Principles of Computer Science I

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CSC 120 – Fall 2005

Lecture Unit 1 - Introduction

Lecture Outline

- What is a computer?
- What is computer science?
- Course mechanics
- Hardware & programming overview
- Compiling & running Java programs
- Binary numbers

Portions based on *Python Programming: An Introduction to Computer Science* by John Zelle

What is a 'computer'?

- What have you used a 'computer' for?
  - Writing a paper… balancing checkbook… playing games…
- Computers also used to…
  - Predict the weather… design airplanes… make movies… run businesses… perform financial transactions… control factories…
- How can one device perform so many tasks?
- What *exactly* is a 'computer'?

Modern Computers

- "A machine (?) that stores and manipulates information under the control of a changeable program."
- Two key elements to definition:
  - Device for manipulating information
    - Calculators, gas pumps also manipulate info… but these are built to only perform single, specific tasks
  - Operate under control of a changeable program
    - Can provide step-by-step instructions to a computer telling it what to do
    - By changing the *computer program*, can get the computer to perform different tasks

A Universal Machine

- Every computer is a machine for *executing* (carrying out) programs
- Many different types of computers
  - Macintoshes, PCs…
  - Thousands of other kinds of computers, real and theoretical
- Remarkable discovery of computer science:
  - All different types of computers have same power
  - With suitable programming, each computer can basically do all the things any other can

Programming

- *Software* (programs) control *hardware* (the physical machine)
- Building software = programming
  - Challenging
    - See the big picture while paying attention to small details, but…
    - Anyone can learn to program
  - Become a more intelligent user of computers
  - Fun
  - Career

Computer Science (CS)

- Is NOT "the study of computers"
  - Dijkstra: computers are to CS as telescopes are to astronomy
- Fundamental question of CS: *What can be computed?*
  - Computers can carry out any process we describe
  - So, what processes can be described in order to solve problems?
- *Algorithm*: Step-by-step process to solve a problem

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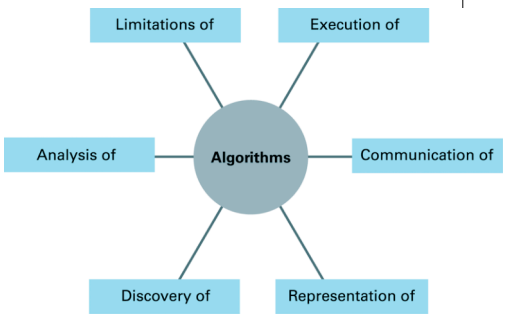
Role of Algorithms in CS



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Algorithms in CS

- Step-by-step process that solves a problem
  - More precise than a recipe
  - Eventually has to stop with an answer
  - General description of a process rather than specific to a computer or programming language
- Areas of CS discipline span
  - Theory (mathematics)
  - Experimentation (science)
  - Design (engineering)

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Subareas of CS

- Architecture — hardware-software interface
- Artificial Intelligence — thinking machines
- Computational Geometry — theory of animation, 3-D models
- Graphics — from Windows to Hollywood
- Operating Systems — run the machine
- Scientific Computing — weather, hearts
- Software Engineering — peopleware
- Theoretical CS — analyze algorithms, models
- Many other subdisciplines… *networking, numerical and symbolic computation, bioinformatics, databases and information retrieval, web and multimedia design, security, human-computer interaction…*

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Course Mechanics

- Syllabus, lectures notes, assignments, etc. on web page
  - *http://fsweb.berry.edu/academic/mans/nhamid/classes/cs120/05fall*
- Class meetings
  - Lectures: Mon/Wed/Fri, 10-10:50AM, SCI 107
  - Labs: Thurs, 3–5PM, SCI 228
- Contact
  - Office: SCI 354B — Phone: 368-5632
  - Email: *nadeem@acm.org*
- Office Hours
  - Mon — 11AM–12:30PM
  - Tue — 11AM–12:30PM
  - Wed — 11AM–12:30PM and 2–4PM
  - Thu — 10AM–12:30PM and 2-3PM
  - (or by appointment…)

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Assignments

- Weekly lab/homeworks
  - Due on Wednesdays
- Programming Projects
- DON'T WAIT UNTIL DAY/NIGHT BEFORE TO START WORKING ON ASSIGNMENTS
  - No late work accepted, without formal excuse/prior arrangement
  - You will NOT be able to complete the programming assignments in one night
- Send email if you have a problem (attached relevant files and say where you're stuck)

