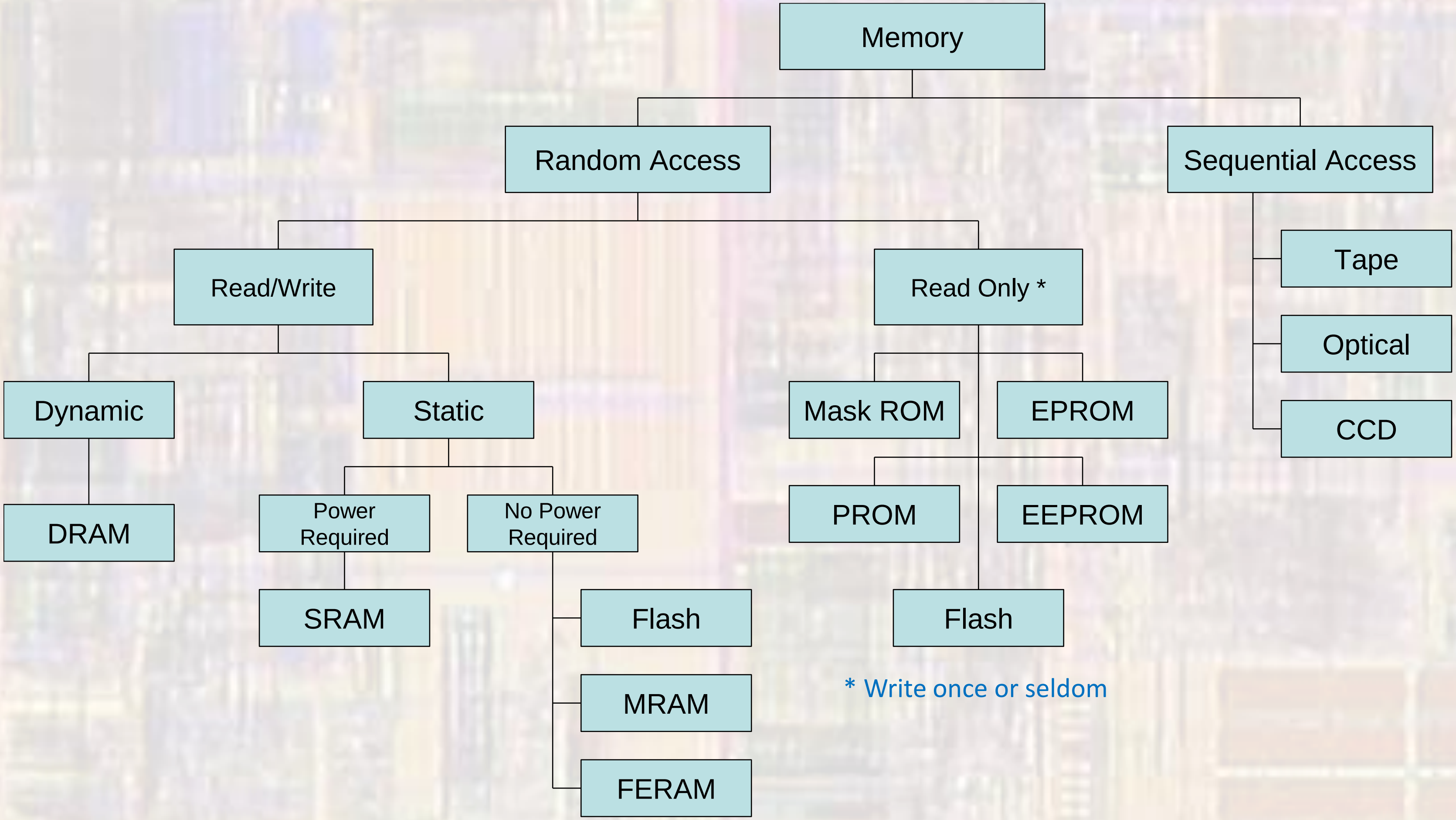
Memory Intro

Last updated 2/1/24

Memory Intro

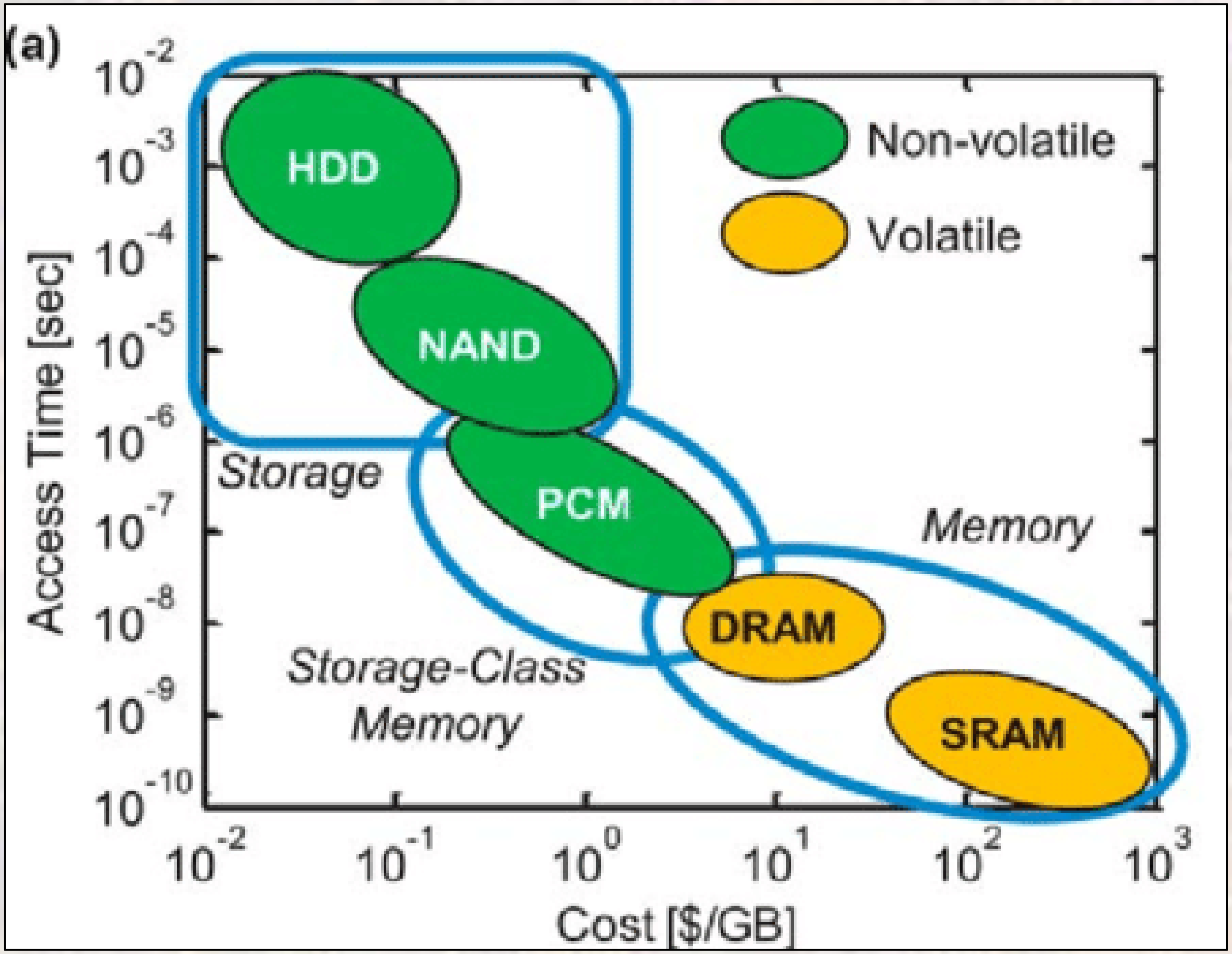
- Memory Taxonomy



* Write once or seldom

Memory Intro

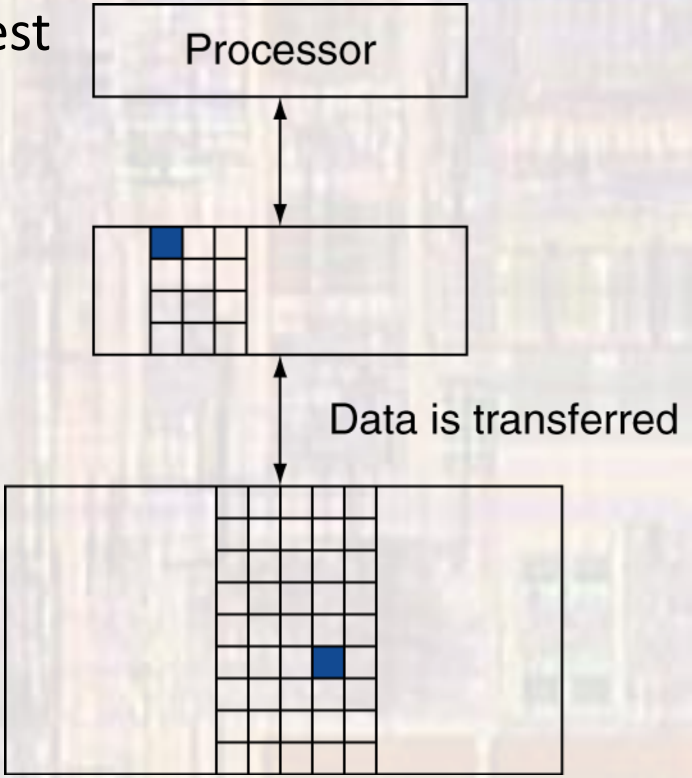
- Cost/Density Comparison



Memory Intro

- Critical Memory Considerations
  - Most dense, cheapest / bit → slowest
  - Least dense, most expensive / bit → fastest
