Introduction to Computer Science

Introduction (again)

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8 January 2012
Overview of Course

- Introduction. What is CS? What is a computer?
- Java review. Data, control constructs, static methods
- Classes. Incorporation, instantiation, inheritance
- Generics. Code reuse
- Data structures. Lists, stacks, queue
Course Goals

- **Programming**
  - exciting to translate ideas into reality
  - basics are simple, yet programming well is difficult; do not underestimate the challenge
  - problem solving is hard and difficult to teach

- **Computer Science**
  - Computer Science is not just programming
  - It is easy to lose sight of the big picture, so we have a general introduction
  - Other (non-programming) topics from time to time: architecture, Monte Carlo methods, $O(N)$, invariants, and so on
Outline of Introduction

- What is Computer Science? Architecture, OS, networking, …
- What is a computer? Architecture, CPU, memory hierarchy
- Interface layers: hardware, operating system, application
- The Java platform
  - JVM and a million other pieces
  - Java history, pragmatics
- Programming languages — not just Java
- Program development; debuggers and so on
- Program style. A program is a text file
- I/O, streams
Outline

What is CS?
   - Brief overview of fields in computer science
   - Layers of Software and Hardware

Anatomy of a Computer

The Java Platform
   - History of Java
   - Diverse Application Areas

Programming Competitions
   - International Olympiad in Informatics

Computers And Society

Algorithms
What is Computer Science?

Computer Science is the study of information, protocols and algorithms for idealized and real automata. Automaton: "self moving" – in our context, self "deciding" or autonomous mechanism. Information: knowledge represented in a form suitable for transmission, manipulation, etc. Protocol: rules for exchanging information. Algorithm: an unambiguous, finite description in simple steps of actions.

Computer Science is not the study of computers, nor is it the practice of their use.
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Mathematics, science, or engineering?

**Mathematics.** The science of numbers, interrelations, and abstractions.

**Science.** Systematic knowledge or practice. Acquiring knowledge through the scientific method of natural phenomena (natural sciences) or human or social behavior (social sciences).

**Engineering.** The applied science of acquiring and applying knowledge to design, or construct works for practical purposes.
What is CS?

- Engineering? Application of science?
- Natural science? Observable phenomena?
- Mathematics? Invisible abstractions?
- Social science? Functioning of human society?

CS is exciting and difficult as it is all these things.
Mathematics is the Queen of Science, and Arithmetic the Queen of Mathematics. - C. F. Gauss

*Philosophy is written in this grand book, the universe which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and read the letters in which it is composed. It is written in the language of mathematics, and its characters are triangles, circles and other geometric figures without which it is humanly impossible to understand a single word of it; without these, one wanders about in a dark labyrinth.*

Galileo Galilee in Assayer
We are at the dawn of new era. The, as yet unfinished, language of computation is the language of science and engineering.
Existential Angst

*The Scream* by the Norwegian artist Edvard Munch, painted in 1893.
What Does A Computer Scientist Do?

Just like mathematics, everyone in modern society uses computing. So getting a computer science degree prepares you for everything and nothing.

The most visible activity is commanding computers to do our bidding, i.e., programming.

What do you want to do?
Fields

- Computer architecture
- Operating systems
- Programming languages and compilers
- Algorithms, data structures, complexity
- Computability theory
- Numerical analysis
- Networking and distributed computing
- Parallel computing
- Information Management/Database systems
- Software development (aka Software Engineering)
- Human-computer communication/interaction
- Graphics and Visual Computing
- Intelligent Systems (aka Artificial Intelligence)
Basic five-stage pipeline in a RISC machine: instruction fetch, instruction decode, execute, memory access, register write back.
Operating Systems — paging
Programming Languages and Compilers

regular expressions → flex/lex → lexical analyzer → token stream → bison/yacc → parser → parse tree

with begin 2 * x;

with comment identifier literal begin

with Ada.Text_IO;

context item
declarative part
statement list

Msg: String;
Put (Msg);
Algorithms and Data Structures — Sorting
Theory of Computation — halting problem

