater range of characters and symbols than ASCII
    - All languages and emojis
- Character set
  - A unique code is allocated to each character or symbol, usually in binary
  - Include all the characters and symbols that can be represented by a computer system

1.2.2 Representation of sound

- Sampling
  - Sound is analogue data, computer cannot work with analogue data
  - Measuring the amplitude of the sound wave
  - Using analogue to digital converter (ADC) to convert to binary data
  - The sound waves are sampled at regular time intervals
  - The amplitude of the sound cannot be measured precisely, so approximate values are stored in binary digits
  - Higher sampling rate and resolution = higher quality
- Sampling resolution
  - The number of bits per sample
  - Defines the number of different amplitudes that can be recorded
  - Determines how quiet / loud the sounds are that can be recorded
  - Measured in bits
- Sampling rate
  - The number of sound samples taken per second
  - Measured in Hertz (Hz)
- CD
  - Sampling resolution = 16 bits
    - Range = $0 \sim 2^{16}-1 = 0 \sim 65535$
  - Sampling rate = 44.1kHz
- Bit rate
  - Bits needed per second
- The benefits and drawbacks of using a larger sampling resolution when recording sound

Benefits	Drawbacks
Larger dynamic range Produces better sound quality Less sound distortion	Produces larger file size Takes longer to transmit / download Requires greater processing power

1.2.3 Representation of (bitmap) images

- Image
  - A series of pixels that are converted to binary
  - Processed by a computer
- Pixel
  - Short for picture element

    - One square / circle of one colour
    - The smallest component of an image
    - Represented by binary numbers
- Colour depth
    - Number of bits used to represent each colour
- Image resolution
    - The number of pixels that make up an image
- Fuzzy image
    - Pixelated
    - No enough pixels to represent the picture properly
- High resolution images drawback
    - Larger file size
    - Less images can be stored on
    - More time to download an image
    - More time to transfer images between devices

1.3 Notes

2022年11月1日 19:39

1.3.1 Measurement of data storage

- IEC system
  - International Electrotechnical Commission

Kibibyte	**KiB**	2^{10}	1024 bytes
Mebibyte	**MiB**	2^{20}	1 048 576 bytes
Gibibyte	**GiB**	2^{30}	1 073 741 824 bytes
Tebibyte	**TiB**	2^{40}	1 099 511 627 776 bytes
Pebibyte	**PiB**	2^{50}	1 125 899 906 842 624 bytes
Exbibyte	**EiB**	2^{60}	1 152 921 504 606 846 976 bytes

- Converting between measurements
  - Smaller to larger = divide
  - Larger to smaller = multiply

1.3.2 Calculation of file size

- File size of an image
  - $image\ resolution \times colour\ depth$
- File size of an audio file
  - $sampling\ rate \times sampling\ resolution \times length\ of\ sample \times channels$

1.3.3/4 Data compression - Lossy and Lossless

- Reasons for compression
  - Reduce file size
  - Save storage space on devices such as HDD / SSD
  - Increase transmission speed
  - Reduce bandwidth needed for transmission
  - Reduced file size reduces costs in situations such as using cloud services
- Lossy file compression
  - Reduces the file size by permanently removing data
  - Eliminates unnecessary data from the file
  - Cannot reconstruct the original file
- Lossy compression for different files

Type	Type of media	Details
1. MPEG-3 (MP3)	Audio	• Remove sounds that human ears cannot hear properly • Outside human ear range, softer sound when two sounds are played at the same time
2. MPEG-4 (MP4)	Multimedia	• Retains an acceptable quality of sound and video
3. JPEG	Images	• Humans eyes don't detect differences in colour shades quite as well as they detect differences in image brightness • Images can be split into pixel blocks by separating pixel colour from brightness • It allows some information to be discarded without causing any real noticeable deterioration in quality

- Lossless file compression
  - Reduces the file size without permanent loss of data e.g. RLE
  - A compression algorithm is used
  - Repeated words or symbols are identified
  - Indexed and put into a table (add example)
  - Replaced with their index (add example)
  - Their positions + the number of times the word / pattern appears are stored in the table (add example)
  - No data is removed in the process
  - Takes more space than lossy files, or even more space than the original file
- RLE

    - Run-length encoding
    - Can be used for repeating characters or colours that are adjacent
    - The characters or colours can be coded along with the number of adjacent repeats
- Flagged RLE
    - Needs a flag value e.g. 255
    - Flag preceding data indicates that what follows are the number of repeating units (255 05 97 = 5 'a's)
    - No flag = run of 1

2.1 Notes

2022年11月28日 18:37

2.1.1 Data packets

- Data packet
  - Data sent over long distances is usually broken up into data packets
  - Quite small, typically 64 KiB
  - Easier to control
  - Each packet can be sent along a different route to its destination
  - Can still transmit data if one route is out of action or very busy
  - Drawback: needs to reassemble data when it reaches its destination
- Data packet structure
  - Header
    - IP address of sender
    - IP address of recipient
    - Sequence number
    - Size of data in bytes
  - Payload
    - Actual binary data
  - Trailer
    - Method identifying the end of the packet
    - Error check (CRC)
- Cyclic redundancy check (CRC)
  - Counts the number of 1s in the data and saves it in the trailer
  - The computer counts the number of 1s in the payload after receiving data
  - Check if it equals to the number of 1s in the CRC
  - If the two values doesn't match the packet is resent
- Packet switching
  - Data is broken down into packets
  - Each packet could take a different route
  - A router controls the route a packet takes
  - The router selects the fastest available route
  - Packets may arrive out of order
  - Once the last packet has arrived, packets are reordered
  - If a packet is missing/corrupted, it is requested again
- Packet switching pros and cons
  - Benefits
    - No need to tie up a single communication line
    - A high data transmission rate is possible
  - Drawbacks
    - Packets can be lost and needs to be resent
    - A delay at the destination for data to be re-ordered

2.1.2 Data transmission

- Transmission modes
  - Simplex
    - Data sent one direction only
  - Half-duplex
    - Data sent in both directions but one direction at a time
  - Full-duplex
    - Data sent in both directions at the same time
- Transmission types
  - Serial
    - Data is sent one bit at a time over a single wire / channel

        - Bits are sent one after another as a single stream
        - Good for longer distances
            - e.g. USB between printer and computer
        - Slower
        - Synchronised arrival
        - All 3 transmission modes
    - Parallel
        - Several bits of data usually one byte are sent down several channels / wires all at the same time
        - Each channel / wire transmits one bit
        - Good for shortershort distances
            - e.g. internal circuits of a computer
        - Faster
        - Risk of unsynchronised / skewed arrival (if over long distance)
        - All 3 transmission modes
- Serial advantages
    - Data arrives in the order sent (synchronised)
    - Can transmit over longer distance
- Parallel advantages
    - Allow faster transmission / response to request of large amount of data
- (Disadvantage = opposite to the other's advantage)

2.1.3 Universal Serial Bus

- Basics
    - The most common type of input / output port found on computers
    - Transmission type = serial
    - Transmission mode = half-duplex / full-duplex
    - Includes port, cable, connection, device
    - Device plugged into a port on computer and transmits data using connection
- Plugging into the computer
    - It is automatically detected by the computer for its presence when plugged into the USB port
    - The appropriate device driver is automatically loaded up
    - Prompts user to download the appropriate driver if needed
- Benefits
    - USB is backward compatible
    - Universal standard
    - Auto configures
    - Can power devices
    - Fast data transfer speed
    - Inexpensive to purchase / manufacture
- Drawbacks
    - Slower transfer rate compared to others such as Ethernet connections
    - Standard USB only supports a maximum cable length of 5m
    - Very early USB standards (V1) may not always be supported by the latest computers although USB is backward compatible
- Comparing USB to USB-C
    - USB
        - Physical characteristics
            - 4 wired shielded cable
            - 2 wires for power
            - Other 2 for data transmission
            - Plugged in using USB ports, inserted only one way
        - +5V power available
        - 1.5 Mbps to 5 Gbps
        - Backward compatible
    - USB-C
        - Physical characteristics

        - 24-pin symmetrical connector
            - It will fit into a USB-C port either way round
        - It is much smaller and thinner than older USB connectors
    - Offer 100W / 20V power, so full-sized devices can now be charged
    - Data speed = 10 Gbps
    - Backward compatible

2.2 Notes

2022年11月28日 18:39

2.2.1 The need to check for errors

- Risks when transmitting data
  - Corruption: 0 become 1 or 1 becomes 0
  - Loss: bits lost
  - Gain: bits gained
- How errors occur
  - Electrical interference
    - All types of wires / cables can suffer from electrical interference
    - Cause data to be corrupted or lost
  - Problems during packet switching
    - This can lead to data loss or even data gain.
  - Skewing of data
    - Bits arrive out of sync
    - Occurs during parallel data transmission and can cause data corruption

