CS201 - PL'S

Names, Scopes, and Bindings

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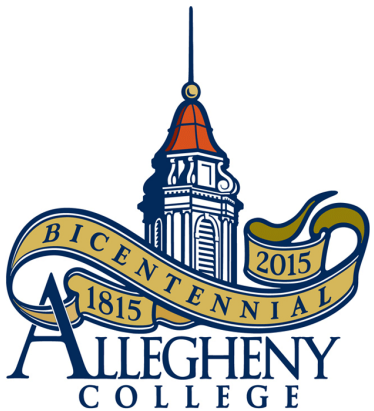


Finishing up on Bye Code

- Not just used for Java: https://en.wikipedia.org/wiki/List_of_JVM_languages
- JVM instruction list: https://docs.oracle.com/javase/specs/jvms/se8/html/jvms-6.html
- Understanding Bytecode makes you a better programmer: http://www.ibm.com/developerworks/ibm/library/it-haggar_bytecode/
- Java Bytecode Fundamentals Blog: http://arhipov.blogspot.com/2011/01/java-bytecode-fundamentals.html

Definitions

- A name is exactly what you think it is
  – Most names are identifiers operators
  – symbols (like '+') can also be names
- A **binding** is an association between two things, such as a name and the thing it names.
- The **scope** of a binding is the part of the program (textually) in which the binding is active.

Binding

Binding Time

is the point at which a binding is created or, more generally, the point at which any implementation decision is made.

- language design time program structure, possible type
- language implementation time
  - I/O, arithmetic overflow, type equality (if unspecified in manual)

Other Implementation Decisions

- program writing time
  – algorithms, names
- compile time
  – plan for data layout
- link time
  –layout of whole program in memory
- load time

More Implementation Decisions

- run time
  - value/variable bindings, sizes of strings
  - NOTE: run time includes
    - program start-up time
    - module entry time
    - elaboration time (point at which a declaration is first “seen”)
    - procedure entry time

Binding

The terms **STATIC** and **DYNAMIC** are generally used to refer to things bound before run time and at run time, respectively.

Binding

- In general, early binding times are associated with greater efficiency
- Later binding times are associated with greater flexibility
- Compiled languages tend to have early binding times
- Interpreted languages tend to have later binding times

Scope Rules - control bindings

- Fundamental to all programming languages is the ability to **name data**
  - i.e., to refer to data using symbolic identifiers rather than addresses
- Not all data is named! For example, dynamic storage in C or Pascal is referenced by pointers, not names

```
double *d = (double *)malloc(8);
*d = 3.14; /* No name is bound to the
value 3.14 */
/* The name ``d'' is bound to the
ADDRESS containing 3.14 */
```

Lifetime and Storage Management

- The period of time from creation to destruction is called the **LIFETIME** of a binding.
- If object outlives binding it's **garbage**.
- If binding outlives object it's a **dangling reference**.
- The textual region of the program in which the binding is active is its **scope**.