Start

Will this program halt?

yes

Halt

no
A report from the United States General Accounting Office begins “On February 25, 1991, a Patriot missile defense system operating at Dhahran, Saudi Arabia, during Operation Desert Storm failed to track and intercept an incoming Scud. This Scud subsequently hit an Army barracks, killing 28 Americans.” The report finds the failure to track the Scud missile was caused by a precision problem in the software.


http://www.ima.umn.edu/~arnold/disasters/disaster.html
Distributed Computing — barber shop problem

Floor Plan of Barbershop

Entrance

Standing Room

Three Barber Chairs

Chairs for waiting customers

Standing Room

Exit
Parallel Computing

- Single data: SISD, MISD
- Multiple data: SIMD, MIMD

Flynn’s taxonomy
# Information Management/Database Systems

The join of two relational tables

<table>
<thead>
<tr>
<th>Name</th>
<th>Have</th>
<th>Result of Join</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dot</td>
<td>cat</td>
<td>Dot cat shots</td>
</tr>
<tr>
<td>Sue</td>
<td>dog</td>
<td>Sue dog shots</td>
</tr>
<tr>
<td>Zan</td>
<td>cat</td>
<td>Zan cat shots</td>
</tr>
<tr>
<td>Bip</td>
<td>bird</td>
<td></td>
</tr>
</tbody>
</table>

The join of two relational tables

```
$ date +%s
1234567890
```
Software Engineering — waterfall model

requirements definition

system and software design

implementation and unit testing

integration and system testing

operation and maintenance
Human-Computer Communication/Interaction

Cue Macintosh_Plus_in_StarTrek
Graphics and Visual Computing

Frozen Fire

- 37 hours to render
- POV ray uses a C-like programming language
C3PO and R2D2 are fantasy robots from the movie Star Wars, while Kiva’s industrial robots can efficiently and intelligently move shelves in a warehouse.
End of the overview of different fields of study in computer science
Computing is complex. There are many layers of interesting stuff between the person and the automaton.
The vastness and minuteness of time and space is a challenge to comprehend.

<table>
<thead>
<tr>
<th>Section</th>
<th>Range (m)</th>
<th>Unit</th>
<th>Example Items</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥</td>
<td>&lt;</td>
<td></td>
</tr>
<tr>
<td><strong>Subatomic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$0$</td>
<td>$10^{-15}$</td>
<td>am electron, quark, string</td>
</tr>
<tr>
<td><strong>Atomic to Cellular</strong></td>
<td>$10^{-15}$</td>
<td>$10^{-12}$</td>
<td>fm proton, neutron</td>
</tr>
<tr>
<td></td>
<td>$10^{-12}$</td>
<td>$10^{-9}$</td>
<td>pm wavelength of gamma rays and X-rays, hydrogen atom</td>
</tr>
<tr>
<td></td>
<td>$10^{-9}$</td>
<td>$10^{-6}$</td>
<td>nm DNA helix, virus, wavelength of optical spectrum</td>
</tr>
<tr>
<td><strong>Human Scale</strong></td>
<td>$10^{-6}$</td>
<td>$10^{-3}$</td>
<td>μm bacterium, fog water droplet, human hair[^1]</td>
</tr>
<tr>
<td></td>
<td>$10^{-3}$</td>
<td>$10^{0}$</td>
<td>mm mosquito, golf ball, soccer ball</td>
</tr>
<tr>
<td></td>
<td>$10^{0}$</td>
<td>$10^{3}$</td>
<td>m human being, American football field, Eiffel Tower</td>
</tr>
<tr>
<td></td>
<td>$10^{3}$</td>
<td>$10^{6}$</td>
<td>km Mount Everest, length of Panama Canal, asteroid</td>
</tr>
<tr>
<td><strong>Astronomical</strong></td>
<td>$10^{6}$</td>
<td>$10^{9}$</td>
<td>Mm the Moon, Earth, one light-second</td>
</tr>
<tr>
<td></td>
<td>$10^{8}$</td>
<td>$10^{12}$</td>
<td>Gm Sun, one light-minute, Earth's orbit</td>
</tr>
<tr>
<td></td>
<td>$10^{12}$</td>
<td>$10^{15}$</td>
<td>Tm orbits of outer planets, Solar System,</td>
</tr>
<tr>
<td></td>
<td>$10^{15}$</td>
<td>$10^{18}$</td>
<td>Pm one light-year; distance to Proxima Centauri</td>
</tr>
<tr>
<td></td>
<td>$10^{18}$</td>
<td>$10^{21}$</td>
<td>Em galactic arm</td>
</tr>
<tr>
<td></td>
<td>$10^{21}$</td>
<td>$10^{24}$</td>
<td>Zm Milky Way, distance to Andromeda Galaxy</td>
</tr>
<tr>
<td></td>
<td>$10^{24}$</td>
<td>$\infty$</td>
<td>Ym visible universe</td>
</tr>
</tbody>
</table>
## SI Prefixes

