COS 217: Introduction to Programming Systems

Welcome!

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.
  - aartig@cs.princeton.edu

Lead Preceptors

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

Graduate Student Preceptors

- Hao (Frank) Wu
  - haow@princeton.edu
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  - haoyuz@princeton.edu

Introductions

Graders
(in alphabetical order)

- Dorothy Chen
  - dschen@princeton.edu
- Annie Chu
  - anyuanc@princeton.edu
- Matthew Colen
  - mcolen@princeton.edu
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  - naphats@princeton.edu

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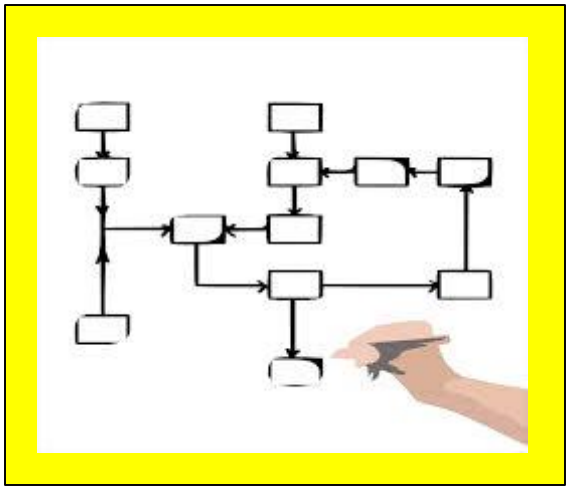
Goal 1: “Pgmming in the Large”



Goal 1: “Programming in the large”

- Help you learn how to compose large computer programs

Topics

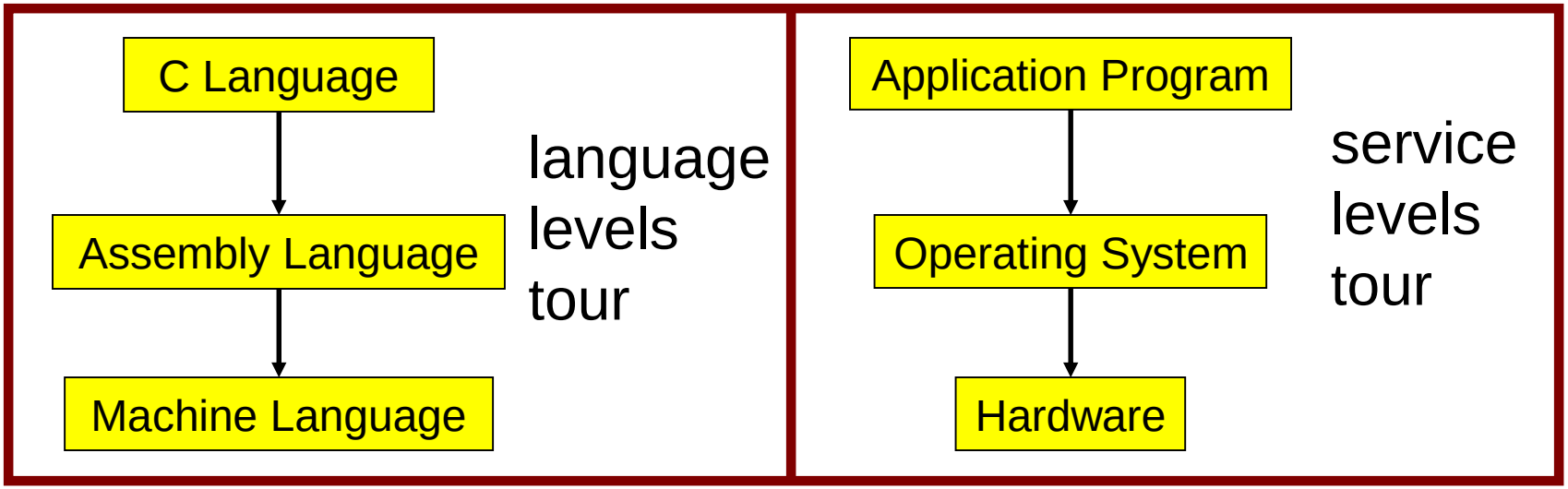
- Modularity/abstraction, information hiding, resource management, error handling
- Testing and debugging your code
- Performance improvement
- Tool support

Goal 2: "Under the Hood"

