SPYING ON YOUR PROGRAMS

by Julia Evans
Stripe

- twitter: @b0rk
- blog: jvns.ca

Tweet questions to @b0rk

python
TM

perl | go | c++ | fortran

php | python | java | smalltalk

INTERCAL | BASIC

LINUX-ONLY

YOUR PROGRAM

=

BLACK BOX

DEBUGGING:

- look at the source code
- add print statements
- know the programming language

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- ~~look at the source code~~
- ~~add print statements~~
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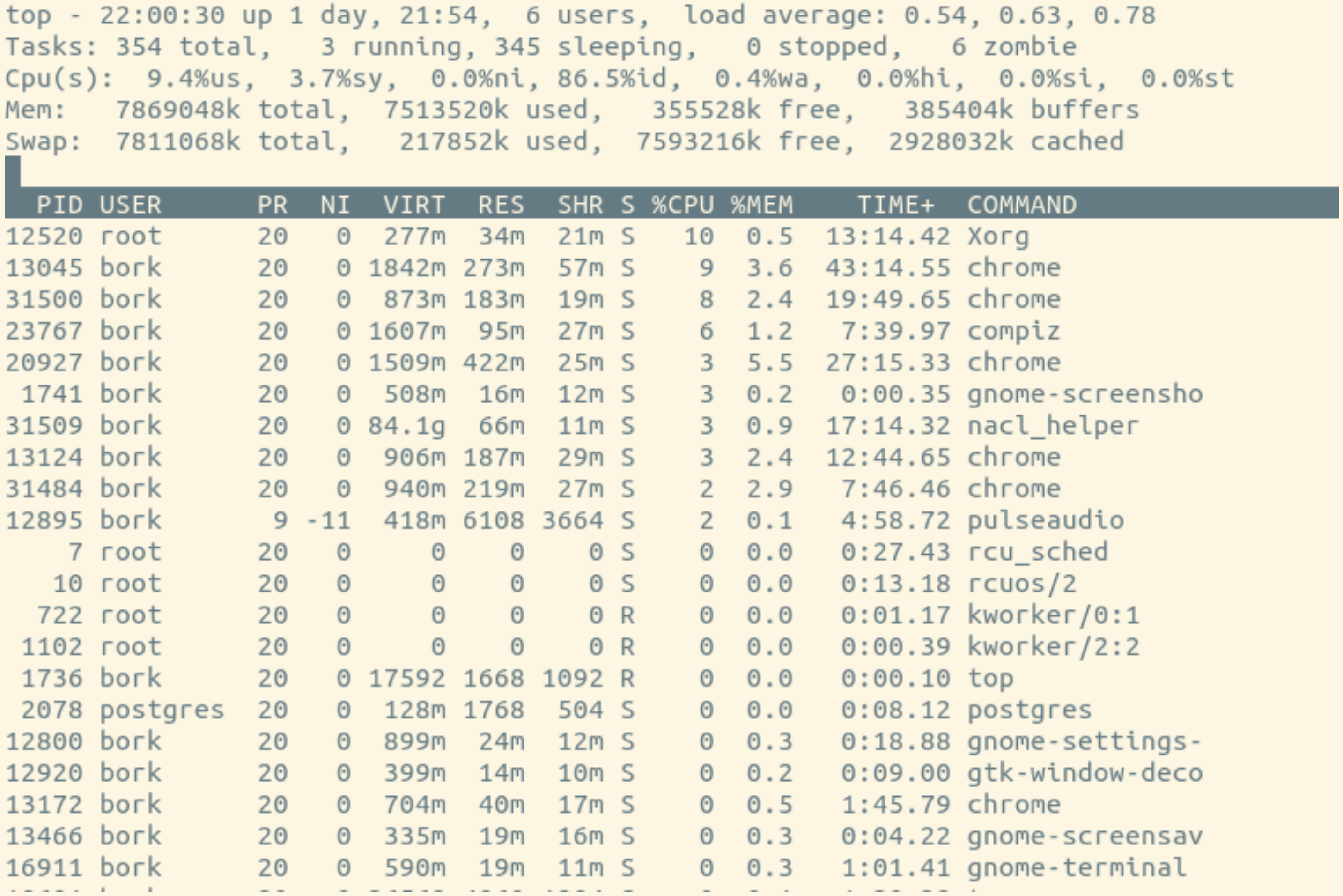
- ★★★ be a wizard★★★



```
top - 22:00:30 up 1 day, 21:54,  6 users,  load average: 0.54, 0.63, 0.78
Tasks: 354 total,   3 running, 345 sleeping,   0 stopped,   6 zombie
Cpu(s):  9.4%us,  3.7%sy,  0.0%ni, 86.5%id,  0.4%wa,  0.0%hi,  0.0%si,  0.0%st
Mem:   7869048k total,  7513520k used,   355528k free,   385404k buffers
Swap:  7811068k total,   217852k used,  7593216k free,  2928032k cached

  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
12520 root      20   0  277m  34m  21m S   10  0.5  13:14.42 Xorg
13045 bork      20   0 1842m 273m  57m S    9  3.6  43:14.55 chrome
31500 bork      20   0  873m 183m  19m S    8  2.4  19:49.65 chrome
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31509 bork      20   0 84.1g  66m  11m S    3  0.9  17:14.32 nacl_helper
13124 bork      20   0  906m 187m  29m S    3  2.4  12:44.65 chrome
31484 bork      20   0  940m 219m  27m S    2  2.9   7:46.46 chrome
12895 bork       9 -11  418m 6108 3664 S    2  0.1   4:58.72 pulseaudio
    7 root      20   0     0    0    0 S    0  0.0   0:27.43 rcu_sched
   10 root      20   0     0    0    0 S    0  0.0   0:13.18 rcuos/2
  722 root      20   0     0    0    0 R    0  0.0   0:01.17 kworker/0:1
 1102 root      20   0     0    0    0 R    0  0.0   0:00.39 kworker/2:2
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16911 bork      20   0  590m  19m  11m S    0  0.3   1:01.41 gnome-terminal
```

