CSCI 334:
Principles of Programming Languages

Lecture 3
Data types, values, and pointers

Instructor: Dan Barowy

Williams

HW1: Due tonight by 10pm

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(assignment had a typo)

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(assignment had a typo)

(come see me if this typo bit you)

HW1: Don't forget your `Makefile`

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(it's worth 30 points)

Final Exam Study Guide

`git` Tutorial

`git` Tutorial

`git clone`

Retrieves repository from {Github, wherever}

`git` Tutorial

`git add <file>`

Adds a file (to your changelist).

`git` Tutorial

`git commit -m <message>`

Commits a changelist with a message.

`git` Tutorial

`git rm <file>`

Removes a file (from your changelist)

`git` Tutorial

`git status`

Displays the status of your changelist

`git` Tutorial

`git diff`

Displays the differences between your changelist and the last committed version

`git` Tutorial

`git push`

Uploads *committed* changes back to {Github, whatever}.

`git` Tutorial

`git pull`

Downloads *latest commits* to existing cloned repository.

`git` Tutorial

See reading on website for more info.

If you're having trouble, come to office hours / TA hours.

Buffered I/O

C Primitive Data Types

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```
int
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```
  int
float
```

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```
  int
float
double
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```
int
float
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These may not have the representation that you expect!

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int
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```
int
```
at least 2 bytes

```
float
double
char
```

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`int`	at least 2 bytes
`float`	#bytes not specified as long as IEEE 754
`double`	#bytes not specified as long as IEEE 754 double
`char`	

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These may not have the representation that you expect!

May vary for different compiler, architecture, OS!

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Nice huh? Everybody knows signed/unsigned, right?

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Nice huh? Everybody knows signed/unsigned, right?

For this class, ordinary primitives are fine.

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Byte widths are not the only portability concern!

(e.g., endianness)

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Take CSCI 237 for more details.

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(writing truly portable C is *difficult*!)

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int a;
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    ~ ^~~
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C is a *weakly typed* language, unlike Java.

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```

C is a *weakly typed* language, unlike Java.

C may warn you (like above), but if you really want to do it, it will let you.

C Complex Data Types: Array

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A sequence of values, stored contiguously

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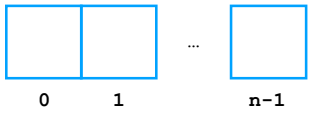

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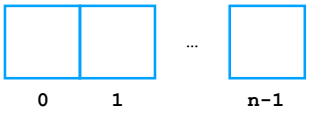

Any *type* of value can be used.

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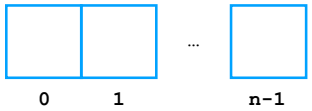
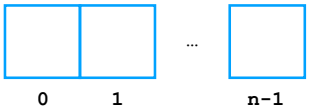


Any *type* of value can be used.

```
int arr[10];
```

C Complex Data Types: Array

A sequence of values, stored contiguously



Any *type* of value can be used.

```
int arr[10];
int * arr[10];
```

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```
int arr[10];
int * arr[10];
struct point arr[10];
```

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int arr[10];
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Amount of storage depends on *type* of value.

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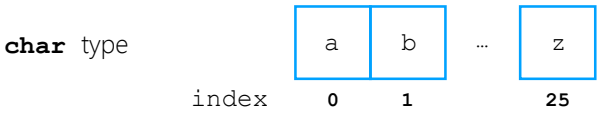

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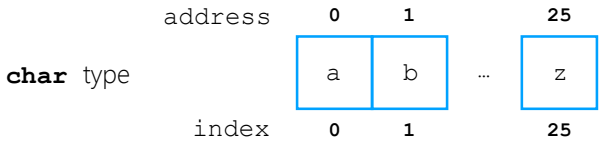

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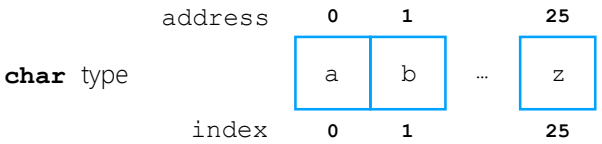

int type

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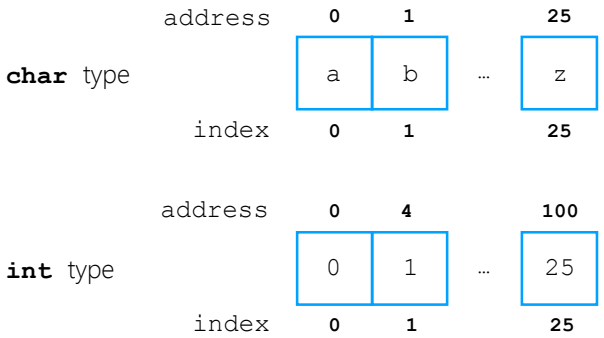

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```
int arr[10];
```