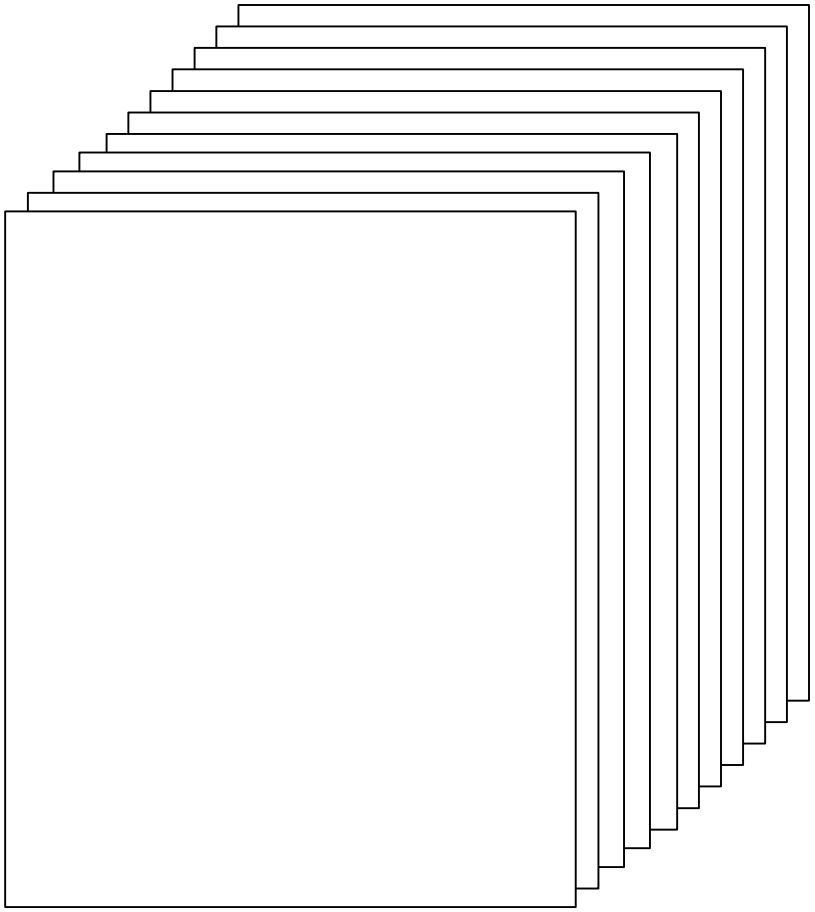
Goal 2: "Look under the hood"

- Help you learn what happens "under the hood" of computer systems

Downward tours



Goals: Summary



Help you to become a...

Power Programmer!!!

Goals: Why C?

Question: Why C instead of Java?

Answer: C supports Goal 2 better

- Languages-level tour
  - Closely related to assembly language
- Services-level tour
  - Linux (our OS) is written in C

Answer: C supports Goal 1 better

- C is a lower-level language
  - Provides more opportunities to create abstractions
- C has some flaws
  - Motivate discussions of software engineering principles

Goals: Why Linux?

Question: Why Linux instead of Microsoft Windows?

Answer 1: Linux is good for education and research

- Open source, well-specified

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

- Variant of Unix, GNU provides rich open-source programming environment

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Lectures

Lectures

- Describe material at conceptual (high) 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 concrete (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 today!

Website

Website

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

Piazza

Piazza

- https://piazza.com/class#spr2015/cos217
- Instructions provided in first precept

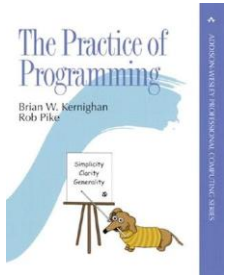
Piazza etiquette

- 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

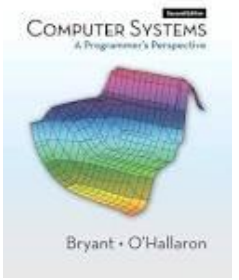
The Practice of Programming (recommended)

- Kernighan & Pike
- "Programming in the large"



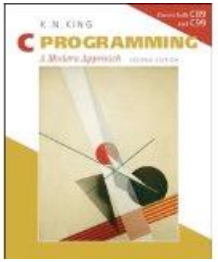
Computer Systems: A Programmer's Perspective (Second Edition) (recommended)

- Bryant & O'Hallaron
- "Under the hood"



C Programming: A Modern Approach (Second Edition) (required)

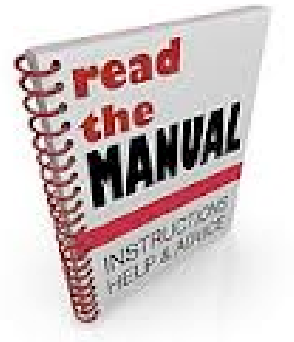
- King
- C programming language and standard libraries



Manuals

Manuals (for reference only, available online)