THIS TALK

- Wizard school (or, an operating systems primer)
- Chapter 1: The Case of the Mystery Config File
- Chapter 2: The Case of the French Website
- Chapter 3: The Case of the Slow Program

WIZARD SCHOOL
-OR-
WHY YOU SHOULD ❤ YOUR OPERATING SYSTEM

WHAT IS AN OPERATING SYSTEM FOR?

When I go to http://google.com, kernel code runs for:

- Typing in the address
- Handling every network packet
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- Communicating with the graphics card

HOW TO CALL OPERATING SYSTEM CODE

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SYSTEM CALLS!!!

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SYSTEM CALLS: AN OS'S INTERFACE

- open a file! (open)
- start a program! (execve)
- change a file's permissions! (chmod)

WHAT WE'VE LEARNED

- Your OS does tons of stuff
- Programs tell it what to do using system calls

USING SYSTEMS KNOWLEDGE TO DEBUG

CHAPTER 1: THE CASE OF THE MYSTERY CONFIG FILE

Does bash use `.bash_profile` or `.bashrc`??!??

STRACE

=

WIZARDRY

STRACE

=

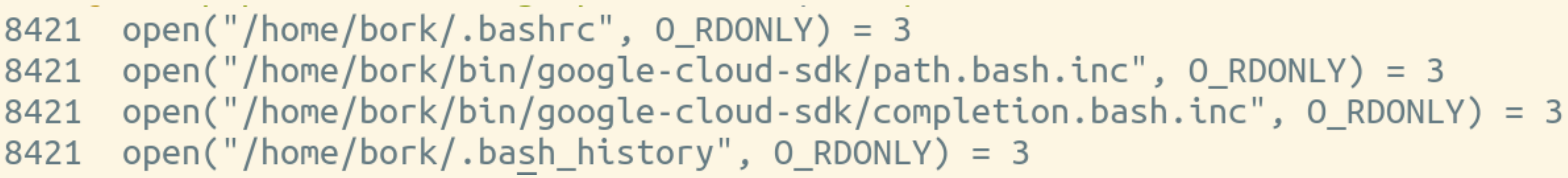
TRACING SYSTEM CALLS

HOW TO STRACE

```
$ strace google-chrome
execve("/usr/bin/google-chrome", ["google-chrome"], [/* 51 vars */])
brk(0)                                  = 0x124f000
access("/etc/ld.so.nohwcap", F_OK)      = -1 ENOENT (No such file or
```

