Debugging and profiling

Andy Buckley
University of Glasgow

MCnet Computing School,
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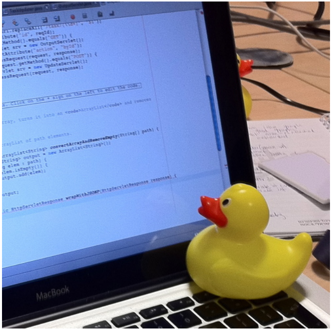
Debugging

Debugging

- Identifying the cause of an error and fixing it
- Want to fix the cause, not just the symptom
- Be patient and methodical, cf. “scientific debugging” **http://c.learncodethehardway.org/book/ex31.html**
- Some bug-hunt tricks are language/compiler-specific…although error messages are getting better!



Rubber duck / Cardboard dog / long-suffering office-mate debugging is not to be sniffed at…

Fixing compilation/linking errors

- Doesn’t apply to Python!
- There is a distinction between compiler errors and linker errors: even visible *aesthetically*! ⇒ EXERCISE
- First, read the error message. Too many “my compiler said this” ‘bug’ reports
- Start at the top: many later messages may be spurious, caused by the first issue
- `clang`/LLVM gives more helpful error messages than GCC (still true circa GCC 5.x, but there’s now GCC highlighting)

Preprocessor-time:

Argh…

Compile-time:

```
compile_time.cc:12:11:
error: expected
primary-expression before :
token
```

Link-time:

```
/tmp/cczS5KsC.o: In
function `main':
link_time.cc:(.text+0x1f):
undefined reference to
`MyStruct::foo()'
```

Isolating runtime bugs

Common bug types

- "FPEs": numeric badness like overflow, nan, div-by-zero;
  - Can turn FPEs into exceptions, cf. `feenableexcept(FE_OVERFLOW|FE_DIVBYZERO|FE_INVALID)`
- Crashing bugs: segfaults/SEGV/GPF – memory violations e.g. out-of-bounds array accesses
- Hangs
- *Wrong!!* And how do you know?

- Failure doesn't necessarily make itself known at the source…maybe only far downstream
- Don't dismiss debug printouts!
  - Not clever, but quick and often useful: first port of call. Debug logging control macros can help
  - "Triangulate" bugs with initial coarse placement and "binary search" ⇒ refinement
- But funkier stuff available, starting with "real" debuggers…

Debuggers

Python: pdb

- Nice little debugger available as a Python module, cf.
  `python -m pdb myscript.py`
- Can also be programmatically enabled in code via
  `import pdb; pdb.set_trace()`
- EXERCISE: **http://tjelvarolsson.com/blog/five-exercises-to-master-the-python-debugger/**

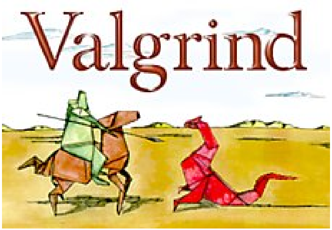
Compiled code: gdb/idb/lldb

- Classic debuggers, rather cryptic: `up,down,n,s,p,bt,...`
- Tip: to pass args, `gdb --args myexec foo bar`
- Tip: to call on scripts:
  `gdb --args ‘which python‘ myscript.py`
- Also useful when extending Python: that’s a great way to really screw up memory!
- EXERCISE:
  http://www.enseignement.polytechnique.fr/informatique/profs/Leo.Liberti/teaching/c++/online/exercises/node67.html

Memory problem debugging – **`valgrind`**

- Valgrind is an amazing suite of tools for *instrumenting* code at runtime
- Essentially hardware emulation: tends to be slooooooooow
- Fantastic for memory leak debugging, and also some profiling
- Main mode: **`valgrind`**

  ```
  valgrind
  --tool=memcheck
  --leak-check=full myprog arg1
  ...
  ```
- EXERCISE: run Valgrind on result of previous debugger fixes



Profiling

Simple profiling with `time`

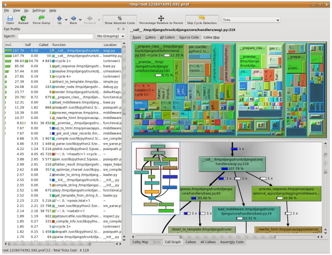
- **So easy! So useful!**
- `time myprogram`
- That’s it. Can run on cmd *sequences*, too:
- `$ time (seq 100000000 | grep 1987 | sed s/5/r/g | wc -l)`

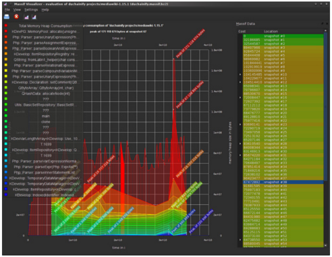
  ```
  49999

  real 0m1.083s
  user 0m1.820s
  sys 0m0.280s
  ```
- EXERCISE: Python `add_numbers`

More `valgrind` tools

- More tools: Cachegrind/callgrind monitor function calls, Massif profiles memory allocation (see http://valgrind.org/info/tools.html)
- **`valgrind --tool=callgrind`** ⇒**`kcachegrind`** tool

  `valgrind --tool=massif` ⇒**`massif-visualiser`** tool
- EXERCISE: profile the C++ linked list


/tmp/root.1226574391.592.prof
Flat Profile
__call__ /tmp/django/trunk/django/core/handlers/wsgi.py:219
Call Graph



Python profiling with `cProfile`

- `python -m cProfile myscript.py`
- Instrumentation will slow down
- EXERCISE:

  ```
  time add_numbers_3.py
  python -m cProfile -s cumtime
  add_numbers_3.py
  ```
- `line_profiler` etc. also available, cf. https://www.huyng.com/posts/python-performance-analysis

And more, more, more…
`perf`, `gprof`, the Mac `ddd` and Instruments, and
…may also be useful

A word of caution on profiling

> *Programmers waste enormous amounts of time thinking about, or worrying about, the speed of noncritical parts of their programs, and these attempts at efficiency actually have a strong negative impact when debugging and maintenance are considered.*
>
> *We should forget about small efficiencies, say about 97% of the time: premature optimization is the root of all evil. Yet we should not pass up our opportunities in that critical 3%.*

– Donald Knuth