Lifetime and Storage Management

Storage Allocation mechanisms

- Static
- Stack
- Heap

Static allocation for

- code
- globals
- static or own variables

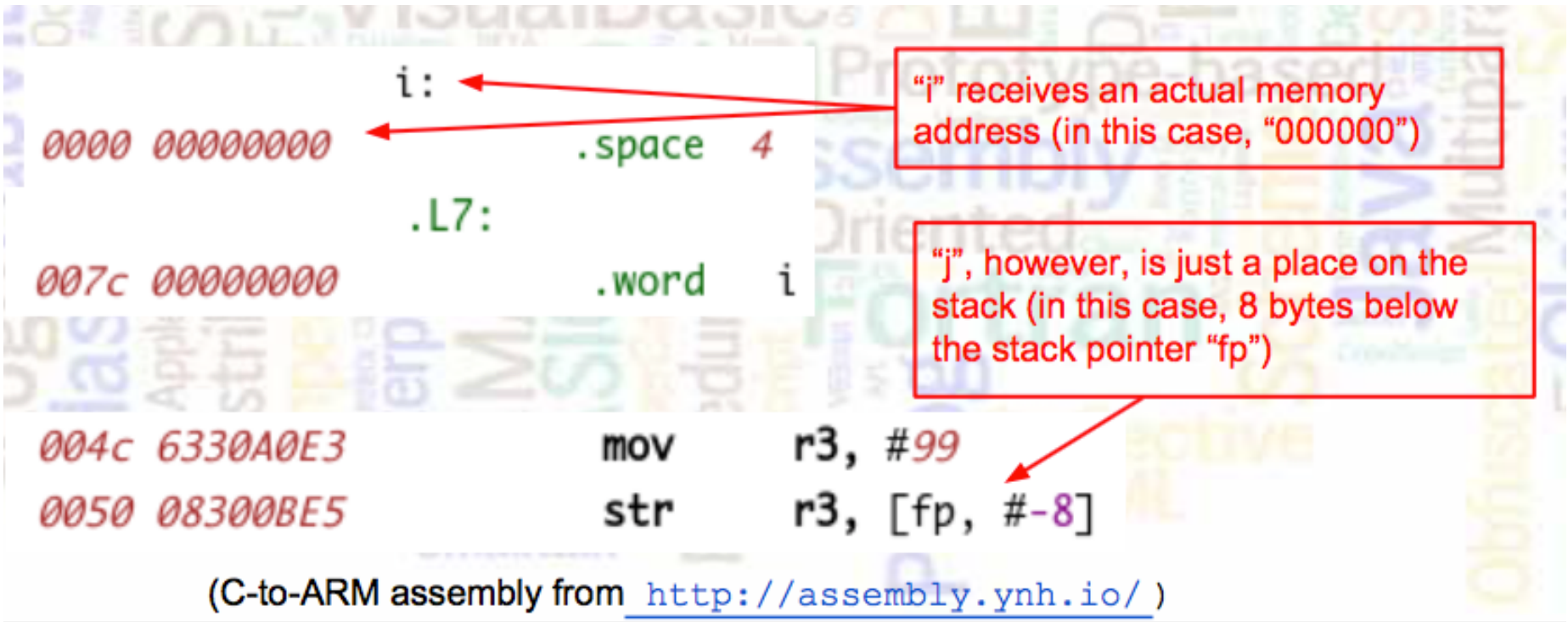
Static Example

In C, variables can be global (visible to any function)

```
int i; /* i is global */
int f(int x) {
  return i+x;  /* i is visible inside function f */
}
main() {
  int j;    /* j is visible only within main */
  i = 10;   /* i is visible inside function main */
  j = 99;
  j = f(3); /* sets j to 13 */
}
```

Static Example

When we compile this, i is stored in a fixed location, while j is allocated on the stack