  - Can't have everything in a single solution

→ **Memory Hierarchy**



- Issue with a hierarchy
  - Must transfer data up and down the hierarchy
  - Some accesses as slow as the slowest level addressed

Memory Intro

- Memory Hierarchy Considerations
  - Two aspects of processor applications make a memory hierarchy workable
    - Temporal Locality
      - You are more likely to uses something you recently used
        - Loops, calculated values, …
    - Spatial Locality
      - You are likely to use something that is close to something you recently used
        - Linear code, small loops, data structures

Memory Intro

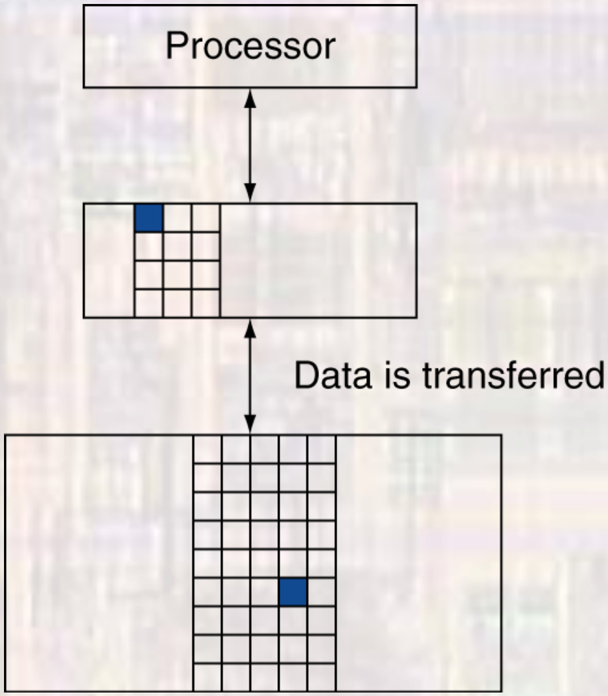
- Memory Hierarchy Considerations

  - Transitions are limited between adjacent levels in the hierarchy

  - Transfer units of information
    - Line or Block
    - Different for each level

