Computer Fundamentals

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Memory Hierarchy

Smaller,
faster,
and
costlier
(per byte)
storage
devices

Larger,
slower,
and
cheaper
(per byte)
storage
devices

L0:
registers

L1: on-chip L1
cache (SRAM)

L2: off-chip L2
cache (SRAM)

L3: main memory
(DRAM) (Disk Cache)

L4: local secondary storage
(local disks)

L5: remote secondary storage
(distributed file systems, Web servers)

CPU registers hold words retrieved from L1
cache

L1 cache holds cache lines retrieved from
the L2 cache memory

L2 cache holds cache lines retrieved
from main memory

Main memory holds disk
blocks retrieved from local
disks

Local disks hold files retrieved
from disks on remote network
servers

Hierarchy List

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

- As one goes down the hierarchy
  - Decreasing cost per bit
  - Increasing capacity
  - Increasing access time
  - Decreasing frequency of access of the memory by the processor – locality of reference

Memory Access Method

| Sequential	Direct	Random	Associative
• Start at the beginning and read through in order • Access time depends on location of data and previous location • e.g. tape	• 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	• Individual addresses identify locations exactly • Access time is independent of location or previous access • e.g. RAM	• 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

Cache & Main Memory

- Small amount of fast memory

- Sits between normal main memory and CPU

- May be located on CPU chip or module
  - An entire blocks of data is copied from memory to the cache because the principle of locality tells us that once a byte is accessed, it is likely that a nearby data element will be needed soon.
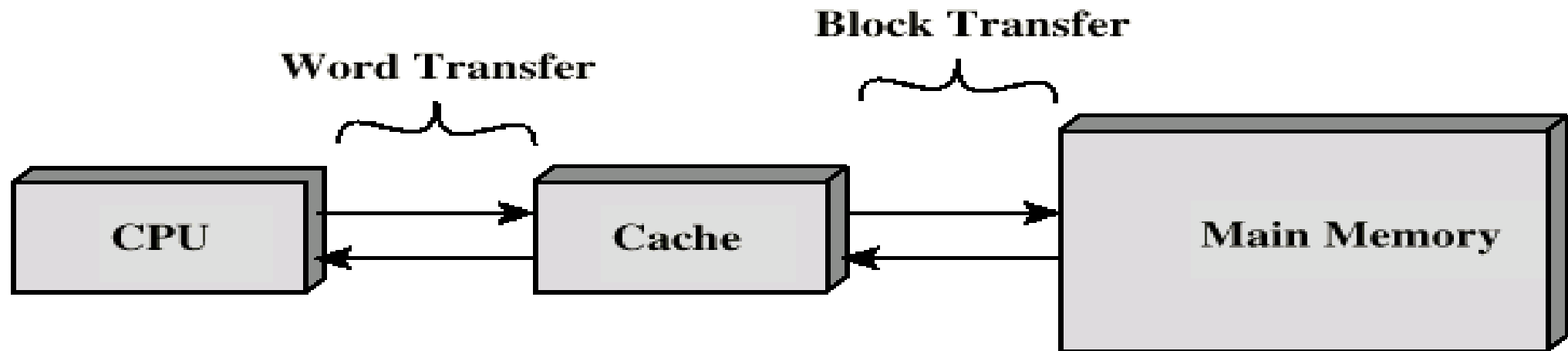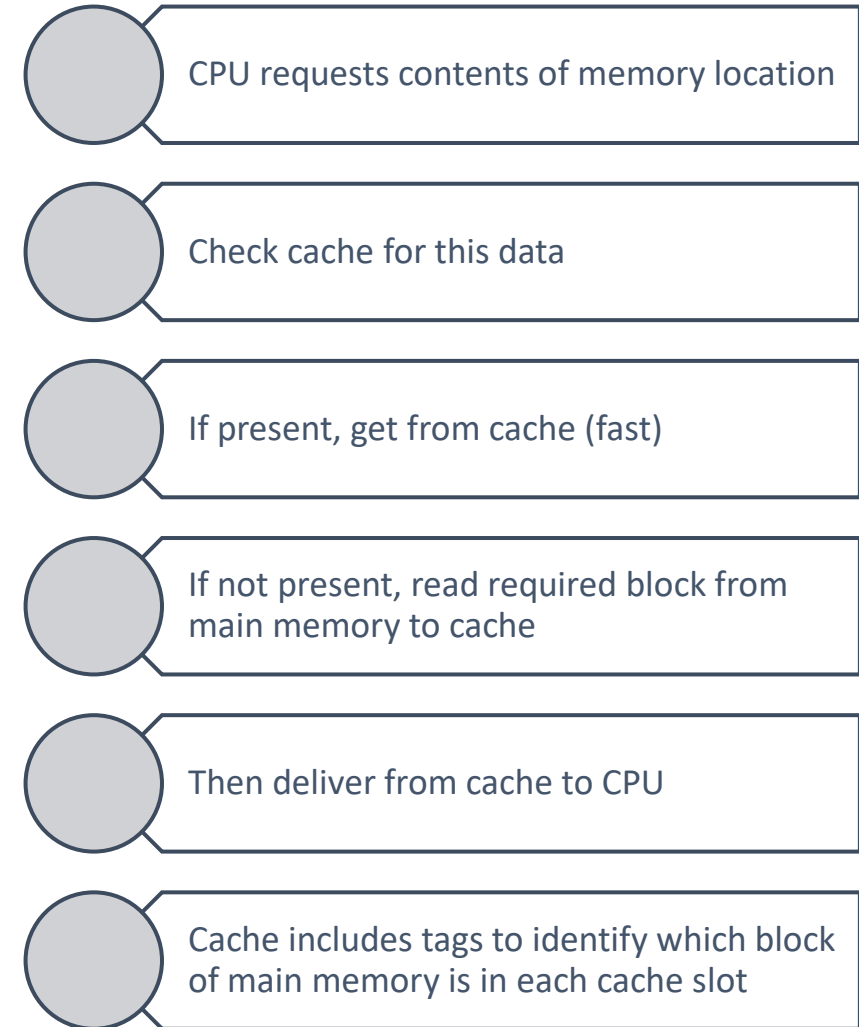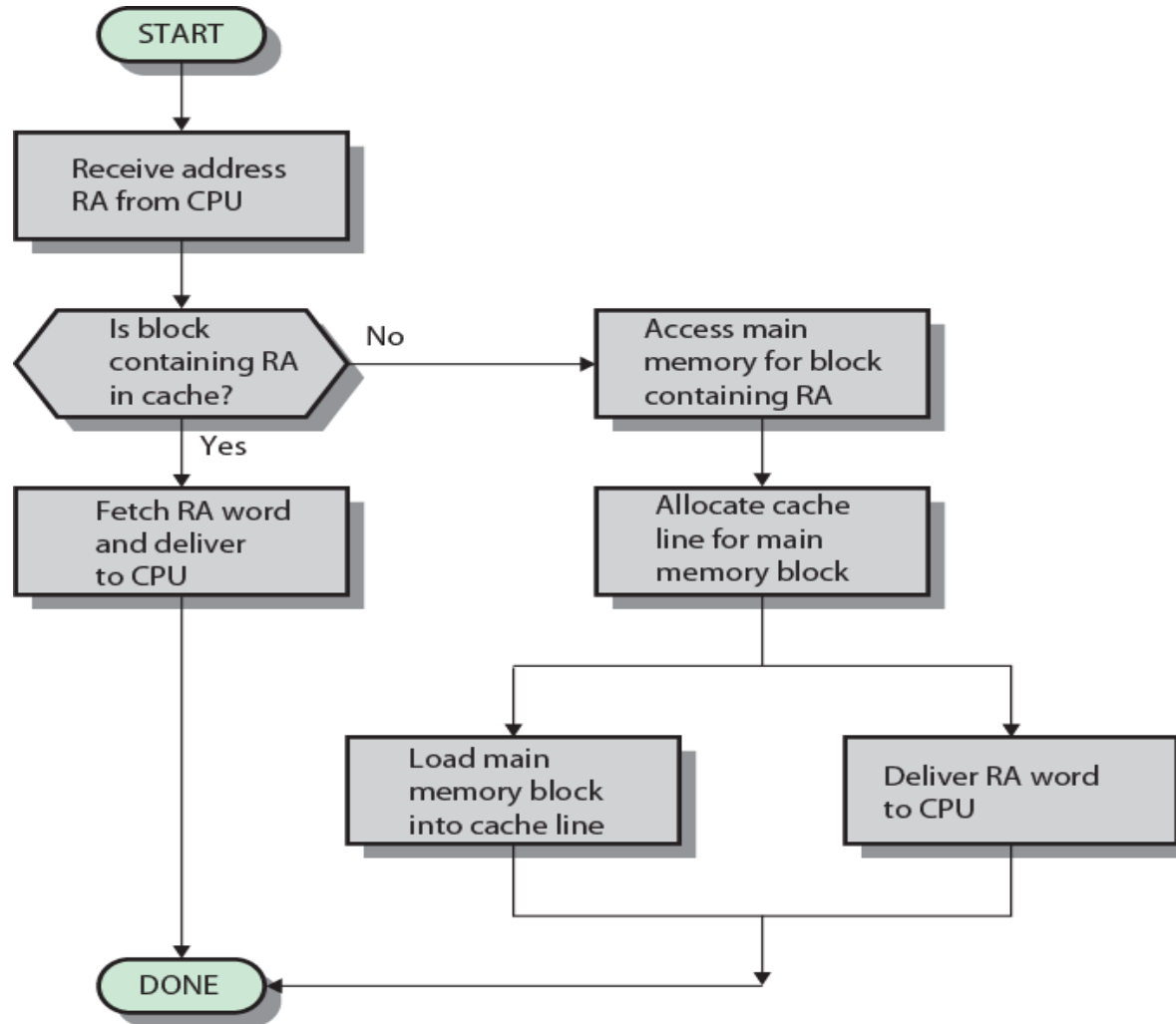
Cache/Main Memory Structure

