COMP350: Algorithms & Optimisation

3: Optimising for CPU & Memory

Learning outcomes

By the end of today's session, you will be able to:

- **Understand** the memory hierarchy in modern PC/Consoles/Mobile
- **Implement** optimisations of Data Structures for memory access
- **Describe** CPU Optimisation

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Introduction

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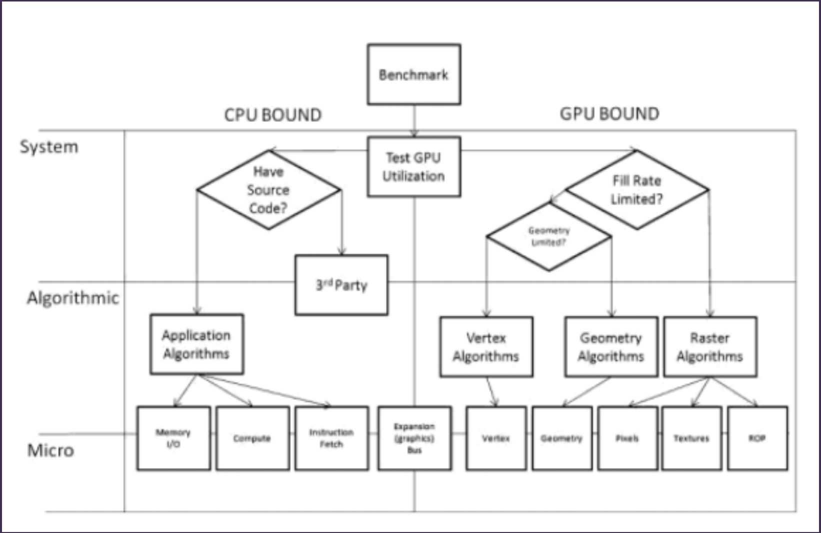
- In this session we are going to assume our application is CPU bound

Optimisation Flow



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Algorithms

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  - Transform: Apply a function to an element
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  - Reverse: Reverse the elements in a container

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  - `http://john-ahlgren.blogspot.co.uk/2013/10/stl-container-performance.html`

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  - Resizing of vector requires a memory allocation
  - If you know the amount of data you are managing, you should use the **reserve** function to allocate the memory in advance

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- You can also customise how these algorithms function by providing predicate functions

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- The containers in those engines should perform exactly like the C++ equivalents
- **BUT!** check the docs as these engines/languages have additional container types

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Coffee Break

Memory & CPU

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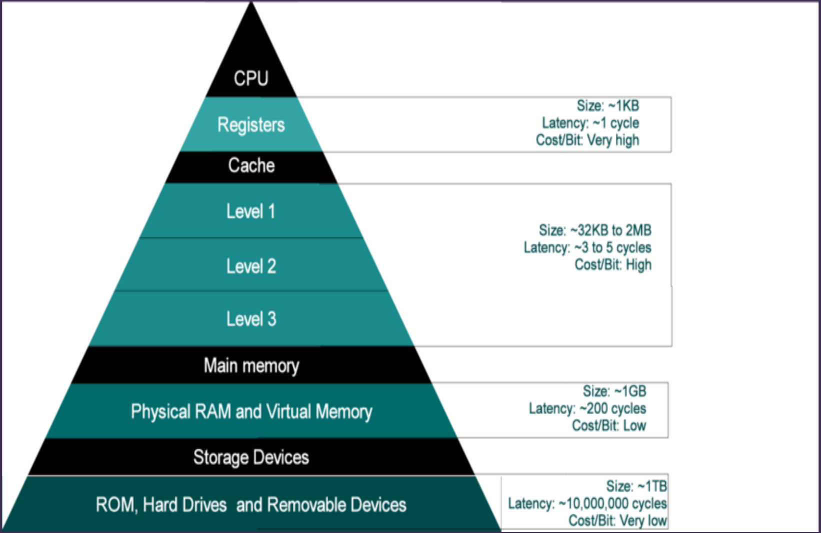
Memory Hierarchy



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- This is where the Cache comes in!

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- NB Ram typically takes 26 cycles + 57 nanoseconds to access

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- Utilise Pre-fetching
- Avoid patterns which break caching

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- You can perhaps collapse several booleans into one integer and use bit flags

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- Make sure your structs or class has data types order highest to lowest

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- However the linker/compiler follows some simple rules
- If you know these, then you can leverage them

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- Functions are laid out in memory in the order they appear in the cpp file
- Function in the cpp are always contigous

Applying Compiler & Linker rules

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- Avoid calling functions from a performance critical section of code
- If you do have to call a function, place it as close as possible (never in another translation unit)
- Use inline functions. Inlining a small function can lead to a performance boost. But this can lead to bloated code if over used (and lead to cache misses)

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- This causes a stall, as the pipeline is flushed and the first instruction of the branch is then called
- To solve this issue, you should attempt to reduce or remove all branches (see loop unrolling &)

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Exercise

Research two of following areas

- Please start of your research journal!
    1. Loop unrolling
    2. Avoiding loops
    3. Memory alignment
    4. Array of Structures vs Structure of Arrays
    5. Memory Pools
    6. Statically allocated memory
    7. STL Algorithms & Containers

Further Reading

- Intel Optimisation Manual - `https://software.intel.com/sites/default/files/managed/9e/bc/64-ia-32-architectures-optimization-manual.pdf`
- Effective STL - `http://voyager.falmouth.ac.uk/vwebv/holdingsInfo?bibId=666539`
- Game Coding Complete 4th Ed Chapter 3 - `http://voyager.falmouth.ac.uk/vwebv/holdingsInfo?bibId=755157`
- Game Engine Architecture 2nd Ed Chapter 3 - `http://voyager.falmouth.ac.uk/vwebv/holdingsInfo?bibId=1084476`