OCR A Level Computer Science

Your notes

1.2 Types of Processor

Contents

CISC vs RISC

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CISC & RISC

- A computer processor will have an **instruction set** that it can use to execute programs
- This will **vary from one processor to the next**
- There are **2 types of processors**:
  - Complex Instruction Set Computer
  - Reduced Instruction Set Computer

CISC (Complex Instruction Set Computer)

- **Complex Instruction Set Computer (CISC)** consists of a **larger instruction set** which includes more complex instructions
- As the instructions are more complex, they can **take more than one clock cycle to execute**
- Has more **general purpose registers**
- Instructions take up **less space in memory**
- Is usually used in **laptops and desktop** computers

RISC (Reduced Instruction Set Computer)

- **Reduced Instruction Set Computer** consists of a **smaller instruction set** with more simple instructions
- Each instruction takes **one clock cycle to execute** which makes it more **suitable for pipelining**
- Compilers are more complicated so will **generate more instructions**
- Has **fewer addressing modes**
- Is usually used in **smartphones and tablets**

What's the Difference Between RISC & CISC?

	RISC	CISC
Feature	Has fewer transistors	Has more transistors

	Takes one clock cycle per instruction	Takes multiple clock cycles per instruction
	Suited to pipelining	Not suited to pipelining
	Compilers are more complicated	Compilers are less complicated
	Has fewer general purpose registers	Has more general purpose registers
	Used in smartphones and tablets	Used in laptops and desktops
	Has fewer addressing modes	Has more addressing modes
Benefits / Drawbacks	Requires less power	Requires more power
	Costs less to manufacture	Costs more to manufacture
	Takes up more space in memory	Takes up less space in memory

- A program that has been **written for a RISC** processor **won't work on a CISC** processor and vice versa
- A program that has been **written for a RISC** processor **won't necessarily work on another RISC** processor as they may have different instruction sets


Your notes


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Graphics Processing Unit (GPU)

What is a GPU?

- A graphics processing unit (GPU) is responsible for **processing graphics** within the computer to **reduce the load on the CPU**
- **CPUs are general purpose processors** whereas **GPUs are designed specifically for graphics**
- GPUs are likely to have built in circuitry or instructions for common graphics operations
- GPUs can perform an instruction on **multiple pieces of data at one time**
- This is useful when processing graphics (e.g. transforming points in a polygon or shading pixels) which means it can perform transformations to on screen graphics quicker than a CPU
- The GPU can either be **part of the graphics card or embedded in the CPU**
- A GPU will usually be multicore and can have up to 76 cores

What can a GPU be used for besides graphics?

Besides graphics processing, a GPU can also be used for:

3D modelling

- The GPU can be used to **render** lighting effects, textures and shadows

Data modelling

- As GPUs can handle many calculations simultaneously, they can handle large datasets and complex operations like sorting and filtering data

Financial modelling

- GPUs are used to simulate different scenarios in risk modelling, option pricing and other financial modelling types
- Lots of simulations can be run in parallel

Data Mining

- Data mining is the process of **analysing large amounts of data to find patterns**
- The main computational tasks are sorting, searching, pattern recognition, statistical analysis and graph algorithms

Performing Complex Numerical Calculations


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- Matrix multiplication and inversion can be done in parallel
- Numerical Simulations
  - Physics and engineering simulations often involve solving complex maths models, which can be done in parallel
- Solving Differential equations
  - Solving differential equations involves computations which can be performed in parallel

Machine learning

- This involves **training a computer on a massive amount of data** which can be done in parallel. There are lots of matrix multiplications and other computations which can be performed
- After the training, GPUs can be used to speed up the process of **making predictions** on new data

Calculations on multiple data at the same time

- There are a number of scenarios where **calculations will be needed to be carried out on multiple data at the same time** e.g. insurance pricing, modelling risk, calculating bills
- This is done by GPUs rather than CPUs due to being set up **for parallel processing**

What types of task are GPUs suited for?

GPUs are suited to certain tasks that utilise:

- **Specialist instructions**
  - GPUs are designed to execute specialist instructions which are common in 3D graphics rendering such as operations on matrices, vectors and geometric transformations
  - These capabilities have been expanded over time and have been generalised which makes GPUs suitable for a wide range of complex calculations besides graphics processing
- **Multiple cores**
  - Although a CPU can have multiple cores, these are optimised for **serial** processing
  - GPUs have smaller cores but these are optimised for parallel processing
  - GPUs can perform many calculations simultaneously - ideal for tasks that can be broken down into smaller parts
  - This is useful in machine learning and situations where large amounts of data need to be processed
- **SIMD processing**

- Single Instruction Multiple Data (SIMD) processing is computers that have multiple processing elements which perform the same operation on multiple data points simultaneously
- GPUs support SIMD processing as they were originally designed to perform the same operations on multiple pixels or vertices simultaneously - this is a common requirement in image processing, simulations and machine learning

Examiner Tips and Tricks

- You don't need to know the ins and outs of these uses of GPUs (like how to solve a differential equation) but you need to know what GPUs can be used for besides graphical processing

What are the benefits of using a GPU?

There are a number of benefits to using a GPU as well as a CPU (it isn't possible to only use a GPU as the CPU assigns tasks to the GPU)

- **Parallel processing**
  - GPUs can handle many tasks simultaneously as they are multicore processors
- **Speed**
  - As GPUs can use parallel processing, this speeds up tasks, particularly those involving large amounts of data or complex computations
- **Efficiency**
  - GPUs can perform more calculations per unit of power consumed in comparison to CPUs making them more energy efficient when it comes to parallel tasks

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Multicore & Parallel Processors

- A multicore system has **more than one processing unit** in a single processor which can **independently process instructions at the same time**
- When a computer has multiple cores it can use **parallel processing** where **each core can work on the same task** to complete it more quickly, or **each core can work on separate tasks at the same time**
- Parallel processing can also be achieved by utilising more than one processor (a CPU and a GPU)

Benefits	Limitations
Speed: If a task can be divided into subtasks that can be executed simultaneously, the total execution time can be reduced	**Limit on maximum speed**: Even with an infinite number of processors, there is a limit to the maximum speed improvement that can be made using parallel processing if a part of the program can't be parallelised
Improved performance: Simultaneous computation can take place on different data subsets (this would be used in machine learning, data mining and scientific computing)	**Complex programming**: It is harder to write code for parallel processing than serial processing. Tasks have to be synchronised and data shared correctly
Better resource utilisation: Parallel processing allows for better use of computer resources as multi-core or multiple processors can be used more effectively	**Debugging difficulty**: It is more difficult to debug a parallel program than a serial program due to the precise timing of specific events
Problem solving: Problems which are large and complex (which lend themselves to parallel processing) can be solved more easily	**Communication between processors**: Communication between processors can take significant time and resources, potentially outweighing the benefits of using parallel processing
Real-Time applications: Real-time applications including graphics rendering are more feasible and will benefit significantly	**Limited applicability**: Not all tasks can be run in parallel and must be executed serially

What are the benefits of using multicore processors?

- **Multitasking**
  - Each core can work on a different task - this is particularly effective when the user has multiple applications open at the same time
- **Background tasks**
  - When using a single core processor, a background task like anti-malware scans can slow down the user's other task. A multi-core processor can assign the background task to one core, to reduce the impact on the other task
- **Improved responsiveness**
  - If a program becomes unresponsive, it won't slow the user's computer down as much if they're using multi-core as other cores will continue running their task


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