2.2.2 Parity checks, checksum and echo checks

- Parity check
  - An agreement is made between the sender and the receiver regarding even or odd parity being used
  - Usually the most significant bit of a byte is reserved for a parity digit
  - The parity digit is set to meet the parity
  - Parity doesn't match = error has occurred
  - Failsafe: two or more bits change
  - Parity blocks
    - A block of data is sent and a parity check is done both horizontally and vertically
    - A parity byte consisting vertical parity checks is also sent during the transmission
    - Not only identifies the error but also indicates where it is
      - Intersection of byte + column with error = where the error is
    - Can detect even number of changes in bits
- Checksum
  - A number is calculated from the data according to an agreed algorithm.
  - This checksum number is sent along with the original data.
  - When the data arrives at its destination the same calculation is carried out on the data.
  - The result is compared to the transmitted checksum, if they are the same then the data has been transmitted correctly.
- Echo checks
  - A copy of the data received is sent back to the sender
  - The returned data is compared with the original data by the sender's computer
  - If the two sets of data are different, then an error occurred
  - Resent if error occurred
  - Cannot find where the error occurred

2.2.3 Check digits

- Check digit
  - The final digit in a code
  - Calculated from all the other digits in the code using a specific algorithm
  - Used to identify errors in data entry caused by mis-typing or mis scanning a barcode
  - Check digit match check digit calculated = error free
- Uses
  - Barcodes on products
    - International Standard Book Numbers (ISBN)

    - Vehicle Identification Numbers (VIN)
- Errors they can detect
    - An incorrect digit entered
    - Transposition errors where two or more digits have changed order
    - Omitted or extra digits
    - Phonetic errors

2.2.4 Automatic repeat request or query (ARQs)

- Positive acknowledgement
    - The sender transmits the first data packet, the receiving device checks it for errors
    - Once the receiving device knows it has received the data error free, it sends a positive acknowledgement back to the sending device
    - When the sending device receives this positive acknowledgement, it knows the data packet was received error free and sends the next data packet.
    - If the sending device does not receive a positive acknowledgement within a set timeframe, a timeout occurs and the sending device will resend the data packet
    - It will keep doing this when a timeout occurs, until it receives a positive acknowledgement, or sometimes a limit is set and when this limit is reached it will stop resending the data.
- Negative acknowledgement
    - The sender transmits the first data, the receiving device checks it for errors
    - If the receiving device detects no errors, no further action is taken
    - If the receiving device detect errors, it will send a negative acknowledgement back to the sender
    - If the sender receives a negative acknowledgement, it knows this means the data was received incorrectly, so it can resend the data packet
    - A timeout is set by the sending device when it sends the data
    - The sending device knows that if it doesn't receive a negative acknowledgement back within that set time period, it doesn't need to be still be waiting for it and can send the next data packet.

2.3 Notes

2022年11月28日 18:39

2.3.1 The purpose of encryption

- Purpose of encryption
  - Keep data safe when it is transmitted using public networks
  - Data can be intercepted by an eavesdropper when it is transmitted over a public network
  - Using encryption helps to minimise the risk
- Encryption
  - It stops data from making any sense to an eavesdropper
  - It is particularly important if the data is sensitive or confidential
  - Plain text is encrypted or scrambled using an encryption algorithm and an encryption key
  - Turns it into cipher text
  - If the cipher text is intercepted, although it can be read, it won't be understandable without applying the correct encryption algorithm and key
- Packet sniffer
  - Hardware or software designed to find the contents of a packet

2.3.2 Symmetric and asymmetric encryption

- Symmetric encryption
  - The same encryption key is used for both encryption and decryption
  - Simple encryptions are easy for computers to crack
    - 256-bit binary encryption keys can be used to make it harder to be cracked
    - Quantum computer can crack longer encryption keys in the future
  - Unsafe because the key can be intercepted as a single key is shared between the sender and the recipient
- Asymmetric encryption
  - A public key and a private key is used
    - Private key: only known to the computer user
    - Public key: made available to everybody
    - Mathematically linked
    - One key cannot be derived from another
  - Both keys are generated by the recipient
  - The public key of the recipient is sent to the sender and used by the sender to encrypt data
  - The ciphertext is sent to the recipient
  - The recipient then decrypt it with private key
  - More secure than symmetric as the private key is never shared

3.1 Computer architecture

2022年11月28日 18:39

3.1.1 The CPU

- CPU
  - Central processing unit
  - Aka microprocessor / processor
  - Often installed as an integrated circuit on a single microchip
  - Processes instructions and data that are input into the computer so that the result can be output
  - Consist of:
    - Control unit (CU)
    - Arithmetic and logic unit (ALU)
    - Registers and buses
- Microprocessor
  - A type of integrated circuit on a single chip

3.1.2a Von Neumann architecture

- Main components
  - Control Unit (CU)
    - Decodes instructions using an instruction set
    - Sends control signals that manage the transfer of data and instructions within the CPU
  - Arithmetic and Logic Unit (ALU)
    - Used to carry out calculations on data and logical operations
    - It holds temporary values during calculations in a register called the accumulator (ACC)
  - System Clock
    - A tiny oscillating crystal
    - Controls the rate at which calculations are performed by the CPU
- Registers
  - Program counter (PC)
    - Stores the address of the next instruction to be processed
  - Memory address register (MAR)
    - Stores address of next instruction/data to be fetched // where data is to be written to
  - Memory data register (MDR)
    - Stores the data that is in use from the address in the MAR
  - Current instruction register (CIR)
    - Stores the instruction that is currently being processed
  - Accumulator (ACC)
    - Built in to the ALU, temporarily stores data being used in a calculation
- Buses
  - Data bus
    - Carries data between the CPU, memory and input/output devices
  - Control bus
    - Carries signals from the control unit (CU) to all the other computer components
  - Address bus
    - Carries addresses throughout the computer system e.g. MAR to RAM

3.1.2b Fetch-Decode-Execute cycle

- Fetch
  - PC starts at 0000
  - The address in the PC is copied to the MAR using an address bus so the CPU knows where to look in RAM
  - The address is sent from the MAR through the address bus to RAM
  - The data stored at the address in RAM is read and sent through the data bus to the MDR

    - If the data is an instruction it is copied to the CIR
    - The PC is incremented by 1
- Decode
    - Instruction sent to the CU by data bus from CIR to be decoded
    - Split into opcode and operand
        - Opcode: the command that the computer will carry out
        - Operand: an address in RAM where data will be read from or written to
    - Opcode is translated into instructions by the CU using the instruction set
- Execute
    - CU send signal (via the control bus) to other components of the computer
    - Operand copied to the MAR
    - Data at address is then fetched from RAM and passed up the data bus to the MDR
    - Passed to accumulator within ALU for calculations to be carried out
    - Results of the calculation can be passed back to the MDR and then stored in a specified location in RAM

3.1.3 Cores, caches and internal clock - CPU performance

- Factors affecting performance
    - Clock Speed
        - Definition: The maximum number of FDE cycles/instructions a CPU can perform in a second
        - The clock speed of a CPU determines how fast it can process instructions
        - A faster clock speed improves the performance
            - Tasks can be performed faster because more FDE cycles / instructions can be processed in a second
        - Typical speed of CPU clock = 3.5GHz
        - Overclocking
            - Using a clock speed higher than the computer was designed
            - Can lead to seriously unsynchronised operations
            - The computer would frequently crash and become unstable
            - Lead to serious overheating of CPU, causing unreliable performance
    - Cache size
        - Very fast volatile memory within the CPU
        - It is inside the CPU so it has faster data access time then the RAM
        - Stores frequently used instructions and data that needs to be accessed faster
        - Larger cache = better performance
    - Number of cores
        - A core is made up of an ALU, a CI and the registers
        - Usually 2,4 or 8 cores
        - It processes instructions and carries out a FDE cycle
        - Multiple cores can process instructions simultaneously and increase the performance of a computer
        - Doubling the amount of cores doesn't necessarily exactly double performance as extra communication between cores is required

3.1.4 Instruction set

- Opcodes
    - Binary numbers because computers only understand binary
    - Instructions written in binary are called **Machine Code** as it is directly understood by a machine, opcodes are therefore written in machine code
- Instruction set
    - A list of all the commands that can be processed by a CPU
    - The commands are machine code
    - Specific to the CPU and different manufacturers can have different instruction sets for their CPUs

