# MEMORY SYSTEM

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# Overview

- Notes
  - Homework 10 is April 18th
    - Verify your submitted file before midnight
- This lecture
  - Cache miss types
  - Virtual memory

# Cache Miss Classifications

- Start by measuring miss rate with an ideal cache
  - 1. ideal is fully associative and infinite capacity
  - 2. then reduce capacity to size of interest
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| ❑ How to improve | ❑ How to improve |
| ○ large blocks | ○ large cache |
| ○ prefetching | |

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| ❑ Cold start: first access to block<br>❑ How to improve<br>○ large blocks<br>○ prefetching | ❑ Cache is smaller than the program data<br>❑ How to improve<br>○ large cache | ❑ Set size is smaller than mapped mem. locations<br>❑ How to improve<br>○ large cache<br>○ more assoc. |

# Miss Rates: Example Problem

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- L1 miss rates
  - 3,000/100,000 = 3%
- L2 miss rates
  - 1,500/3,000 = 50%

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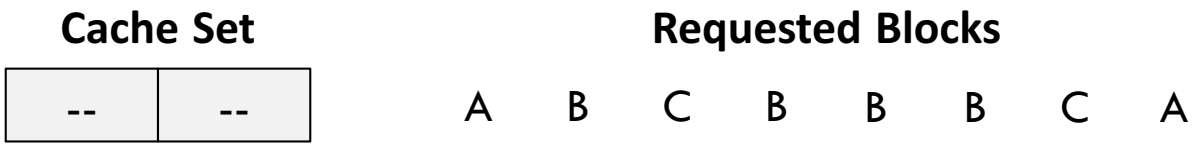

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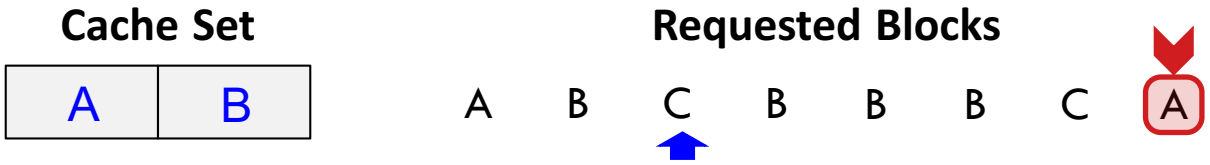

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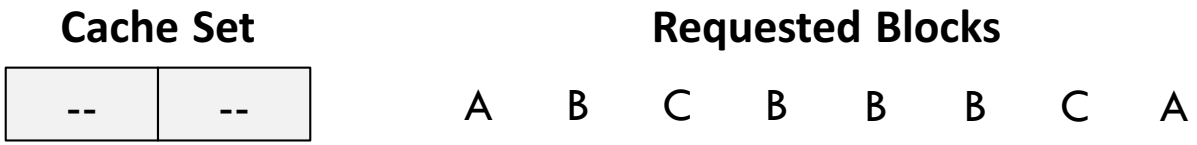

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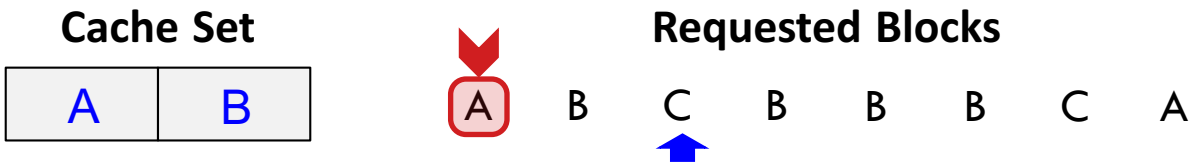

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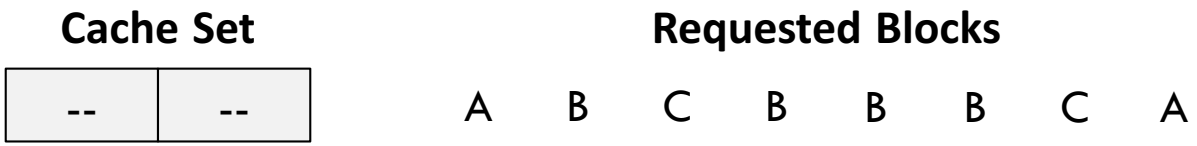