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Unit</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>$10^{12}$</td>
<td>tera</td>
<td>T</td>
<td>trillion</td>
</tr>
<tr>
<td>$10^{9}$</td>
<td>giga</td>
<td>G</td>
<td>billion</td>
</tr>
<tr>
<td>$10^{6}$</td>
<td>mega</td>
<td>M</td>
<td>million</td>
</tr>
<tr>
<td>$10^{3}$</td>
<td>kilo</td>
<td>k</td>
<td>thousand</td>
</tr>
<tr>
<td>$10^{2}$</td>
<td>hecto</td>
<td>h</td>
<td>hundred</td>
</tr>
<tr>
<td>$10^{1}$</td>
<td>deca</td>
<td>da</td>
<td>ten</td>
</tr>
<tr>
<td>$10^{0}$</td>
<td>(none)</td>
<td></td>
<td>one</td>
</tr>
<tr>
<td>$10^{-1}$</td>
<td>deci</td>
<td>d</td>
<td>tenth</td>
</tr>
<tr>
<td>$10^{-2}$</td>
<td>centi</td>
<td>c</td>
<td>hundredth</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>milli</td>
<td>m</td>
<td>thousandth</td>
</tr>
<tr>
<td>$10^{-6}$</td>
<td>micro</td>
<td>μ</td>
<td>millionth</td>
</tr>
<tr>
<td>$10^{-9}$</td>
<td>nano</td>
<td>n</td>
<td>billionth</td>
</tr>
<tr>
<td>$10^{-12}$</td>
<td>pico</td>
<td>p</td>
<td>trillionth</td>
</tr>
</tbody>
</table>
XXDD PRESENTS:
SOME NEW
SCIENCE MNEMONICS

ORDER OF OPERATIONS
PARENTHESES, EXONENTS, DIVISION / MULTIPICATION, ADDITION / SUBTRACTION
TRADITIONAL: PEERICES, MATHIES, PLAIN SALLY

SI PREFIXES
Kilo, mega, giga, terra, peta, exa, zetta
Yotta
Milli, micro, nano, pico, femto, atto, zepto
Yocto
TRADITIONAL: T H E M S L

Please email my dad a shark of people expect here drugs and sex

Karl Marx gave the proletariat eleven zeppelins. No space.
Microsoft made no profit from anyone's zones. No space.

TAXONOMY
Kingdom, Phylum, Class, Order, Family, Genus, Species
Traditional: King Philip Cried Over Good Sex

I'm not sure what dynasty this, really.

Katy Perry claims organisms feel good sometimes

Buddhist, Frank from your family game system.

Ectoderm, endoderm, mesoderm, mezoderm,
Ectoderm, endoderm, mestoderm

I'm not sure what dynasty this, really.

Poly cystic ovarian syndrome does cause problems that hormonal contraceptives partially negate.

