CS 365: Computer Systems Architecture

Prof. Sanjeev Setia

Overview

❑ Prerequisites
  ○ CS 265 (Assembly Language Programming)
  ○ ECE 301 (Digital Logic)
❑ Textbook
  ○ Hennessy/Patterson (Computer Organization & Design, 2nd Edition)
❑ Grading
  ○ Two midterm exams (30%), Final Exam (15%)
  ○ Assignments (40%)
  ○ Quizzes (10%) - not announced in advance
  ○ Class Participation (5%)

Logistics

- Class Web Page
  - http://www.cs.gmu.edu/~setia/cs365/
  - Slides, Handouts, Old Exams, Useful Links
- Office Hrs
  - Monday, 2 – 4 pm, Room 347, S&T II
  - setia@cs.gmu.edu
- TA
  - Noorullah Moghul nmoghul@gmu.edu
  - Office Hrs: TBA
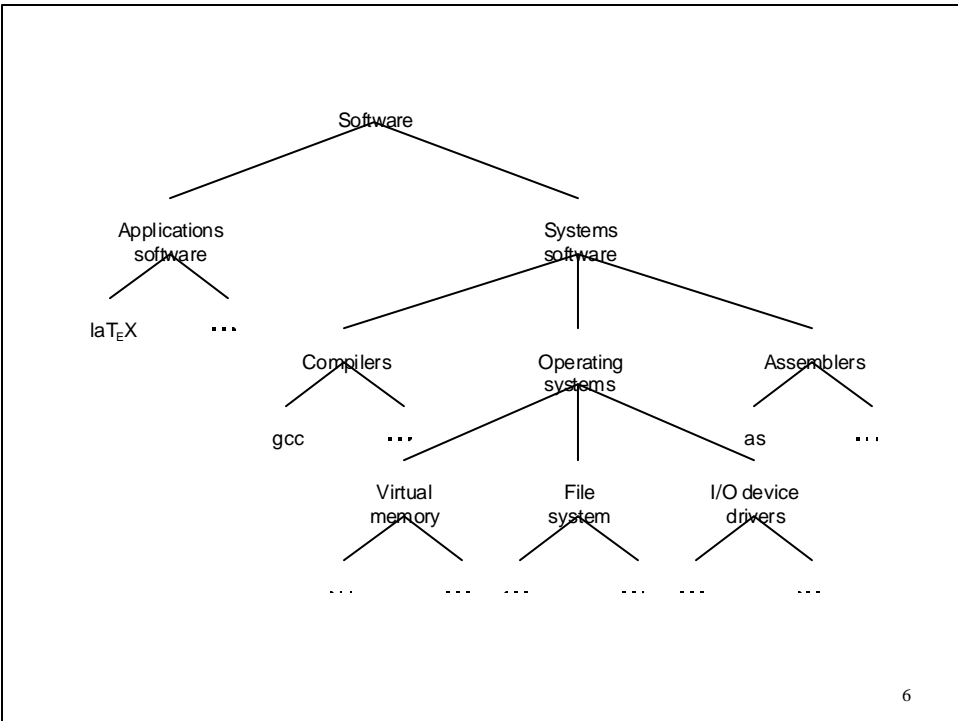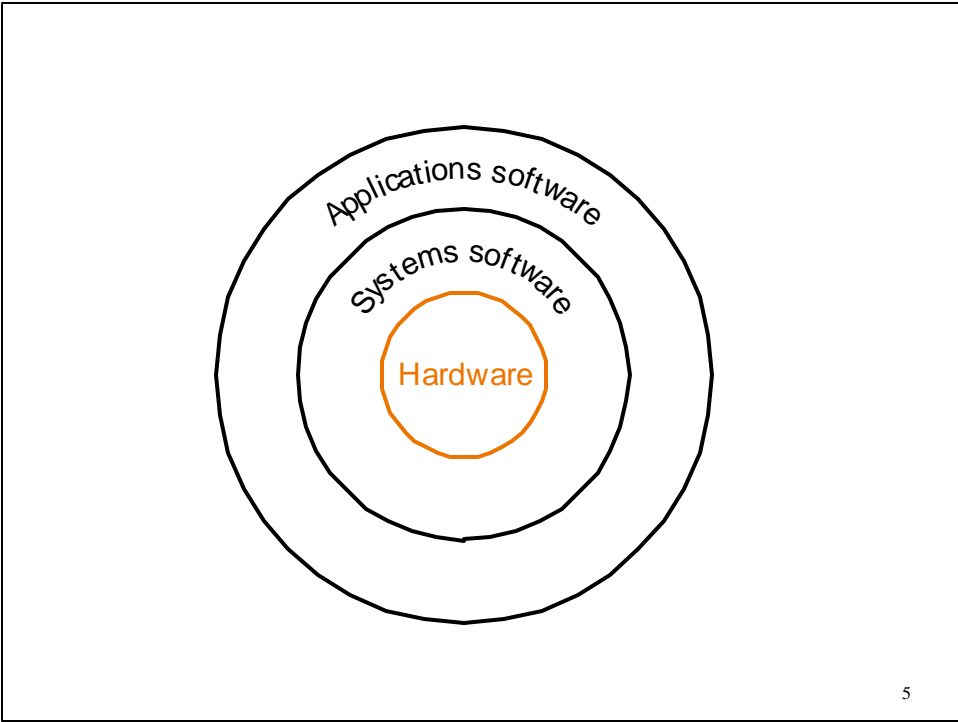 - Office: Room 435, S&T II

