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Debugging Hung Python Processes With GDB

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(Based on work by Brian Bouterse and David Malcolm, Red Hat)

Why are we here?

There are (roughly) 3 type of programs to debug:

1. “Program doesn't do what I want!”
   - Debug with prints/pdb...
2. “Program crashed!”
   - Inspect traceback, goto 1.
3. “My program seems stuck and **I don't know** what it's doing!”
   - ???

What will we learn?

- Tools to help you know **what** the program is doing?
- Won't teach you **how** to debug
- Still need to think about the **why**

Who Am I?

- Python user since 2008
- Working at Red Hat since 2014
- Before that – Intelligence Core, IDF
- Contributes for OpenStack (Neutron)
- Coding Enthusiastic
- Problem Solver (race conditions, deadlocks...)

pdb

- Allows for easy, gdb-like interface with code

- Requirement: put a breakpoint & restart program
  - Cannot attach!

```
import pdb; pdb.set_trace()
```

- This is also a problem

pdb commands

- list — Print surrounding source code
- bt — Print program's backtrace
- print — Print variable or function’s return value
- up, down — Move up and down the stack
- Can also run code!

rpdb (as in “remote pdb”)

- Same interface as pdb, installable with pip
- Requirement: put a breakpoint & restart program:

```
import rpdb
rpdb.Rpdb(port=1337).set_trace()
```

- Connect with ‘telnet’

Trigger rpdb.set_trace() with SIGTRAP

```
# Trigger rpdb.set_trace() on SIGTRAP with
# specified IP/port
rpdb.handle_trap("0.0.0.0", 1337)
```

- Recent versions already have it build in
- Problem?

strace (syscall tracer)

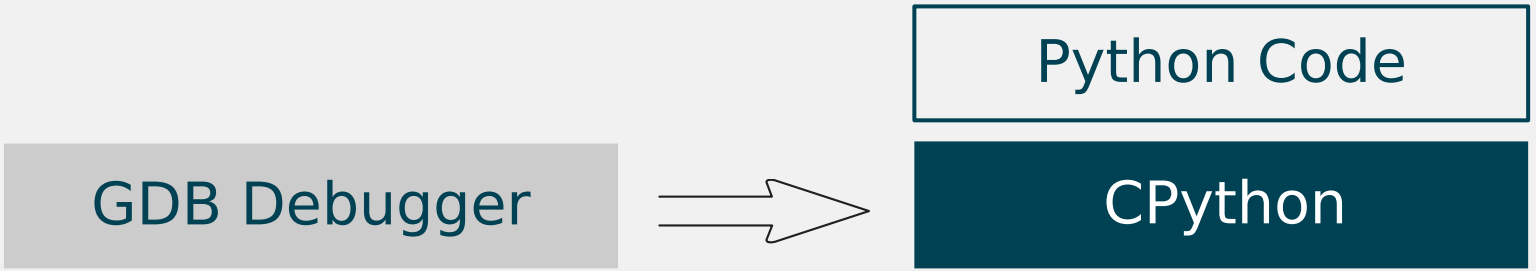
- Success

  open("/dev/null", O_RDONLY) = 3
- Failure

  open("/foo/bar", O_RDONLY) = -1 ENOENT (No such file or directory)
- Blocking

  select(1, [0], NULL, NULL, NULL

Conceptual Model



Why use GDB for Python?

- Production application where pdb can't go
- Remote applications where rpdb isn't available
- “My program seems stuck and **I don't know** what it's doing!”
  - Solution: use GDB!

GDB Basics

- Connect to a running process: `gdb -p <pid>`
- `c` to continue
- Ctrl+C to stop execution again
- Ctrl+D to detach (which continues)

GDB Commands

- list — Print surrounding source code
- bt — Print program’s backtrace
- print — Print variable or function’s return value
- up, down — Move up and down the stack
- Problem?