OPEN

```
strace -e open bash
```



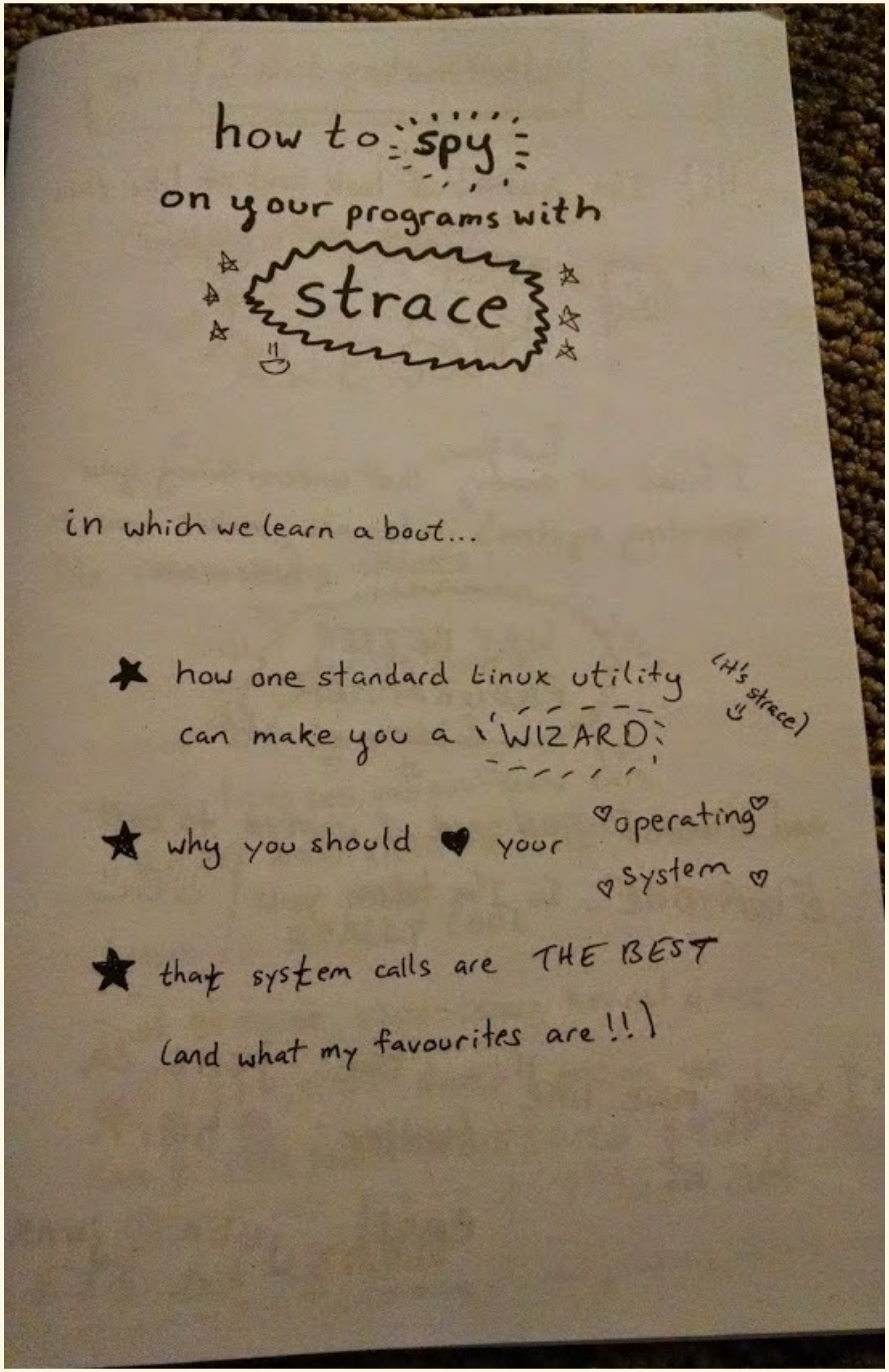
```
8421  open("/home/bork/.bashrc", O_RDONLY) = 3
8421  open("/home/bork/bin/google-cloud-sdk/path.bash.inc", O_RDONLY) = 3
8421  open("/home/bork/bin/google-cloud-sdk/completion.bash.inc", O_RDONLY) = 3
8421  open("/home/bork/.bash_history", O_RDONLY) = 3
```

BASHRC WINS!