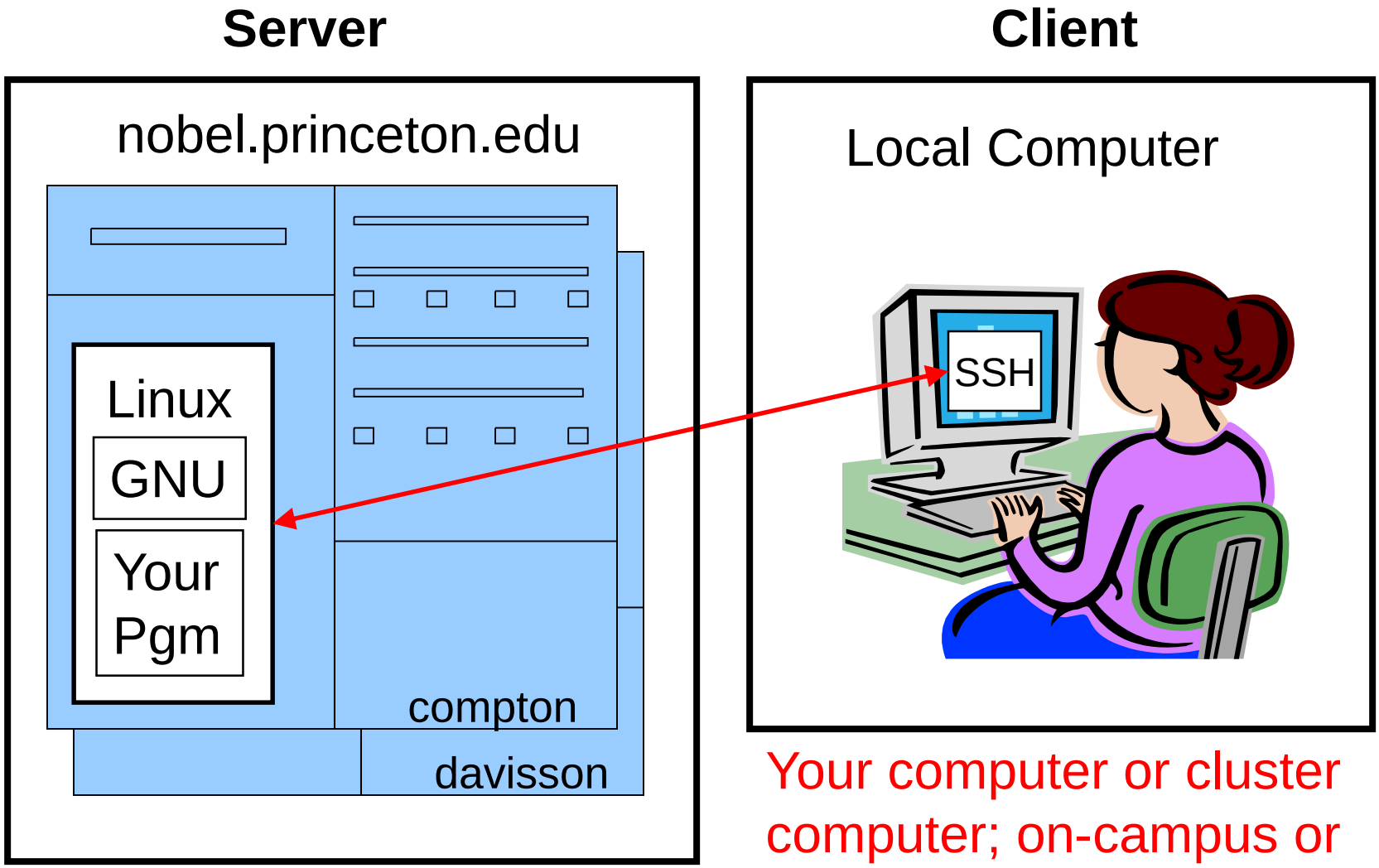
- ***IA32 Intel Architecture Software Developer's Manual, Volumes 1-3***
- ***Tool Interface Standard & Executable and Linking Format***
- ***Intel 64 and IA-32 Architectures Optimization Reference Manual***
- ***Using as, the GNU Assembler***



See also

- Linux **`man`** command
  - **`man`** is short for "manual"
  - For more help, type **`man man`**

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

Programming Assignments

Programming assignments

- A "de-comment" program
- A string module
- A symbol table module
- IA-32 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

- **Due on Sunday, February 15 (at 9:00 PM)**

Start early!!!

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- **Policies**
- Schedule

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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

Assignment Related Policies

Some highlights:

- You may not reveal any of your assignment solutions (products, descriptions of products, design decisions) on Piazza.
- **Getting help**
  - 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
  - must declare your sources in your readme file for the assignment
- **Giving help**
  - only via the course's Piazza account or interactions that might legitimately appear on the course's Piazza account
  - 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 (not verbally)

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Course Schedule

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

Any questions so far?

