CS 271: Computer Architecture and Assembly Language

Winter 2013

January 7, 2013

Introduce yourself!

On a piece of paper . . .

- Name, year
- CS/EE classes you've taken
- Are these office hours OK?
    - Mon Noon–2pm, Wed 4pm—5pm
    - Tues 9am–1am, Thurs 4pm–5pm
- Experience programming in assembly?
  If so, for what architecture?
- What do you hope to learn in this class?

Turn in to me before you leave!

(I'll give you some time at the end of class)

Outline

Course logistics

What is this course about?

- What is the scope?
- What is a computer architecture?
- What is an assembly language?

Learning objectives

Contact info and office hours

Instructor	Eric Walkingshaw walkiner@eecs.oregonstate.edu
Office hours (KEC 3093)	Mon: Noon – 2pm Wed: 4pm – 5pm **or by appointment**

Teaching Asst.	Yaofei Feng fengy@engr.oregonstate.edu
Office hours (KEC Atrium)	Tues: 9am – 11am Thurs: 4pm – 5pm

Course details

Lectures	Strand Agriculture Hall 203 MWF 3:00–3:50 pm
Mailing list	cs271-w13@engr.orst.edu
Web page	`eecs.oregonstate.edu/~walkiner/cs271-wi13/`

Materials, tests, and coursework

- No textbook!
- Slides and links will be posted to the course web page (possibly some required reading)

Estimated grading breakdown

- 10% – written homework
- 30% – programming assignments
- 30% – midterms (2×15% each)
- 30% – final exam

Subject to change! Check the class web page

Academic honesty

For written homework and programming assignments:

- **Discussion is encouraged!**
- Each student should submit their own final work
- Should understand and be able to reproduce your answers
- Goal is to **learn** the material

If you work with other students, **list them** on your submission!

Important dates

No class!

Jan 21 – MLK Jr. Day

I'm out of town

Feb 25 – Mar 1 (More details when we get closer.)

Final exam

Tues, Mar 19, Noon–2pm

Check the class web page regularly!

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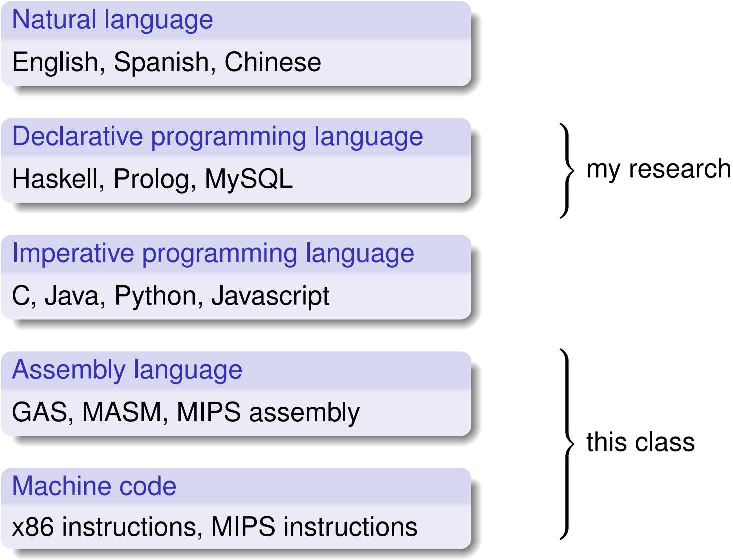
Levels of abstraction from computer hardware



Natural language

English, Spanish, Chinese

Declarative programming language

Haskell, Prolog, MySQL

Imperative programming language

C, Java, Python, Javascript

Assembly language

GAS, MASM, MIPS assembly

Machine code

x86 instructions, MIPS instructions

my research

this class

Moving down the hierarchy

Natural language

- Used by humans, ambiguous semantics
- Translated to programming language by a **programmer**

Programming language

- Well-defined syntax/semantics, portable to different architectures
- Translated to assembly by a **compiler**

Assembly language

- Mnemonic instructions for a specific architecture
- Translated to machine code by an **assembler**

Machine code

- Binary instructions for a specific architecture

What is a computer architecture?

