CSCI 334:
Principles of Programming Languages

Lecture 4

Memory and call-by-value semantics

Instructor: Dan Barowy

Williams

HW3 will be posted soon

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HW1 solutions will be in my box by the end of the day.

HW1 grades are back

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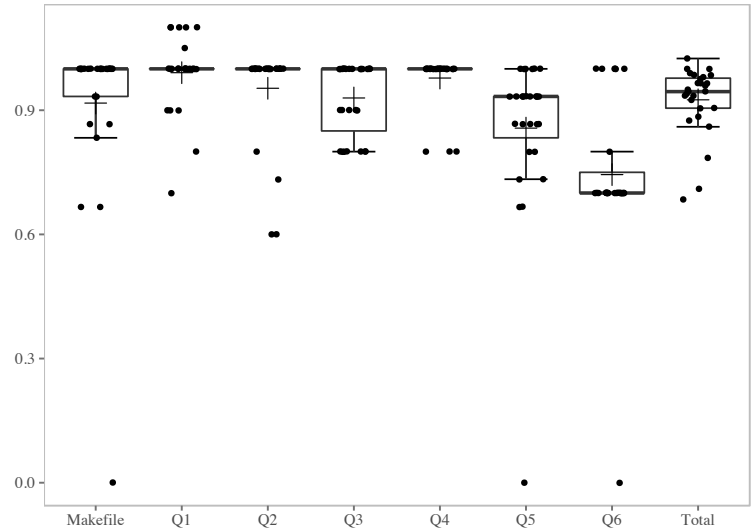
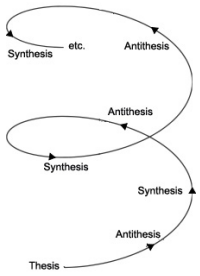
Grades are sent back, with feedback,
as a “pull request” in Github.

HW1 grade distribution



Resubmissions



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6. You can earn back up to 50% of missing points.

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This is the path to excellence

Reading Responses

Mental technique #2: motivation

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(Simone Biles)

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Why are you here?

Why do we need pointers?

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1. “Any problem in computer science can be solved with another level of indirection.” —Butler Lampson

Why do we need pointers?

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2. They are necessary for building “persistent” data structures.

Storage Duration

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We will focus on two: *automatic* and *allocated*

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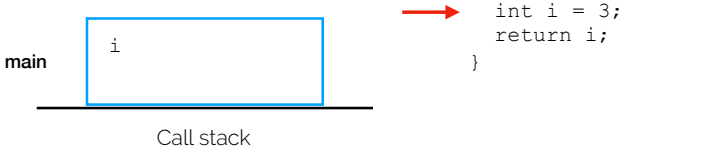
In reality, nearly every C implementation will store `i` ***on the call stack***.

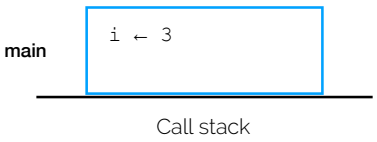
Storage Duration: Automatic




```
#include <stdio.h>

int main() {
  int i = 3;
  return i;
}
```

Storage Duration: Automatic

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Call stack

Where does `i` get returned? How?

Storage Duration: Automatic

```
#include <stdio.h>

int main() {
  int i = 3;
  return i;
}
```

Call stack

`main`'s stack frame and all variables in it (i.e., `i`) are automatically deallocated when `main` ***goes out of scope***.

Activity

```
#include <stdio.h>

int add(int x, int y) {
  int z = x + y;
  return z;
}

int main() {
  int x = 1;
  int z = add(x, 3);
  return z;
}
```

2 → `return z;`

1 → `int x = 1;`

3 → `return z;`

Diagram the stack and variables when the program is at the three points.

Storage Duration: Allocated

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int *i = malloc(sizeof(int));
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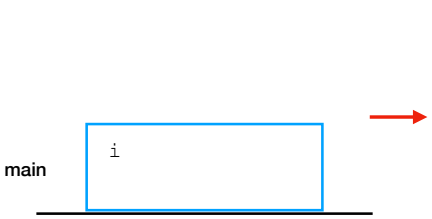
You have to do this even if `i` goes out of scope!

Failing to free when you are done is a bug called a ***memory leak***.

