COS 217: Introduction to Programming Systems

Jennifer Rexford

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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)

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Introductions

Instructor-of-Record
- Jen Rexford, Ph.D.
  - jrex@cs.princeton.edu

Lead Preceptors
- Robert Dondero, Ph.D.
  - rdondero@cs.princeton.edu
- Iasonas Petras, Ph.D.
  - ipetras@cs.princeton.edu

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Introductions: Other Preceptors

Robert MacDavid

Hussein Nagree

Reid Oda

Sergiy Popovych

Huilian (Sophie) Qiu

Laura Roberts

KatieAnna Wolf

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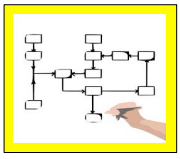
Goal 1: "Programming in the Large"

Goal 1: "Programming in the large"
- Help you learn how to compose large computer programs

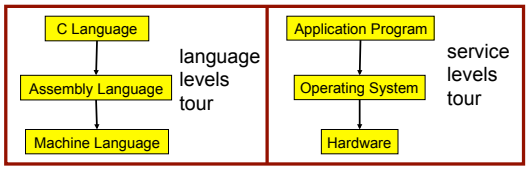


Topics
- Modularity/abstraction, information hiding, resource management, error handling, testing, debugging, performance improvement, tool support

Goal 2: "Under the Hood"

Goal 2: "Look under the hood"
- Help you learn what happens "under the hood" of computer systems

Downward tours



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Goals: Summary

Help you to become a...

Power Programmer!!!

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Goals: Why C?

Question: Why C instead of Java?

Answer 1: C supports Goal 2 better

Answer 2: C supports Goal 1 better

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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

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

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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 September 21

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Website

Website
- Access from http://www.cs.princeton.edu
  - Academics → Course Schedule → COS 217
  - Home page, schedule page, assignment page, policies page

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Piazza

Piazza
- http://piazza.com/class#fall2015/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

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Books

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

Computer Systems: A Programmer's Perspective (Third Edition) (recommended)
- Bryant & O'Hallaron
- "Under the hood"

C Programming: A Modern Approach (Second Edition) (required)
- King
- C programming language and standard libraries

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Manuals

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

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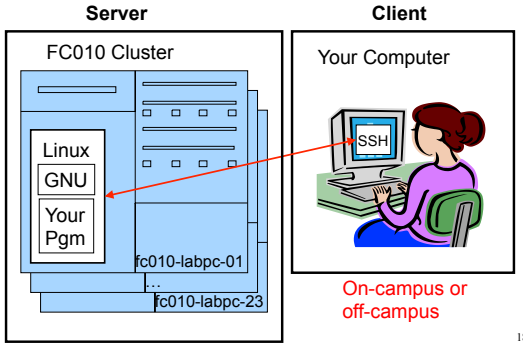
Programming Environment



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Grading

Course Component	Percentage of Grade
Assignments *	50
Midterm Exam **	15
Final Exam **	25
Subjective ***	10

* 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

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Programming Assignments

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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Policies

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

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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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Course Schedule

Weeks	Lectures	Precepts
1-2	Number Systems C (conceptual)	Linux/GNU C (pragmatic)
3-6	"Programming in the Large"	Advanced C
6	Midterm Exam	
7	Recess	
8-13	"Under the Hood" (conceptual)	"Under the Hood" (programming asgts)
	Reading Period	
	Final Exam	

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Any questions?

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The C Programming Language

Who? Dennis Ritchie

When? ~1972

Where? Bell Labs

Why? Compose the Unix OS

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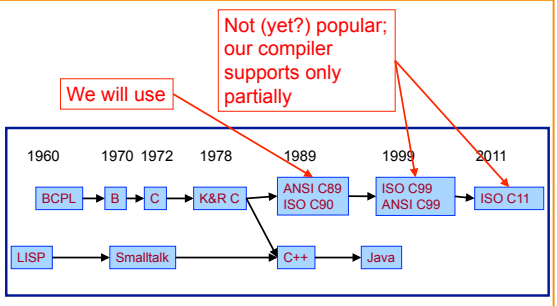
Java vs. C: History



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Java vs. C: Design Goals

Java Design Goals	C Design Goals
Language of the Internet	Compose Unix
High-level; insulated from hardware and OS	Low-level; close to HW and OS
Good for application-level programming	Good for system-level programming
Support object-oriented programming	Support structured programming
Look like C!	

