ICS 233 – Fall 2007

Computer Architecture & Assembly Language

College of Computer Sciences & Engineering
King Fahd University of Petroleum & Minerals

Professor: Muhamed Mudawar, Room 22/328, Phone 4642
Office Hours: SMW 10 am – 12 noon
Course URL: http://www.ccse.kfupm.edu.sa/~mudawar/ics233/
Email: mudawar@ccse.kfupm.edu.sa

Catalog Description

Machine organization; assembly language: addressing, stacks, argument passing, arithmetic operations, decisions, modularization; Input/Output Operations and Interrupts; Memory Hierarchy and Cache memory; Pipeline Design Techniques; Super-scalar architecture; Parallel Architectures.

Prerequisite: COE 202, ICS 201

Textbooks

David A. Patterson and John L. Hennessy, *Computer Organization and Design: The Hardware / Software Interface*, Third Edition, Morgan Kauffmann Publishers, 2005.

Robert L. Britton, *MIPS Assembly Language Programming*, Pearson Prentice Hall, 2004,

Course Learning Outcomes

Towards the end of this course, students should be able to:

- Describe the instruction set architecture of a MIPS processor
- Analyze, write, and test MIPS assembly language programs
- Describe the organization/operation of integer & floating-point arithmetic units
- Design the datapath and control of a single-cycle CPU
- Design the datapath/control of a pipelined CPU and handle hazards
- Describe the organization/operation of memory and caches
- Analyze the performance of processors and caches

Grading Policy

Lab	20%
Assignments and Quizzes	10%
Projects	20%
Midterm Exam I	15%
Midterm Exam II	15%
Final Exam	20%

- Written assignments should be submitted at the beginning of class time in the specified due date. Late written assignments are not accepted, especially if the solution is discussed in class.
- Late projects are accepted, but will be penalized 5% for each late day.

Software Tools used in Projects

- PCSpim or MARS simulator: runs MIPS-32 assembly language programs
- Logisim simulator: educational tool for designing and simulating CPUs

Course Topics

Introduction

- Introduction to computer architecture, assembly and machine languages, components of a computer system, memory hierarchy, instruction execution cycle, chip manufacturing process, technology trends, programmer's view of a computer system.

Instruction Set Architecture

- Instruction set design, RISC design principles, MIPS instructions and formats, registers, arithmetic instructions, bit manipulation, load and store instructions, byte ordering, jump and conditional branch instructions, addressing modes, pseudo instructions.

MIPS Assembly Language Programming

- Assembly language tools, program template, directives, text, data, and stack segments, defining data, arrays, and strings, array indexing and traversal, translating expressions, if-else statements, loops, indirect jump and jump table, console input and output.

Procedures and the Runtime Stack

- Runtime stack and its applications, defining a procedure, procedure calls and return address, nested procedure calls, passing arguments in registers and on the stack, stack frames, value and reference parameters, saving and restoring registers, local variables on the stack.

Interrupts

- Software exceptions, syscall instruction, hardware interrupts, interrupt processing and handler, MIPS coprocessor 0.

Integer Arithmetic and ALU design

- Review of data representation, binary and hexadecimal numbers, signed integers, binary and hexadecimal addition and subtraction, carry and overflow, characters and ASCII table, integer multiplication, shift-add multiplication hardware, Shift-subtract division algorithm and hardware, MIPS integer multiply and divide instructions, HI and LO registers, multifunction ALU design.

Floating-point arithmetic

- Floating-point representation, IEEE 754 standard, FP addition and multiplication, rounding, MIPS floating-point coprocessor and instructions.

CPU Performance

- CPU performance and metrics, CPI and performance equation, MIPS, Amdahl's law.

Single-Cycle Datapath and Control Design

- Designing a processor, register transfer, datapath components, register file design, clocking methodology, control signals, implementing the control unit, estimating longest delay.

Pipelined Datapath and Control

- Pipelining concepts, timing and performance, 5-stage MIPS pipeline, pipelined datapath and control, pipeline hazards, data hazards and forwarding, control hazards, branch prediction.

Memory System Design

- Memory hierarchy, SRAM, DRAM, pipelined and interleaved memory, cache memory and locality of reference, cache memory organization, write policy, write buffer, cache replacement, cache performance, two-level cache memory.