GEOLOGIC PERIODS
(Precambrian) Cambrian Ordovician Silurian Devonian Carboniferous Permian Triassic Jurassic Cretaceous Paleogene Neogene

Traditional: I need lenoning

Resistor color codes
Black, brown, red, orange, yellow, green, blue, violet, gray, white
Traditional: Some I cringe

"Big brother reptilian overlords," yelled Glenn, "brainwashing via ground water!!"
On: bold, respect others: you'll gradually become versable, great wikipediaing

Planets
Mercury Venus Earth Mars
Jupiter Saturn Uranus Neptune
Traditional: My very excellent mother just served us nachos

Mary's, 'Vagina' explanation made Joseph suspect upstairs neighbor

Uh huh.
kilo, mega, giga, tera, peta, exa, zetta
Karl Marx gave the proletariat eleven zeppelins.
milli, micro, nano, pico, femto, atto, zepto
MicroSoft made no profit from anyone’s zunes.
Every Player That Gets Mangled May Never Play Football Again
Exa Peta Tera Giga Mega Micro Nano Pico Femto Atto
Because computers represent information in binary form, it is important to know how many pieces of information can be represented in $n$ bits. $2^n$ pieces of information can be store in $n$ bits, and so is it necessary to be familiar with powers of two. It should be immediately obvious that $\lceil \log_2 n \rceil$ bits of are required to represent $n$ things.
Because information is represented in ones and twos, doubling (exponential growth) is an important concept in computing. To grasp it better we use an ancient Indian chess legend.

A picture of Krishna playing Chess from the National Museum, New Delhi
Legend of the Ambalappuzha Paal Payasam

According to the legend, Lord Krishna once appeared in the form of a sage in the court of the king who ruled the region and challenged him for a game of chess (or chaturanga). The sage told the king that he would play for grains of rice—one grain of rice in the first square, two grains in the second square, four in the third square, eight in the fourth square, and so on. Every square would have double the number of grains of its predecessor. The king lost the game and soon realized that even if he provided all the rice in his kingdom, he would never be able to fulfill the promised reward. The sage appeared to the king in his true form, that of lord Krishna, and said he could serve paal-payasam (sweet pudding made of milk and rice) in the temple freely to the pilgrims every day until the debt was paid off.
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 128 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|     |
| 256 | 512 | 1024 | 2048 | 4096 | 8192 | 16384 | 32768 |   |   |   |   |   |   |   |   |   |
| 256 | 512 | 1024 | 2048 | 4096 | 8192 | 16384 | 32768 |   |   |   |   |   |   |   |   |   |
| 65536 | 131K | 262K | 524K | 1M | 2M | 4M | 8M |   |   |   |   |   |   |   |   |   |
| 16M | 33M | 67M | 134M | 268M | 536M | 1G | 2G |   |   |   |   |   |   |   |   |   |
| 4G | 8G | 17G | 34G | 68G | 137G | 274G | 549G |   |   |   |   |   |   |   |   |   |
| 1T | 2T | 4T | 8T | 17T | 35T | 70T | 140T |   |   |   |   |   |   |   |   |   |
| 281T | 562T | 1P | 2P | 4P | 9P | 18P | 36P |   |   |   |   |   |   |   |   |   |
| 72P | 144P | 288P | 576P | 1E | 2E | 4E | 9E |   |   |   |   |   |   |   |   |   |
We might try gains of sand instead of wheat. How much does a gain of sand weight? One grain of sand weighs about 0.01 grams.
Powers of Two

Suppose we double that one grain of sand and double that amount of sand again. And we do this again and again.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>0.01g</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>0.02g</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>0.04g</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>0.08g</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>0.16g</td>
</tr>
<tr>
<td>5</td>
<td>32</td>
<td>0.32g</td>
</tr>
<tr>
<td>6</td>
<td>64</td>
<td>0.64g</td>
</tr>
<tr>
<td>7</td>
<td>128</td>
<td>1.28g</td>
</tr>
<tr>
<td>8</td>
<td>256</td>
<td>2.56g</td>
</tr>
<tr>
<td>9</td>
<td>512</td>
<td>5.12g</td>
</tr>
</tbody>
</table>
# Powers of Two

