Characteristics of Computer Memory

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Characteristics of Computer Memory

- Memory Type
- Memory Size
- Location
- Word Length
- Unit of transfer
- Access method
- Performance & Cost
- Physical type
- Physical characteristics
- Organization

Location

- In CPU
- Internal to processor
- External to processor (peripheral device)

Wordlength

- Word size
  - —The natural unit of organisation

- The number of bits stored or retrieved in one memory access is called word length
- Word length typically varies from 1 to 8 bytes

Unit of Transfer

- Internal
  - Usually governed by data bus width
- External
  - Usually a block which is much larger than a word
- Addressable unit
  - Smallest location which can be uniquely addressed
  - Word internally
  - Cluster on disks

Access Methods (1)

- Sequential
  - Start at the beginning and read through in order
  - Access time depends on location of data and previous location
  - e.g. tape
- Direct
  - Individual blocks have unique address
  - Access is by jumping to vicinity plus sequential search
  - Access time depends on location and previous location
  - e.g. disk

Access Methods (2)

- Random
  - Individual addresses identify locations exactly
  - e.g. RAM
- Associative
  - Data is located by a comparison with contents of a portion of the store
  - Access time is independent of location or previous access
  - e.g. cache

Performance

- Access time
  - —Time between presenting the address and getting the valid data
- Memory Cycle time
  - —Time may be required for the memory to "recover" before next access
  - —Cycle time is access + recovery (maybe rewrite)
- Transfer Rate
  - —Rate at which data can be moved

