

CSE 333 – SECTION 2

Memory Management

Questions, Comments, Concerns

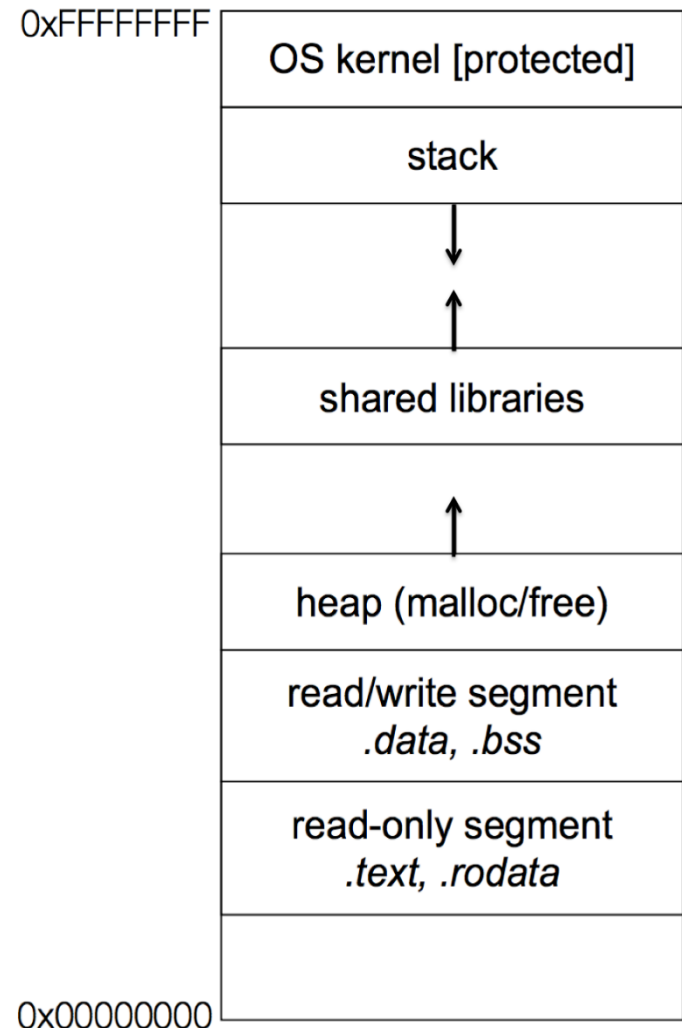
- Do you have any?
- Exercises going ok?
- Lectures make sense?
- Homework 1 – If you haven't started by now... ☹

Exercises!

- Comments
 - Program Comments – Author, copyright, description at the top
 - Function Comments – Near the prototype/declaration in header files; local functions are a more complex story, but near the prototype works for those too.
- `clint` or `cppclint` errors
- Valgrind errors
- Check for error codes/return values and handle them correctly!

Memory Management

- Heap
 - Large pool of unused memory
 - `malloc()` allocates chunks of this memory
 - `free()` deallocates memory and reclaims space
- Stack and stack frame
 - Stores temporary/local variables
 - Each function has its own stack frame
- Lifetime on heap vs. Lifetime on stack



Memory Diagram + GDB Example

- Source Code
 - (Lecture Example with ll.h, ll.c and example_ll_customer.c)
- What does the diagram look like as the program executes?
- Is gdb consistent with your diagram?
- GDB Tip: Use option `-tui` to get a visual debugging interface – Very useful!
- Typing “help” in gdb pulls up a table of contents gdb help manual. You can then type “help sectionName” to view gdb info on different things
- Some Useful GDB Commands
 - `break`, `backtrace`, `next`, `step`, `list`, `finish`, `nfo args`, `info locals`, `display`, `bt`, `frame`, `watch`

Memory Errors

- Use of uninitialized memory
- Reading/writing memory after it has been freed – Dangling pointers
- Reading/writing to the end of malloc'd blocks
- Reading/writing to inappropriate areas on the stack
- Memory leaks where pointers to malloc'd blocks are lost
- Mismatched use of malloc/new/new[] vs free/delete/delete[]

Valgrind is your friend!!

