Agenda

Course overview
• Introductions
• Course goals
• Resources
• Grading
• Policies
• Schedule

Getting started with C
• History of C
• Building and running C programs
• Characteristics of C
• C details (if time)
Introductions

Instructor-of-Record

• Aarti Gupta, Ph.D.
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Lead Preceptors

• Robert Dondero, Ph.D.
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• Iasonas Petras, Ph.D.
  • ipetras@cs.princeton.edu
Introductions: Preceptors

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Huilian (Sophie) Qiu
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Goal 1: “Programming in the large”

- Help you learn how to compose large computer programs

Topics

- Modularity/abstraction, information hiding, resource management, error handling, testing, debugging, performance improvement, tool support
Goal 2: “Under the Hood”

Goal 2: “Look under the hood”
• Help you learn what happens “under the hood” of computer systems

Downward tours

- C Language
- Assembly Language
- Machine Language

= Application Program
= Operating System
= Hardware

language levels tour

service levels tour
Goals: Summary

Help you to become a…

Power Programmer!!!
Goals: Why C?

Question: Why C instead of Java?

Answer 1: C supports Goal 2 better

Answer 2: C supports Goal 1 better
Goals: Why Linux?

**Question:** Why Linux instead of Microsoft Windows?

**Answer 1:** Linux is good for education and research

**Answer 2:** Linux (with GNU) is good for programming
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Lectures

• Describe material at conceptual level
• Slides available via course website
• Suggestion: Bring hard copy of slides

Lecture etiquette

• Please don’t use electronic devices during lectures
Precepts

Precepts

- Describe material at physical (low) level
- Support your work on assignments
- Hard copy handouts distributed during precepts
- Handouts available via course website

Precept etiquette

- Attend your precept
- Use SCORE to move to another precept
  - Trouble: See Colleen Kenny-McGinley (CS Bldg 210)
    - But Colleen can’t move you into a full precept
- Must miss your precept: inform preceptors & attend another

Precepts begin Monday, February 1
Website

- Academics → Course Schedule → COS 217
- Home page, schedule page, assignment page, policies page
Piazza

• http://piazza.com/class#spring2016/cos217/
• Instructions provided in first precept

Piazza etiquette

• Study provided material before posting question
  • Lecture slides, precept handouts, required readings
• Read all (recent) Piazza threads before posting question
• Don’t show your code!!!
  • See course policies
Books

The Practice of Programming (recommended)
- Kernighan & Pike
- “Programming in the large”

- Bryant & O’Hallaron
- “Under the hood”

- King
- C programming language and standard libraries
Manuals (for reference only, available online)

- *Intel 64 and IA-32 Architectures Software Developer’s Manual, Volumes 1-3*
- *Intel 64 and IA-32 Architectures Optimization Reference Manual*
- *Using as, the GNU Assembler*

See also
- *Linux man command*
Programming Environment

Server

CourseLab Cluster

Linux
GNU
Your Pgm
courselab01
courselab02

Client

Your Computer

On-campus or off-campus

SSH
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Grading

<table>
<thead>
<tr>
<th>Course Component</th>
<th>Percentage of Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignments *</td>
<td>50</td>
</tr>
<tr>
<td>Midterm Exam **</td>
<td>15</td>
</tr>
<tr>
<td>Final Exam **</td>
<td>25</td>
</tr>
<tr>
<td>Subjective ***</td>
<td>10</td>
</tr>
</tbody>
</table>

* Final assignment counts double; penalties for lateness

** Closed book, closed notes, no electronic devices

*** Did your involvement benefit the course as a whole?
  • Lecture and precept attendance and participation counts
Programming assignments

- A “de-comment” program
- A string module
- A symbol table module
- Assembly language programs
- A buffer overrun attack (partner from your precept)
- A heap manager module (partner from your precept)
- A Unix shell

First assignment is available now

Start early!!!
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Study the course “Policies” web page!

Especially the assignment collaboration policies

- Violations often involve **trial by Committee on Discipline**
- Typical course-level penalty is **F for course**
- Typical University-level penalty is **suspension from University for 1 academic year**
Assignment Related Policies

Some highlights:

• You may not reveal any of your assignment solutions (products, descriptions of products, design decisions) on Piazza.

