Computer Organization
PhD Qualifying Exam Review

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Presentation By
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Introduction

We won’t try to teach you a year’s worth of material in just under 30 minutes, instead our goal is to point you towards the **most important** information to review on your own!

Please remember you are responsible for knowing everything the department recommends, these our just our **OPINIONS**, and what we would focus on if we had limited time.
Computer Technology Trends

What to Know:
- Computers getting: Faster, Smaller, Hotter
- Technological limits closing in, driving:
  Multithreading (SMT)
  Multicore (CMP)
  Multiprocessor (SMP)
- Increased focus on application:
  Security, Reliability, etc
Computer Performance Assessment

What to Know:
- Basics of Benchmarking:
  - Terminology: SPEC Suite, CPI, IPC, Wall Time
  - Types: Synthetic, Kernel, Toy, Real
  - Difficulties / Pitfalls
- How to compare different Machines

$$\text{CPU time} = \frac{\text{Seconds}}{\text{Program}} = \frac{\text{Instructions} \times \text{Cycles} \times \text{Seconds}}{\text{Instruction} \times \text{Cycle}}$$
ISA and Machine Language

What to Know:

- Difference between RISC and CISC

- Different instruction types:
  - Logic, Arithmetic, Memory, Control

- How to read/write basic ISA code
  - If you practice, practice MIPS!
Instruction Representation

What to Know:

- Understand how basic ISA is represented

No need to memorize!
Number/Data Representations

What to Know:

- How to read/convert the following:
  - Binary, Octal, Decimal, Hexadecimal

- Two’s Compliment, Signed/Unsigned Representations

- Difference between ASCII/binary / BCD
Addressing Modes

What to Know:

- Register Addressing
  - operand is a register

- Base/displacement Addressing
  - operand is at mem location given by register + optional offset

- Immediate Addressing
  - operand is a constant within the instruction itself

- PC-relative Addressing
  - address is sum of PC and constant in instruction
Arithmetic and Logic ALU Operations

What to Know:

- Understand basic RISC ALU operations:
  - ADD, SUB, OR, AND, XOR, NOT, SHIFT, ROT

- How to perform the following boolean arithmetic:
  - Addition, Subtraction, Multiplication, Division
Floating Point Arithmetic

What to Know:

- Takes Longer, Requires Special Hardware
- Single Precision (32), Double Precision (64)
Processors

What to Know:

- Break down instructions into smaller parts
- Process pieces of several instructions at the same time
- Multiple ALU’s, Floating Point Units
Basic Pipelining

What to Know:
- Understand the stages of the 5-stage MIPS Pipeline
Pipeline Hazards

What to Know:

- Structural Hazards
  - Can occur if single piece of hardware used in multiple stages

- Memory Hazards
  - Read After Write (RAW)
  - Write after Read (WAR)
  - Write after Write (WAW)
Pipeline Hazards (Continued)

What to Know:

- Know how to spot the above hazards!!

- Methods for resolving the hazards
  - Forwarding
  - Add more hardware
  - Stall
Memory Hierarchy

What to Know:

- Modern systems use layer memory approach
- Lowest layer, small fast, highest layer, big, slow

Big Fat Disk Drive (\(~ 500\) MB)
Dynamic Ram (\(~ 4\) GB)
Level 3/Level 2 Cache (\(~ 2\) MB)
Level 1 Cache (\(~ 128\) KB)
Register File (\(~ 1\) KB)
Caches

What to Know:

- How to calculate size of tags versus associativity, block size, number of sets, address size, etc.

- Replacement policies, write back vs. write through

- Tradeoffs between Associativity vs. Speed/Power

- Understand miss rates as a metric for analysis
Physical / Virtual Memory

What to Know:

- One physical address space, multiple virtual address spaces

- Reasons to use a virtual address
That’s all Folks!

On to PhD Qualifying Exam 2005!