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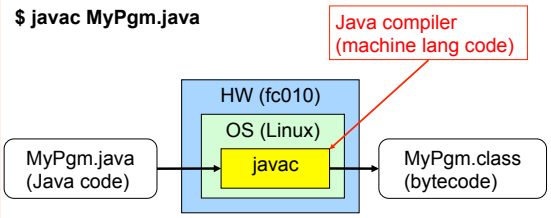
Building Java Programs

$ javac MyPgm.java



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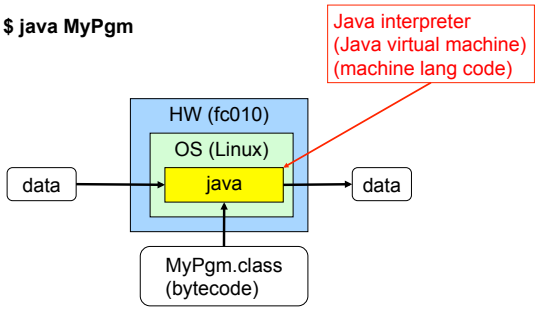
Running Java Programs

$ java MyPgm



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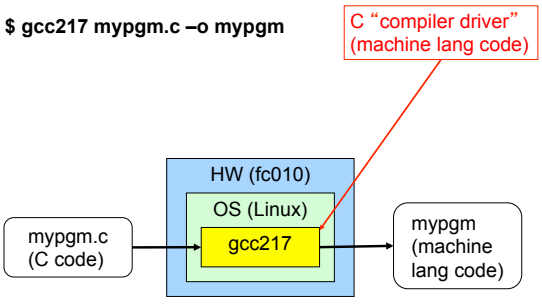
Building C Programs

$ gcc217 mypgm.c –o mypgm



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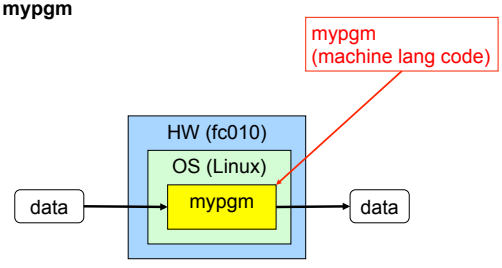
Running C Programs

$ mypgm



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Java vs. C: Portability

Program	Code Type	Portable?
MyPgm.java	Java source code	Yes
mypgm.c	C source code	Mostly
MyPgm.class	Bytecode	Yes
mypgm	Machine lang code	No
javac (Java compiler)	Machine lang code	No
java (Java interpreter)	Machine lang code	No
gcc217 (C compiler driver)	Machine lang code	No

Conclusion: Java programs are more portable

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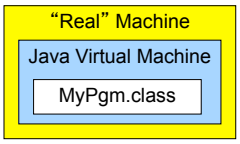
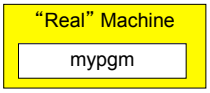
Java vs. C: Efficiency



Java programs run on "virtual" machine which runs on "real" machine



C programs run on "real" machine

Conclusion: C programs are faster

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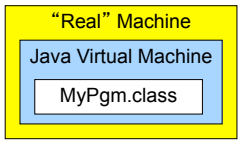
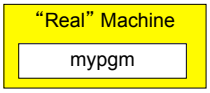
Java vs. C: Safety



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

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Java vs. C: Characteristics

	Java	C
Portability	+	-
Efficiency	-	+
Safety	+	-

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Java vs. C: Characteristics

If this is Java…

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Java vs. C: Characteristics

Then this is C

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- **C details (if time)**

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Java vs. C: Details

Remaining slides provide some details

Use for future reference

Slides covered now, as time allows…

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Java vs. C: Details

	Java	C

Overall Program Structure	Hello.java:
	`public class Hello`
	`{ public static void main (String[] args)`
	`{ System.out.println( "hello, world");`
	`}`
	`}`
		hello.c:
		`#include <stdio.h>`
		`int main(void)`
		`{ printf("hello, world\n");`
		`return 0;`
		`}`