3.1.5 Embedded systems

- Definition
    - A combination of hardware and software which is designed to carry out a specific set of functions
- Features
    - It has a microprocessor
    - It has dedicated hardware
    - Uses firmware
    - It is normally built into a larger device/system
    - User normally cannot reprogram
    - It does not require much power
    - It is cheap to manufacture
    - Works automatically
    - It is small (in size)
    - It is a real-time system
- Uses
    - Domestic appliances - freezers, washing machines
    - Cars
    - Security systems
    - Lighting systems
    - Vending machines
- Input
    - An operator can input data manually
    - Data come from an automatic source
- Programmable / non-programmable
    - Non-programmable devices need, in general, to be replaced if they require a software upgrade
    - Programmable devices permit upgrading by two methods:
        - Connecting the device to a computer and allowing the download of updates to the software
        - Automatic updates via a Wi-Fi, satellite or cellular link
- Pros and cons
    - Benefits
        - Small in size and therefore easy to fit in devices
        - Relatively low cost to make compared to other systems
    - Drawbacks
        - It can be difficult to upgrade some devices to take advantage of new technology
        - Troubleshooting faults in the device becomes a specialist task
- Compared to computers
    - Computers are multi-functional while an embedded system is not

3.2 Input and output devices

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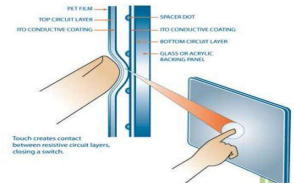
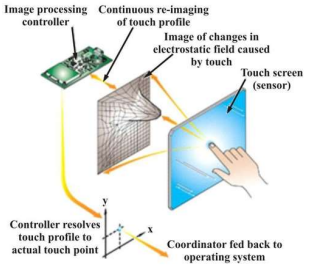
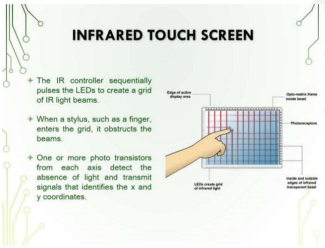
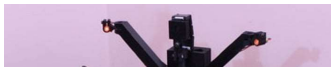
3.2.1 Input devices

- Definition
  - Allow data to be entered into the computer system

Input Device	Detail	Used for
Barcode scanner 	It uses a red laser to scan a barcode so that the data stored in the barcode can be obtained. Light from the lines in the barcode is reflected back to the scanner.	It is used in a supermarket to get the price of a product and as part of a stock control system
Digital camera 	It captures light through a lens and converts it into binary.	It is built into a mobile phone to allow the user to photograph items or people.
Keyboard 	It allows the user to press keys that have a designated ASCII/Unicode value that is converted to binary. Using keyboards regularly can lead to repetitive strain injury (RSI)	It is one of the main methods of input that allows a user to type data into a personal computer.
Microphone 	It captures soundwaves and converts them to binary.	It is built into a mobile phone to capture the user's voice so that it can be heard by the other users. It can also be used as a sensor to detect sound.
Optical mouse 	It captures the light that is bounced back from a laser that is shone from the mouse to the surface underneath, to track the mouse's movements.	It is one of the main methods of input that allows a user to select icons and menu options whilst using a personal computer.

	from a laser that is shone from the mouse to the surface underneath, to track the mouse's movements.	that allows a user to select icons and menu options whilst using a personal computer.
QR code scanner 	It uses a sensor or a camera to capture light reflected from a QR code and converts it to binary. QR codes can usually be read using the camera on a smartphone.	It can be an application that is downloaded onto a mobile phone and used to SCAN QR codes that store information, e.g. a website link.
Resistive touch screen 	Made up of two layers. A voltage is applied across the two surfaces. When the top layer is touched it makes contact with the bottom layer completing a circuit. The point of contact is detected where the change in voltage occurred.	Had good resistance to dust and water so can be used by engineers or roadside mechanics exposed to the elements. Can be used with bare fingers, stylus and gloved hand.
Capacitive touch screen 	An electrostatic field is created on the screen. As human skin is conductor of electricity, when the screen is touched the electrostatic field is changed and the point of contact can be determined.	Capacitive touch screens are very durable, have high scratch resistance and allow multi-touch.
Infra-red touch screen 	Infrared sensors and transmitters form a grid of infrared beams. If any of the beams are broken the point of contact can be determined.	Infrared screens have good durability and can work if the screen is scratched or cracked. They allow multi-touch.
2D scanner 	2D scanners (or flatbed scanners) are usually used to scan documents. The document is converted into a digital format that can be stored on a computer.	2D scanners can be used at airports to read passports which enable automatic border controls.
3D scanner 	3D scanners scan solid objects to produce 3D digital images. They make use of lasers and a turntable which rotates the solid	The images can be used in computer-aided design (CAD) software. They can also be used in medical

	3D digital images. They make use of lasers and a turntable which rotates the solid object to be scanned from all angles.	aided design (CAD) software. They can also be used in medical applications to scan parts of the human anatomy.

3.2.2 Output devices

- Definition
  - Allow result of data processing to be seen / heard

Output Device	Detail	Used for
Actuator 	It is a component that outputs an action, often a type of movement, that causes another device to operate	It can be used in an automated system to move or turn on/off another device, e.g. a light
Digital light processing (DLP) projector 	It is a device that uses light reflected from millions of little mirrors to output an image.	It can be used in a classroom to project an image onto an interactive whiteboard
Liquid crystal display (LCD) projector 	This is a device that shines light through crystals and then through a lens to project an image onto a blank wall or screen.	This can be used to project an image in a home cinema system
Inkjet printer 	This is a device that squirts liquid ink from nozzles to output a document or image	It can be used in a house to print photographs

	ink from nozzles to output a document or image	print photographs
Laser printer 	This is a device that uses a rotating drum and powdered toner to output a document	It can be used in an office to print letters.
Light emitting diode (LED) screen 	This is a screen that uses LEDs as a backlight to output an image	This screen can be built into a mobile phone
Liquid crystal display (LCD) screen 	This is a screen that shines light through crystals to output an image.	This can be built into a television screen
Speaker 	This is a device that outputs sound.	This can be built into a mobile phone so one user can hear another user's voice

		phone so one user can hear another user's voice
3D printer 	This is a device that builds layers of material to output a 3D object	This can be used in medicine to create prosthetic limbs

3.2.3 Sensors

- Definition
  - Input devices which read or measure physical properties from their surroundings
- ADC
  - Converts the analogue physical quantities into discrete digital values
- Types of sensors
  - Temperature
    - Measures temperature of the surroundings by sending signals
    - These signals will change as the temperature changes
  - Moisture
    - Measures water levels in, for example, soil
    - It is based on the electrical resistance of the sample being monitored
  - Humidity
    - Slightly different to moisture
    - This measures the amount of water vapour in, for example, a sample of air
    - Based on the fact that the conductivity of air will change depending on the amount of water present
  - Light
    - These use photoelectric cells that produce an output in the form of an electric current depending on the brightness of the light
  - Infrared (active)
    - Use an invisible beam of infrared radiation picked up by a detector
    - If the beam is broken, then there will be a change in the amount of infrared radiation reaching the detector (sensor)
  - Infrared (passive)
    - These sensors measure the heat radiation given off by an object
  - Pressure
    - A transducer and generates different electric currents depending on the pressure applied
  - Gas

        - Most common ones are oxygen or carbon dioxide sensors
        - They use various methods to detect the gas being monitored
        - Produce outputs that vary with the oxygen or carbon dioxide levels present
    - pH
        - These measure acidity through changes in voltages in, for example, soil
    - Magnetic field
        - Measure changes in magnetic fields
        - The signal output will depend on how the magnetic field changes
    - Accelerometer
        - Measure acceleration and motion of an application, i.e. the change in velocity
        - A piezoelectric cell is used whose output varies according to the change in velocity
    - Flow (rate)
        - Measure the flow rate of a moving liquid or gas
        - Produce an output based on the amount of liquid or gas passing over the sensor
    - Level
        - These sensors use ultrasonics to detect changing liquid levels in, for example, a tank
        - Or capacitance / conductivity to measure static levels (for example, height of water in a river)
        - Level sensors can also be optical or mechanical in nature
- How systems work
    - Sensors send data to the microprocessor / computer
    - The signals are converted to digital if necessary using an analogue to digital converter
    - The computer / microprocessor analyses the data received by checking it against stored values
    - Monitoring system
        - If new data is outside the acceptable range, a warning message is sent to a screen or an alarm is activated
        - The microprocessor / computer has no effect on what is being monitored - it is simply 'watching the process'
    - Control system
        - If outside acceptable range:
            - Computer / microprocessor sends signals to control valves / motors / etc.
        - Output from the system affect the next set of inputs from sensors

3.3 Data storage

2023年3月9日 18:43

Quizlet
https://quizlet.com/672811123/cs-igcse-2023-33-data-storage-flash-cards/?x=1jqt

