An Intro to GDB and Debugging in C

Presented by HKN

Checking out the Code:

Log into your EWS machine and type

```
git clone git://github.com/HKNTutorials/gdb-intro.git
cd gdb-intro
```

Intro to Debugging

- First approach: print everything.
- Better way: **gdb**
  - Interactive
  - Watch program execute
  - See function's callers

Getting Started with GDB

First, you must compile and link your program with debugging symbols

- Use `-g` flag (gcc, g++ and clang)
- **we provided a makefile which will compile all the sample code for you (with debugging info).** Run it by typing "make".

Then run your program in gdb

- `gdb ./my_program`

Run and Start

- Two different ways to begin execution of your program.
- `run <command arguments>` executes the program until you hit a breakpoint (or a segfault). It does not stop GDB at all, so you will not be able to do anything unless you set breakpoints.
- `start <command arguments>` stops GDB at the first line of code to be executed, so you can send GDB commands.

Exercise: `printargs`

- This program prints out the list of arguments passed into it.
- Try to load it in GDB and use the "`run <arguments>`" command to correctly pass arguments to the program.

Stepping Through Code

- `step (s)` and `next (n)` commands - both try to execute until the next line of code, but step will take you into a function call while next will not.
- `continue (c)` command will run your program until it hits a breakpoint, or until it exits or receives a signal

Ending the Program

- `quit (q)` to quit gdb. If your program is still running, it will ask you to confirm.
- `kill` ends the program you are debugging. You can run it again (or another program) if you wish.

Examining Variables and the Stack

- `list (l)` to see current code
- `print (p)` - can evaluate any C expression (no function calls)
- `display / undisplay`
- `backtrace (bt)` shows the sequence of function calls up to the current point

Breakpoints

- Breakpoints are a mechanism which stop your program before executing a particular line of code
- `break (b) <location>`
- `b <source_file>:<line number>` or `b <function_name>`
- `info breakpoints` shows you all current breakpoints
- `delete (d) <breakpoint number>` removes a breakpoint.

Exercise: exp

This program is supposed to calculate the exponential function via it's taylor series

e^x = 1 + x + (x^2)/2 + ... + (x^n)/ n! + ...

But instead all the results it gives are infinite. Try to debug it: set a few breakpoints, and see what it does.

Exercise: square_ints

This segfaults. So before you try this, we need to talk about what a segfault is.

What is a Segfault?

- A segfault is an exception that is typically caused by incorrectly accessing memory.
- Not all memory usage bugs cause page faults. **Segfaults are a best effort mechanism** - they aren't guaranteed to occur.

The Unix Memory Model

- In LC3, programs have unrestricted access to memory. In x86 / Linux, this is no longer true.
  - Some regions of address space are allocated for program use (can access).
  - Some regions of address space are allocated for OS use (OS code can access, your programs can't - will segfault). Typically includes the lowest and highest addresses.
  - Some regions are unallocated - OS may allocate this on demand. Accessing this memory when the OS doesn't allow it gives a segfault.
- **You are free to mess up your own program's memory**

Common Causes of a Segfault

- Out-of-bounds access to array
- Dereferencing uninitialized, null, or already-freed pointers
- Stack overflow (functions calling themselves too many times)

More Exercises

- Try debugging `fibonacci` first.
- For a challenge, try to figure out what's going wrong in `floating_point`.

Still have problems?

