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# CSE 374

# Programming Concepts & Tools

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Lecture 11 – gdb and Debugging

# Administrivia

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- HW4 due Thursday, 11 pm:
  - C code and libraries. How's it look?
  - Some tools: gdb (debugger) and clint.py (style checker). gdb demo today.
  - Due Thursday, 11 pm
- Midterm next Monday, in class
  - Everything up to hw4/basic C
  - Closed book – will provide reference summary info on test as needed
  - Old exams on web now for studying
  - Review Q&A Sunday, 1 pm, LOW 101

# Agenda

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- Debuggers, particularly gdb
- Why?
  - To learn general features of breakpoint-debugging
  - To learn specifics of gdb
  - To learn general debugging “survival skills”
    - Skill #1: don’t panic!
    - Skill #2: be systematic – have a plan

# How to avoid debugging

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- Don't put bugs in the program!!
- Think before typing – design before coding
- Write down design (comments) as you go
  - Functions: declaration+comments should be complete spec
  - Significant data: declaration + comments should be complete spec
  - If someone has to read the code to figure out how to use something or understand data structures, comments are bad
  - Review/check comments and compare to code as you work
    - Will catch errors before you run the program
- Turn on compiler warnings (-Wall); use assert; get the computer to find problems for you.
- But things can still go wrong...

# An execution monitor?

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- What would you like to “see inside” and “do to” a running program?
- Why might all that be helpful?
- What are reasonable ways to debug a program?
- A “debugger” is a tool that lets you stop running programs, inspect (sometimes set) values, etc.
  - A “MRI” for observing executing code

# Issues

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- Source information for compiled code. (Get compiler help)
- Stopping your program too late to find the problem. (Art)
- Trying to “debug” the wrong algorithm
- Trying to “run the debugger” instead of understanding the program
- It’s an important tool
- Debugging C vs. Java
  - Eliminating crashes does not make your C program correct
  - Debugging Java is “easier” because (some) crashes and memory errors do not exist
  - But programming Java is “easier” for the same reason!

# `gdb`

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- `gdb` (Gnu debugger) is part of the standard Linux toolchain.
- `gdb` supports several languages, including C compiled by `gcc`.
- Modern IDEs have fancy GUI interfaces, which help, but concepts are the same.
- Compile with debugging information: `gcc -g`
  - Otherwise, `gdb` can tell you little more than the stack of function calls.
- Running `gdb`: `gdb executable`
  - Source files should be in same directory (or use the `-d` flag).
- At prompt: `run args`
- Note: You can also inspect core files, which is why they got saved on older systems after every crash
  - (Mostly useful for analyzing crashed programs after-the-fact, not for systematic debugging. The original use of `db`.)

# Basic functions

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- backtrace
- frame, up, down
- print expression, info args, info locals

Often enough for “crash debugging”

Also often enough for learning how “the compiler does things” (e.g., stack direction, malloc policy, ...)



# Breakpoints

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- break function (or line-number or ...)
- conditional breakpoints (break XXX if expr)
  1. to skip a bunch of iterations
  2. to do assertion checking
- going forward: continue, next, step, finish
  - Some debuggers let you “go backwards” (typically an illusion)
- Often enough for “binary search debugging”
- Also useful for learning program structure (e.g., when is some function called)
- Skim the manual for other features.

# A few tricks

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- Everyone develops their own “debugging tricks”; here are a few:
  - Always checking why a seg-fault happened (infinite stack and array-overflow very different)
  - Printing pointer values to see how big objects were.
  - “Staring at code” even if it does not crash
  - Printing array contents (especially last elements)
  - . . .

# Advice

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- Understand what the tool provides you
- Use it to accomplish a task, for example “I want to know the call-stack when I get the NULL-pointer dereference”
- Optimize your time developing software
  - Think of debugging as a systematic experiment to discover what’s wrong — not a way to randomly poke around. Observation: the problem; hypothesis: I think the cause is ...; experiment: use debugger to verify
- Use development environments that have debuggers?
- See also: jdb for Java
- Like any tool, takes extra time at first but designed to save you time in the long run
  - Education is an investment

# gdb summary – running programs

- Be sure to compile with `gcc -g`
- Open the program with: `gdb <executable file>`
- Start or restart the program: `run <program args>`
- Quit the program: `kill`
- Quit gdb: `quit`
- Reference information: `help`
  
- Most commands have short abbreviations
- `<return>` often repeats the last command
  - Particularly useful when stepping through code

# gdb summary – looking around

- bt – stack backtrace
- up, down – change current stack frame
- list – display source code (list n, list <function name>)
- print expression – evaluate and print expression
- display expression – (re-)evaluate and print expression every time execution pauses.
  - undisplay – remove an expression from this recurring list.
- info locals – print all locals (but not parameters)
- x (examine) – look at blocks of memory in various formats

# gdb summary – breakpoints, stepping

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- `break` – set breakpoint. (`break <function name>`, `break <linenumber>`, `break <file>:<linenumber>`)
- `info break` – print table of currently set breakpoints
- `clear` – remove breakpoints
- `disable/enable` – temporarily turn breakpoints off/on without removing them from the breakpoint table
  
- `continue` – resume execution to next breakpoint or end of program
- `step` – execute next source line
- `next` – execute next source line, but treat function calls as a single statement and don't step into them
- `finish` – execute to the conclusion of the current function
  - How to recover if you meant “next” instead of “step”