One view: The machine language the CPU implements

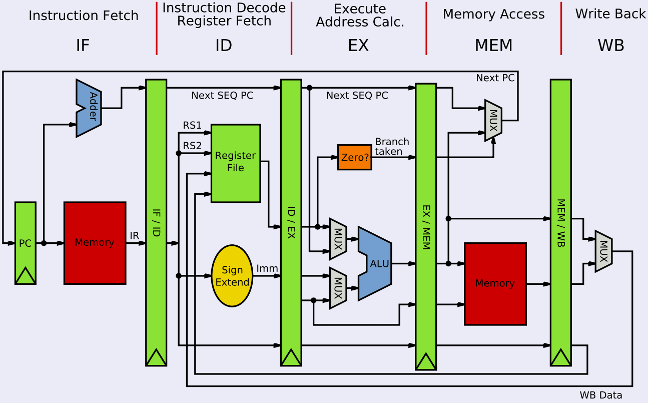
Instruction set architecture (ISA)

- Built in data types (integers, floating point numbers)
- Fixed set of instructions
- Fixed set of on-processor variables (registers)
- Interface for reading/writing memory
- Mechanisms to do input/output

What is a computer architecture?

Another view: The implementation of the CPU in hardware

Microarchitecture – implements the ISA



In this course . . .

MIPS architecture

- RISC architecture – reduced instruction set computer
    - vs. CISC – *complex* instruction set computer
- Very widely used in embedded systems

We'll study:

- the ISA in gory detail
- the microarchitecture at a higher level

What is an assembly language?

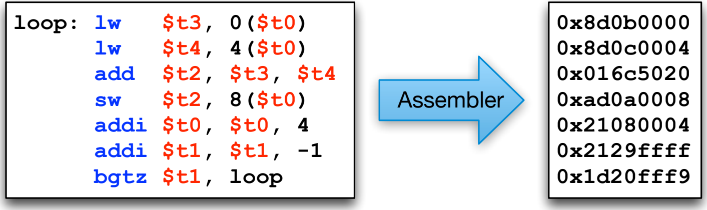
A **programming interface** to the ISA

An assembly language provides:

- A set of **mnemonics** for machine instructions
  - Opcodes, register names, addressing modes
- A way to **name** memory addresses and constants
- Other conveniences for generating machine code

What is an assembler?

An **assembler** is software that translates assembly code to machine code



```
loop: lw   $t3, 0($t0)
      lw   $t4, 4($t0)
      add  $t2, $t3, $t4
      sw   $t2, 8($t0)
      addi $t0, $t0, 4
      addi $t1, $t1, -1
      bgtz $t1, loop
```

```
0x8d0b0000
0x8d0c0004
0x016c5020
0xad0a0008
0x21080004
0x2129ffff
0x1d20fff9
```

Assembly program (text file)
source code

Machine code (binary)
object code

Assembly vs. programming languages

Why use assembly?

- Easier than writing machine code!
- Provides direct control of hardware components
    - Access to features not exposed in a higher-level language
- Performance (dubious)
- A good way to learn a computer architecture :)

Common uses of assembly

- Embedded systems – size/speed efficiency
- Device drivers – direct control

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What should you learn in this class?

1. Understand how data is represented in computers.
   - Programs, integers, and floating point numbers.
   - Big-endian vs. little-endian.
   - Binary, hex, and decimal number systems.
   - Parity bits, error-correcting codes.

2. High-level understanding of a computer architecture.
   - What are the major components?
   - Instruction execution cycle and pipelining.
   - Relationship of assembly to an instruction set architecture.
   - Role of the operating system.

What should you learn in this class?

3. Understand exactly what an assembler does.
    - Translation from assembly instructions to machine code.
    - Operation and register mnemonics.
    - Replacing labels with offsets.
    - Expansion of macro instructions.

4. Experience programming in an assembly language.
    - Instruction formats and register conventions.
    - Implementing branches, loops, and procedure calls.
    - Interacting with the operating system through system calls.

5. Understand the mechanics of procedure calls.
    - Simulate the system stack in assembly language.
    - Return values and parameter passing.
    - Alternative procedure call mechanics.