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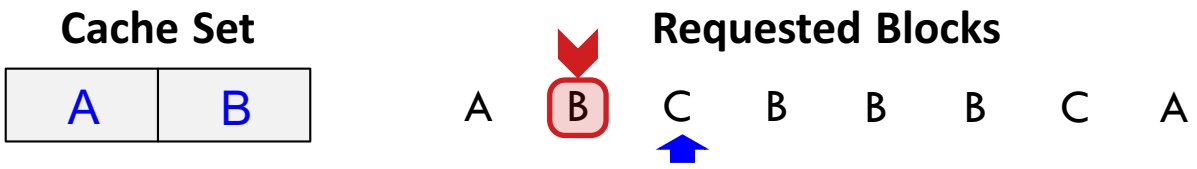

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  - Replace the block accessed nearest in the past
- Random replacement
  - hardware randomly selects a cache block to replace

# Example Problem

- Blocks A, B, and C are mapped to a single set with only two block storages; find the miss rates for LRU and MRU policies.
- 1. A, B, C, A, B, C, A, B, C
- 2. A, A, B, B, C, C, A, B, C

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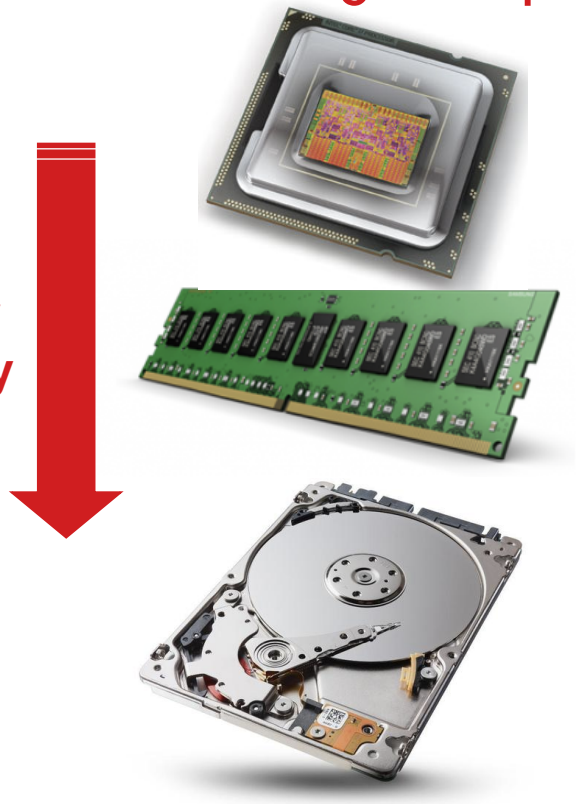
- 1. A, B, C, A, B, C, A, B, C
  - LRU : 100%
  - MRU : 66%
- 2. A, A, B, B, C, C, A, B, C
  - LRU : 66%
  - MRU : 44%

# Memory Hierarchy

- Lower levels provide greater capacity longer time
  - Does the program fit in main memory?
  - What if running multiple programs?



# Virtual Memory

- Use the main memory as a "cache" for secondary memory
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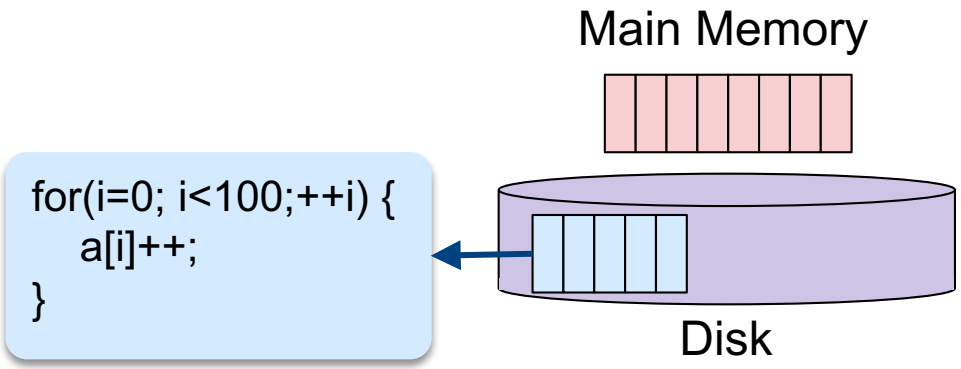

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- Allow efficient and safe sharing the physical main memory among multiple programs
  - Replacement policy?