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The C Programming Language

Who? Dennis Ritchie

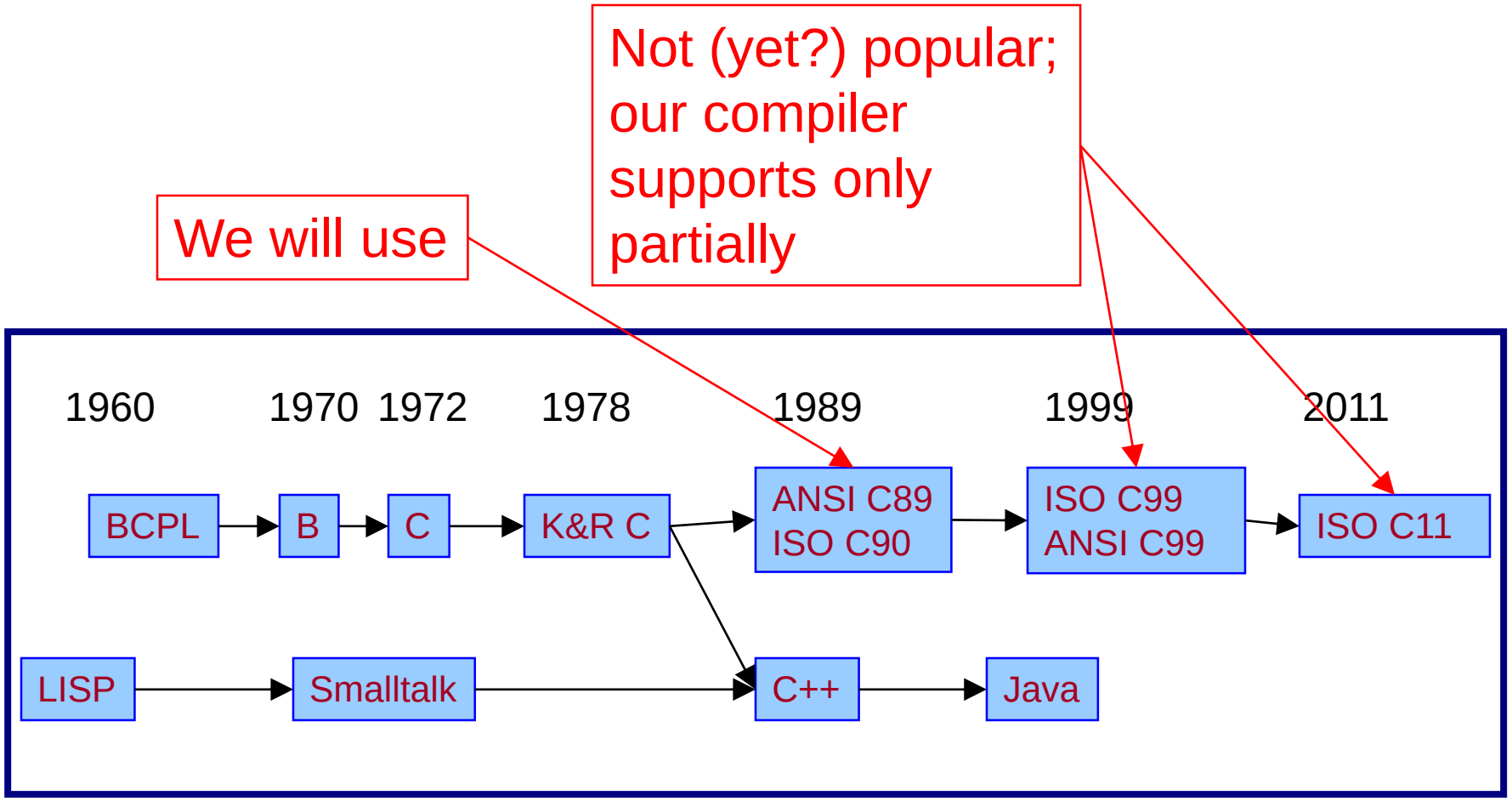
When? ~1972

Where? Bell Labs

Why? Develop the Unix OS

"C is quirky, flawed, and an enormous success. While accidents of history surely helped, it evidently satisfied a need for a system implementation language *efficient enough* to displace assembly language, yet *sufficiently abstract* and fluent to describe algorithms and interactions in a wide variety of environments."