3

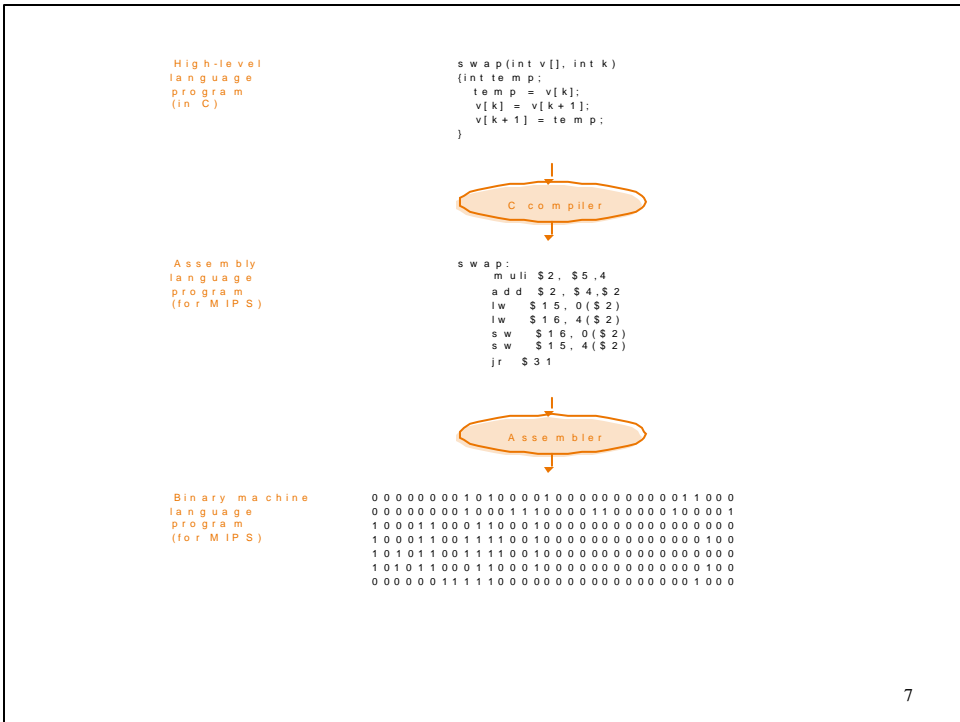# Computer Systems

- Software
  - Application programs – Word Processors, Email, Internet Browsers, Games
  - Systems Software – Compilers, Operating Systems
- Hardware
  - CPU
  - Memory
  - I/O devices (mouse, keybord, display, disks, networks,……..)

4

Applications software

Systems software

Hardware

Software

Applications software

Systems software

laT$_E$X   ...

Compilers

Operating systems

Assemblers

gcc   ...

as   ...

Virtual memory

File system

I/O device drivers

...   .