• **Getting help:** To help you compose an assignment solution you may use only authorized sources of information, may consult with other people only via the course's Piazza account or via interactions that might legitimately appear on the course's Piazza account, and must declare your sources in your readme file for the assignment.

• **Giving help:** You may help other students with assignments only via the course's Piazza account or interactions that might legitimately appear on the course's Piazza account, and you may not share your assignment solutions with anyone, ever, in any form.

Ask the instructor-of-record for clarifications

• Only the instructor-of-record can waive any policies (and not verbally)
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Getting started with C
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# Course Schedule

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Lectures</th>
<th>Precepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Number Systems C (conceptual)</td>
<td>Linux/GNU C (pragmatic)</td>
</tr>
<tr>
<td>3-6</td>
<td>“Programming in the Large”</td>
<td>Advanced C</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Midterm Exam</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Recess</td>
</tr>
<tr>
<td>8-13</td>
<td>“Under the Hood” (conceptual)</td>
<td>“Under the Hood” (programming asgts)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reading Period</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Final Exam</td>
</tr>
</tbody>
</table>
Any questions?
Agenda

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The C Programming Language

Who? Dennis Ritchie
When? ~1972
Where? Bell Labs
Why? Compose the Unix OS
Java vs. C: History

- BCPL
- B
- C
- K&R C
- ANSI C89
- ISO C90
- ISO C11
- ISO C99
- ANSI C99
- 1960
- 1970
- 1972
- 1978
- 1989
- 1999
- 2011
- LISP
- Smalltalk
- C++
- Java

Not (yet?) popular; our compiler supports only partially.

We will use ISO C11.
# Java vs. C: Design Goals

<table>
<thead>
<tr>
<th>Java Design Goals</th>
<th>C Design Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language of the Internet</td>
<td>Compose Unix</td>
</tr>
<tr>
<td>High-level; insulated from hardware and OS</td>
<td>Low-level; close to HW and OS</td>
</tr>
<tr>
<td>Good for application-level programming</td>
<td>Good for system-level programming</td>
</tr>
<tr>
<td>Support object-oriented programming</td>
<td>Support structured programming</td>
</tr>
<tr>
<td>Look like C!</td>
<td></td>
</tr>
</tbody>
</table>
Agenda

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Getting started with C
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$ javac MyPgm.java

Java compiler (machine lang code)
Running Java Programs

$ java MyPgm

Data (input) → java program (MyPgm) → Java interpreter (Java virtual machine) → Machine language code → Data (output)

HW (CourseLab) → OS (Linux) → MyPgm.class (bytecode) → Java interpreter (Java virtual machine) → Machine language code → Data (output)
Building C Programs

$ gcc217 mypgm.c -o mypgm

C “compiler driver” (machine lang code)
Running C Programs

$ mypgm

mpgm (machine lang code)
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Getting started with C
  • History of C
  • Building and running C programs
  • Characteristics of C
  • C details (if time)
## Java vs. C: Portability

<table>
<thead>
<tr>
<th>Program</th>
<th>Code Type</th>
<th>Portable?</th>
</tr>
</thead>
<tbody>
<tr>
<td>MyPgm.java</td>
<td>Java source code</td>
<td>Yes</td>
</tr>
<tr>
<td>mypgm.c</td>
<td>C source code</td>
<td>Mostly</td>
</tr>
<tr>
<td>MyPgm.class</td>
<td>Bytecode</td>
<td>Yes</td>
</tr>
<tr>
<td>mypgm</td>
<td>Machine lang code</td>
<td>No</td>
</tr>
<tr>
<td>javac (Java compiler)</td>
<td>Machine lang code</td>
<td>No</td>
</tr>
<tr>
<td>java (Java interpreter)</td>
<td>Machine lang code</td>
<td>No</td>
</tr>
<tr>
<td>gcc217 (C compiler driver)</td>
<td>Machine lang code</td>
<td>No</td>
</tr>
</tbody>
</table>

**Conclusion:** Java programs are more portable
Java vs. C: Efficiency

Java programs run on “virtual” machine which runs on “real” machine.

C programs run on “real” machine.