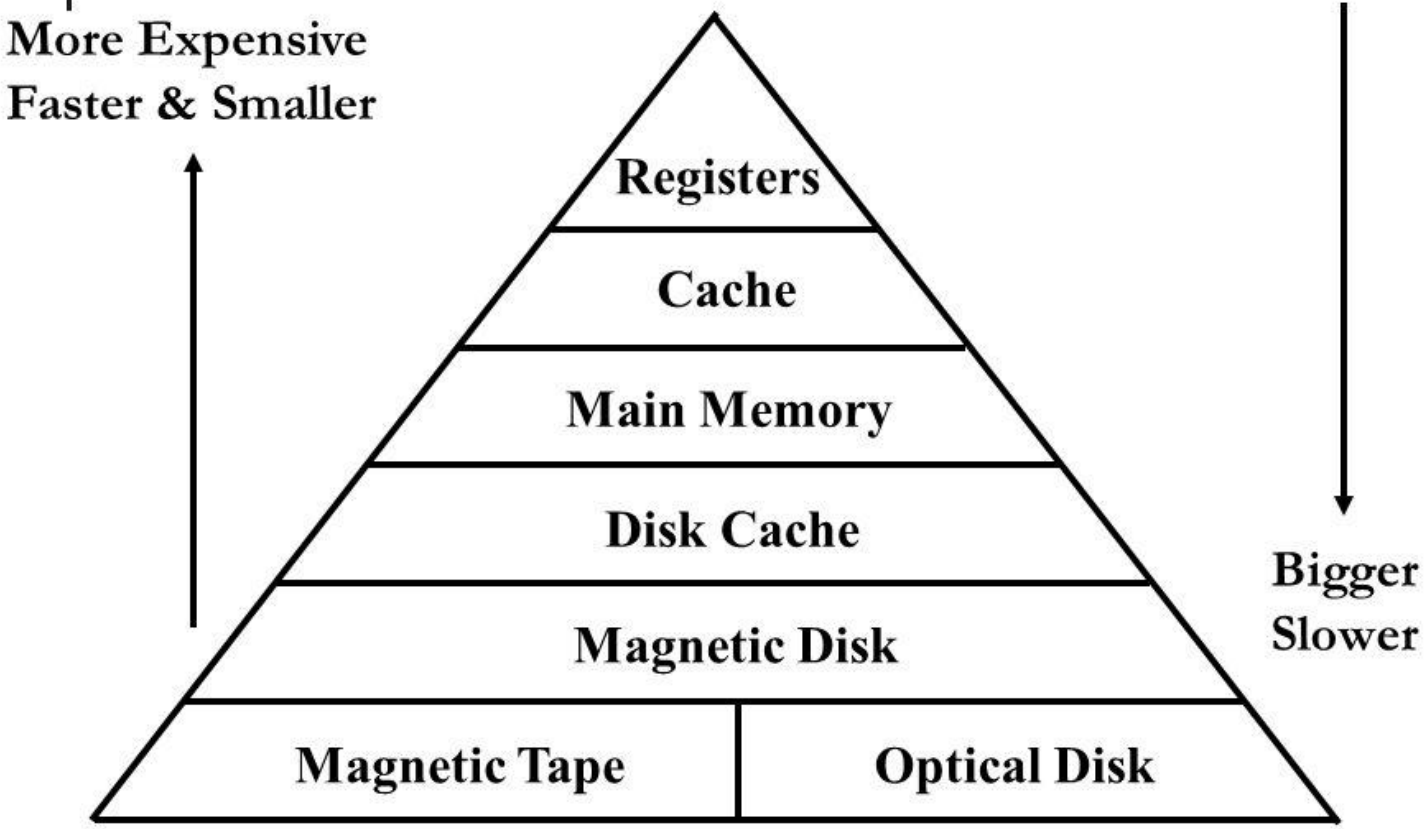
Physical Types

- Semiconductor
  - RAM
- Magnetic
  - Disk & Tape
- Optical
  - CD & DVD [& Magneto-optical (MO)]
- Others
  - Bubble
  - Hologram
  - ……