High-level
language
program
(in C)

```
swap(int v[], int k)
{int temp;
   temp = v[k];
   v[k] = v[k+1];
   v[k+1] = temp;
}
```

C compiler

Assembly
language
program
(for MIPS)

```
swap:
   muli $2, $5,4
   add  $2, $4,$2
   lw   $15, 0($2)
   lw   $16, 4($2)
   sw   $16, 0($2)
   sw   $15, 4($2)
   jr   $31
```

Assembler

Binary machine
language
program
(for MIPS)

```
00000000101000010000000000011000
00000000100011110000011000100001
10001100011000100000000000000000
10001100111100100000000000000100
10101100111100100000000000000000
10101100011000100000000000000100
00000011111000000000000000001000
```

Instruction Set Architecture

Like software, hardware has multiple layers

Application

Operating System

Compiler   Firmware

Instruction Set Architecture

Instr. Set Proc.   I/O system

Datapath & Control

Digital Design

Circuit Design

Layout
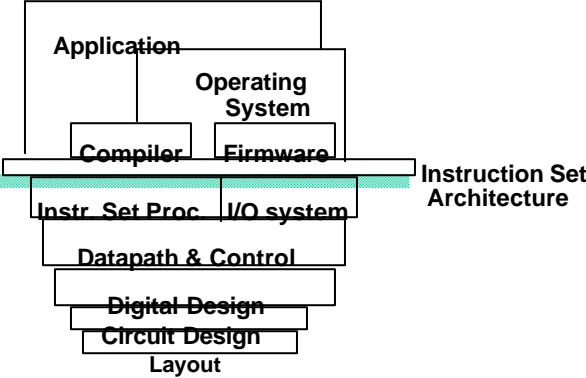
Instruction Set Architecture

❑ Computer Architecture =

Instruction Set Architecture +
Machine Organization

❑ Instruction Set Architecture is the interface between the hardware + low-level software

   ○ Focus of this class

9

Topics

❑ Instruction set architecture (Chapter 3)
   ○ MIPS instruction set
❑ Performance issues (Chapter 2)
❑ Arithmetic and how to build an ALU (Chapter 4)
❑ Constructing a processor to execute our instructions (Chapter 5)
❑ Pipelining to improve performance (Chapter 6)
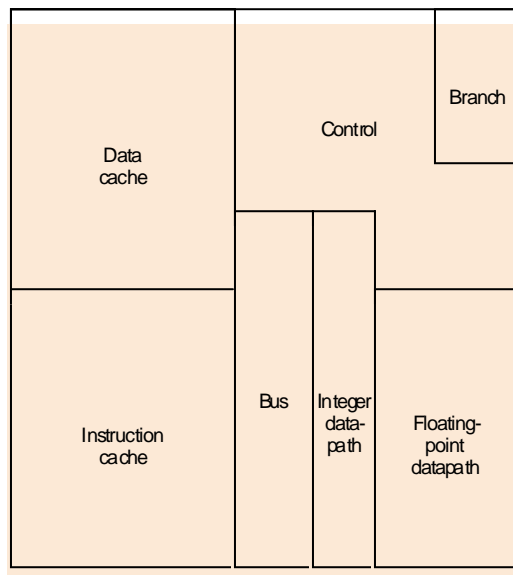❑ Memory: caches and virtual memory (Chapter 7)
❑ I/O (Chapter 8)

10

Components of a computer

- ❒ Processor
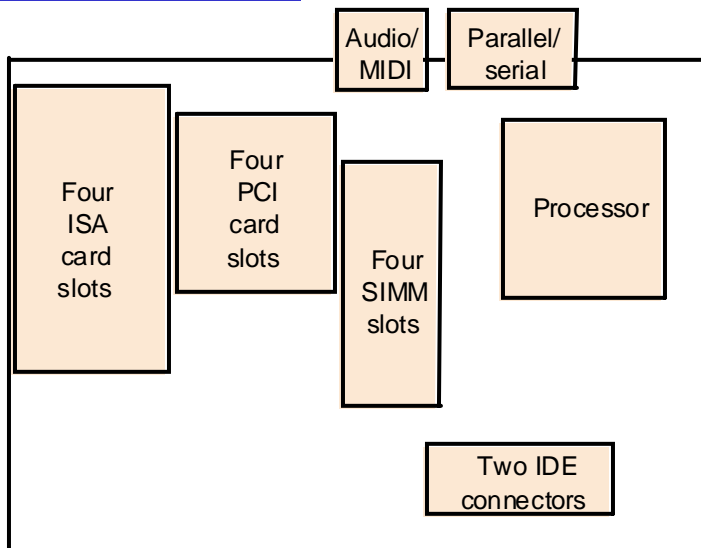 - ○ Datapath
  - ○ Control
- ❒ Memory
- ❒ Input
- ❒ Output