3.3.1 Primary memory

- Primary memory
  - Usually referred to as the internal devices used to store data that the CPU can access directly
- Volatile / non-volatile
  - Volatile memory only stores information to run programs while the computer is on
  - It is reset and emptied once the computer is turned off
  - Volatile memory requires electricity to store data using transistors and capacitors
  - Volatile memory includes RAM and Cache memory
  - All other primary memory and secondary storage is non-volatile
- Characteristics
  - Directly accessible by the CPU
  - Could be volatile
  - Are always internal to the computer
- Devices
  - RAM
  - ROM
  - Cache memory
- Random access memory (RAM)
  - When you run an application or a program, data is retrieved from secondary storage and placed temporarily in RAM
  - Commonly used to store
    - Currently running data
    - Currently running (application) software
    - Currently running instructions
    - Currently running parts of OS
    - Currently running utility software
  - It is directly accessible by the CPU
    - Access time is much faster than secondary storage
  - It is read / write
  - Volatile
  - Usually the more RAM installed the faster the computer will operate
    - Smaller RAM needs to access secondary storage more often which is slower
  - Can be upgraded easily
    - Usually easy to swap in a new RAM module
- Read-only memory (ROM)
  - It is read only / permanent
    - The contents cannot be changed or written to
  - Primarily used to store programs and instructions that the computer needs to access when starting up BIOS
    - Known as start-up instructions or bootstrap
  - It is non-volatile
  - Can't usually be changed
    - Permanently attached to the motherboard

3.3.2 Secondary and off-line storage

- Secondary storage
  - Allow users to store applications, data and files
  - The user's data is stored permanently and they can change it or read it as they wish

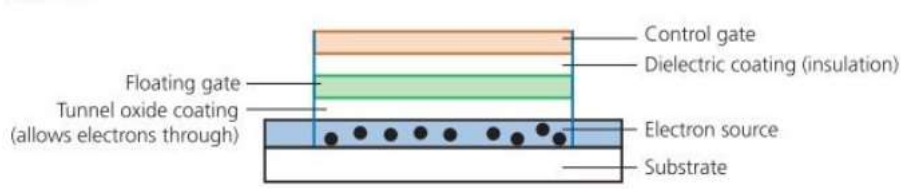
    - It can also be removed to allow data to be transferred between computers
- Characteristics
    - Not directly accessible by the CPU
    - All are non-volatile devices
    - Can be external or internal to the computer
- Purpose of secondary storage
    - For non-volatile / permanent / long-term storage of files / data
    - To store data that is not currently required by the CPU
    - To store data to transfer it to another computer
- Devices
    - Internal
        - Hard disk drive (HDD)
        - Solid state drive (SSD)
    - External
        - CD
        - DVD
        - Blu-ray
        - Flash drives / USB memory stick
        - External HDD
        - External SSD
- Compare to primary memory
    - They can store more data
    - Data access time is considerably longer than RAM or ROM
- 3 main categories
    - Magnetic
    - Solid State
    - Optical

3.3.3a Secondary storage: magnetic

- Hard disk drives (HDD)
    - Uses platters (discs) which are divided into track and sectors
    - Surface is covered in magnetic dots which can be magnetised in one of two different directions and therefore can represent 1s and 0s.
    - Data is read and written using electromagnets
    - Data is stored on the surface in sectors and tracks
    - A sector contains a fixed number of bytes
    - Very slow data access speed compared to RAM
- Latency
    - The time it takes for a specific block of data on a data track to rotate around to the read-write head
- Removeable hard disk drives
    - Can be connected to a computer using USB ports
    - Can be moved between devices and used as back-up devices or to transfer data

3.3.3b Secondary storage: solid state

- SSD
    - No moving parts
    - Uses NAND or NOR technology
    - Made of transistors used as control and floating gates and laid in a grid
    - Floating gates are used to control the flow of the electrons through the transistors
        - This changes the data in the transistors from 1 to 0, or from 0 to 1.
    - Non-volatile (data is not lost when the power is turned off)

- 

- Benefits
  - No latency because there is no moving parts in SSD and all data is retrieved at the same rate
  - More reliable because no moving parts go wrong
  - Considerably lighter so suitable for laptops
  - Don't have to 'get up to speed' before they work properly
  - Lower power consumption
  - Run much cooler than HDDs so suitable for laptop computers
  - Very thin because no moving parts
  - Data access is considerably faster
- Drawbacks
  - More expensive per GB of data
  - Low durability
    - Only 20GB of write operations per day over a 3 year period
    - Limited number of read / write cycles
  - Charge can leak away after 12 months without using
- Memory sticks / flash memories / pen drives
  - Connect to a computer through the USB port
  - Used as a method for transferring files between computers or as small back-up devices for music or photo files
  - It can be used as a dongle for complex or expensive software
    - The dongle contains additional files that are needed to run the software properly
  - Benefits
    - Small
    - Portable
    - Cheap
    - Universal standard
  - Drawbacks
    - Can be fragile
    - Might not be compatible for all computers
    - Easy to get lost

3.3.3c Secondary storage: optical

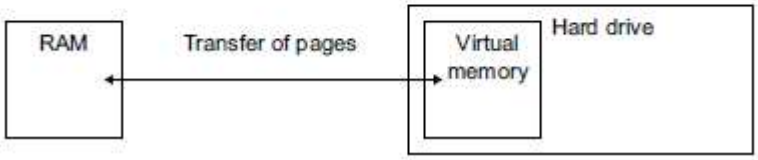
- Reading data
  - Laser is used
  - Laser beams shines onto surface of the disk
  - It is rotated at a constant speed to be read
  - Surface is covered in a track that spirals from the centre
  - Data is represented on the surface using pits and lands
  - Pits and lands represent binary values
  - Pits reflect light back differently (to the area in between / land)
  - Optical device can determine the binary value from the light reflection
- Writing data
  - The disc is rotated
  - Laser beam is used
  - The laser beam makes indentations on the surface of the disc called pits and lands
  - The pits and lands represent 1s and 0s
  - The data is written in a spiral / concentric tracks
  - It is called burning data to the disc
- Storage capacity
  - Blu-Ray > DVD > CD

3.3.4 Virtual memory

- How it works
  - The hard drive is partitioned to create virtual memory
  - When RAM is full pages of data that are not required are transferred from RAM to virtual memory
    - A page = a block of data used in virtual memory system
  - When the data is required again the pages are transferred back to RAM and other pages are swapped out

The diagram shows:
- a hard drive
- the hard drive portioned in some way to create virtual memory
- RAM
- an indication of pages transferred between the RAM and the virtual memory.

- For example:



- Benefits
  - Programs can be larger than physical memory and still be executed
  - There is no need to waste memory with data that isn't being used (e.g. during error handling)
  - It reduces the need to buy and install more expensive, larger RAM memory
- Why 3D modelling software might need to use virtual memory
  - To extend the RAM capacity
  - To stop the 3D modelling software from freezing / crashing when the physical RAM is full
  - To allow the computer to process the large amount of data required for 3D modelling

3.3.5-6 Cloud storage

- Cloud storage
  - A collection of servers that store data in a remote location, and are normally accessed using an internet connection
  - Storage consisting of physical servers that are often in a remote location and maintained/backed up by a third-party company
  - Storage that is normally accessed using a network
- Key terms

Data redundancy	The same data is stored on more than one server In case of maintenance, repair or failure, allowing clients to access data at any time.
Server	Large capacity data storage that holds clients files and data.
Clients	The customers who save their files to the cloud (might have to pay)

- Benefits
  - Customer / client files stored on the cloud can be accessed at any time from any device anywhere in the world provided internet access is available
  - There is no need for a customer / client to carry an external storage divide with them, or even use the same computer to store and retrieve information
  - The cloud provides the user with remote back-up of data with obvious benefits to alleviate data loss / disaster recovery
  - If a customer / client has a failure of their hard disk or back-up device, cloud storage will allow recovery of their data
  - The cloud system offers almost unlimited storage capacity
- Drawbacks
  - If the customer / client has a slow or unstable internet connection, they would have many problems accessing or downloading their data / files
  - Costs can be high if large storage capacity is required; it can also be expensive to pay for high download / upload data transfers limits (more bandwidth) with the customer / client internet service provider (ISP)

- The potential failure of the cloud storage company is always possible, this poses a risk of loss of all back-up data

3.4 Network Hardware

2023年3月14日 23:41

3.4.1 Network Interface Card

- NIC
  - The component in a device that enables it to connect to a network
  - Every device that connects to a network requires a NIC
  - This can be wired or wireless hardware
  - Sometimes it is removable but most modern devices have them built in
  - A MAC address is usually written to the NIC at manufacture