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Programming Assignments

- Completed programs must 'work'!!!
  - Compile and run (will learn what that means later)
- If you leave programming assignments to the last minute, you will run a major risk of having incomplete work

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Materials and Resources

- Textbook:
  - *Java Concepts, 4th Edition*, Cay Horstmann
- Online course website: Check regularly
- Software (in computer lab SCI 228)
  - Java 5.0 (JDK): *http://java.sun.com/j2se/1.5.0/download.jsp*
    - Compiler; runtime system
  - DrJava: *http://www.drjava.org*
    - Editor; development environment

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Grading and Evaluation

- Class participation and attendance (10%)
- Lab participation and attendance (10%)
- Assignments/Projects (40%)
- Exams (40%) *Tentative dates:*
  - First exam: Friday, September 23, 2005
  - Second exam: Friday, October 28, 2005
  - Final exam: ???
- Policies (see syllabus)
  - Attendance
  - Academic integrity
  - Late work
  - Disabilities

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Hardware Basics

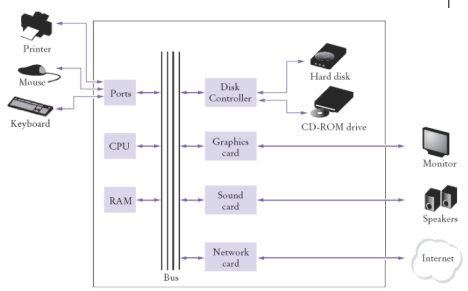

Figure 5 Schematic Diagram of a Computer

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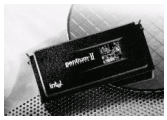
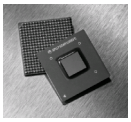
Central Processing Unit (CPU)

- Heart and brain of the machine
- Chip composed of transistors, wiring
- Two primary components
  - Arithmetic/Logic Unit (ALU) performs arithmetic and logical operations
  - Control Unit controls the order in which instructions in the program are executed





Pentium (left) and *PowerPC G3* chips

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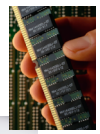
Memory

- Stores programs and data
- CPU can only directly access info. in *main memory* or *primary storage* (RAM- random access memory)
  - Relatively expensive
  - Volatile (loses data when no power)
- Secondary storage- more permanent
  - Hard disk
  - Floppy, CD, DVD, tape, …



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RAM - Main Memory

- Ordered sequence of storage cells
- Each holds one piece (a 'word') of data
- 'Data' is a sequence of bits (on/off - 0/1)
- 8 bits = 1 byte

- Each memory cell has a unique address (integer number)

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Peripheral Devices

- Input Devices
  - keyboard
  - mouse
- Output Devices
  - printer
  - video display
  - LCD screen
- Auxiliary Storage
  - disk drive
  - CD-ROM drive
  - DVD-ROM drive

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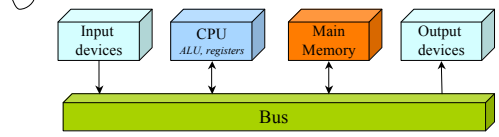
Fetch-Execute Cycle

- How the CPU operates

- Fetch the next instruction
- Decode the instruction into control signals
- Get data if needed (from memory)
- Execute the instruction



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Machine Code

- Instructions/operations that CPU 'understands'
- Different vendors (Intel, Sun, IBM) use different sets of machine instructions

- Extremely primitive
- Encoded as (binary) numbers

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Programming Languages

- Could we use English to give instructions to a computer?
  - "I saw the man in the park with the telescope."
    - Who had the telescope? Who was in the park?
  - 'Natural languages' are full of ambiguity and imprecision
    - Made up for by lots of redundancy and shared human knowledge
- Computer scientists design precise notations for expressing instructions/statements: *programming languages*
- Programming languages have structures with
  - Precise form (*syntax*)
  - Precise meaning (*semantics*)

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High-level Languages

- Designed to be used and understood by humans
  - C, C++, Java, Perl, Scheme, BASIC, …
- All have well-defined, unambiguous syntax and semantics

- Problem:
  - Humans write *code* (programs) in high-level languages
  - Computers only 'understand' machine language (0's, 1's)

- *Compiler*: Program that translates programs from high-level language to machine code

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Java Programming Language

- Benefits
  - Simple (compared to C++)
  - Safe (security features prevent many 'bad' things)
  - Platform-independent ('write once, run anywhere')
  - Rich library (packages)
    - Lots of code already written for you to do lots of stuff
  - Designed for Internet (applets)