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1024</td>
<td>10.24g</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>2048</td>
<td>20.48g</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>4096</td>
<td>40.96g</td>
<td>an ounce</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>262144</td>
<td>2.6kg</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>524288</td>
<td>5.2kg</td>
<td>a pound</td>
</tr>
<tr>
<td>20</td>
<td>1048576</td>
<td>10kg</td>
<td>two pounds</td>
</tr>
<tr>
<td>21</td>
<td>2097152</td>
<td>21kg</td>
<td>three pounds</td>
</tr>
<tr>
<td>30</td>
<td>1073741824</td>
<td>1073kg</td>
<td>one ton</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>1099511627776</td>
<td>12,000 tons</td>
<td></td>
</tr>
</tbody>
</table>
Powers of Two

Suppose we double 1 second and double that amount of time again. And we do this again and again.

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>1 second</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>2 seconds</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>4 seconds</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>8 seconds</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>16 seconds</td>
</tr>
<tr>
<td>5</td>
<td>32</td>
<td>32 seconds</td>
</tr>
<tr>
<td>6</td>
<td>64</td>
<td>a minute</td>
</tr>
<tr>
<td>7</td>
<td>128</td>
<td>2 minutes</td>
</tr>
<tr>
<td>8</td>
<td>256</td>
<td>4 minutes</td>
</tr>
<tr>
<td>9</td>
<td>512</td>
<td>8 minutes</td>
</tr>
</tbody>
</table>
## Powers of Two

<table>
<thead>
<tr>
<th>10</th>
<th>kilo</th>
<th>1 024</th>
<th>17 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td></td>
<td>524 288</td>
<td>one week</td>
</tr>
<tr>
<td>20</td>
<td>mega</td>
<td>1 048 576</td>
<td>two weeks</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>33 554 432</td>
<td>a year</td>
</tr>
<tr>
<td>30</td>
<td>giga</td>
<td>1 073 741 824</td>
<td>34 years</td>
</tr>
<tr>
<td>40</td>
<td>tera</td>
<td>1 099 511 627 776</td>
<td>37 millennia</td>
</tr>
<tr>
<td>50</td>
<td>peta</td>
<td>125 899 906 842 624</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>exa</td>
<td>1 152 921 504 606 846 976</td>
<td>age of universe</td>
</tr>
</tbody>
</table>
Powers of Two

Notice that $2^{10} \approx 10^3$, so these powers have significance:

<table>
<thead>
<tr>
<th>Power</th>
<th>Prefix</th>
<th>Value</th>
<th>Approximate Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>kilo</td>
<td>1 024</td>
<td>17 minutes</td>
</tr>
<tr>
<td>20</td>
<td>mega</td>
<td>1 048 576</td>
<td>two weeks</td>
</tr>
<tr>
<td>30</td>
<td>giga</td>
<td>1 073 741 824</td>
<td>34 years</td>
</tr>
<tr>
<td>40</td>
<td>tera</td>
<td>1 099 511 627 776</td>
<td>37 millennia</td>
</tr>
<tr>
<td>50</td>
<td>peta</td>
<td>1 258 999 069 459 416</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>exa</td>
<td>1 152 921 504 606 846 976</td>
<td>age of universe</td>
</tr>
<tr>
<td>70</td>
<td>zetta</td>
<td>1 180 591 620 717 411 303 424</td>
<td></td>
</tr>
</tbody>
</table>

One ought not to use SI prefixes for power of 2 (just powers of 10).
Powers of Two

Some other powers have special significance in computing.