3.4.2 MAC Address

- Features
  - Uses
    - Uniquely identifies a device on a network
    - Used to identify the sender and recipient's devices when transmitting data
  - A unique address
  - Doesn't change, static address
  - Assigned to NIC by the manufacturer
  - Can be local or universal
- Format
  - 48 bits
  - Written in 6 pairs of hex digits
  - First 3 pairs are the manufacturer's code
  - Second 3 pairs are the device serial number

3.4.3 IP Address

- Uses
  - A unique address that specifically identify where the device is connected to the internet
  - Contains the network prefix and the host number
  - Allocated to the device when it connects to the internet
- Assign
  - Private IP address
    - The router assigns an IP address in a LAN (local area network)
  - Public IP address
    - The ISP (internet service provider) assigns an IP address in a WAN (wide area network / internet)
- Static IP address
  - Permanently assigned to a device by ISP
  - Don’t change each time a device logs onto the internet
  - Used for:
    - Web server
    - Online database
    - File Transfer Protocol (FTP) server
  - Addressing
    - The device can access the website resources directly
    - This gives the device a consistent location and also means less bandwidth
      - Reducing network traffic (and takes less time to retrieve data)
- Dynamic IP address
  - Assigned by the ISP each time a device logs onto the internet
  - Done using Dynamic Host Configuration Protocol (DHCP)
  - Can be different every time a device connects to the internet
  - Assigned to most of the devices
- IPv4 and IPv6 address

- Too many devices on the network so we need to move to IPv6
- Differences

	IPv4	**IPv6**
Bits used	32 bits	128 bits
Number base used	Denary	Hexadecimal
Separated by	Full stop (.)	Colons (:)
Format	4 groups of denary digits	8 groups of hex digits
Range of values	0-255	0-FFFF

3.4.4 Routers

- Router
  - A device that forwards packets to their correct destination in a network
- Job of a router
  - Allow devices on the same network to communicate
  - Allocate IP address to devices on the network
  - Allow connections to other networks
- Connecting to devices
  - Both with cables and wirelessly
- Firewall
  - Usually included by modern routers
  - Protect the computers on a network

4.1 Types of software and interrupts

2023年5月6日 17:22

4.1.1 System and application software

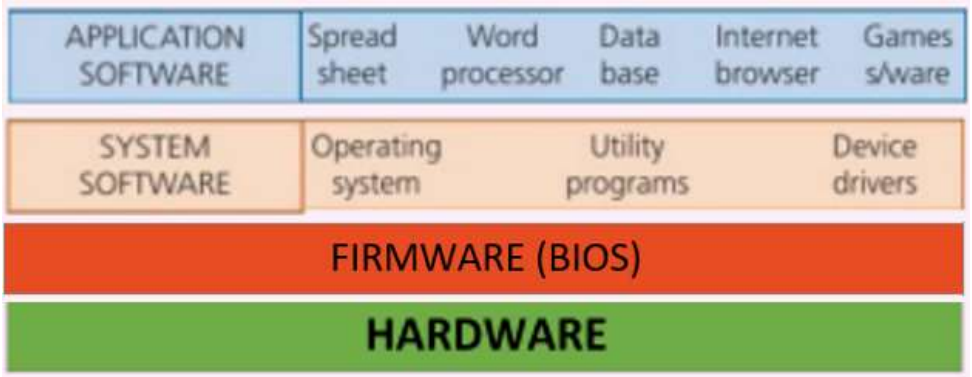
- Software
  - The non-physical elements or programs that run on computer hardware
- System software
  - Provides the services that the computer requires, including operating system and utility software
- Application software
  - Provides the services that the user requires
- System software examples
  - Operating systems: Microsoft Windows, Apple MacOS, Google Android, Apple iOS
  - Utility software: anti-virus, file management, disk defragmenter, screensavers
- Application software examples
  - Word processors, spreadsheets, presentation software, video-editing software

4.1.2 Operating systems

- Operating system
  - Enables computer systems to function correctly
  - Allows users to communicate with computer systems by providing a useable interface
  - Provides an environment in which applications can run
  - Can disguise the complexity of computer hardware and software
- Examples of operating systems
  - MacOS
  - Windows
  - Linux
  - Android
  - iOS
  - iPadOS
- Functions
  - Managing files
  - Handling interrupts
  - Providing an interface
  - Managing peripherals and drivers
  - Managing memory
  - Managing multitasking
  - Providing a platform for running applications
  - Providing system security
  - Managing user accounts

4.1.3 Firmware

- Firmware (BIOS)
  - A program that provides low level control for devices
- Operating system startup process
  - Part of the operating system needs to be loaded into RAM
  - Handled by the BIOS (Firmware)
  - The BIOS is held in non-volatile devices such as ROM
  - The BIOS tells the computer the location of the secondary storage device that holds the operating system
  - The part of the operating system required for boot up is loaded into RAM and executed
  - Once boot up has finished, the operating system can be completely available
- Software structure
  - Applications require an Operating System to run

- An Operating System requires Firmware (BIOS) to run
- The Firmware communicates with the hardware of the device
    - e.g. the bootloader is run on the hardware
- 

4.1.4 Describe the role and operation of interrupts

- Interrupt
    - An interrupt is a signal sent from a device (hardware) or from software to the microprocessor
    - This will cause the microprocessor to temporarily stop what it is doing so it can service (deal with) the interrupt
- Interrupt service routine (ISR)
    - Software that handles and executes the operations required by the interrupt
- How an interrupt is generated
    - Timing signals
    - An input/output process
    - A hardware fault
    - User interaction
        - Hardware interrupts include pressing a key on the keyboard and moving the mouse
    - Software errors that cause a problem
        - Software interrupts include division by zero and two processes trying to access the same memory location
- How it is handled using an interrupt service routine (ISR)
    - Once an interrupt is received a small program is run called an interrupt service routine
    - It pauses the current processing, services the interrupt and then returns to the previous process
    - Priorities
        - Each interrupt is assigned a priority level
        - It allows the microprocessor to decide whether it needs to stop what it is doing or whether it can carry on and service the interrupt later
        - It also allows interrupts to be put into a queue for servicing depending on their priority level
        - An interrupt with a high priority level can interrupt another interrupt that is being serviced

4.2 Types of programming languages, translators and IDEs

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4.2.1 High level and low level languages

- Machine code
  - Only language that the computer understands
  - Written in binary or hex
  - Any other programming language that is used needs to be translated into machine code before it can be understood by a computer
  - Codes used are determined by the computer's instruction set
- High level language
  - Uses natural language statements
  - e.g. C++, Python, Java, Visual Basic
  - Advantages
    - Relatively easier to read and understand - written using words - closer to English sentences
    - Easier to write in a shorter time
    - Easier to debug as it's being developed
    - Easier to maintain once in use
    - No knowledge of hardware or instruction set is required
    - Portable - can be used on different types of computer
  - Disadvantages
    - Programs can be larger
    - Programs can take longer to execute
    - Programs may not be able to make use of special hardware
    - One line of code requires several lines of machine code
- Low level language
  - Uses binary, hex, short character codes (mnemonics)
  - e.g. machine code, assembly language
  - Advantages
    - Code can perform simple tasks very quickly
    - Can make use of special hardware
    - Hardware can be controlled directly (from firmware)
    - Code doesn't take up much space in primary memory
  - Disadvantages
    - Takes longer to write and debug programs
    - Programs are more difficult to understand

4.2.2 Assembly languages

- Assembly language
  - LLL
  - Use mnemonics codes
  - Usually 3 letters for each code
  - Translated into machine code using an assembler
- Assembler
  - Translates a low level assembly language program into machine code
  - An executable file of machine code is produced
  - One LLL statement is usually translated into one machine code instruction
  - Assembled programs are used without the assembler
  - An assembled program is usually distributed for general use

4.2.3-4 Translators

- Why is it needed
  - Computer only understand machine code written in binary or hex

    - Any other program language needs to be translated into machine code to be understood by the computer
- Interpreter
    - Used to translate HLLs into machine code
    - Checks/translates one line of code and then executes it before moving on to the next line Stops when an error is found
    - When corrected the program can be run from the same position // allows error correction in real time
    - Needs an interpreter to run for each time
    - Good for developing and debugging programs
- Compiler
    - Used to translate HLLs into machine code
    - Checks all code before executing any code
    - Produces error report with all errors found for the whole code (before translating/running any of the code)
    - Produces executable file
    - Can be run without recompiling after being compiled
    - Good for distributing a completed program
    - Not good for developing and debugging
- Compiler vs. interpreter

	Compiler	**Interpreter**
Advantages	• Programs can be run without a compiler • Programs can be stored ready for use • Program takes up less space in memory when it is executed • Program executed in a shorter time	• Easier to edit programs during development • Easier and quicker to debug and test programs during development
Disadvantages	• Takes longer to write, test and debug during development	• Programs can take longer to execute Programs cannot be run without the interpreter