  - If what we want is in the memory we are looking at → HIT

  - If what we want is not in the memory we are looking at → MISS



Memory Intro

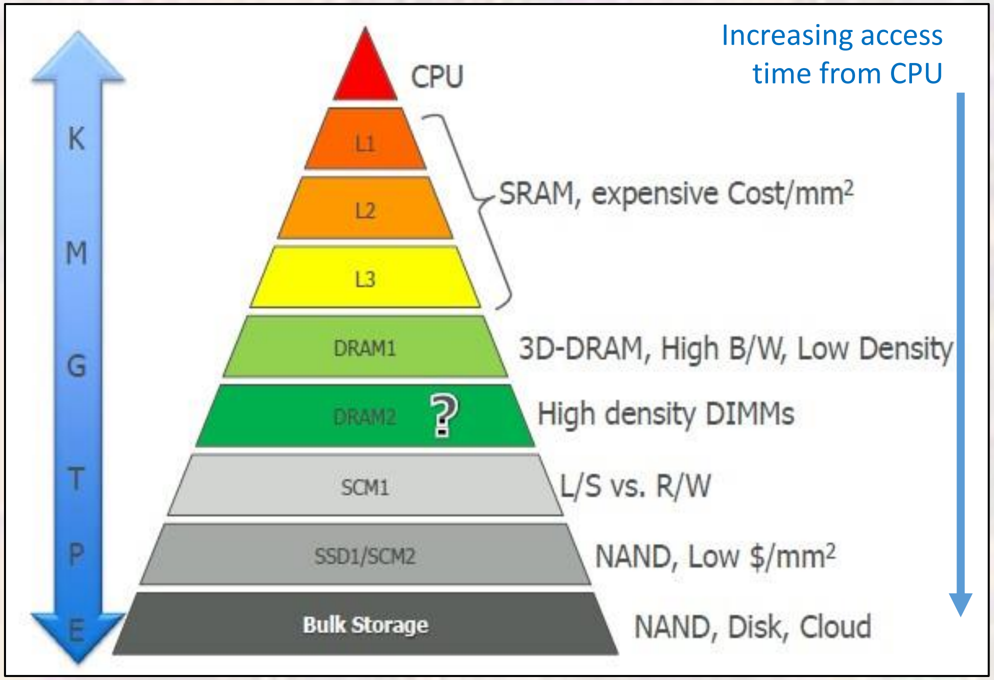
- Memory Hierarchy Considerations
  - Typical System

    Registers (Flip-Flops)

    Cache (SRAM)

    Main Memory (DRAM)

    Storage (HDD or Flash)



  - Advanced systems may have 2,3,4 levels of cache
    - Each is progressively slower and larger
    - Size is targeted at holding entire applications

Memory Intro

- Exponential shorthand

  - Use of K, M, G, T is situationally dependent
    - In science and math:
      - K = $x10^3$
      - M = $x10^6$
      - G = $x10^9$
      - T = $x10^{12}$
    - In computer and digital systems:
      - K = $x2^{10}$ = x1,024 Kilo
      - M = $x2^{20}$ = x1,048,576 Mega
      - G = $x2^{30}$ = x1,073,741,824 Giga
      - T = $x2^{40}$ = x1,099,511,627,776 Tera

Memory Intro

- Quick binary size calculation method
  - Multiplying exponential numbers (with the same base) → adding the exponents

$2^{12} = 2^2 2^{10} = 4\ K$

Requires 12 bits

$2^{16} = 2^6 2^{10} = 64\ K$

Requires 16 bits

$2^{23} = 2^3 2^{20} = 8\ M$

Requires 23 bits

$2^{35} = 2^5 2^{30} = 32\ G$

Requires 35 bits

$16K = 2^4 2^{10} = 2^{14}$

Requires 14 bits

$2K = 2^1 2^{10} = 2^{11}$

Requires 11 bits

$1M = 2^0 2^{20} = 2^{20}$

Requires 20 bits

$128G = 2^7 2^{30} = 2^{37}$

Requires 37 bits