Demo: buggy code

buggy.c demo + code fix

Some buggy code

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

3. //Returns an array containing [n, n+1, ... , m-1, m]. If n>m, then the
4. //array returned is []. If an error occurs, NULL is returned.

5. int *RangeArray(int n, int m) {
6.     int length = m-n+1;
7.
8.     //Heap allocate the array needed to return
9.
10.    int *array = (int*) malloc(sizeof(int)*length);
11.
12.    //Initialize the elements
13.    for(int i=0;i<=length; i++)
14.        array[i] = i+n;

15.    return array;
16. }

17. //Accepts two integers as arguments
18. int main(int argc, char *argv[]) {
19.     if(argc != 3) return EXIT_FAILURE;
20.     int n = atoi(argv[1]), m = atoi(argv[2]); //Parse cmd-line args
21.     int *nums = RangeArray(n,m);

22.     //Print the resulting array
23.     for(int i=0; i<= (m-n+1); i++)
24.         printf("%d", nums[i]);
25.     puts("");

26.     return EXIT_SUCCESS;
27. }
```

Valgrind output

```
==22891== Command: ./warmup 1 10
==22891==
==22891== Invalid write of size 4
==22891== at 0x400616: RangeArray (warmup.c:14)
==22891== by 0x400683: main (warmup.c:22)
==22891== Address 0x51d2068 is 0 bytes after a block of size 40 alloc'd
==22891== at 0x4C2A93D: malloc (in /usr/lib/valgrind/vgpreload_memcheck-amd64-linux.so)
==22891== by 0x4005EC: RangeArray (warmup.c:10)
==22891== by 0x400683: main (warmup.c:22)
==22891==
==22891== Invalid read of size 4
==22891== at 0x4006A5: main (warmup.c:26)
==22891== Address 0x51d2068 is 0 bytes after a block of size 40 alloc'd
==22891== at 0x4C2A93D: malloc (in /usr/lib/valgrind/vgpreload_memcheck-amd64-linux.so)
==22891== by 0x4005EC: RangeArray (warmup.c:10)
==22891== by 0x400683: main (warmup.c:22)
==22891==
1 2 3 4 5 6 7 8 9 10 11
==22891==
==22891== HEAP SUMMARY:
==22891== in use at exit: 40 bytes in 1 blocks
==22891== total heap usage: 1 allocs, 0 frees, 40 bytes allocated
==22891==
==22891== 40 bytes in 1 blocks are definitely lost in loss record 1 of 1
==22891== at 0x4C2A93D: malloc (in /usr/lib/valgrind/vgpreload_memcheck-amd64-linux.so)
==22891== by 0x4005EC: RangeArray (warmup.c:10)
==22891== by 0x400683: main (warmup.c:22)
==22891==
==22891== LEAK SUMMARY:
==22891== definitely lost: 40 bytes in 1 blocks
==22891== indirectly lost: 0 bytes in 0 blocks
==22891== possibly lost: 0 bytes in 0 blocks
==22891== still reachable: 0 bytes in 0 blocks
==22891== suppressed: 0 bytes in 0 blocks
==22891==
==22891== For counts of detected and suppressed errors, rerun with: -v
==22891== ERROR SUMMARY: 3 errors from 3 contexts (suppressed: 3 from 3)
```


Compiling separate source files (Make preview)

- Header files (*.h)
- Source files (*.c)
- Makefile

Section exercise

- Handouts.
- Work with a partner, if you wish.
- Look at the expandable vector code in `imsobuggy.c`.
- First, try to find all the bugs by inspection.
- Then try to use Valgrind on the same code.
- Code is located at <http://courses.cs.washington.edu/courses/cse333/17au/sections/sec2-code/>