4.2.5 Integrated development environment (IDE)

- IDE
    - Software that provides useful functions for a programmer writing a computer program
- Common functions
    - Code editor
        - The program can be written an edited without using a separate text editor
    - Run-time environment
        - Enables a user to debug code with special tools
        - Single-stepping - allows the programmer to step through the code one line at a time
        - Breakpoint - setting a point to stop the execution of the program
        - Report window - shows the contents of variables at different points in the program
    - Translator
        - Interpreter and maybe a compiler
        - The interpreter is used for developing and the compiler to finish and distribute the final program
    - Error diagnostics
        - Dynamic error checking
            - Highlight errors as they are being typed
            - Can alert the programmer to change the code and fix bugs before the program is run
        - This highlighting might be underlining the code or changing the colour of the text
    - Auto-completion

    - Offer context-sensitive prompts with text completion when code is being typed
    - Can help to maintain the consistent spelling and use of variables throughout the program
- Auto-correction
    - Some IDEs will provide correction options when an error is identified.
    - Select from a list of possible correction options
    - It is not true auto-correct which is when spelling mistakes are corrected automatically
- Prettyprinting
    - Use colour codes to help identify variables, integers and strings

5.1 The internet and the world wide web

2023年6月12日 13:48

5.1.1 The differences between the internet and the world wide web (WWW)

- Internet
  - Derived from interconnected network
  - A worldwide collection of interconnected networks
  - Relies on a physical infrastructure that allows networks and individual devices to connect to other networks and devices
- World wide web
  - A collection of web pages that make use of the internet to transfer pages between devices
  - Can be accessed by users using web browser software
- Application that use internet
  - World wide web
  - Email
  - Video conferencing
  - File transfers
  - Online chatting
- Protocols used by the internet
  - TCP (transmission protocols)
  - IP (internet protocol)
- Protocols used by www
  - Http (hypertext transfer protocol)
  - Https (hypertext transfer protocol secure)

5.1.2 Uniform resource locator

- URL
  - Uniform resource locator
  - A text-based address for a webpage
  - Components
    - Protocol e.g. https
    - Domain name e.g. www.Cambridgeassessment.org.uk
    - Webpage / filename e.g. index.html

5.1.3 http and https

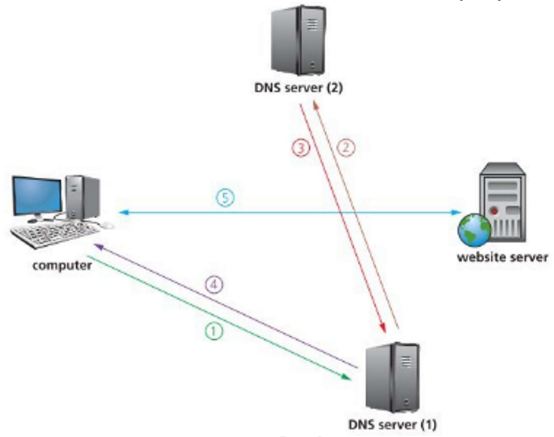
- Http
  - The rules that need to be followed to allow web pages and data to be transferred across the internet
  - = hypertext transfer protocol
- Https
  - It is a rule that encrypts data when it is transferred
  - Makes it more secure than http
  - = hypertext transfer protocol secure

5.1.4 Web browsers

- Web browser
  - Application software which allows users to access and display web pages on their devices
  - Web pages are written in HTML code
  - Main purpose of a web browser is to render the HTML codes and display the results
- Functions / features of a web browser (remember 4)
  - Store favourites
  - Keep a history of websites visited
  - Navigate backwards and forwards through pages already opened
  - Private browsing can be enabled

- Allow multiple tabs/web pages to be open
- Allows files to be downloaded from website/internet

5.1.5 Retrieval and location of webpages

- Web server
  - Holds web pages which can be transferred to devices when requested
  - Each server can be identified by a unique IP address
- DNS (Domain Name Server)
  - A database of URLs with matching IP address
  - Users don't have to remember IP addresses for the websites they want to visit
- Retrieving and displaying webpages using a browser and DNS
  - URL entered in browser
  - The browser asks the DNS server for the IP address of the website
  - If the DNS server cannot find the URL in its database or cache it sends a request to a second DNS server
  - The second DNS server can then finds the URL in its cache / database and map it onto the correct IP address
  - The IP address is sent back to the first DNS server which stores the IP address and URL in its cache / database
  - The IP address is sent back to the user's computer
  - The computer sets up a communication with the website server and the required pages are downloaded
  - HTML files are sent from the website server to the computer
  - The browser renders the HTML and display the content on screen
  - 

5.1.6 Cookies

- Cookies
  - Small files / code stored on user's computer
  - Small look-up table with pairs of values (key + data e.g. music + rock)
- Transmission
  - Sent from web servers to browsers
- Processing cookies
  - If the browser finds an existing cookie for a website visiting it reads the cookie
  - Cookie holds key info on user's preferences (e.g. language)
- Things they allow to do
  - Allow user tracking
  - Maintain user preferences
  - Customise webpage for each individual user
- Types of cookies
  - Session cookies
    - Are temporary
    - Does not collect information from the computer
    - They cease to exist when the web browser / website session is closed
    - Advantages
      - They do not store personal information

        - Do not personally identify user
    - e.g. virtual shopping basket
- Persistent cookies
    - Are permanently stored in secondary storage
    - Collect information from the computer
    - Cease to exist when expiry date reached or the deleted by the user
    - Advantages
        - They store personal information / user preferences if agreed
        - Do not need to type login details every time when visiting the website
        - Efficient way of carrying data
- How cookies are stored and read
    - The first time user logs on
        - User's browser requests webpage from website for the first time
        - Web server sends webpage + cookie back to browser
        - Persistent cookie is stored on the user's hard drive
        - Session cookie is stored in temporary memory
        - When web browser / website session is closed
            - Persistent cookie remains stored
            - Session cookie is deleted from memory
    - User logs in to website again
        - Browser send request for the webpage to the web server
        - Web server checks and identifies persistent cookies stored on user's computer
            - User's details are recognised
        - User's history data is matched with data of other online websites for advertising
        - Webpage sent back to the web browser
        - The web browser customises the webpage for the user
- Uses of persistent cookies
    - Storing preferences so the user does not have to select their preferences each time they visit the site
    - Storing account details so the user does not have to remember/enter their username and password each time they visit the site
    - Storing recent purchases to allow the user to quickly re-order more items
    - Storing the pages visited / items selected to display relevant adverts
    - Storing shopping basket so when the user leaves the site the items are still in their basket

5.2 Digital currency

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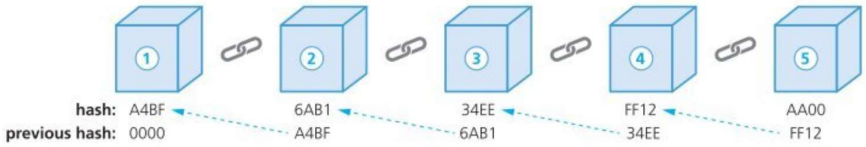
5.2.1 Digital currency

- Digital currency
  - Only exists electronically
  - e.g. bitcoin

5.2.2 The Blockchain process

- Blockchain
  - A digital ledger (book of accounts) that tracks each transaction
  - Keeps a series of time-stamped records that link to each other
- Blockchain structure
  - The first block = genesis block
  - Each block is identified by its hash value
  - The blocks are linked together by storing the hash value of the previous block in the chain
  - Information stored
    - Data for transfer, e.g. name of sender and recipient, amount of money
    - Hash value of the block
    - Hash value of the previous block in the chain
  - The hash value of the block will change if information inside is altered, so the blocks beyond it become invalid as the link between them is broken
  - 

- Distributed and decentralised model
  - Every person on a peer-to-peer network receives a complete copy of the blockchain
  - When a new user is created they get a copy of everything in the whole blockchain system
  - When a new block is created a copy is sent to everyone on the network for verification before being added to the blockchain
  - Help to maintain the integrity and trustworthiness of the data

5.3 Cyber security

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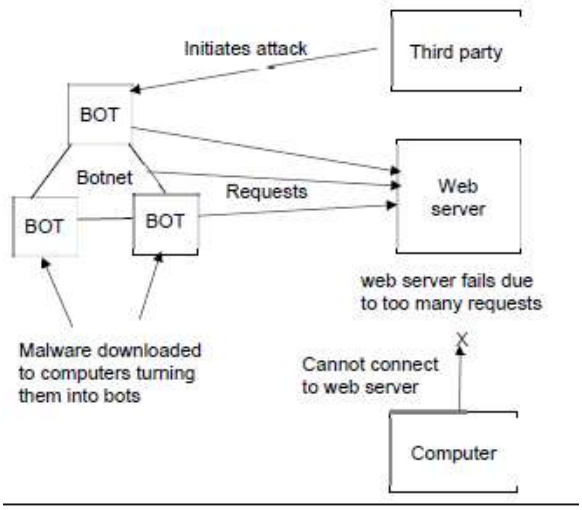
5.3.1a Cyber security threats - forms of attack