<table>
<thead>
<tr>
<th>Power</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>128</td>
<td>size of ASCII char</td>
</tr>
<tr>
<td>8</td>
<td>256</td>
<td>size of Latin-1 char</td>
</tr>
<tr>
<td>16</td>
<td>65,536</td>
<td>size of Java short</td>
</tr>
<tr>
<td>31</td>
<td>2,147,483,648</td>
<td>no. of neg int</td>
</tr>
<tr>
<td>33</td>
<td>4,294,967,296</td>
<td>size of Java int</td>
</tr>
<tr>
<td>63</td>
<td>9,233,372,036,854,775,808</td>
<td>no. of neg long</td>
</tr>
<tr>
<td>64</td>
<td>18,446,744,073,709,551,616</td>
<td>size of Java long</td>
</tr>
</tbody>
</table>
One challenge in computer science is the vast scale of computing devices. A computer may have a terabyte ($10^{12}$ bytes) worth of storage. A computer may execute ten instructions every nanosecond ($10^{-9}$ seconds).
Software is a tool that enables us to do things more efficiently and quicker than ever thought possible.

Everyone wants to be the person causing the earth to move. But the lever is really important.
Interface Layers

User

Application

Operating System

Hardware
Computing is complex. There are many layers of interesting stuff between the person and the automaton.

- person (user)
- user-interface (mouse, etc)
- application (program)
- high-level programming language
- machine language
- operating system (OS)
- hardware
- logical devices
- physics
Definitions

- **interface** — An *interface* defines the communication boundary between two entities, such as a piece of software, a hardware device, or a user. It generally refers to an abstraction that an entity provides of itself to the outside.

- **API** — An *application programming interface (API)* is a set of procedures that an operating system, library, or service provides to support requests made by computer programs.

- **IDE** — In computing, an *Integrated development environment (IDE)* is a software application that provides facilities to computer programmers of a source code editor, a compiler and/or interpreter, build automation tools, and usually a debugger.
The program controls the computer, yet it needs critical assistance (from the operating system) to communicate with the outside environment and even to run effectively.
For a deeper appreciation of programming a computer, we should examine briefly the many layers upon which the user depends. An important lesson in organizing these complex systems is that the boundaries should be well chosen. Rapidly changing technology, competing business interests, and new insights make it impossible to settle these boundaries once and for all. Whole college classes like computer architecture, operating systems, compiler construction, and programming languages go into the subjects more deeply.
Hardware and Operating System Platform

Application

System calls: `open()`, `read()`, `mkdir()`, `kill()`

OS:
- File system
- Process management
- Networking

Hardware:
- CPU
- Memory
- Network interface
- Monitor
- Disk
- Keyboard
Example Platforms

- Hardware: IBM PowerPC, Intel x86, Sun Ultra-SPARC II
- OS: Microsoft Windows XP, Mac OS X v10.5 “Leopard”, Linux, Solaris 10

Try:

cs> uname -io
RackMac3, 1 Darwin

olin> uname -io
X86_64 GNU/Linux
Good interfaces mean you don’t have to understand the lower layers. You don’t have to understand flip-flops to programs. The point is:

- Many interfaces are software and software interfaces are an important design problem for programmers
- Many existing interfaces are in flux requiring an understanding of the lower layers.
Outline

What is CS?
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Computers And Society

Algorithms
Computer Hardware
AMD 64X2 dual core
Computer Hardware

Intel quad
Computer Architecture—CPU

Clock

Control

Instruction Register

Program Counter

MAR

MDR

ALU

Condition Codes

Registers

Bus

Increment
control unit is the part of the cpu that controls all the internal actions of the cpu, especially the fetch/execute cycle.

arithmetic/logic unit (ALU) is the part of the cpu that does operations: addition, multiplication, etc.

memory data register (MDR) is the register of the cpu that contains the data to be stored in the computer’s main storage, or the data after a fetch from the storage. It acts like a buffer keeping the contents of storage ready for immediate use by the cpu.
Computer Architecture

Computer Memory Hierarchy

- Processor registers: very fast, very expensive
- Processor cache: very fast, expensive
- Random access memory: fast, affordable
- Flash/USB memory: slower, cheap
- Hard drives: slow, very cheap
- Tape backup: very slow, affordable

