CS M151B: Computer Systems Architecture

Week 1

Disc 1E

- TA: Uen-Tao Wang
- Email: uentao.wang@cs.ucla.edu
- Office Hours: T 1-3PM
  - The other TA's are scheduled for
    - M 3-5PM
    - W 1-3PM
- TA Room: BH 2432

Discussion Format

- To be determined... by you!

Performance Measure

- Execution Time = Instruction Count * Cycles Per Instruction * Cycle Time
- CPI: Cycles Per Instruction (average over all instructions in some set)
  - Measured in... cycles / instruction
- Instruction Count: Instruction Count
- Clock Cycle Time: Time between rising edges of the clock (AKA the period)
  - Measured in seconds (or other units of time) per cycle

Amdahl's Law

- ET after improvement =

  ET affected by improvement / Amount of Improvement + ET unaffected

Computer Architecture

Computer Systems(?) Architecture

Computer Systems(?) Architecture

- What's the difference?

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Computer architecture

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In electronics engineering and computer engineering, **computer architecture** is a set of disciplines that describes a computer For example, at a high level, computer architecture may be concerned with how the central processing unit (CPU) acts and ho (2011) computer architectures include cluster computing and non-uniform memory access.[*citation needed*]

Computer architects use computers to design new computers. Emulation software can run programs written in a proposed inst at this stage, compiler designers often collaborate with the architects, suggesting improvements in the instruction set. Modern estimate energy consumption in joules, and give realistic estimates of code size in bytes. These affect the convenience of the u expense of the computer's largest physical part: its memory. That is, they help to estimate the value of a computer design.

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Just call it Computer Architecture

- A focus on:
  - The components that comprise a computer
  - How they're interconnected
  - The abstractions that allow users to use components.

For this class...

- You won't need to know about the names and specs of specific processors.
  - ...but it's sure to impress the ladies
- You will learn about the general components and concepts that comprise the architecture of computers.

Main Goal

- To make you a better person

More specifically...

- As computer scientists, understand past the decisions and design choices in computer architecture improvement
- Understand how compiled code written in high level language is run on computer.
- Develop an intuition as to how to further improve hardware.

Architecture Layering

- Application
- Compiler
- ISA (Instruction Set Architecture)
- Microarchitecture
- Physical Components

Instruction Set Architecture

- The specifications or rules for how we want the low level architecture to operate.
  - Assembly instructions and machine language opcodes
  - Native data types
  - Registers
  - Addressing modes
  - Memory model
  - Exception handling
- Does not specify how to implement these “rules” or “specs”

Microarchitecture

- The method of how to implement a given ISA.
- Specifies all of the components (ALU, MUX, registers, clock) and how they're connected
- Goal: The components are connected in a way as to follow the rules of the ISA

Performance Measures

- CPI: Cycles Per Instruction (average over all instructions in some set)
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- Clock Rate: Number of cycles per second
  - Measured in cycles per second or hz

Which layer affects which metric?

	IC	CPI	CT
App	✓	✓	
Comp	✓	✓	
ISA	✓	✓	✓
MicroArch		✓	✓
PD		✓	✓

- "IC and CPI influenced by software, CPI and CT influenced by hardware... but..."

How can ISA influence CT?

- Recall, ISA defines instructions and behaviors that are implemented by microarchitecture.
- If ISA is changed so that microarchitecture is changed (e.g. a module that causes a bottleneck is made unnecessary), this may influence clock cycle time.
- Then isn't it really the microarchitecture that changed the clock cycle time?

Maybe?

- That argument could be made.
- You could also argue that the source of the change is the ISA so the ISA is “most” responsible.
- It's just sematics at this point.

How to decrease execution time?

- $ET = IC * CPI * CT$

Reduce IC?

- Application writers write concise code?
- Compiler optimizes code and eliminates instructions while maintaining behavior?
- ISA defines many instructions to do complex actions in a single instruction?

Tradeoffs?

- Writing optimized code or writing optimizing compilers add complexity and make more work for program and compiler writers
- Writing better code is not a reliable source of improvement for every program because significant reductions cannot always be found.
- More complex instructions add complexity to microarchitecture.
- Performance not always improved by having complicated instructions.

Reduce CPI?

- Application writers choose instructions that take fewer cycles?
- Compilers choose instructions that take fewer cycles?
- ISA + microarchitecture defines only simpler instructions that take few clock cycles to complete?

Reduce CT?

- Increase clock rate?

Tradeoffs?

- Clock can only go as fast as slowest component.
- Power wall – Too much heat.
- Memory wall – processor may be running faster, but overall performance may not improve due to memory latency bottleneck.
- May increase CPI.

End of

The First Week

-Nine Weeks Remain-