GDB commands

- list — Print surrounding source code
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- Problem?

example1.py

```
import os
import time

def foobar(amount):
    time.sleep(amount)

def main():
    print "Hello, World! My pid is %d" % os.getpid()
    foobar(amount=1337)
    print "Bye, World!"

if __name__ == '__main__':
    main()
```

A function call in CPython

```
#8  0x00007ff43137e666 in fast_function (nk=<optimized
    out>, na=0, n=0, pp_stack=0x7ffd25b961a0,
    afunc=<function at remote 0x7ff43172d6e0>)
    at /usr/src/debug/Python-2.7.10/Python/ceval.c:4196

#9  call_function (oparg=<optimized out>,
    pp_stack=0x7ffd25b961a0)
    at /usr/src/debug/Python-2.7.10/Python/ceval.c:4131

#10 PyEval_EvalFrameEx (f=f@entry=Frame 0x7ff43185fc20
    for file example1.py, line 10, in <module> (),
    throwflag=throwflag@entry=0)
    at /usr/src/debug/Python-2.7.10/Python/ceval.c:2753
```

Calling into the kernel

```
#0  0x00007ff4306add43 in __select_nocancel ()
    from /lib64/libc.so.6
#1  0x00007ff42fe2ffc0 in floatsleep (secs=<optimizedout>) at
    /usr/src/debug/Python2.7.10/Modules/timemodule.c:948
#2  time_sleep (self=<optimized out>, args=<optimized out>) at
    /usr/src/debug/Python-2.7.10/Modules/timemodule.c:206
#3  0x00007ff43137e8be in call_function
    (oparg=<optimized out>, pp_stack=0x7ffd25b95f40) at
    /usr/src/debug/Python-2.7.10/Python/ceval.c:4110
#4  PyEval_EvalFrameEx (f=f@entry=Frame 0x7ff431738050,
    for file example1.py, line 6, in bar (),
    throwflag=throwflag@entry=0)
    at /usr/src/debug/Python-2.7.10/Python/ceval.c:2753
```

Python extensions for GDB

Python extensions for GDB

- py-list — Print surrounding *python* source code
- py-bt — Print *python* stack trace
- py-print — Print *python* variables
- py-up, py-down — Move up and down the *python* stack
- py-locals — Print all *python* locals

`py-list` output of example1.py

```
(gdb) py-list

   1    #!/usr/bin/env python
   2    import os
   3    import time
   4
   5    def foobar(amount):
  >6        time.sleep(amount)
   7
   8    def main():
   9        print "Hello, World! My pid is %d" % os.getpid()
  10        foobar(amount=1337)
  11        print "Bye, World!"
```

`py-bt` output of example1.py

```
(gdb) py-bt

#4 Frame 0x7f547357d3c0, for file ./example1.py,
        line 6, in foobar (amount=1337)
    time.sleep(amount)

#8 Frame 0x7f547357d050, for file ./example1.py,
        line 10, in main ()
    foobar(amount=1337)

#11 Frame 0x7f54735bedd0, for file ./example1.py,
        line 14, in <module> ()
    main()
```

Demo

GDB and threads

- `info threads`
  - Current thread is marked with *
- Switch: `thread <id>`
- `thread apply all <COMMAND>`
  - `thread apply all py-bt`
  - `thread apply all py-list`

Working with Core Dumps

- Also works with core dumps.
- Generate coredump: `` `gcore <pid>` ``
- `` `gdb /path/to/program <core_file>` ``

Gotchas

- You need debuginfo libraries installed
  - GDB will tell you what you need
- Optimized out Python code = bad GDB
- Root is required for GDB's attach

What’s next?

- A lot

- Example: `py-print` can’t traverse namespaces
- Example: `py-print` can’t call functions
- Example: run pdb.set_trace() from GDB?

- Code in Python’s HG, please contribute!

References

- https://wiki.python.org/moin/DebuggingWithGdb
- https://fedoraproject.org/wiki/Features/EasierPythonDebugging
- https://sourceware.org/gdb/current/onlinedocs/gdb/Threads.html
- https://github.com/tamentis/rpdb#trigger-rpdb-with-signal
- https://hg.python.org/cpython/rev/6de3de3ab71f/

Questions?

Thank You

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