Levels:
- Power on immediate term
- Power on very short term
- Power off short term
- Power off mid term
- Power off long term
Memory Hierarchy

<table>
<thead>
<tr>
<th>type</th>
<th>access</th>
<th>size</th>
<th>cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>registers</td>
<td>5ns</td>
<td>1e2</td>
<td></td>
</tr>
<tr>
<td>caches (SRAM)</td>
<td>10ns</td>
<td>1e6</td>
<td>100.00</td>
</tr>
<tr>
<td>main memory (DRAM)</td>
<td>100ns</td>
<td>1e9</td>
<td>1.00</td>
</tr>
<tr>
<td>hard disk</td>
<td>5000ns</td>
<td>1e11</td>
<td>.05</td>
</tr>
</tbody>
</table>

As the technology improves and the costs go down over time, the typical size of each layer goes up. The ratio in access time between two layers influences the design of the computer hardware. When the ratio changes significantly a different design may achieve better performance.
A final note about computers. The computing platform today is less concerned about the individual computer and more concerned about the network of interconnected computers on the Internet.

*The computer is the network*

Slogan of Sun Microsystems

*Cue The Network is the Computer*
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Algorithms
1991: a small group led by James Gosling at Sun Microsystems rejected C/C++ as the basis for digital consumer devices.

1993: Failed in win the contract from Time-Warner for the interactive cable television trial in Orlando, Florida.

1995: WWW, browsers, Java, applets

2009: Oracle buys Sun

2010: Oracle sues Google over Java use in Android Java. “The lawsuit is one battle in a whole war of the mobile industry. Virtually every major player is locked in courtroom battles with another – many fighting on multiple fronts. Software patents, which tend to be broad and subject to multiple interpretations, make for useful tools to bludgeon competitors.”
MyProgram.java

API

Java Virtual Machine

Hardware-Based Platform

Java platform
The Java™ Platform

- Java Technology Enabled Devices
- Java Technology Enabled Desktop
- Workgroup Server
- High-End Server

Editions:
- Micro Edition
- Standard Edition
- Enterprise Edition
Some of the major components surrounding Java:

- Java virtual machine (JVM) specification
- Virtual machine implementation (for Solaris, Window, and Linux), translation tools (`java` and `javac`), and development tools
- Java programming language specification
- A core library (the package `java.lang`), extensive libraries (APIs) for networking, graphics, etc., and additional APIs for special purposes (e.g., telephony)
Java Platform

Additional components surrounding Java:

▶ API documentation
  (No reference material will be given to you. We expect you to go out on the Internet, find it, and know some parts of it in detail.)

▶ An IDE for developing Java programs and GUIs: Netbeans
  (We expect you to be able to develop Java programs; we don’t explicitly teach using an IDE.)

(In lab and lecture we have other priorities and we expect a lot from you. However, don’t be reluctant to ask your classmates, instructors, the help desk, etc., if you have questions. Asking knowledgeable people is still the fastest way to learn.)
### Sun Java SE 6 platform overview

<table>
<thead>
<tr>
<th>Java Language</th>
<th>Tools &amp; Tool APIs</th>
<th>Deployment Technologies</th>
<th>User Interface Toolkits</th>
<th>Integration Libraries</th>
<th>Networking</th>
<th>lang and util Base Libraries</th>
<th>Java Virtual Machine</th>
<th>Platforms</th>
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<tr>
<td>java</td>
<td>javac</td>
<td>javadoc</td>
<td>apt</td>
<td>jar</td>
<td>javap</td>
<td>JPDA</td>
<td>JConsole</td>
<td>Java Hotspot™ Client VM</td>
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<tr>
<td>Security</td>
<td>Int'l</td>
<td>RMI</td>
<td>IDL</td>
<td>Deploy</td>
<td>Monitoring</td>
<td>Troubleshoot</td>
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<td>Java Hotspot™ Server VM</td>
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<td>Java SE 6</td>
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<td>Solaris™</td>
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<td>VisualVM</td>
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<td>Linux</td>
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<tr>
<td>JVM TI</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Windows</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Other</td>
</tr>
</tbody>
</table>

