Programming Languages

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Macrh 13, 2023

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- 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.

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

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- 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

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Binding Times are very important in programming languages!

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

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```
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

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- If object outlives binding it's **garbage**.
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- The textual region of the program in which the binding is active is its **scope**.

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Storage Allocation mechanisms

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Static allocation for

- code
- globals
- static or own variables

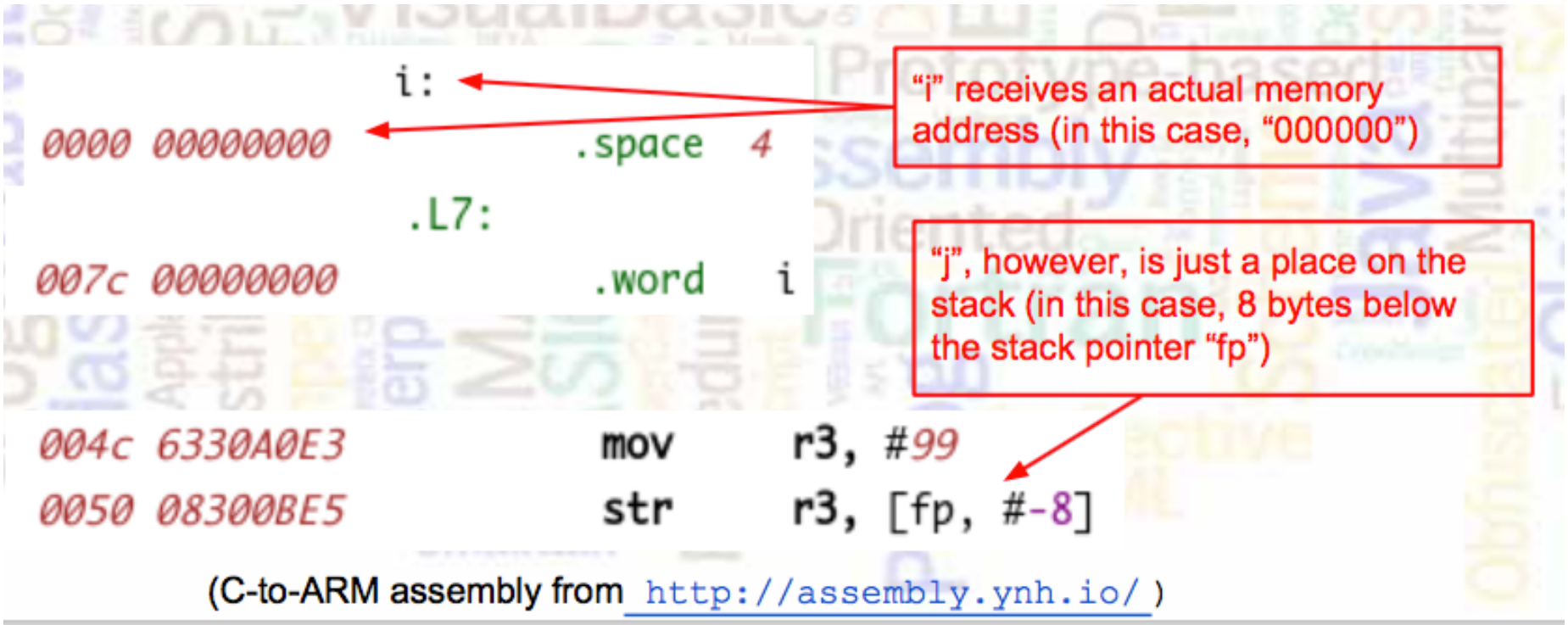
Static Example

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



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Static scoping (also called "lexical scoping")

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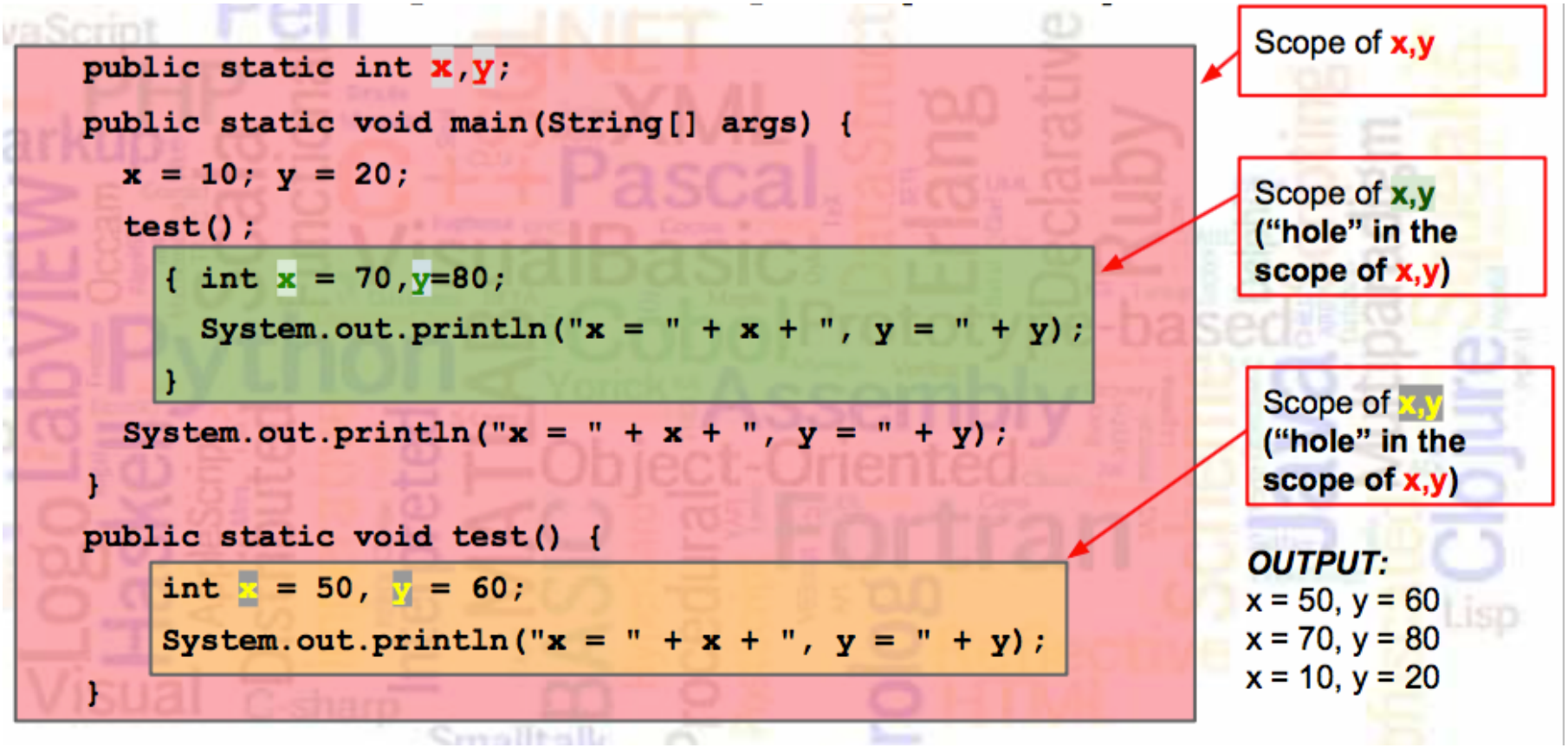
Dynamic scoping

- 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"

JavaScript Case Study