Conclusion: C programs are faster.
Java vs. C: Safety

Java programs run on “virtual” machine defined by interpreter; can provide safe environment (e.g. array bounds checks)

C programs run directly on “real” machine

Conclusion: Java programs are safer
## Java vs. C: Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portability</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Efficiency</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Safety</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>
If this is Java...
Java vs. C: Characteristics

Then this is C
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Java vs. C: Details

Remaining slides provide some details

Use for future reference

Slides covered now, as time allows…
Java vs. C: Details

<table>
<thead>
<tr>
<th>Overall Program Structure</th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hello.java:</td>
<td>public class Hello</td>
<td></td>
</tr>
<tr>
<td></td>
<td>{ public static void main</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(String[] args)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>{ System.out.println(</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&quot;hello, world&quot;);</td>
<td></td>
</tr>
<tr>
<td></td>
<td>}</td>
<td></td>
</tr>
<tr>
<td></td>
<td>}</td>
<td></td>
</tr>
<tr>
<td>Building</td>
<td>$ javac Hello.java</td>
<td>$ gcc217 hello.c –o hello</td>
</tr>
<tr>
<td>Running</td>
<td>$ java Hello</td>
<td>$ hello</td>
</tr>
<tr>
<td></td>
<td>hello, world</td>
<td>hello, world</td>
</tr>
<tr>
<td></td>
<td>$</td>
<td>$</td>
</tr>
</tbody>
</table>
# Java vs. C: Details

<table>
<thead>
<tr>
<th>Character type</th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>char</td>
<td>char // 16-bit Unicode</td>
<td>char /* 8 bits */</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Integral types</th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>byte</td>
<td>// 8 bits</td>
<td>(unsigned) char</td>
</tr>
<tr>
<td>short</td>
<td>// 16 bits</td>
<td>(unsigned) short</td>
</tr>
<tr>
<td>int</td>
<td>// 32 bits</td>
<td>(unsigned) int</td>
</tr>
<tr>
<td>long</td>
<td>// 64 bits</td>
<td>(unsigned) long</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Floating point types</th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>float</td>
<td>float</td>
<td>double</td>
</tr>
<tr>
<td>double</td>
<td>double</td>
<td>long double</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Logical type</th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>boolean</td>
<td>boolean</td>
<td>/* no equivalent */</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/* use integral type */</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Generic pointer type</th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>// no equivalent</td>
<td></td>
<td>void*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constants</th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>final int MAX = 1000;</td>
<td>#define MAX 1000</td>
<td>const int MAX = 1000;</td>
</tr>
<tr>
<td></td>
<td>enum {MAX = 1000};</td>
<td></td>
</tr>
</tbody>
</table>
## Java vs. C: Details

<table>
<thead>
<tr>
<th></th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arrays</strong></td>
<td>int [] a = new int [10]; float [][] b = new float [5][20];</td>
<td>int a[10]; float b[5][20];</td>
</tr>
<tr>
<td><strong>Array bound checking</strong></td>
<td>// run-time check</td>
<td>/* no run-time check */</td>
</tr>
<tr>
<td><strong>Pointer type</strong></td>
<td>// Object reference is an implicit pointer</td>
<td>int *p;</td>
</tr>
<tr>
<td><strong>Record type</strong></td>
<td>class Mine { int x; float y; }</td>
<td>struct Mine { int x; float y; }</td>
</tr>
</tbody>
</table>
Java vs. C: Details

<table>
<thead>
<tr>
<th>Strings</th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>String s1 = &quot;Hello&quot;; String s2 = new String(&quot;hello&quot;);</td>
<td>char *s1 = &quot;Hello&quot;; char s2[6]; strcpy(s2, &quot;hello&quot;);</td>
</tr>
<tr>
<td>String concatenation</td>
<td>s1 + s2</td>
<td>#include &lt;string.h&gt;</td>
</tr>
<tr>
<td></td>
<td>s1 += s2</td>
<td>strcat(s1, s2);</td>
</tr>
<tr>
<td>Logical ops *</td>
<td>&amp;&amp;,</td>
<td></td>
</tr>
<tr>
<td>Relational ops *</td>
<td>=, !=, &gt;, &lt;, &gt;=, &lt;=</td>
<td>=, !=, &gt;, &lt;, &gt;=, &lt;=</td>
</tr>
<tr>
<td>Arithmetic ops *</td>
<td>+, -, *, /, %, unary -</td>
<td>+, -, *, /, %, unary -</td>
</tr>
<tr>
<td>Bitwise ops</td>
<td>&gt;&gt;, &lt;&lt;, &gt;&gt;&gt;, &amp;,</td>
<td>, ^</td>
</tr>
<tr>
<td>Assignment ops</td>
<td>=, *=, /=, +=, -=, &lt;&lt;=, &gt;&gt;=, &gt;&gt;&gt;, &gt;&gt;&gt;=, &amp;=, ^=,</td>
<td>=, %=</td>
</tr>
</tbody>
</table>