**Java SE API**

- AWT
- Swing
- Java 2D
- IDL
- JDBC™
- JNDI™
- RMI
- RMI-IIOP
- Scripting
- Beans
- Intl Support
- I/O
- JMX
- JNDI
- Math
- Networking
- Override Mechanism
- Security
- Serialization
- Extension Mechanism
- XML JAXP
- lang and util
- Collections
- Concurrency Utilities
- JAR
- Preferences API
- Ref Objects
- Reflection
- Regular Expressions
- Versioning
- Zip
- Instrument
Precarious pyramid
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Computers And Society

Algorithms
International Olympiad in Informatics (IOI)

World-wide competitions for pre-college students exist in many subjects. In addition to computer science, competitions are held in math, physics, chemistry, biology linguistics, geography, *inter alia*.

The national organization of the US, USA Computing Olympiad (USACO), trains and selects the team representing the USA.

Unlike the other subjects, it is easy to participate with USACO. They offer on-line practicing, and exciting world-wide contests every month.

usaco.org
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Computers And Society

Algorithms
Computers Are Misunderstood

- Buffer overruns in old languages like C/C++ cause risks
- Intellectual property, copyrights
- Computer voting, computer money
- Free software works better
- Correct software is hard
WASHINGTON – Federal agencies are facing a severe shortage of computer specialists, even as a growing wave of coordinated cyberattacks against the government poses potential national security risks, a private study found.

Buffer Overrun
Society has not found the right incentive for the creation of useful and correct software.
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Computers And Society

Algorithms
The greedy algorithm used to give change.
Amount owed: 41 cents.

Subtract Quarter
41 - 25 = 16

Subtract Dime
16 - 10 = 6

Subtract Nickel
6 - 5 = 1

Subtract Penny
1 - 1 = 0
Imagine the coin example with only 25-cent, 10-cent, and 4-cent coins. We could make 41 cents change with one 25-cent coin and four 4-cent coins, but the greedy algorithm could only make change for 39 or 43 cents, as it would have committed to using one 10-cent coin.

Imagine the coin example with only 25-cent, 10-cent, 6-cent, and 1-cent coins. We could make 25+18 cents change with one 25-cent coin and three 6-cent coins (four coins total), but the greedy algorithm would make change for 43 cents using one 25-cent coin, one 10-cent coin, one 6-cent coins, and two 1-cent coins (five coins total), as it would have committed to using one 10-cent coin.

It would appear to be necessary to try all possibilities, and this would take a very long time. Fortunately, a clever algorithm exists for making change that does something unexpected. It computes the change for all amounts (not just one), this turns out to be much faster.
Traveling Salesman Problem

Brute-Force Solution:
\[ O(n!) \]

Dynamic Programming Algorithms:
\[ O(n^2 2^n) \]

Selling on eBay:
\[ O(1) \]

Still working on your route?

\[ \sim \]

Shut the hell up.
Zero Knowledge Proof

Peggy has a secret word used to open a door in a cave shaped like a circle. Victor says he’ll pay her for the secret, but not until he’s sure she really knows it. Peggy says she’ll tell him the secret, but not until she receives the money. They devise a scheme by which Peggy can prove that she knows the word without telling to Victor. First, Victor waits outside while Peggy goes out of sight and stands at one side or the other of the door. Victor does not see which way she goes, nor can he hear or watch Peggy if she opens the door.
Second, Victor randomly calls out a path for Peggy to take back to the mouth of the cave.
Cryptography

Third, Peggy takes the indicated path proving she may have opened the door.

With a 50% probability, Peggy has returned by using the password. Victor can repeat the test as long as it takes to convince himself that Peggy indeed knows the password. Each test decreases the chance the Peggy got lucky by standing on the side of the door which Victor will pick.