

4 JUNE 2024

SOFTWARE DEVELOPMENT GRAB- BAG

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U.S. DEPARTMENT OF
ENERGY

Argonne National Laboratory is a
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INTRODUCTION

- A ton of software out there:
 - There are 28 million public github repositories
 - I count 3355 man pages in “section 1” on my laptop
 - 7516 packages in spack
 - 309 modules on Aurora
- 25 years and I am sort of ok with like three of those
- I’ve learned a ton by “wait, what was that thing you just did?”
 - Let’s re-create the best parts of that basement computer lab
 - The “In” story

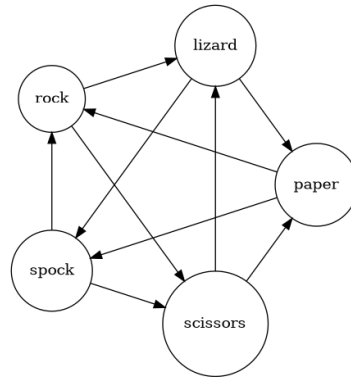
PLAN OF ATTACK

- <https://github.com/roblatham00/development-tricks> :
 - Code fragments, examples, longer writeups
 - Pull requests, discussions – we can keep on learning, refining, improving
- First tip: “Never give a live demo”. *This presentation is full of live demos...*
- Interrupt, interject, heckle – I’m hoping for as much content from audience as from me.
- (Is a slide deck even the right approach for this content?)

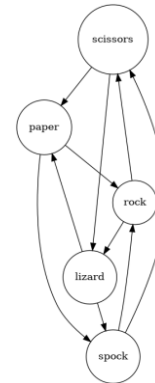
GRAPHVIZ

- <https://graphviz.org/>
 - Maybe the best thing AT&T Research has contributed to the world...
 - Familiar pattern: relationships, entities described in a file; separate utilities render
- Consider “rock paper scissors lizard spock”

```
digraph rpsls {  
  node [shape=circle]; scissors;  
  node [shape=circle]; paper;  
  node [shape=circle]; rock;  
  node [shape=circle]; lizard;  
  node [shape=circle]; spock;  
  
  scissors -> paper;  
  paper -> rock;  
  rock -> lizard;  
  lizard -> spock;  
  spock -> scissors;  
  scissors -> lizard;  
  lizard -> paper;  
  paper -> spock;  
  spock -> rock;  
  rock -> scissors;  
}
```



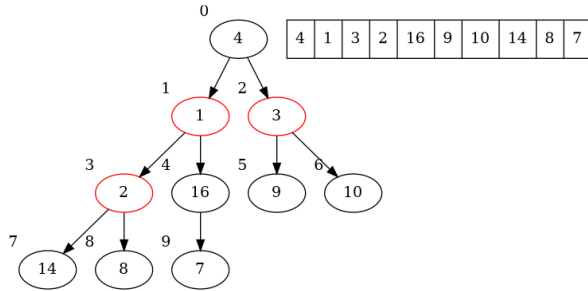
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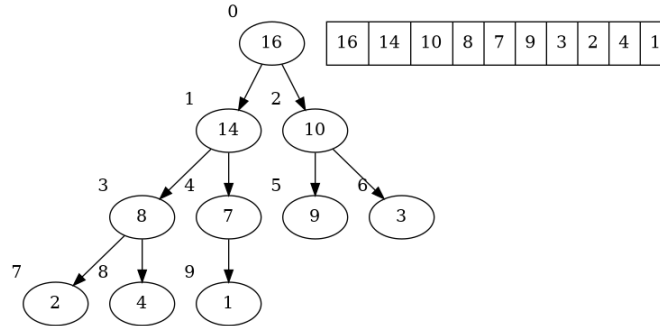
dot

GRAPHVIZ IN A PROGRAM

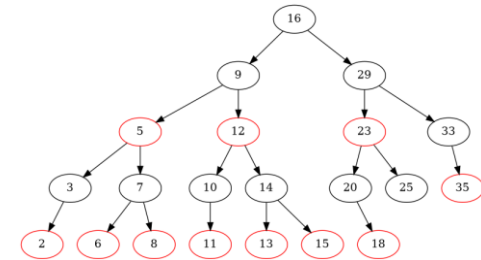
- “printf” but better: see [graphviz/test heap.cc](#)