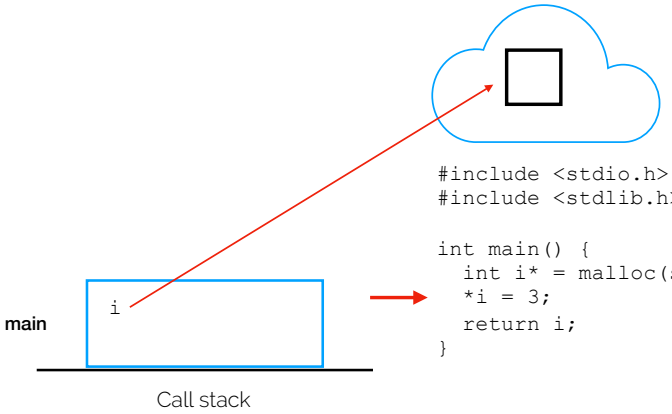
Storage Duration: Allocated




```
#include <stdio.h>
#include <stdlib.h>

int main() {
  int i* = malloc(sizeof(int));
  *i = 3;
  return i;
}
```

Storage Duration: Allocated

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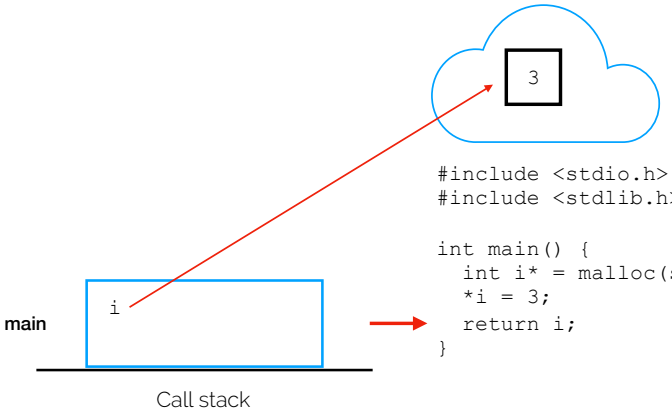


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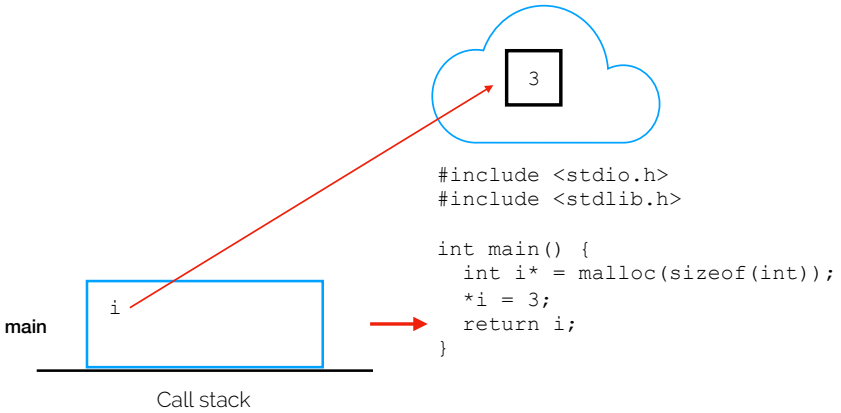


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Anyone see a problem?

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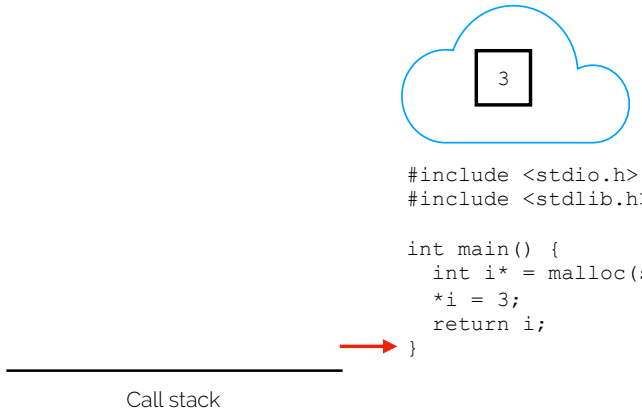


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3 is now unreachable, and we cannot reclaim it. **Memory leak.**