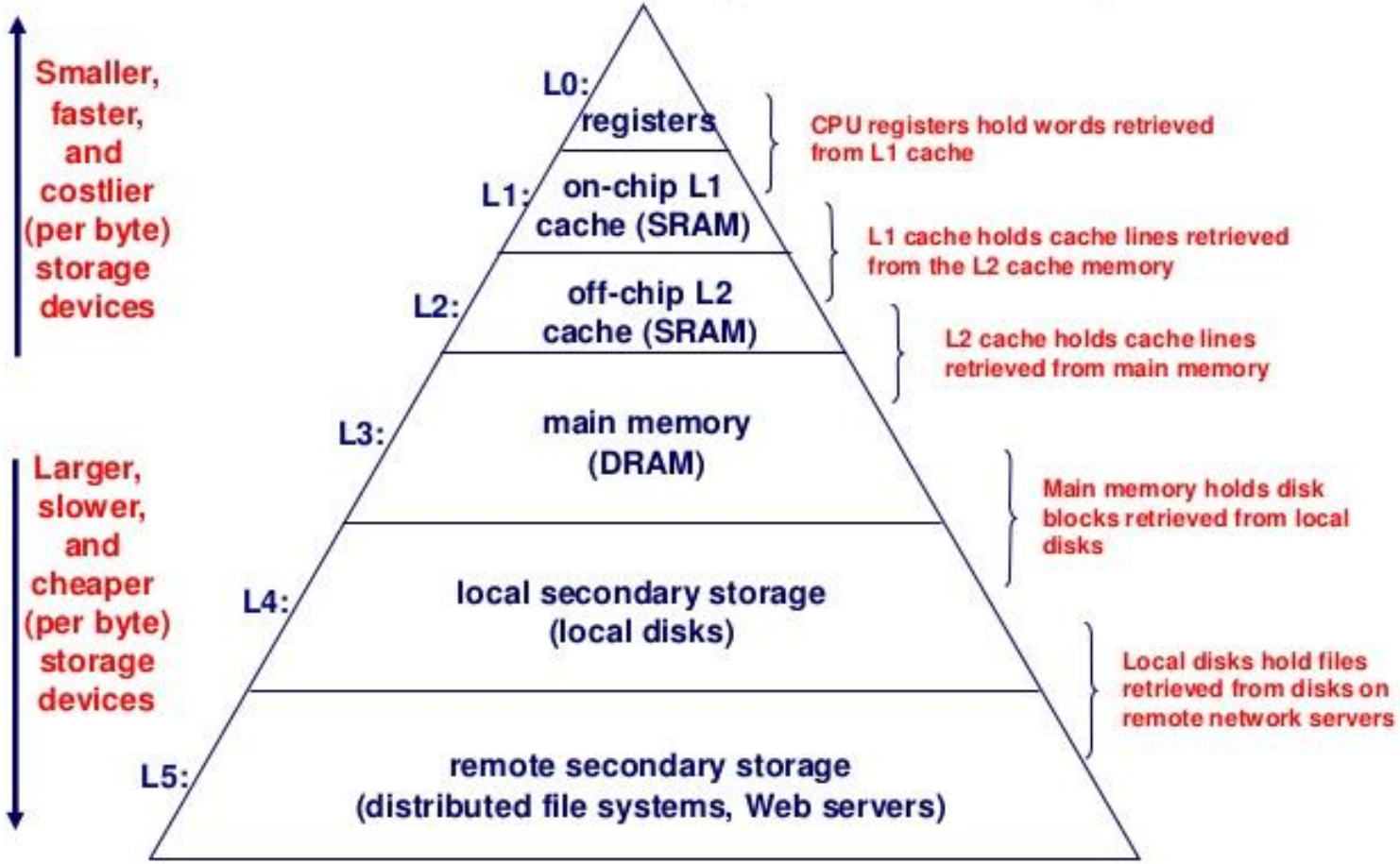
The Bottom Line

- How much?
  - Capacity
- How fast?
  - Access / Transfer Rate
- How expensive?
  - $$$$$

Memory Hierarchy



An Example Memory Hierarchy



Hierarchy List

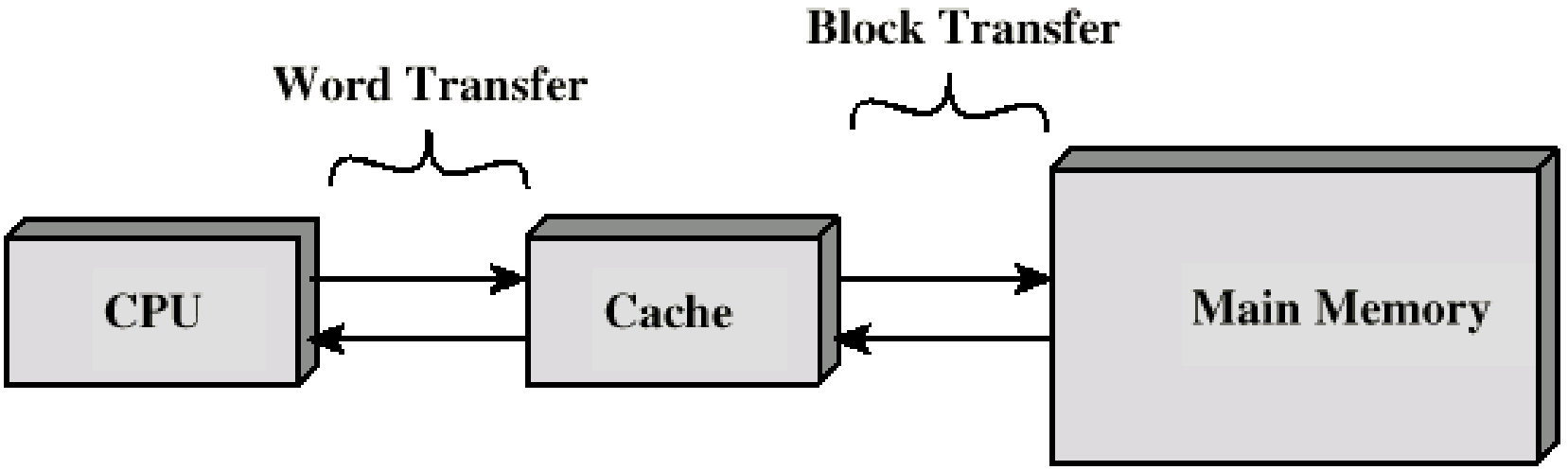
- Registers
- L1 Cache
- L2 Cache
- Main memory
- Disk cache
- Disk
- Optical
- Tape

So you want fast?

- It is possible to build a computer which uses only static RAM (large capacity of fast memory)
- This would be a very fast computer
- This would be very costly