Initial state of heap



“heap-ified” heap



Another example:
Red-black tree

GDB STUNTS

- The “Debugging with GDB” manual is 968 pages long and you should probably read it (I haven’t...)
- Front end: I like “cgdb” (pictured left).
 - also consider “TUI mode”, emacs front ends, probably others
- **raise(SIGSTOP)** : program will block; now you can attach to it. (I used to insert “sleep(3600)” to do the same thing)

```
1 #include <iostream>
2 #include <signal.h>
3
4 int fib(int x) {
5     if (x == 0) return 0;
6     if (x == 1) return 1;
7     /* if you want to be able to attach to your program at a specific spot,
8      * raising SIGSTOP ('raise(3)' is defined in signal.h) will make the
9      * program block until you attach and * continue */
10    → if (x == 5) raise(SIGSTOP);
11    return (fib(x-2) + fib(x-1));
12 }
13
14 int main(int argc, char **argv)
15 {
16     std::cout << fib(atoi(argv[1])) << std::endl;
17 }
18 ~
19
20 /home/robl/work/presentations/development-tricks/gdb/fib.cc
#3 0x00007fd62650426e in __GI_raise (sig=19) at ../sysdeps/posix/raise.c:26
warning: 26  ../sysdeps/posix/raise.c: No such file or directory
(gdb) up
#4 0x000056032bbd31e3 in fib (x=5) at fib.cc:10
10     if (x == 5) raise(SIGSTOP);
(gdb) where
#0  __pthread_kill_implementation (no_tid=0, signo=19, threadid=<optimized out>)
    at ./nptl/pthread_kill.c:44
#1  __pthread_kill_internal (signo=19, threadid=<optimized out>)
    at ./nptl/pthread_kill.c:78
#2  __GI___pthread_kill (threadid=<optimized out>, signo=signo@entry=19)
    at ./nptl/pthread_kill.c:89
#3  0x00007fd62650426e in __GI_raise (sig=19) at ../sysdeps/posix/raise.c:26
#4  0x000056032bbd31e3 in fib (x=5) at fib.cc:10
#5  0x000056032bbd31ff in fib (x=6) at fib.cc:11
#6  0x000056032bbd31f0 in fib (x=8) at fib.cc:11
#7  0x000056032bbd31f0 in fib (x=10) at fib.cc:11
#8  0x000056032bbd3234 in main (argc=2, argv=0x7ffdf0f4674d8) at fib.cc:16
(gdb) |
```

PROFILING WITH GDB

- “so dumb it shouldn’t work”
 1. Run program under debugger
 2. Interrupt periodically
 3. See which routines your program is running
- Try it with “mc-pi.c”
 - Three functions (fast, medium, slow)
 - Interrupt a few times
 - Unsurprisingly, (nearly) always hits the “1 million points” routine
- Sampling profilers struggle with i/o

```
55 unsigned seed;  
56 srand(getpid());  
57  
58 double nparts=100000000;  
59  
60 for (i=0; i<nparts; i++) {  
61     x = (double)rand_r(&seed)/(double)RAND_MAX;  
62     y = (double)rand_r(&seed)/(double)RAND_MAX;  
63  
64     if (x*x + y*y < 1.0) {  
65         in++;  
66     }  
67 }  
68  
69 return in/(double)nparts * 4.0;  
70 }  
71 int main(int argc, char **argv)  
72 {  
73     for (int i=1; i<100000; i++) {  
74         small_monte();  
75     }  
76 }  
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/home/robl/work/presentations/development-tricks/profiling/mc-pi.c
Program received signal SIGINT, Interrupt.
0x00007ffff7dde0b8 in rand_r (seed=seed@entry=0x7ffffffffffd704) at ./stdlib/rand_r.c:36
warning: 36 ./stdlib/rand_r.c: No such file or directory
(gdb) up
#1 0x000055555555553c0 in large_monte () at mc-pi.c:61
61 x = (double)rand_r(&seed)/(double)RAND_MAX;
(gdb) where
#0 0x00007ffff7dde0b8 in rand_r (seed=seed@entry=0x7ffffffffffd704) at ./stdlib/rand_r.c:36
#1 0x000055555555553c0 in large_monte () at mc-pi.c:61
#2 0x000055555555550e5 in main (argc=<optimized out>, argv=<optimized out>) at mc-pi.c:76
(gdb) c
Continuing.
^C
Program received signal SIGINT, Interrupt.
0x0000555555555540a in large_monte () at mc-pi.c:65
65 in++;
(gdb) where
#0 0x0000555555555540a in large_monte () at mc-pi.c:65
#1 0x000055555555550e5 in main (argc=<optimized out>, argv=<optimized out>) at mc-pi.c:76
(gdb) |

ANOTHER EXAMPLE



Before: spending way too much time in deallocate (purple)



After: program behaving as expected

LTRACE: LIBRARY TRACER

```
% ~/work/soft/mpich/bin/mpirun -np 1 ltrace -x @libmpi.so --output=cpi.ltrace.0 ./cpi :\
                                -np 1 ltrace -x @libmpi.so -o cpi.ltrace.1 ./cpi