Java vs. C: History



Java vs. C: Design Goals

Java Design Goals	C Design Goals
Language of the Internet	Support development of 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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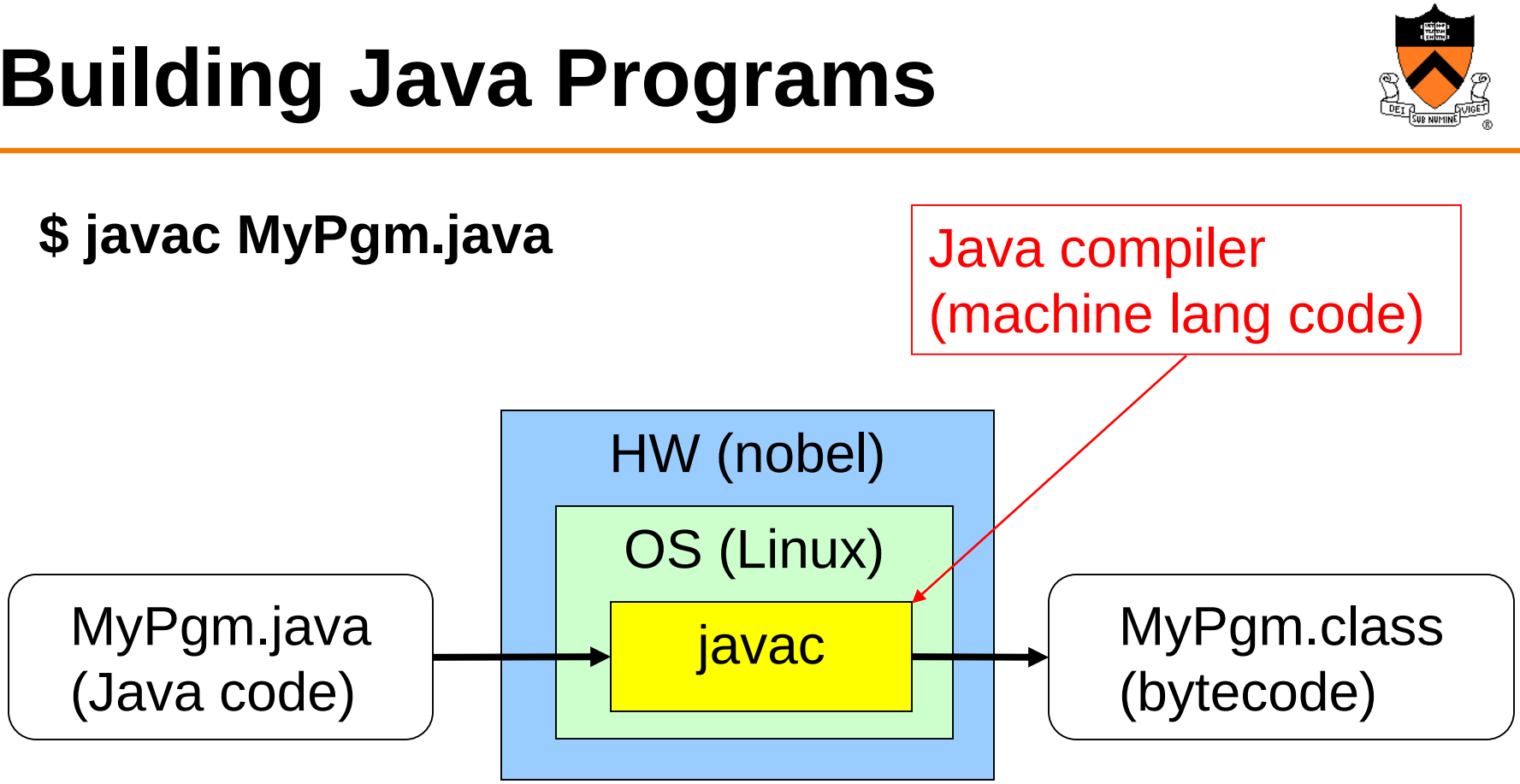