- Brute force attacks
  - Try every possible combination of characters to crack a code or a password
  - Check for common passwords / use a list of words
- Data interception
  - Listening or tapping into communication links to try and obtain confidential information
  - Wired network = packet sniffing
    - Examine data packets sent over a network
    - Data intercepted sent back to the hacker
  - Wireless networks = Wardriving or Access Point Mapping
    - A combination of hardware and software can be used outside a building or someone's house to intercept wireless signals and reveal personal data
- Distributed denial of service (DDoS) attacks
  - Multiple computers are used as bots
  - Malware downloaded to the computers
  - Numerous requests are sent to a server at the same time
  - The server is unable to respond to all the requests
  - It times out as a result
  - Website become too slow to use or crashes completely
  - Prevent people from accessing the website / email / online services

One mark for each part of the diagram (MAX six).
The diagram demonstrates:
- Malware downloaded to several computers
- … turning it into a bot/zombie
- … creating a network of bots/zombies
- Third party/hacker initiating the attack
- Bots send requests to a web server at the same time
- The web server fails due to the requests
- Legitimate requests cannot reach the web server



- DDoS aims
  - Revenge
  - To affect a company's reputation
  - Entertainment value
  - To demand a ransom to stop it
  - To test a system's resilience
- DDoS prevention methods
  - Firewall
  - Proxy Server
  - Users scanning their computers using anti-malware software
- Hacking

- The act of gaining illegal access to a computer system without the user's permission
- Read / copy / alter data stored
- With the intention of committing a criminal offence e.g. blackmail, identify theft, fraud and financial gain

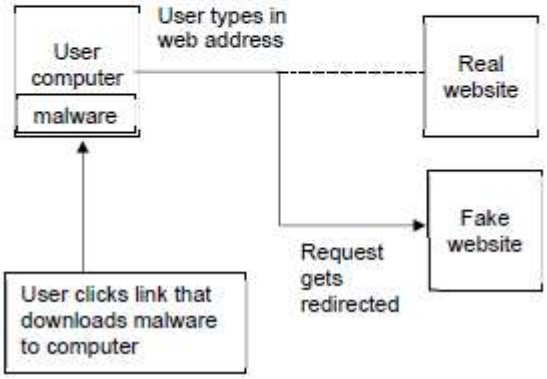
5.3.1b Cyber security threats - malware

- Malware types
  - Viruses
  - Worms
  - Trojan horse
  - Spyware
  - Adware
  - Ransomware
- Viruses
  - Software/code that replicates itself on a network
  - Need an active host program to be launched for the virus to be run
  - Deletes / damages / corrupts data / files
  - Takes up storage/memory space
  - Can be sent as email attachments or in software downloaded from infected websites
- Worms
  - Software / code that replicates itself on a network
  - Don't need a host program
  - Takes-up bandwidth
  - Deletes / damages / corrupts data / files
  - Takes up storage / memory space
  - Opens back doors to computers over the network
  - Used to deposit other malware on networked computers
- Trojan horse
  - Disguised as legitimate software but with malicious code e.g. spyware / ransomware inside it
  - Needs to be executed by an end user
  - Arrives as an email attachment or downloaded from infected websites
  - When it is downloaded / installed the other malware it contains is installed
  - Once installed cyber criminals can gain access to personal data
- Spyware
  - Malware that resides on a computer and monitors a user's activities
  - Monitor and capture web browsing, sending back bank details and passwords to cybercriminals
  - Key logging software is often part of spyware
    - It logs every key pressed by a user and can detect passwords being typed in
    - Data sent to third party
- Adware
  - Software / code that generates / displays (unwanted) adverts on a user's computer
  - Some may contain spyware / other malware
  - Some when clicked may link to viruses
  - Reduces device performance
  - Reduces internet speed
  - Redirects internet searches / user to fake websites
- Ransomware
  - Software / code that stops a user accessing their computer or data by encrypting the data / files / computer
  - A fee has to be paid to decrypt the data / computer

5.3.1c Cyber security threats - social engineering

- Phishing
  - A legitimate looking email is sent by cybercriminals
  - May contain links or attachments that when clicked or opened take the user to a fake website
  - May trick users into responding with personal data

- Are harmless unless a link or attachment is opened
- Pharming
  - Malicious code on a user's computer or on an infected website (could have been introduced using malware)
  - The code redirects the user's browser to a fake website without the user's knowledge
    - Problem not initiated by the user
  - Used by cybercriminals to obtain personal data which can be used for fraud and identity theft
  - One mark for each correct part of the diagram.
    Diagram shows:
    - User clicks/opens attachment/link that triggers downlo
    - Malicious software downloaded onto user's computer
    - User enters website address
    - User is redirected to fake website

    e.g.
  - 

- Pharming prevention
  - Checking the spelling and tone of the email/website
  - Checking the URL attached to a link
  - Scanning a download with anti-malware
  - Only downloading data / software from trusted sources
  - Never providing personal details online
  - Install a firewall to check if the website is valid
- Social engineering
  - Tricks people to obtain data
  - Involves a cybercriminal creating a social situation that can lead to a potential victim dropping their guard
  - Emotions that can be exploited
    - Curiosity
    - Fear
    - Empathy / Trust
  - e.g. instant messaging (curiosity), scareware (fear), email scam (trust)

5.3.2 Cybersecurity - keeping data safe

- Authentication
  - The ability of a user to prove who they are
  - Three common factors
    - Something you know
    - Something you have
    - Something that is unique to you
- Password authentication
  - Improve security
    - Making a password stronger e.g. longer password, combination of numbers, uppercase and lowercase letters and symbols
    - Changing it regularly
    - Lock out after set number of attempts
      - Stops brute force attacks and makes it more difficult to guess
- Biometric authentication
  - Data needed to enter is unique to individual therefore it is very difficult to replicate

    - Lock out after set number of attempts
    - e.g. fingerprint / retina scan
- Two step verification / multifactor authentication
    - Extra data is sent to device / email / phone number set by user
        - Making it more difficult for hacker to obtain it
    - Data has to be entered into the same system
        - If attempted from a remote location, it will not be accepted
- Firewall
    - The primary defence to any computer system
    - Can be either hardware or software
    - Acts as a barrier between a computer and a public network
    - Monitors traffic coming into and out of the computer system
    - Checks that the traffic meets any criteria / rules set
    - Blocks any traffic that does not meet the criteria / rules set
    - Set blacklist / whitelist
- Proxy server
    - Can be software or hardware
    - Acts on behalf of a computer connecting to a web-server
    - Can also act as a firewall
    - Main tasks
        - Prevents direct access to a web-server
        - Keeps a user's IP address secret
        - Filters traffic and can block access to websites
        - Attacks hit the proxy-server first
        - Cache allows faster access to website (save websites that are often visited)
- Comparing proxy server and firewall

Similarities	Differences
• Check incoming and outgoing signals • Filter traffic • Store whitelist/blacklist • Block incoming/outgoing signals • Block unauthorised access • Keep a log of traffic • Can be hardware or software (or both)	• Proxy can hide user's IP address, firewall does not • Proxy intention is to divert attack from server, firewall is to stop unauthorised access • Proxy protects a server, firewall protects individual computer • Proxy examines requests for a website but a firewall does not • Proxy transmits website data to the user firewall does not • Proxy allows faster access to a web page using cache, but a firewall does not have a cache • Proxy can hide internal network from internet firewall cannot

- Secure Sockets Layer (SSL)
    - A security protocol
    - Encrypts any data that is sent between a browser and a web server
    - Uses digital certificates requested by the user's browser
    - The certificate contains the website's public key that can be used to authenticate the website
    - Once the certificate is authenticated, data transmission will begin
- Access levels
    - Users in an organisation can be allocated different access levels
    - Providing users with different permission for the data
    - Limiting access to reading data limiting the data that can be viewed
    - Limiting access to editing data
    - Normally linked to a username
- Privacy settings
    - e.g. Set a level of privacy for social media posts
    - Types of privacy settings

Type	Detail
'Do not track' setting	• Stop websites collecting and using browsing data • Leads to improved safety
Check to see if payment	• Prevents the need to type in payment details again

methods have been saved on websites	• Entering details = risk to be intercepted
Safer browsing	• An alert is given when the browser encounters a potentially dangerous website
Web browser privacy options	• e.g. storing browsing history / cookies
Website advertising out-puts	• A website may be tracked by third parties who gather information about an account for advertising purposes
Apps	• e.g. the sharing of location