Cache Memory

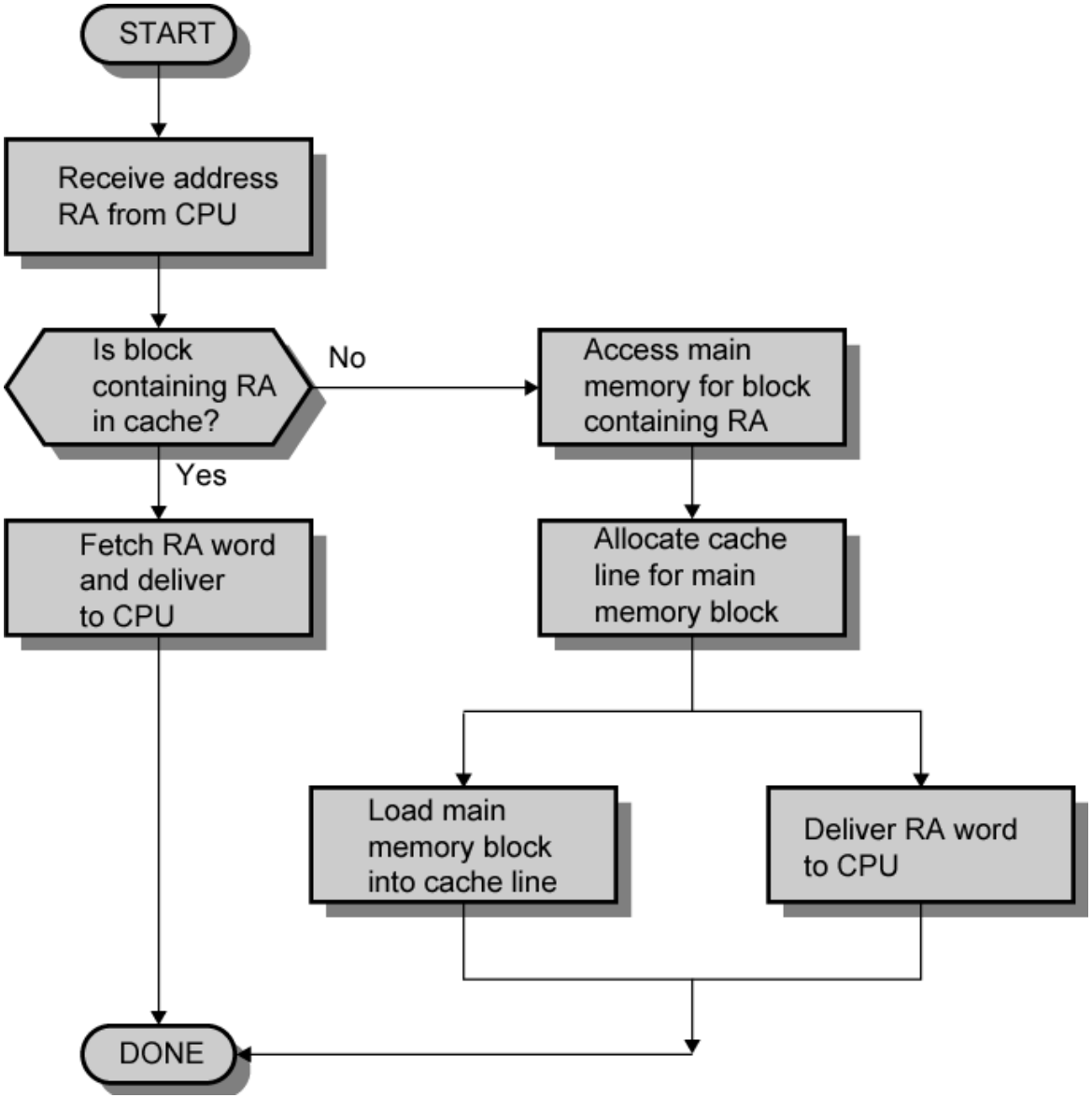
- Small amount of fast memory
- Sits between normal main memory and CPU
- May be located on CPU chip or in system
- Objective is to make slower memory system look like fast memory.



Cache operation – overview

- CPU requests contents of memory location
- Check cache for this data
- If present, get from cache (fast)
- If not present, read required block from main memory to cache
- Then deliver from cache to CPU
- Cache includes tags to identify which block of main memory is in each cache slot

Cache Read Operation - Flowchart



Cache Design

The performance of cache memory is frequently measured in terms of Hit ratio

$$\text{Hit Ratio} = \frac{\text{Number of hits}}{\text{No of Hits} + \text{No of misses}}$$

If the hit ratio is high means most of the time CPU access cache instead of main memory

Size does matter

- Cost
  - More cache is expensive
- Speed
  - More cache is faster (up to a point)
  - Checking cache for data takes time

Typical Cache Organization