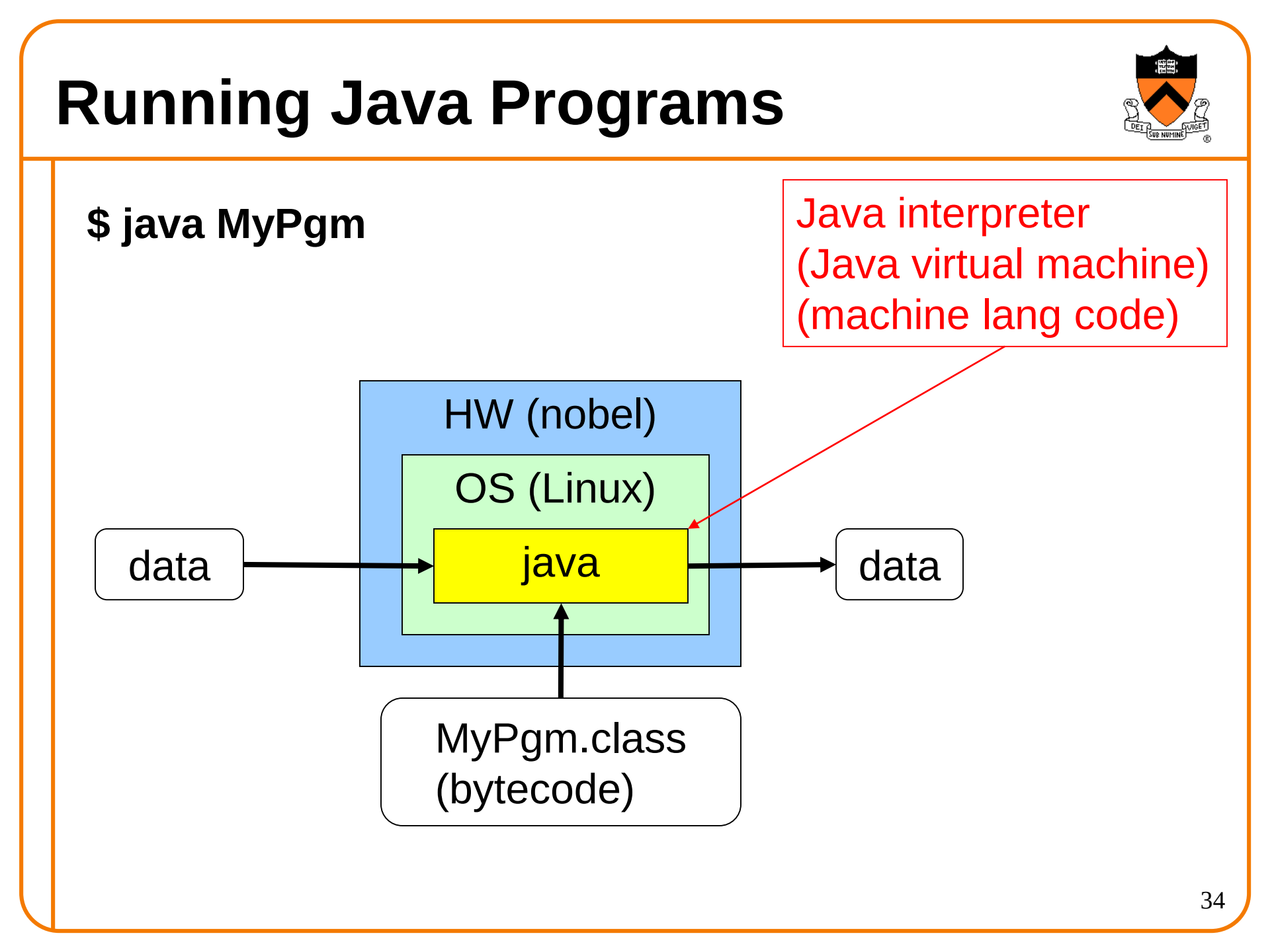
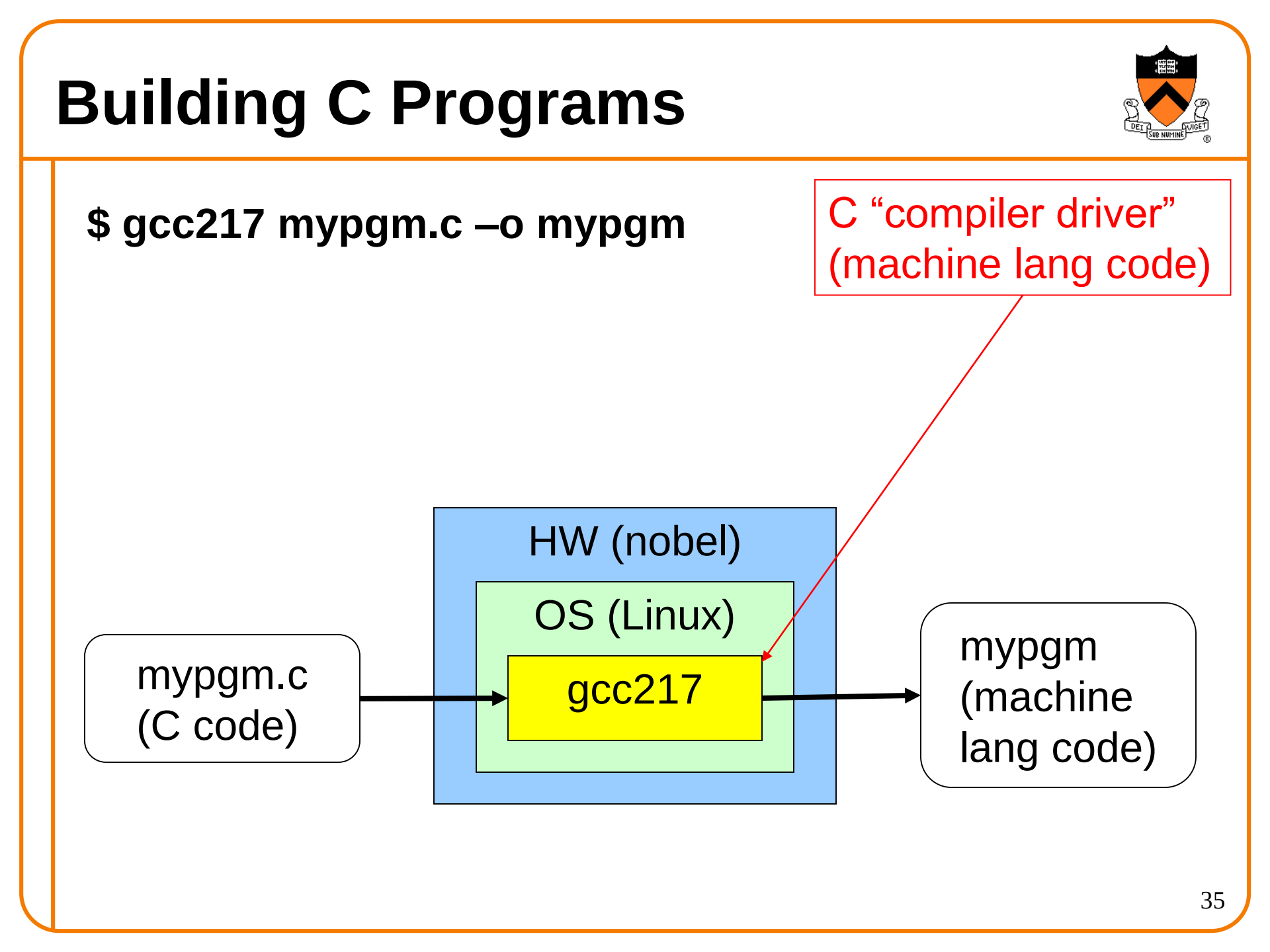
Building Java Programs