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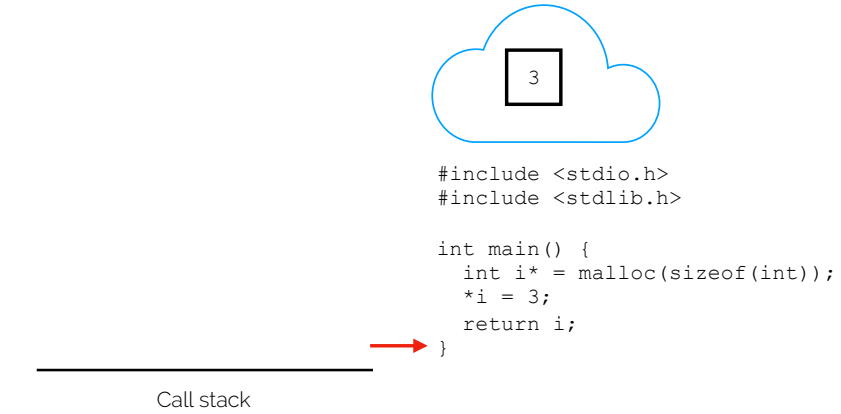


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How should we fix it?

Activity

```
#include <stdio.h>

void add(int *x, int *y, int *z) {
  *z = *x + *y;
}

int main() {
  int x = 1;
  int y = 3;
  int z;
  add(&x, &y, &z);
  return z;
}
```

2 → `}`

1 → `int z;`

3 → `return z;`

Diagram the stack and variables when the program is at the three points.

Call-by-value

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(program evaluation strategy)

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Examples:

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Java

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Examples:

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```

How does a function “obtain” a parameter value?

Call-by-value semantics: copying

Call-by-value

Call stack

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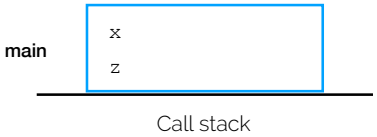


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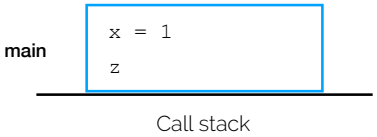


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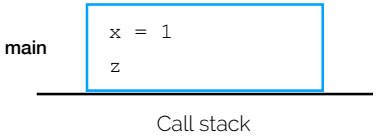


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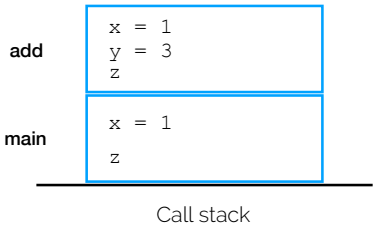


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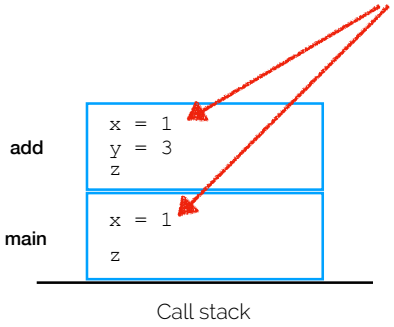
Call-by-value

Not the same x!

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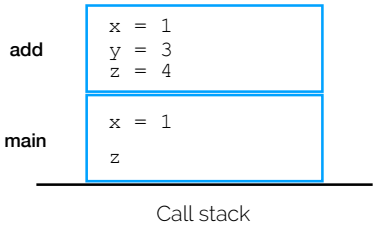


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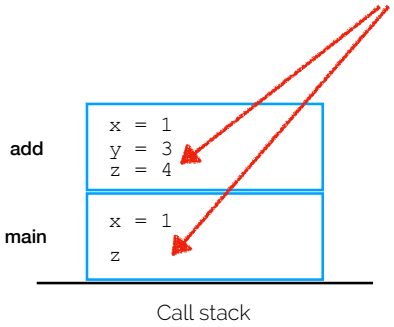
Not the same z!

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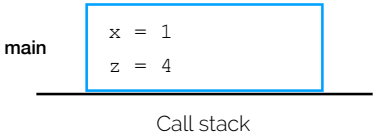


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```

What can a function return?

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C String Trick

Ensuring null termination is not always easy.

`memset` can make reasoning about C strings easier.

```
char *memset(char *buf, char c, size_t len)
```

e.g.,

```
memset(&dst,'\0',sizeof(dst))
```

Assuming that dst is an automatic buffer.