Memory System Design

Virendra Singh

Associate Professor

Computer Architecture and Dependable Systems Lab

Department of Electrical Engineering

Indian Institute of Technology Bombay

http://www.ee.iitb.ac.in/~viren/

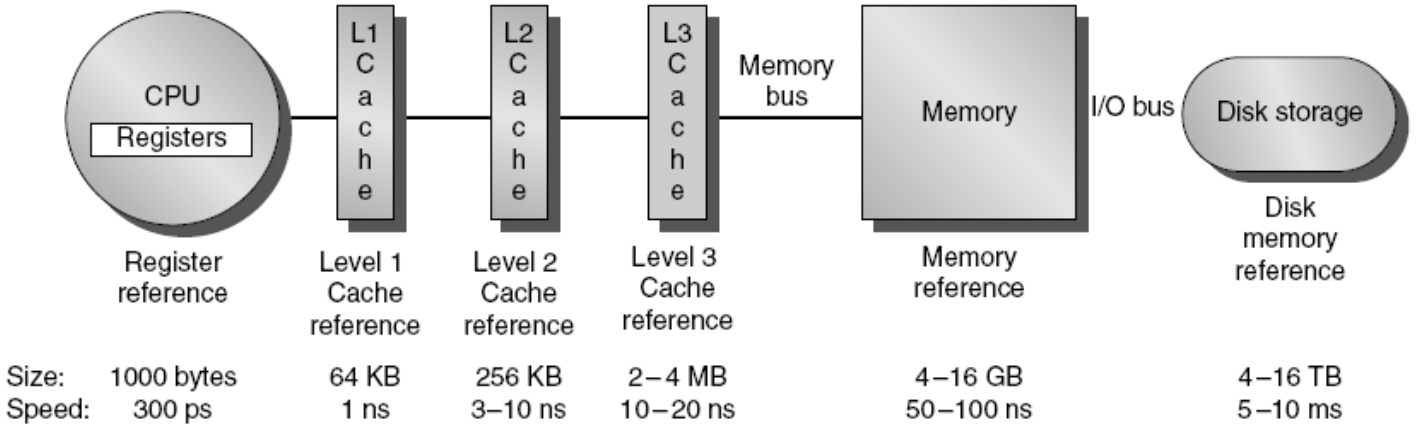
E-mail: viren@ee.iitb.ac.in

CP-226: Computer Architecture

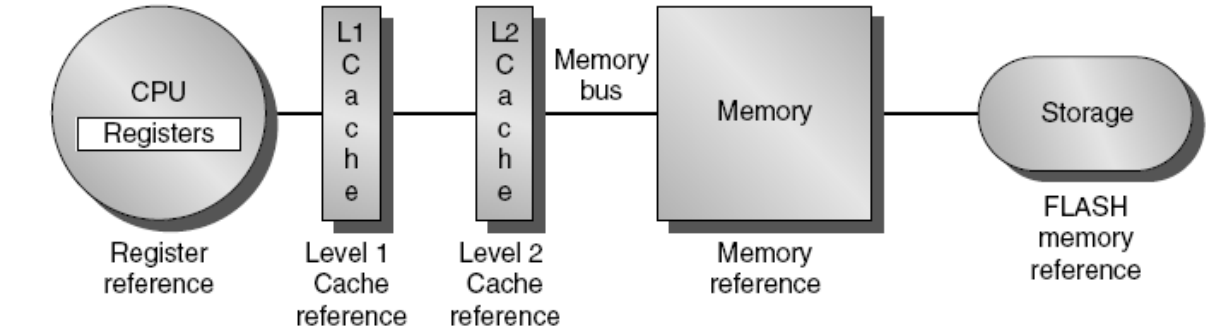
Lecture 20 (10 April 2013)

