

C, Memory

CS 2130: Computer Systems and Organization 1

April 12, 2023

Announcements

- Homework 8 due Monday at 11pm
 - Gradescope submission available today
 - Limited number of submissions, test your code before submitting

switch example

Header Files

C header files: `.h` files

- Written in C, so look like C
- Only put header information in them
 - Function headers
 - Macros
 - `typedefs`
 - `struct` definitions
- Essentially: information for the **type checker** that does not produce any actual binary
- `#include` the header files in our `.c` files

Header files

- Things that tell the type checker how to work
- Do not generate any actual binary

C files

- Function definitions and implementation
- Include the header files

Including Headers

```
#include "myfile.h"
```

- Quotes: look for a file where I'm writing code
- Our header files

```
#include <string.h>
```

- Angle brackets: look in the standard place for includes
- Code that came with the compiler
- Likely in `/usr/include`

Macros

```
#define NAME something else
```

- Object-like macro
- Replaces **NAME** in source with **something else**

```
#define NAME(a,b) something b and a
```

- Function-like macro
- Replaces **NAME(X,Y)** with **something Y and X**

Lexical replacement, *not* semantic

Interesting Example

```
#define TIMES2(x) x * 2
#define TIMES2b(x) ((x) * 2)
```

```
/* bad practice */
/* good practice */
```

```
int x = ! TIMES2(2 + 3);
```

$int\ x = ! \frac{2 + 3 * 2}{0}; \rightarrow 0$

```
int y = ! TIMES2b(2 + 3);
```

$int\ y = ! \underbrace{((2+3) * 2)}_5; \rightarrow 0$

header example
`string.h`
variadic functions

Memory

An Interesting Stack Example

```
int *makeArray() {
    int answer[5];
    return answer;
}

void setTo(int *array, int length, int value) {
    for(int i=0; i<length; i+=1)
        array[i] = value;
}

int main(int argc, const char *argv[]) {
    int *a1 = makeArray();
    setTo(a1, 5, -2);
    return 0;
}
```

The heap: unorganized memory for our data

- Most code we write will use the heap
- *Not a heap data structure...*

The Heap: Requesting Memory

```
void *malloc(size_t size);
```

- Ask for **size** bytes of memory
- Returns a (**void ***) pointer to the first byte
- It does not know what we will use the space for!
- Does not erase (or zero) the memory it returns

What is the closest thing to `malloc` in Java?

malloc Example

```
typedef struct student_s {
    const char *name;
    int credits;
} student;

student *enroll(const char *name, int transfer_credits) {
    student *ans = (student *) malloc(sizeof(student));
    ans->name = name;
    ans->credits = transfer_credits;
    return ans;
}
```

The Heap: Freeing Memory

Freeing memory: `free`

```
void free(void *ptr);
```

- Accepts a pointer returned by `malloc`
- Marks that memory as no longer in use, available to use later
- You should `free()` memory to avoid *memory leaks*

Garbage - memory on the heap our code will never use again

- Weird: defined in terms of the future!
- Compiler can't figure out when to free for you

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What about Java?

Garbage Collector

Garbage Collector - frees garbage “automatically”

- **Unreachable memory** - memory on heap that is unreachable through pointers on the stack (or reachable by them)
 - Subset of all the garbage
 - Identifiable!
- Takes resources to work
- *Very* popular - most languages have garbage collectors
 - Java, Python, C#, ...

malloc man page

Common Memory Bugs (reading)