Running Java Programs

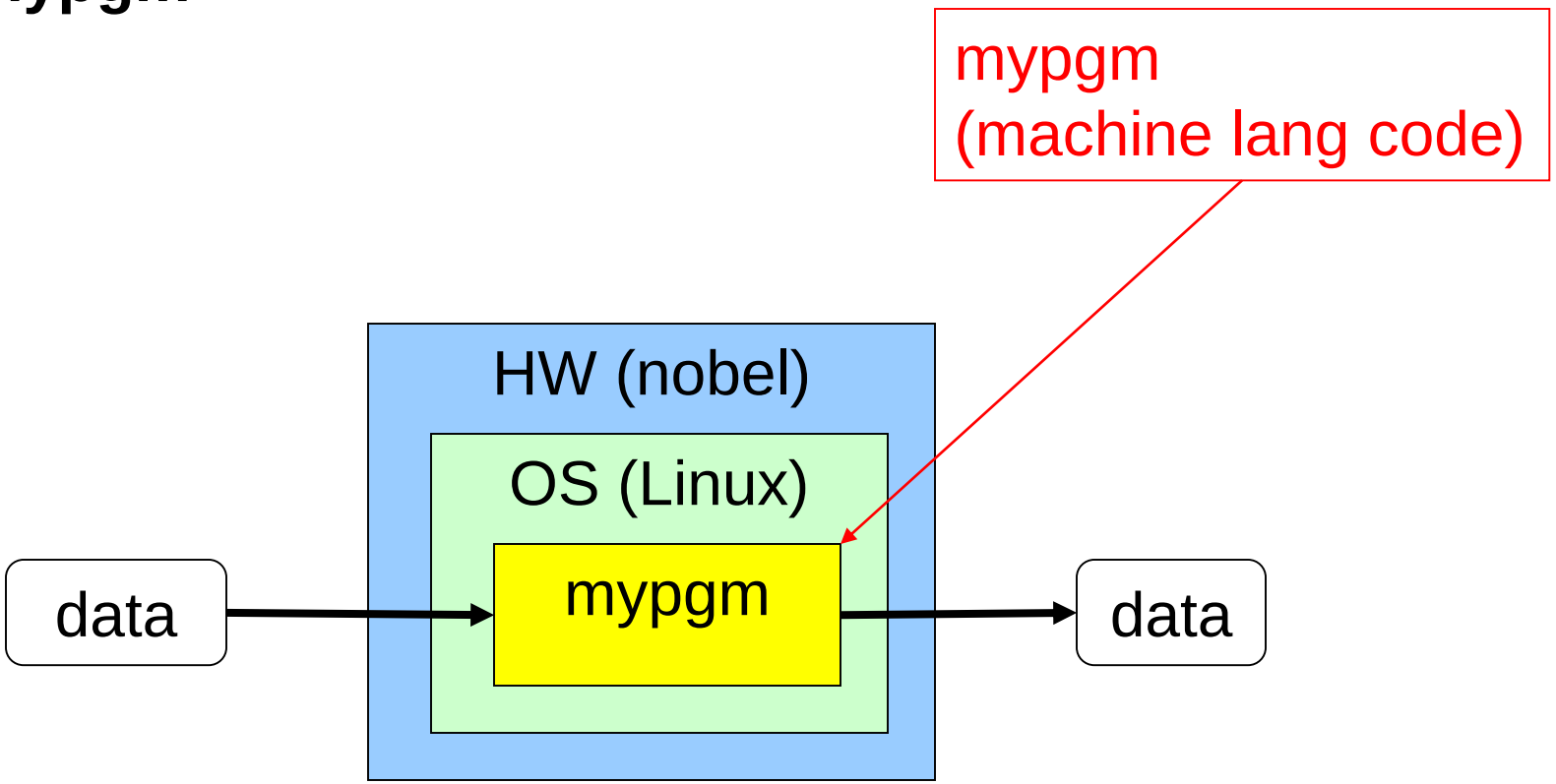


Building C Programs



Running C Programs

$ mypgm



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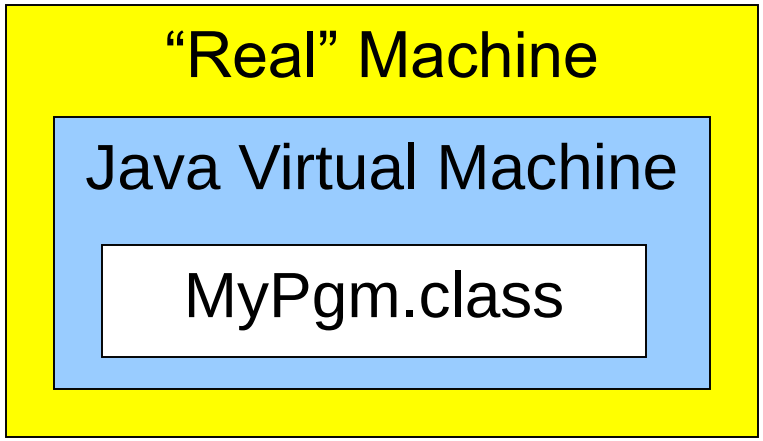
Java vs. C: Portability

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

Java programs are more portable

Java vs. C: Efficiency

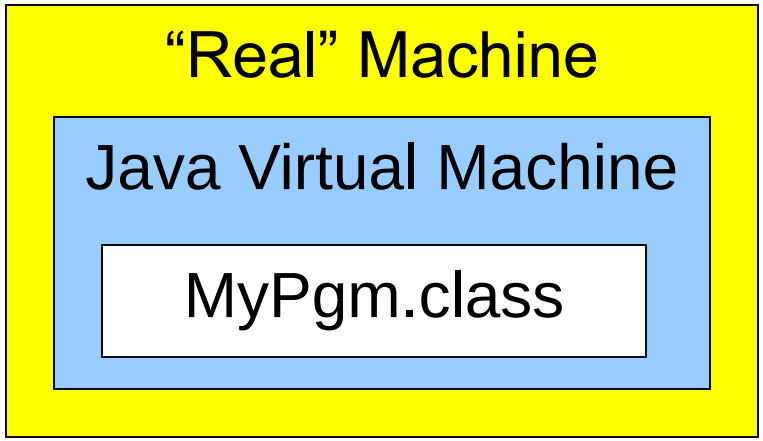


Java programs run on "virtual" machine which runs on "real" machine

C programs run on "real" machine

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

Java programs are safer

Java vs. C: Characteristics

	Java	C
Portability	+	-
Efficiency	-	+
Safety	+	-

Java vs. C: Characteristics

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

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`
		`$`

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};`

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;`
		`};`

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

Getting Started

Check out the course website **soon**

- **Study "Policies" page**
- First assignment is available

Establish a reasonable computing environment **soon**

- Instructions given in first precept