Building	`$ javac Hello.java`	`$ gcc217 hello.c -o hello`

Running	`$ java Hello`
	`hello, world`
	`$`
		`$ hello`
		`hello, world`
		`$`

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Java vs. C: Details

	Java	C
Character type	`char // 16-bit Unicode`	`char /* 8 bits */`

Integral types	`byte // 8 bits`
	`short // 16 bits`
	`int // 32 bits`
	`long // 64 bits`
		`(unsigned) char`
		`(unsigned) short`
		`(unsigned) int`
		`(unsigned) long`

Floating point types	`float // 32 bits`
	`double // 64 bits`
		`float`
		`double`
		`long double`

Logical type	`boolean`	`/* no equivalent */` `/* use integral type */`
Generic pointer type	`// no equivalent`	`void*`

Constants	`final int MAX = 1000;`	`#define MAX 1000`
		`const int MAX = 1000;`
		`enum {MAX = 1000};`

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Java vs. C: Details

	Java	C

Arrays	`int [] a = new int [10];`
	`float [][] b =`
	`new float [5][20];`
		`int a[10];`
		`float b[5][20];`

Array bound checking	`// run-time check`	`/* no run-time check */`
Pointer type	`// Object reference is an` `// implicit pointer`	`int *p;`

Record type	`class Mine`
	`{ int x;`
	`float y;`
	`}`
		`struct Mine`
		`{ int x;`
		`float y;`
		`};`

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Java vs. C: Details

	Java	C

Strings	`String s1 = "Hello";`
	`String s2 = new String("hello");`
		`char *s1 = "Hello";`
		`char s2[6];`
		`strcpy(s2, "hello");`

String concatenation	`s1 + s2` `s1 += s2`	`#include <string.h>` `strcat(s1, s2);`
Logical ops *	`&&, ||, !`	`&&, ||, !`
Relational ops *	`=, !=, >, <, >=, <=`	`=, !=, >, <, >=, <=`
Arithmetic ops *	`+, -, *, /, %, unary -`	`+, -, *, /, %, unary -`
Bitwise ops	`>>, <<, >>>, &, |, ^`	`>>, <<, &, |, ^`
Assignment ops	`=, *=, /=, +=, -=, <<=, >>=, >>>=, =, &=, ^=, |=, %=`	`=, *=, /=, +=, -=, <<=, >>=, =, &=, ^=, |=, %=`

* Essentially the same in the two languages

Java vs. C: Details

	Java	C

if stmt *	`if (i < 0)`
	`  statement1;`
	`else`
	`  statement2;`
		`if (i < 0)`
		`  statement1;`
		`else`
		`  statement2;`

switch stmt *	`switch (i)`
	`{ case 1:`
	`  ...`
	`  break;`
	`  case 2:`
	`  ...`
	`  break;`
	`  default:`
	`  ...`
	`}`
		`switch (i)`
		`{ case 1:`
		`  ...`
		`  break;`
		`  case 2:`
		`  ...`
		`  break;`
		`  default:`
		`  ...`
		`}`

goto stmt	`// no equivalent`	`goto someLabel;`

* Essentially the same in the two languages

Java vs. C: Details

	Java	C

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

	Java	C
return stmt *	`return 5;` `return;`	`return 5;` `return;`

Compound stmt (alias block) *	`{`
	`  statement1;`
	`  statement2;`
	`}`
		`{`
		`  statement1;`
		`  statement2;`
		`}`

Exceptions	`throw, try-catch-finally`	`/* no equivalent */`
Comments	`/* comment */` `// another kind`	`/* comment */`

Method / function call	`f(x, y, z);`
	`someObject.f(x, y, z);`
	`SomeClass.f(x, y, z);`
		`f(x, y, z);`

* Essentially the same in the two languages

Example C Program

```
#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

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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

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