- Anti-malware
  - Anti-virus
    - Scans the computer system (for viruses)
    - Has a record of known viruses
    - Removes / quarantines any viruses that are found
    - Checks data before it is downloaded
      - Stops download if virus found / warns user that the file may contain virus
  - Anti-spyware
    - Scans the computer for spyware
    - Look at rules / file structure to identify spyware
    - Removes / quarantines any spyware that is found
    - Can prevent spyware being downloaded
    - Features
      - Detect and remove spyware already installed on a device
      - Prevent a user from downloading spyware
      - Encrypt files to make the data more secure in case it is spied on
      - Encryption of keyboard strokes to help remove the risk posed by the keylogging aspects of some spyware
- Automatic software updates
  - To automatically keep the device up to date with latest security patches
  - Usually done overnight
  - Done to fix security issues or improve performance
  - May slow device down or the device may not be suitable for the latest software
- Checking the email / text message
  - Checking the spelling and tone of communications
    - Spelling mistakes, 'Dear Customer', threats or urgency should be warning signs in communication
  - Checking the URL attached to a link
    - Is the link looking strange or unrelated to the organisation sending it
- What can be used for each type of attack

	Brute-force attack	Data interception	DDoS	hacking	malware	pharming	Phishing	Social engineering
Access levels				x				
Anti-malware (anti-virus, anti-spyware)					x	x		
Authentication (username and password, biometrics, two-step verification)	x			x				
Automating software updates	x				x	x		
Checking the spelling and tone of communications							x	
Checking the URL attached to a link							x	
Firewalls			x	x	x	x		
Privacy settings		x						x
Proxy-servers	x		x		x	x		
Secure socket layer (SSL) security protocol		x						

6.1 Automated systems

2023年10月8日 17:26

6.1.1 Automated systems

- Automated system definition
  - A combination of software and hardware that is designed and programmed to work automatically without the need of any human intervention
  - Often involve human monitoring
- Components of an automated system (alter depending on the context of the question but still mention all these points)
  - Sensors
    - Continuously take readings from the surroundings
    - Send the digitised data to a microprocessor or computer
  - Microprocessors
    - Receive data from sensor
    - Compare data to stored data in database/file
    - Send signal to actuator (mention if in range + not in range)
    - e.g. compare data to stored values
  - Actuators
    - Responsible for controlling the output
    - Controls motors, wheels, solenoids, etc.
- Sensors list
  -

Infrared (active)	Humidity	Proximity	Pressure	Infrared (passive)
Accelerometer	Level	Temperature	Magnetic field	Flow (rate)
Acoustic / sound	Gas	pH	Moisture	Light

6.1.2 Automated systems - applications, advantages and disadvantages

- Specific scenarios

Scenario	**Inputs needed (sensors)**	**What decisions will the microprocessor be making?**	**What outputs will the actuator control?**
Industrial: A nuclear power station	• Temperature • Pressure • Flow level • Gas • Radiation level	• Check against a large database of operational data and parameters • Control actuators when needed	• Operate pumps, valves or emergency shutdown
Transport: Self-parking cars	• Accelerometer • Proximity	• Find parking spaces and warn the driver • Calculate the position of surrounding objects, the sensor giving a 3D image • Send output to wheels and motors	• Control motors and wheels so the car can park
Agriculture: Irrigation system	• Level (Weather station↓) • Thermometer • Anemometer • Hygrometer • Barometer • Level sensor • Light sensor	• Receive data at automatic weather stations + level sensor • Decide if it is necessary to start / stop pumps based on data received	• Operate the pumps
Weather: remote	• Thermometer	• Data from the sensors and the	• Tipping the

weather station	• Anemometer • Hygrometer • Barometer • Level sensor • Light sensor	calculated values calculated and stored on a central database	bucket of the rain gauge to reset the instrument at a pre-determined time interval
Gaming: game controller	• Accelerometers • Proximity sensors	• Calculate the response using the collected value	• Display images on screen
Lighting: lighting system in a house	• Light • Proximity • Infrared (detect people)	• Get data from sensors • Detect if there is people in the room using and check if the room is too dark or bright • Turn on	• Turn light on/off
Science: Chemical process in a lab	• pH • Temperature • Pressure • Gas • Level • Colorimeter	• Keep record of changes detected • Check if the amount needed is added	• Operate tap of burette to control flow of liquid

- Advantages
  - Operations can be carried out faster than a human operator
  - Safer because automated system is more likely to make timely interventions
  - Allows humans to keep away from hazardous environments
  - Processes are more likely to run under optimal conditions for longer
  - Lower long term cost than using a large number of human workforce
  - Efficient use of materials and resources leads to increased productivity
  - More consistent and repeatable results
- Disadvantages
  - Initially expensive to set up
  - Requires significant testing and calibration to ensure that it works as intended
  - Any computerised system is subject to cyber attacks
  - Requires highly specialised and ongoing maintenance
  - Only able to respond to specific situations within certain parameters so not as flexible as trained human
  - Can result in significant job losses

6.2 Robotics

2023年10月8日 17:26

6.2.1 What is robotics

- Robotics definition
  - A branch of computer science that brings together the design, construction and operation of robots
- Examples uses and activities

Factories	Home	Drones
• Welding parts together • Spray-painting panels on a car • Fitting windscreens to cars • Cutting out metal parts to a high precision • Bottling and labelling plants • Warehouses (automatic location of items)	• Autonomous floor sweepers • Autonomous lawn mower • Ironing robots • Pool cleaning • Automatic window cleaners • Entertainment	• Unmanned aerial vehicles • Can be used to make parcel deliveries • Can be used in reconnaissance

6.2.2 Characteristics of a robot

- Robotics characteristics
  - A mechanical structure or framework
  - Electrical components, e.g. sensors, microprocessors and actuators
  - Programmable

6.2.3 Roles, advantages and disadvantages of robots

- Advantages
  - More efficient
  - More accurate
  - Replace human in dangerous working conditions
  - Less running cost
  - More consistent
  - Can work 24 hours a day / do not need breaks
- Disadvantages
  - Initially expensive to buy and setup
  - Can lead to unemployment
  - Robots can find it difficult to do non-standard tasks
  - Systems can be hacked
- Roles that robots can perform

Areas	Example of use	Advantage	Disadvantage
Industry	Manufacture of microchips	More accurate than a human	Can be hacked
Transport	Driverless vehicles	Can work 24 hours a day	Can find it difficult to do non-standard tasks e.g. in a car accident
Agriculture	Harvesting of crops	Reduces running costs	Can lead to unemployment
Medicine	Surgical procedures	Replace human in dangerous working conditions, won't be infected	Can be hacked
Domestic	Robot vacuum cleaners	Do not need to rest	Lead to unemployment
Entertainment	Robots in theme parks to interact with visitors	More consistent	Initially expensive to buy and setup

6.3 Artificial intelligence

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6.3.1-2 Introduction to and Characteristics of Artificial Intelligence (AI)

- AI definition
  - AI is a branch of computer science dealing with the simulation of intelligent behaviours by computers
- Characteristics of AI
  - The collection of data
  - Rules for using that data
  - The ability to reason (to draw conclusions based on data)
  - Can include the ability to learn and adapt
  - Makes one or more predictions (to make a decision)
  - Can find / analyse patterns

6.3.3 AI systems - basic operation and components

- Expert system
  - A form of AI that has been developed to mimic human knowledge and experiences
- Components of an expert system
  - Knowledge base
    - A collection of facts obtained from a number of expert resources
    - Needs a knowledge base because it needs facts to generate the rules and make the decisions
  - Rule base
    - Rules that are used by the inference engine to draw conclusions by using logical thinking and IF statements
  - Inference engine
    - The main processing element of the expert system.
    - Asks questions through the interface
    - The next question asked will be based on the previous response
    - Examines the knowledge base and uses the rules base to find a match
  - Interface
    - How the expert system interacts with the user
    - Could be dialogue boxes, buttons, voice
    - Usually questions have yes/no answers
- Machine learning
  - When a program has the ability to automatically adapt its own processes and/or data
- Machine learning characteristics
  - They learn from past experiences and examples
  - They can make predictions or take decisions based on previous scenarios (tic tac toe, chess)
  - They have very powerful processors which make them fast and accurate
  - They can manage and analyse huge amounts of complex data
  - They can perform tasks that would take humans years to complete
- Example: how a program can help a robot navigate through a puzzle using AI
  - Use machine learning algorithms
  - Collects data about where it has been + obstacles/problems
  - Store successful actions + unsuccessful actions
  - Identify and store patterns to make sure it does not repeat the same incorrect route
  - So it knows how to react to obstacles next time and what is most likely to work next time