Code checking tools
Background on memory allocation
Types of problem
Uninitialized values
Invalid read / write
Mis-used delete
Memory leaks

Lab 7: Code checking tools

Comp Sci 1585
Data Structures Lab:
Tools for Computer Scientists

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Outline

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Code Checking Tools

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Today we will talk about tools that will help you find bugs in your code.

- `$ valgrind` and its memcheck tool
- `$ asan` is part runtime library, part compiler feature that instruments your code at compile time.
- `$ cppcheck` does static code checking (some overlap).

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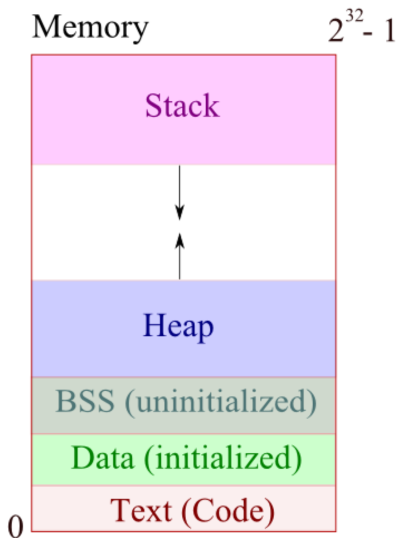
Stack and Heap

Recall the stack frames in GDB
(which you can navigate through using bt, up, down, etc)



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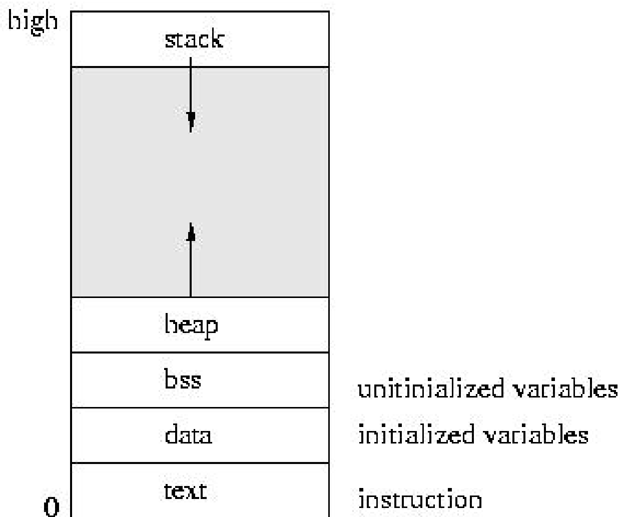
Stack and Heap



Stack and Heap

- The stack (on x86) starts at a high address and grows down
- The heap (on x86) starts at the bottom and grows up
- Destructors on stack-allocated class instances are called when the function returns
- Destructors on heap-allocated class instances are called when `delete` is called on the pointer

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Types of problem

1. Uninitialized values
2. Unallocated or out-of-bounds read / write
   - Out-of-bounds stack access
   - Out-of-bounds heap access
   - Use after free
3. Mismatched or double delete
4. Memory leaks

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Uninitialized Values: valgrind, memory-sanitizer

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- Reading a value that hasn't been initialized from the stack or the heap.
- Especially dangerous when program flow depends on that value.
- **valgrind**
  `$ valgrind --track-origins=yes` keeps track of where uninitialized values were allocated.
- **asan** is faster
  ```
  $ g++ -g -fsanitize=address -fno-omit-frame-pointer invalid-stack.cpp -o invalid-stack
  ```
  and set environment variables (script provided today in repo: `symbolizer.sh`)
- Some IDEs check unititialized values via plugins (e.g., CodeBlocks/KDevelop and Cppcheck plugin).

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Invalid Reads / Write: valgrind, address-sanitizer

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- Reading or writing values from unallocated memory.
- Sometimes may result in a segfault, but not always.
- **valgrind** isn't perfect:
  you can invalidly read and write to things on the stack without complaint, though it can detect out-of-bounds heap access and use-after-free.
- **asan** works for all of these types:

```
$ g++ -g -fsanitize=address -fno-omit-frame-pointer invalid-stack.cpp -o invalid-stack
```

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Misused delete: valgrind, address-sanitizer

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1. Mismatched delete, using:
   `new` with `delete[]` or
   `new[]` with `delete`
   Both are problematic, why?
2. Double delete: deleting the same memory twice.
   Why is this an issue?

valgrind and asan can both detect both

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Memory Leaks: valgrind

Valgrind runs leak checks after the program terminates:

- **Directly lost:** No pointer to that block anymore.
- **Indirectly lost:** A pointer to that block exists, but it's in a directly lost block.
- **Still reachable:** Still have a pointer to that block (don't worry about this)
- **Possibly lost:** No pointer to the beginning of the block, but a pointer to somewhere inside the block.
- `$ valgrind --leak-check=full` may help you determine where
- Valgrind Memcheck Manual: `http://valgrind.org/docs/manual/mc-manual.html`

The first two are the important ones to check for on homeworks