Two Types of Scoping

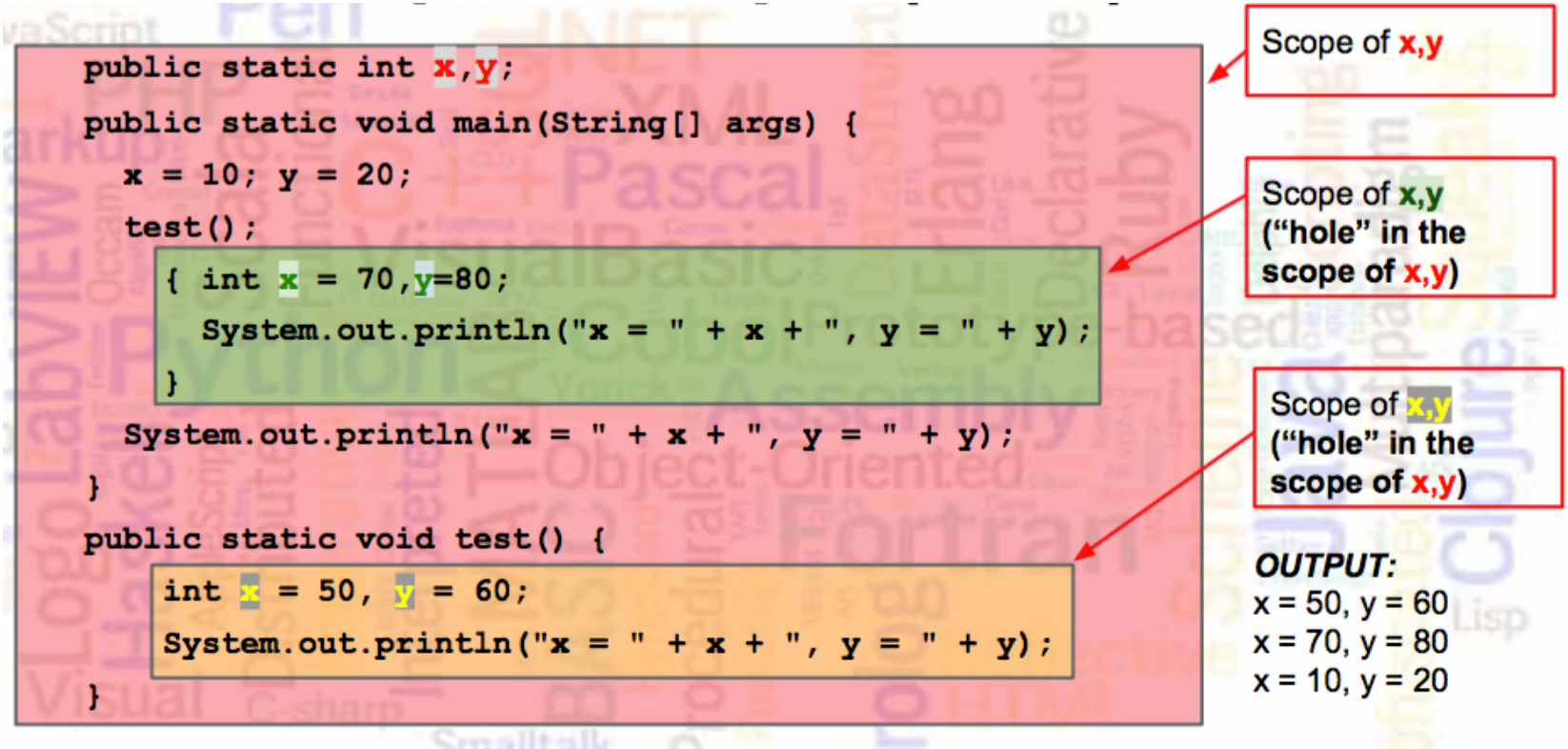
Static scoping (also called “lexical scoping”)

- most familiar (Java, C)
- scope of variables known at compile time

Dynamic scoping

- scope depends on order of function calls at execution time
- pretty rare nowadays

Static Scope Example (Java)



What Happens Here? (Java)

```
public static int x,y;
public static void main(String[] args) {
  x = 10; y = 20;
  test1();
}
public static void test1() {
    int x = 50, y = 60;
    test2();
}
public static void test2() {
    System.out.println("x = " + x + ", y = " + y);
}
```

Does this print “x = 10, y = 20”
or
“x = 50, y = 60” ?

What Happens in Dynamic Scoping?

```
int x,y;
start() {
   x = 10; y = 20;
   test1();
   test2();
}
test1() {
    int x = 50, y = 60;
    test2();
}
test2() {
    System.out.println("x = " + x + ", y = " + y);
}
```

Outputs "x = 50, y = 60"

Outputs "x = 10, y = 20"

Reading Assignment

PLP Chapter 03

Questions

Do you have any questions from this class discussion?