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Caveats

- Programs we write in this course will not be fancy
  - Today's sophisticated programs/games built by teams of highly skilled programmers, artists, other professionals
- Java language
  - Was designed for professionals, not students
  - Evolving - features change with different versions (we'll be using 5.0)
  - Cannot learn all Java in one semester
    - In fact, no one can hope to learn entire Java library in a lifetime…
- Goal of this course: Learn how to think about problem solving and expressing precise solutions using a programming language

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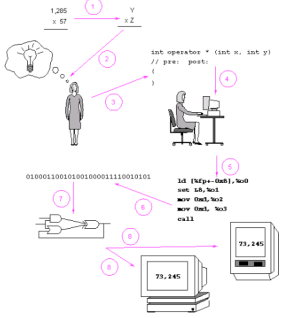
Writing a Program

- Specify the problem
  - remove ambiguities
  - identify constraints
- Develop algorithms, design classes, design software architecture
- Implement program
  - revisit design
  - test, code, debug
  - revisit design
- Documentation, testing, maintenance of program
- From ideas to electrons



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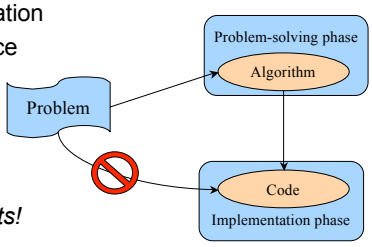
Software Life Cycle

- Problem-solving and design
- Implementation
- Maintenance



- *No shortcuts!*

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Algorithms and Programs

- Algorithm
  - instructions for solving a problem in a finite amount of time using a finite amount of data
  - expressed in a precise, but general, way (using English?), independent of type of computer
- Program
  - an algorithm written for a computer using a particular computer/programming language

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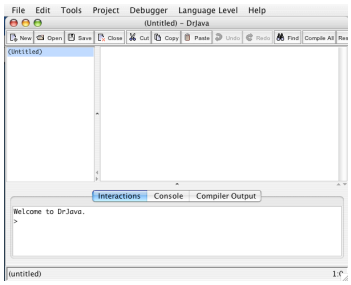
Writing and Compiling a Java Program Using DrJava

IDE = Integrated Development Environment



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Java Compilation Process

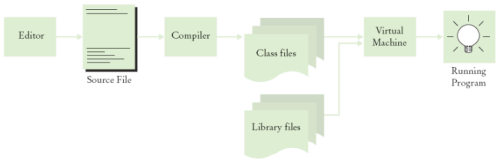

Figure 14 From Source Code to Running Program

HelloTester Program

```
public class HelloTester {

  public static void main( String[] args ) {
    // Display a greeting in the console window

    System.out.println( "Hello, World!" );
  }

}
```

- Note:
  - Java is *case-sensitive* (upper/lowercase matters!)
  - Java doesn't care about layout (spaces/new lines)
    - But we (human beings) need proper layout in order to easily read and understand programs

Basic Java Concepts

- Classes
  - Fundamental building blocks of Java programs
  - Every program made up of one or (usually) more classes
- Methods
  - Collection of programming instructions (statements) that describe how to carry out a particular task
  - Every method has a name
  - Every Java application needs at least a `main` method (i.e. a method named 'main')

Plumbing

- For now, just understand the following skeleton to be the basic 'plumbing' necessary for writing a Java program
  - Name the class according to what it is for
  - Fill in your instructions where the dots are

```
public class ClassName {

  public static void main( String[] args ) {
    ...
  }

}
```


HelloTester Program

• Defines a new *class*
• 'public' means usable by everyone

```
public class HelloTester {

  public static void main( String[] args ) {
    // Display a greeting in the console window

    System.out.println( "Hello, World!" );
  }

}
```

- Every Java source code file can contain at most one public class, and name of the public class must match (spelling & capitalization) the name of the file containing the class (with .java extension)

HelloTester Program

• Defines a *method* called 'main'
• 'static' means the method does not operate on an *object*

```
public class HelloTester {

  public static void main( String[] args ) {
    // Display a greeting in the console window

    System.out.println( "Hello, World!" );
  }

}
```

- The 'args' *parameter* is a required part of the main method - contains command-line arguments which we will not use for now

HelloTester Program

• This line is a *comment*

```
public class HelloTester {

  public static void main( String[] args ) {
    // Display a greeting in the console window

    System.out.println( "Hello, World!" );
  }

}
```

- Comments are purely for benefit of human readers to explain in more detail some part of the code
- All text between // and the end of the line is completely ignored by compiler