CADSL

Memory Hierarchy



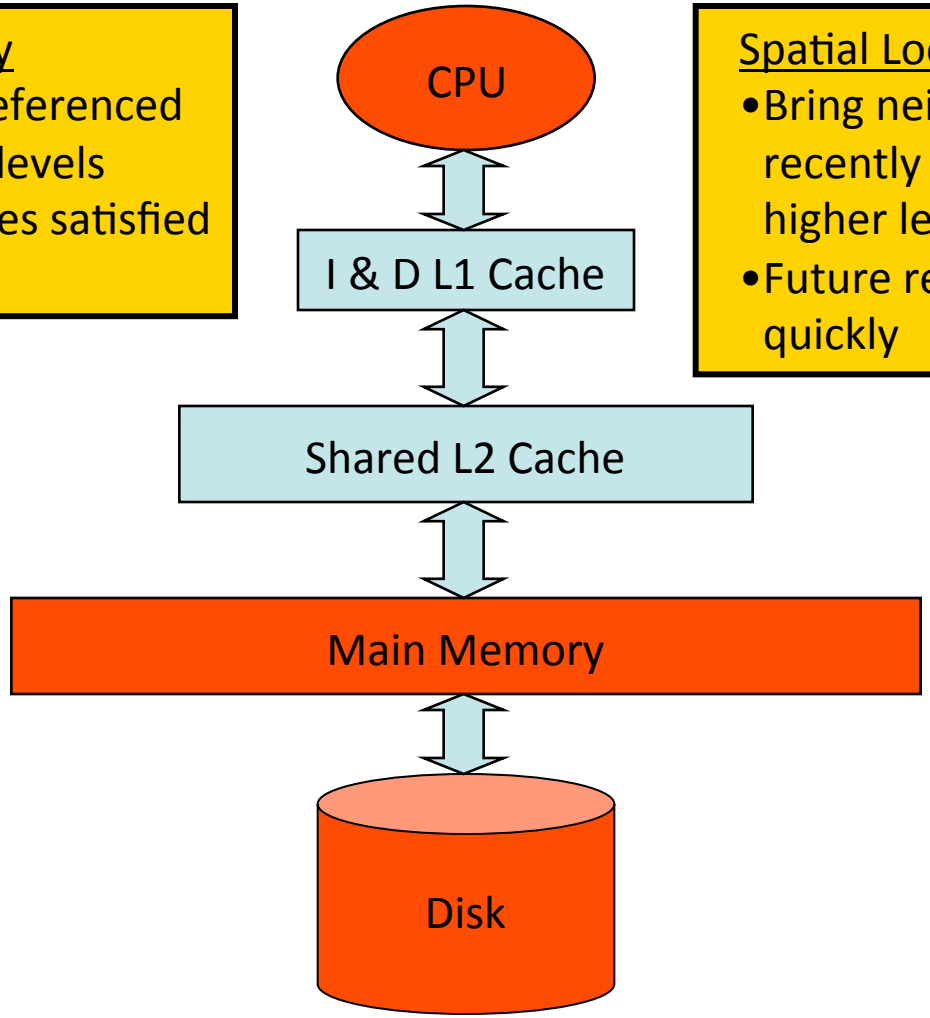
(a) Memory hierarchy for server



(b) Memory hierarchy for a personal mobile device

Memory Hierarchy

Temporal Locality
- Keep recently referenced items at higher levels
- Future references satisfied quickly



Spatial Locality
- Bring neighbors of recently referenced to higher levels
- Future references satisfied quickly

Four Burning Questions

- These are:
  - Placement
    - Where can a block of memory go?
  - Identification
    - How do I find a block of memory?
  - Replacement
    - How do I make space for new blocks?
  - Write Policy
    - How do I propagate changes?
- Consider these for registers and main memory
  - Main memory usually DRAM

Placement

Memory Type	Placement	Comments
Registers	Anywhere; Int, FP, SPR	Compiler/programmer manages
Cache (SRAM)	Fixed in H/W	*Direct-mapped, set-associative, fully-associative*
DRAM	Anywhere	O/S manages
Disk	Anywhere	O/S manages

Register File

- Registers managed by programmer/compiler
  - Assign variables, temporaries to registers
  - Limited name space matches available storage

Placement	Flexible (subject to data type)
Identification	Implicit (name == location)
Replacement	Spill code (store to stack frame)
Write policy	Write-back (store on replacement)

Main Memory and Virtual Memory

- Use of virtual memory
  - Main memory becomes another level in the memory hierarchy
  - Enables programs with address space or working set that exceed physically available memory
    - No need for programmer to manage overlays, etc.
    - Sparse use of large address space is OK
  - Allows multiple users or programs to timeshare limited amount of physical memory space and address space

- Bottom line: efficient use of expensive resource, and ease of programming

Virtual Memory

- Enables
  - Use more memory than system has
  - Program can think it is the only one running
    - Don't have to manage address space usage across programs
    - E.g. think it always starts at address 0x0
  - Memory protection
    - Each program has private VA space: no-one else can clobber
  - Better performance
    - Start running a large program before all of it has been loaded from disk

Thank You