* Essentially the same in the two languages
## Java vs. C: Details

<table>
<thead>
<tr>
<th></th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>if stmt *</td>
<td><code>if (i &lt; 0) statement1; else statement2;</code></td>
<td><code>if (i &lt; 0) statement1; else statement2;</code></td>
</tr>
<tr>
<td>switch stmt *</td>
<td><code>switch (i) { case 1: ... break; case 2: ... break; default: ... }</code></td>
<td><code>switch (i) { case 1: ... break; case 2: ... break; default: ... }</code></td>
</tr>
<tr>
<td>goto stmt</td>
<td><code>// no equivalent</code></td>
<td><code>goto someLabel;</code></td>
</tr>
</tbody>
</table>

* Essentially the same in the two languages
## Java vs. C: Details

<table>
<thead>
<tr>
<th></th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
</table>
| **for stmt**   | `for (int i=0; i<10; i++)
statement;` | `int i;
for (i=0; i<10; i++)
statement;` |
| **while stmt** | `while (i < 0)
statement;`               | `while (i < 0)
statement;` |
| **do-while stmt** | `do
statement;
while (i < 0)` | `do
statement;
while (i < 0);` |
| **continue stmt** | `continue;`             | `continue;`                              |
| **labeled continue stmt** | `continue someLabel;` | `/* no equivalent */` |
| **break stmt** | `break;`               | `break;`                                  |
| **labeled break stmt** | `break someLabel;` | `/* no equivalent */` |

* Essentially the same in the two languages*
## Java vs. C: Details

<table>
<thead>
<tr>
<th></th>
<th>Java</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>return stmt *</td>
<td><code>return 5; return;</code></td>
<td><code>return 5; return;</code></td>
</tr>
<tr>
<td>Compound stmt</td>
<td><code>{ statement1; statement2; }</code></td>
<td><code>{ statement1; statement2; }</code></td>
</tr>
<tr>
<td>(alias block) *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exceptions</td>
<td><code>throw, try-catch-finally</code></td>
<td>/* no equivalent */</td>
</tr>
<tr>
<td>Comments</td>
<td><code>/* comment */</code></td>
<td><code>/* comment */</code></td>
</tr>
<tr>
<td></td>
<td><code>// another kind</code></td>
<td></td>
</tr>
<tr>
<td>Method / function</td>
<td><code>f(x, y, z);</code></td>
<td><code>f(x, y, z);</code></td>
</tr>
<tr>
<td>call</td>
<td><code>someObject.f(x, y, z);</code></td>
<td></td>
</tr>
<tr>
<td></td>
<td><code>SomeClass.f(x, y, z);</code></td>
<td></td>
</tr>
</tbody>
</table>

* Essentially the same in the two languages*
#include <stdio.h>
#include <stdlib.h>

int main(void)
{
    const double KMETERS_PER_MILE = 1.609;
    int miles;
    double kMeters;

    printf("miles: ");
    if (scanf("%d", &miles) != 1)
    {
        fprintf(stderr, "Error: Expected a number.\n");
        exit(EXIT_FAILURE);
    }

    kMeters = (double)miles * KMETERS_PER_MILE;
    printf("%d miles is %f kilometers.\n", miles, kMeters);
    return 0;
}
Summary

Course overview

• Introductions
• Course goals
  • Goal 1: Learn “programming in the large”
  • Goal 2: Look “under the hood”
  • Use of C and Linux supports both goals
• Resources
  • Lectures, precepts, programming environment, Piazza, textbooks
  • Course website: access via http://www.cs.princeton.edu
• Grading
• Policies
• Schedule
Summary

Getting started with C
  • History of C
  • Building and running C programs
  • Characteristics of C
  • Details of C
    • Java and C are similar
    • Knowing Java gives you a head start at learning C
Getting Started

Check out course website soon
  • Study “Policies” page
  • First assignment is available

Establish a reasonable computing environment soon
  • Instructions given in first precept