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HelloTester Program

• This *statement* prints a message on the screen

```
public class HelloTester {

  public static void main( String[] args ) {
    // Display a greeting in the console window

    System.out.println( "Hello, World!" );
  }

}
```

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Statements

- Each statement ends with a semicolon
  - Forgetting ; is a very common error and will confuse the compiler
- Statements inside the *body* of a method (i.e. enclosed between braces { }) are executed one by one
- `println` is a method that prints a line of text
  - Destination of the output could be a file, window, networked computer, printer, …
  - We specify the *console* (terminal) *window* using the `out` object, contained in the `System` class

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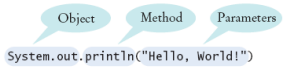
Invoking a Method

- To do something with an object, you *call* (or, *invoke*) a method by specifying
  - Object you want to use
  - Name of the method you want to use
  - Pair of parentheses, containing additional information the method needs to operate
    - This additional information is called the *parameter(s)*



  - (Notice different meanings of the periods)

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Strings

- Sequence of characters enclosed in quotation marks
  - "Hello, World!"
  - "main"
- Any text strings must be enclosed in quotation marks so compiler treats them as plain text and doesn't try to interpret them as program instructions

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Comments

- Two forms of comments in Java
  - `// … till end of line`
  - `/*  … between … */`
    - This form of comments can span multiple lines
- Use comments as you are writing your code
  - Include header comment at the top of any source code files you work on
- Skeleton class file for all assignments
  - GenericClass.java
  - Example: HelloProblem.java

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Number Systems

- How many ones in 943?
  - 943 = 9 hundreds + 4 tens + 3 ones
    = 900 ones + 40 ones + 3 ones
    = $9 \times 10^2 + 4 \times 10^1 + 3 \times 10^0$
- Base
  - The foundational value of a number system, which dictates the number of digits and the value of digit positions
- Positional notation
  - The position of each digit has a place value
  - The number is equal to the sum of the products of each digit by its place value

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Bits 'n Bytes

- Electric circuit states correspond to on (1) or off (0)
- Computers represent all data by combinations of 0s and 1s
- Numbers are represented using a binary, or base-2, system.
- Base 2
  - Only two digits 0, 1
  - Bit: a single digit
  - Byte: a group of 8 bits (an 8 digit binary number)
  - Word: a group of 16 (short), 32, or 64 (long) bits
- Letters ('A', 'a', 'B', …) are represented using one or two bytes

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Binary (Base-2) Numbers

Decimal	Binary
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010
11	1011
12	1100

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Binary Place Values

1 1 1 0

$1x2^3 + 1x2^2 + 1x2^1 + 0x2^0 =$

$1x8 + 1x4 + 1x2 + 0x1 =$

$8 + 4 + 2 + 0 = 14_{(decimal)}$

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Numbers on the Computer

- Have limited size (number of bits)
  - With four decimal digits, the biggest number we can write is 9999_{10} *(subscript indicates base-10)*
  - With four bits (binary digits), the biggest number we can write is $1111_2 = 15_{10}$
- Computers have a scheme for representing negative numbers
  - The left-most bit can be used to tell the sign, but it's not exactly just a sign bit
- Java thus works with numbers in a range of values
  - *e.g.* from $-32{,}768_{10}$ to $32{,}767_{10}$
  - If a number gets too big (or small) it "wraps around"
- Keep this in mind (it can be a source of errors)

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Interesting Number Bases

- Base-2 – Ancient Chinese world view (yin/yang)
- Base-5 – "Hand" (5 fingers on a hand)
- Base-10 – "Decimal" (10 fingers)
- 12 as a grouping system (Europe, China)
- Base-20 – Mayan culture (20 digits, fingers and toes)
- Base-60 – Sumerian culture, used as grouping number by many other cultures (has many factors)

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Predictions that didn't make it

- "I think there is a world market for maybe five computers." – Thomas Watson, IBM chair, 1943
- "Where … the ENIAC is equipped with 18,000 vacuum tubes and weighs 30 tons, computers in the future may have only 1,000 vacuum tubes and weigh only 1.5 tons." – *Popular Mechanics*, 1949
- "Folks, the Mac platform is through—totally." – John C. Dvorak, *PC Magazine*, 1998
- "There is no reason anyone would want a computer in their home." – Ken Olsen, Digital Equipment Corp. president, chairman, and founder, 1977
- "I predict the Internet .. will go spectacularly supernova and in 1996 catastrophically collapse." – Bob Metcalfe, 3Com founder, 1995

L. Kappelman, "The Future is Ours," CACM 44:3 (2001), p46

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