Process 0 of 2 is on LAPTOP-QV97NQLH
Process 1 of 2 is on LAPTOP-QV97NQLH
pi is approximately 3.1415926544231318, Error is 0.0000000008333387
wall clock time = 0.000877
% ls
README.md  cpi  cpi.c  cpi.ltrace.0  cpi.ltrace.1
% cat cpi.ltrace.1
MPI_Init(0x7fff3ea6656c, 0x7fff3ea66560, 0x7fff3ea66560, 0x557133b15d48) = 0
MPI_Comm_size(0x44000000, 0x7fff3ea66584, 2, 0xffffffff) = 0
MPI_Comm_rank(0x44000000, 0x7fff3ea66580, 2, 0xffffffff) = 0
MPI_Get_processor_name(0x7fff3ea665d0, 0x7fff3ea66588, 0x7fff3ea66588, 0xffffffff) = 0
fprintf(0x7f292664f5c0, "Process %d of %d is on %s\n", 1, 2, "LAPTOP-QV97NQLH") = 37
fflush(0x7f292664f5c0) = 0
MPI_Bcast(0x7fff3ea6657c, 1, 0x4c000405, 0) = 0
MPI_Reduce(0x7fff3ea66590, 0x7fff3ea66598, 1, 0x4c00080b) = 0
MPI_Finalize(0, 264, 2, 4) = 0
+++ exited (status 0) +++
```

SOURCE CODE NAVIGATION

- Cscope: <https://cscope.sourceforge.net/>
 - really good for C; ok for C++
- Ctags: <https://github.com/universal-ctags/ctags>
 - Supports a ton of languages, but cannot do “who called me”

TERMINAL MULTIPLEXING

- “screen” and “tmux”
- On your own machine: “infinite” searchable scrollbar
- Remote machines: Detach/re-attach

SHELL

- Put git status in your prompt:

```
source ${HOME}/.bash/git-prompt.sh
export GIT_PS1_SHOWDIRTYSTATE=yes
export GIT_PS1_SHOWSTASHSTATE=yes
export GIT_PS1_SHOWUPSTREAM=auto
export GIT_PS1_SHOWCONFLICTSTATE=yes
export GIT_PS1_SHOWCOLORHINTS=yes

export PS1='[\u@\h \w$(__git_ps1 " (%s)")]$ '
```

```
[robl@aurora-uan-0012 mpich (main *)]$ git status
On branch main
Your branch is ahead of 'origin/main' by 1 commit.
  (use "git push" to publish your local commits)

Changes not staged for commit:
  (use "git add <file>..." to update what will be committed)
  (use "git restore <file>..." to discard changes in working directory)
  (commit or discard the untracked or modified content in submodules)
        modified:   modules/hwloc (untracked content)
        modified:   src/mpi/romio/adio/common/ad_fstype.c

Untracked files:
  (use "git add <file>..." to include in what will be committed)
        build/
        cfg.sh
        src/mpi/romio/build/

no changes added to commit (use "git add" and/or "git commit -a")
```

SHELL UTILITIES

- Shell scripts:
 - Run with “-xv”: echo the line, expand shell variables
 - set -eu : unset variables are errors, not blank and exit on first error
- Give awk a try (example to the left)
 - NR : “number of records seen”
 - \$1 : first token
 - (\$0 : entire line)

```
% head -50 /usr/share/dict/words
A
AA
AAA
... (a bunch of lines omitted)
ASCII's
ASCIIs
% head -50 /usr/share/dict/words | \
    awk '{if (NR%5 == 0) print NR " " $1}'
5 AB
10 ABM's
15 ACLU's
20 AF
25 AIDS
30 AL
35 AM's
40 AOL
45 AP's
50 ASCII's
```

LEARNING NEVER ENDS

- **Non-trivial problems for learning new languages**

- Project Euler (<https://projecteuler.net/>)
- Advent of Code (<https://adventofcode.com/>)

- **Bookshelf**

- *Autotools* by John Calcote:
- *Introduction to Algorithms* by Cormen, Leieron, Rivest, and Stein:
- *Learning the Bash Shell* by Cameron Newham:
- *Pro Git* by Chacon and Straub:
- *21st Century C* by Ben Klemens:
- *C++ Primer (5th Edition)* by Lippman, Lajoie, Moo:
- *Effective Modern C++* by Scott Meyers:

- **Websites**

- Julia Evans produces these great mini-writeups of complex topics <https://wizardzines.com/>
- stackoverflow.com: "people will do *anything* for fake internet points"

BALANCE

- The “ah-ha” moments come when you step away from the keyboard
- Me:
 - Pinball
 - Cooking
 - Ice hockey
 - Ultimate frisbee
 - Biking
 - Woodworking
 - Board games
 - Improv classes (it’s been years....)
- You?