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Reading:

C Complex Data Types: Array

```
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Reading:

```
arr[3]
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Reading:

`arr[3]` (returns 4th element)

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int arr[10];
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Writing:

C Complex Data Types: Array

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Reading:

`arr[3]` (returns 4th element)

Writing:

```
arr[3] = 2;
```

C Complex Data Types: Array

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int arr[10];
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Reading:

`arr[3]` (returns 4th element)

Writing:

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```
(assigns to 4th element)

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A sequence of values, of heterogeneous type, stored contiguously

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```
struct Account {
  int account_no;
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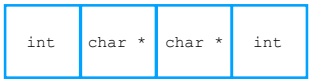

C Complex Data Types: Struct

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  int account_no;
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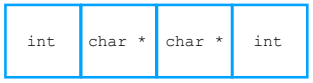
```

"fields"



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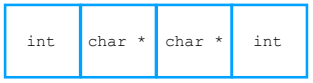

The actual storage layout varies wildly! Do not assume anything!

C Complex Data Types: Struct

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```
struct Account my_account;
```

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```
struct Account my_account;
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Reading:

C Complex Data Types: Struct

```
struct Account my_account;
```

Reading:

```
my_account.account_no
```

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```
my_account.account_no = 12345678
```

C Complex Data Types: Struct

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struct Account my_account;
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Reading:

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(assigns to `account_no` field)

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Acc my_account;
my_account.account_no = 12345678;
```

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One value, stored in the same memory location

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union never_do_this {
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We will never use them in this class.

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You should avoid them.

C Complex Data Types Are Composable

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Perfectly valid and acceptable C:

C Complex Data Types Are Composable

Perfectly valid and acceptable C:

```
typedef struct Account {
  int account_no;
  char *first_name;
  char *last_name;
  int balance;
} Acc;

Acc arr[1000];
```

C Complex Data Types Are Composable

Perfectly valid and acceptable C:

```
typedef struct Account {
  int account_no;
  char *first_name;
  char *last_name;
  int balance;
  struct birthday {
    int year;
    int month;
    int day;
  }
} Acc;
```

Pointers

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So simple they cause confusion.

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A pointer is just an address.

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int *ptr;
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The type tells you the type of the value at that address.

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int
```

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What address does `ptr` point to?

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Right now it points at nothing.

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Right now it points at nothing.

`ptr` is a variable, just like any other variable.

Pointers

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int i;
int *ptr;
ptr = &i;
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`&` is the *address of* operator.

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What is `j`'s value?

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There are two important pointer operations.

2. We can follow a pointer to a value.

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int i;
int *ptr;
ptr = &i;
int j = *ptr;
```

What is `j`'s value?

`*` is the *dereference* operator.

Pointers

```
int i = 3;
int *ptr;
ptr = &i;
int j = *ptr;
```

What is `j`'s value now?

Storage Duration

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This can be a tad complex.

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We will focus on two: *automatic* (now) and *allocated* (next class)

Storage Duration: Automatic

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int i = 3;
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`i` has automatic duration, because you didn't specify anything.

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C will automatically acquire (***allocate***)
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`i` has automatic duration, because you didn't specify anything.

C will automatically acquire (***allocate***)
and release (***deallocate***) memory for this variable.

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

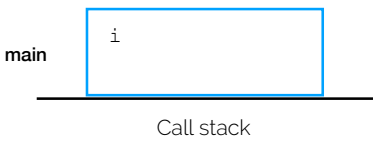
Storage Duration: Automatic

```
#include <stdio.h>

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

Call stack

Storage Duration: Automatic



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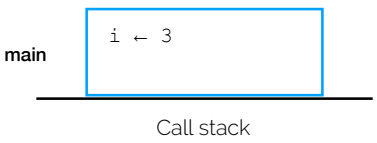

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```
#include <stdio.h>

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

Where does `i` get returned? How?

Storage Duration: Automatic

Call stack

```
#include <stdio.h>

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

`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 →

1 →

3 →

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