(a) Cache

(b) Main memory
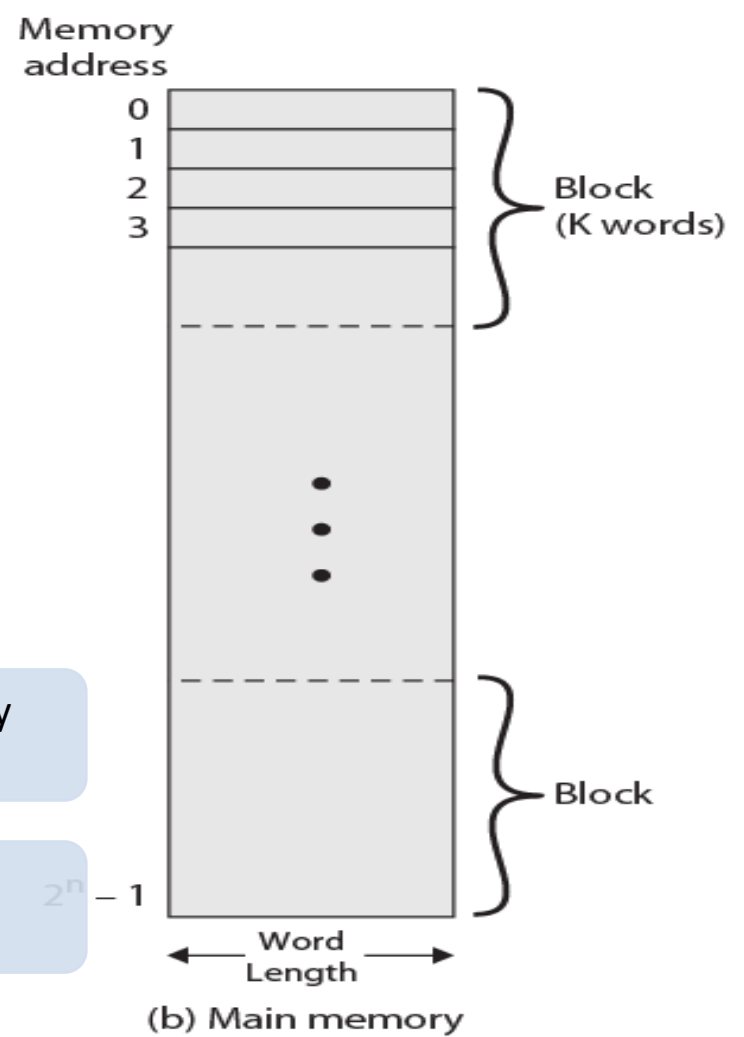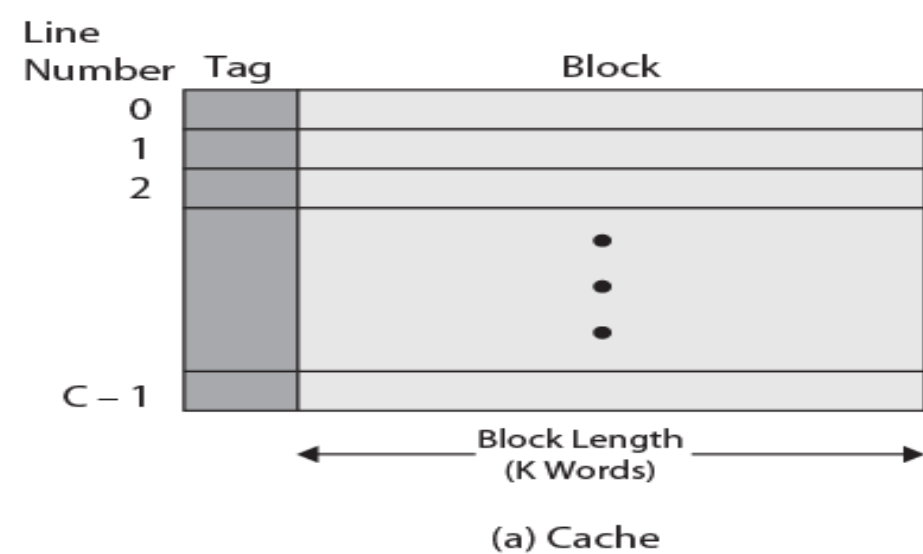
A Hit	• is when data is found at a given memory level.
A *miss*	• is when it is not found.

Cache Operations

Random-Access Memory (RAM)

- Key features
  - RAM is packaged as a chip, Basic storage unit is a cell (one bit per cell)
  - Its internal memory of the CPU for storing data, program, and program result
  - Used for Read/ Write
  - Volatile (Temporary Storage)

Static RAM (SRAM)	Dynamic RAM (DRAM)
• memory retains its contents as long as power is being supplied. • Made up of transistor • Static because it doesn't need to be refreshed • SRAM is more often used for system cache. • SRAM is faster than DRAM	• memory must be constantly refreshed or it will lose its contents. • This is done by placing the memory on a refresh circuit that rewrites the data several hundred times per second • Made up of memory cells composed of capacitors and one transistor. • DRAM is typically used for the main memory in computing devices

ROM(Read Only Memory)

- The memory from which we can only read but cannot write on it.

- This type of memory is non-volatile.

- The information is stored permanently in such memories during manufacture.

- A ROM stores such instructions that are required to start a computer. This operation is referred to as **bootstrap.**

- **Different Types of ROM:**
  - MROM (Masked ROM)
  - PROM (Programmable Read Only Memory)
  - EPROM (Erasable and Programmable Read Only Memory)
  - EEPROM (Electrically Erasable and Programmable Read Only Memory)

Thank You