11

Inside a Processor chip

			Branch
Data cache		Control	
Instruction cache	Bus	Integer data-path	Floating-point datapath

12

PC Motherboard

		Audio/ MIDI	Parallel/ serial	

Four ISA card slots

Four PCI card slots

Four SIMM slots

Processor

Two IDE connectors

13

I/O devices

❑ Input devices
  ○ Mouse, keyboard, scanners
❑ Output devices
  ○ CRT display, audio speakers, printers
❑ Storage devices
  ○ Disks (Read Section 1.3)
  ○ Tapes, floppies, CDROM, DVDROM,…
❑ Network cards

14

Technology => dramatic change

□ Processor
- logic capacity: about 30% per year
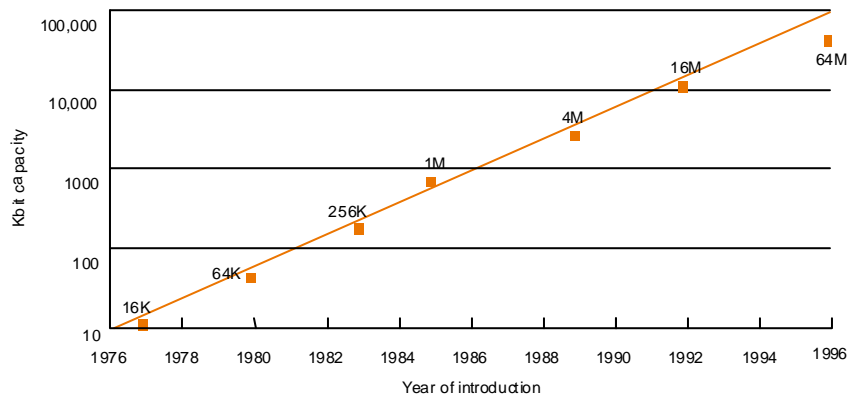- clock rate: about 20% per year

□ Memory
- DRAM capacity: about 60% per year
                 (4x every 3 years)
- Memory speed: about 10% per year
- Cost per bit: improves about 25% per year

□ Disk
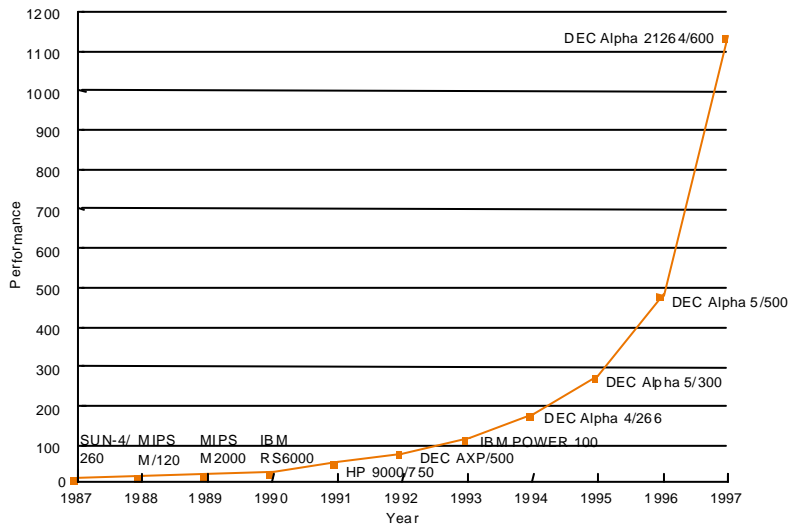- capacity: about 60% per year

15

Capacity per DRAM chip

Kbit capacity vs Year of introduction

- 16K — 1976
- 64K — 1980
- 256K — 1983
- 1M — 1985
- 4M — 1989
- 16M — 1992
- 64M — 1996

16

Performance Increase of Workstations

Why study computer architecture?

❒ you want to call yourself a "computer scientist"

  ○ Computer architecture impacts every other aspect of computer science

❒ you want to build software people use (need performance)

❒ you need to make a purchasing decision or offer "expert" advice

Other topics in Chapter 1

❑ Section 1.4 – Chip manufacturing process
❑ Brief discussion of how disks work, mice, etc.
❑ Historical overview

You will need to read this chapter thoroughly for completing Assignment 1

19