- `help` command from within GDB
- Google
- Get Prof. Lumetta's GDB reference sheet

Appendix: Extra Information

General Issues with Debugging

- **Intrusiveness:** if code depends on timing in some way (e.g. code that reads time in some way, parallel interacting threads, processes that communicate with each other, etc.), stepping through it in a debugger might change it's behavior. Large amounts of I/O also can impact these types of programs.
- Amount of info available to you
- **Confounding:** you might have several bugs, and the combined symptoms make them harder to diagnose than if they occurred individually

Issues: Determinism

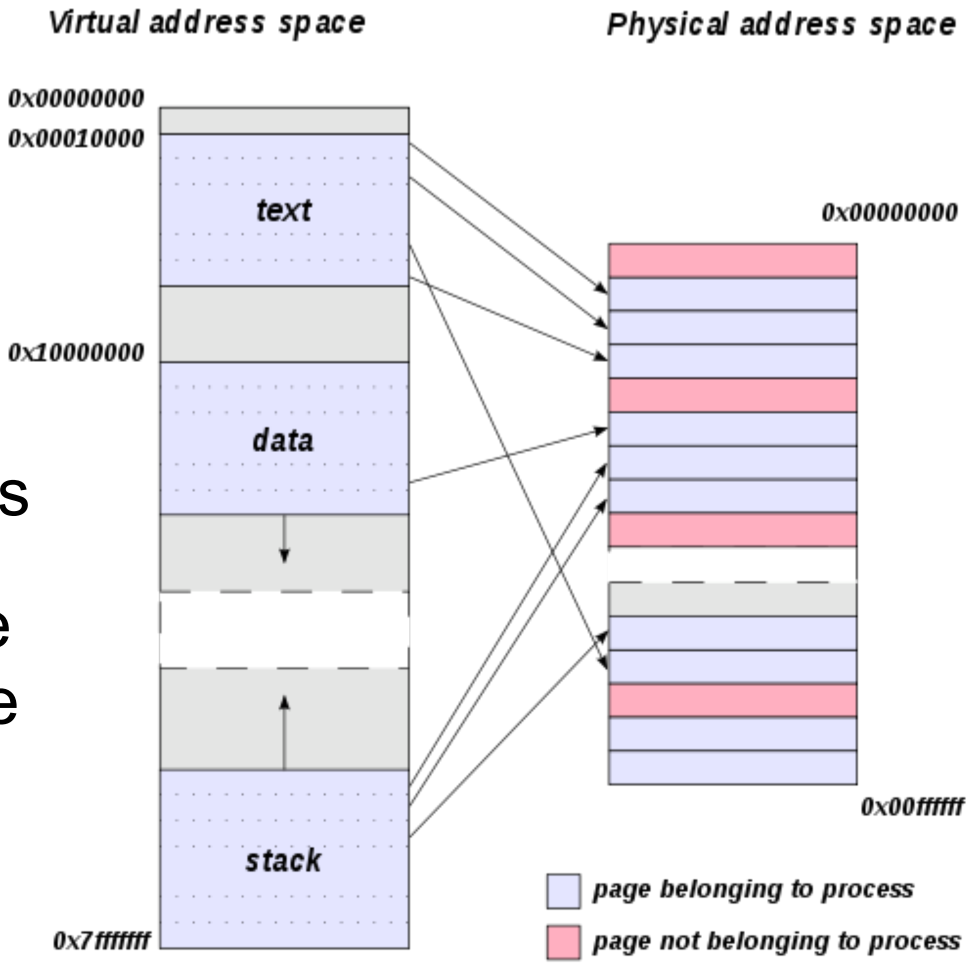
- Program execution is determined by all inputs to the program - **If you can capture all inputs, you should be able to reproduce all bugs**
- Obvious inputs:
  - Input files, user input (standard in), network io
- Less-obvious or problematic inputs:
  - Timing info, scheduling decisions (parallel programming) - this is especially difficult to handle
  - seeds for random number generation

Ways to use Debuggers

- Most common: run your program from within a debugger
- Postmortem debugging - Examine core dumps (first run "ulimit -c unlimited")
- Remote debugging (taught in ECE 391)
- Attaching debugger to currently running process

Causes of Segfaults

- Segfaults are usually caused by page faults
- Not all incorrect memory accesses cause a page fault
- Because of the way the paging mechanism works (this is architecture dependent)
- A page fault occurs if the program accesses space that isn't allocated to it
- Programs are free to do anything with their memory
- ECE 391 covers the details



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