Week 1
Introduction

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CS 212 – Spring 2004

Mundane Details

- Staff
  - Instructor: Paul Chew
  - TAs: David Levitan, Sofya Tenenbaum, one or two more
- Lecture
  - W 3:35 – 4:25, Phillips 203
- Sections
  - Not mandatory
- Website:
  - cs.cornell.edu/courses/212/2004sp/
- Text
  - None required, but some that might be helpful are listed on the website
- Software
  - JDK 1.4+
  - IDE: CS 211 is using DrJava (see CS 211 website)

The Course

- Description

  "A project course that introduces students to the ways of software engineering using the Java programming language. The course requires the design and implementation of several large programs."

- Objectives
  - Improve your programming skills
  - Learn something about software engineering
    - Top-down and bottom-up design
    - Software reuse
    - Abstraction
    - Testing
  - Develop project management skills
  - Learn about computer science

Course Topics

- Introduction, computer architecture, JVM
- Compilers, syntax, grammars
- Context-free grammars, BNF
- Recursive descent parsing, abstract syntax trees (ASTs)
- Programming in a group
- Software engineering, UML
- Call stack, Bali functions
- Recursion
- Software engineering tools
- Pointers, the heap
- Bali++ (object oriented Bali)

Topics will be covered in roughly this order

When to Take CS212

- At same time as CS211
  - Coordination of topics
  - Coordination of assignment due dates
- After CS211
  - You'll have more experience
  - But possibly less connection with *your* CS211
- Before CS211
  - No!

The Project

- Build a rudimentary IDE (Interactive Development Environment)
  - A compiler for a C-like language (Bali)
  - IDE: compiler, editor, viewer
- Compiled code: sam-code
  - Resembles (sort of) Java Byte Code (JBC)
  - Runs on SaM (simplified substitute for the JVM – Java Virtual Machine)
- Four parts
  - Part 1
    - Introduction to SaM, simple expressions
  - Part 2
    - Compiling expressions, control structures
  - Part 3
    - Compiling functions, GUI
  - Part 4
    - Compiling classes

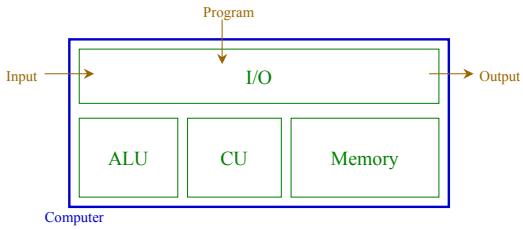
Working in Groups

- Partners *are* allowed
  - Good practice for later team projects
  - Teams of 1, 2, or 3
- Partnership rules
  - You choose team
  - For a given assignment, once you start with a team, you must continue
  - Can change teams for each assignment
  - More details on course website

Computer Architecture: Memory

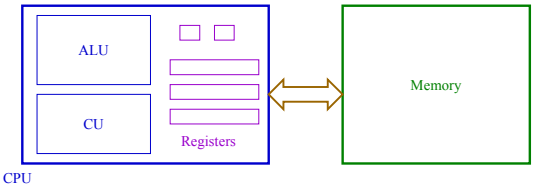
- A computer contains a large collection of circuits that can be used to store *bits* (a bit is a 0 or a 1)
  - Bits are grouped into *bytes* (8 bits)
  - Bytes are grouped into words or *cells*
- *Memory* consists of a large collection of cells
  - Each memory cell has an *address* (usually from 0 to numCells–1)
  - Cells can be accessed in any order
  - Computer memory is often called
    - *Main memory* or
    - *RAM* (Random Access Memory)

Von Neumann Model



- Memory: holds both data and program
- Arithmetic Logic Unit: handles arithmetic and logic calculations
- Control Unit: interprets instructions; controls ALU, Memory, I/O
- I/O: storage, input, output

Central Processing Unit (CPU)



- Registers hold small amounts of data
  - PC: program counter
  - IR: instruction register (current instruction)
  - SP: stack pointer
  - more...

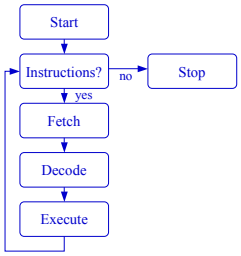
Machine Language vs. Assembly Language

- Machine Language
  - Instructions and coding scheme used internally by computer
  - Humans do not usually write machine language
  - Typical machine language instructions have two parts
    - Op-code (operation code)
    - Operand
- Assembly Language
  - Symbolic representation of machine language
  - Use mnemonic word for op-code
    - Example: PUSHIMM 5
  - Typically provide additional features to help make code readable for humans
    - Example: names as labels instead of numbers

Machine Instruction Categories

- Data transfer
  - Copy data from one memory location to another
    - LOAD: copy data from a memory cell to a register
    - STORE: copy data from a register to a memory cell
    - I/O instructions
- Arithmetic / Logic
  - Request activity in ALU
    - Arithmetic (ADD, SUB, TIMES, ...)
    - Logic (AND, OR, NOT, XOR)
    - SHIFT, ROTATE
- Control
  - Direct execution of program
    - JUMP, JUMPC (conditional jump)

Fetch and Decode Cycle



- CU fetches next instruction from memory at the address specified by program counter (PC)
- CU places instruction into the instruction register (IR)
- CU increments the PC to prepare for next cycle
- CU decodes instruction to see what to do
- CU activates correct circuits to execute the instruction (e.g., ALU performs an addition)

Java Byte Code (JBC)

- A Java compiler creates JBC
  - A sequence of bytes
  - Not easily readable by humans
  - JBC is machine code for an virtual (pretend) computer called the Java Virtual Machine (JVM)
  - A byte code interpreter reads and executes each instruction
- javap –c classfile
  - Can use this to see JBC

Java Virtual Machine (JVM)

- JBC is code for the JVM
  - No such machine really exists
  - A *JVM interpreter* must be created for each machine architecture on which JBC is to run
- The JVM is designed as an "average" computer
  - Uses features that are widely available (e.g., a stack)
- Design goals
  - Should be easy to convert Java code into JBC
  - Should be reasonably easy to create a JVM interpreter for most computer architectures

SaM (Stack Machine)

- Goals
  - Approximate the JVM
  - But simpler
- We will produce sam-code, assembly language for SaM, our own virtual machine
- We have a SaM Simulator (thanks David Levitan) that we can use to execute sam-code
- In place of JBC for the JVM
- We will produce sam-code for SaM

Some Sam-Code Instructions

- SaM's main memory is maintained as a Stack
- The SP (stack pointer) register points at the next empty position on the stack
  - The first position has address 0
  - Addresses increase as more items are pushed onto the Stack
- PUSHIMM c
  - (push immediate)
  - Push integer c onto Stack
- ADD
  - Add top two Stack items, removing those items, and pushing result onto Stack
- SUB
  - Subtract top two Stack items, removing those items, and pushing result onto Stack
  - Order is important
    - stack[top-1] – stack[top]

More Sam-Code Instructions

- ALU Instructions
  - ADD, SUB, TIMES, DIV
  - NOT, OR, AND
  - GREATER, LESS, EQUAL
- Stack Manipulation Instructions
  - PUSHIMM c
  - DUP, SWAP
  - PUSHIND
    - (push indirect)
    - Push stack[stack[top]] onto Stack
  - STOREIND
    - (store indirect)
    - Store stack[top] into stack[stack[top-1]]