OTHER AWESOME SYSTEM CALLS

- `write` for log files
- `execve` for starting programs
- `recvfrom` for receiving data

STRACE ZINE

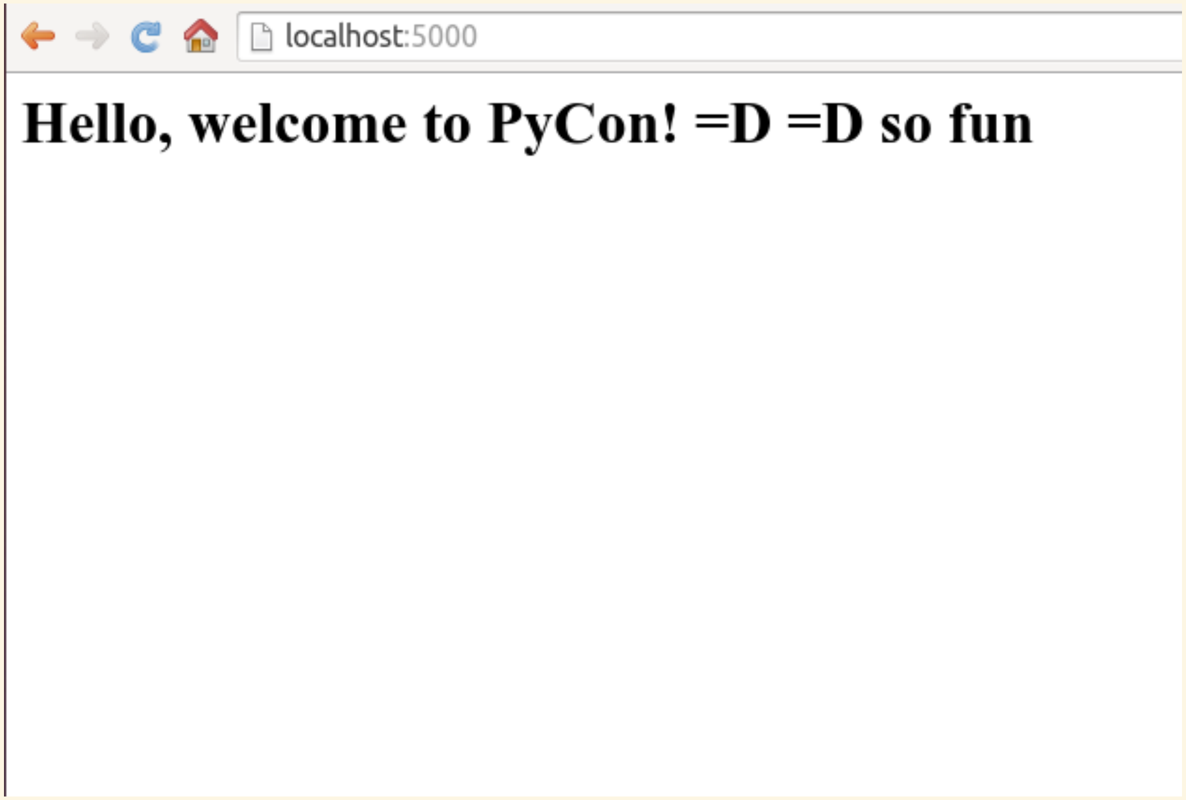


how to spy on your programs with strace

in which we learn a bout...

- ★ how one standard Linux utility can make you a WIZARD (it's strace) ☺
- ★ why you should ♥ your ♡operating♡ ♡system♡
- ★ that system calls are THE BEST (and what my favourites are!!)

CHAPTER 2:
THE CASE OF THE FRENCH WEBSITE



Hello, welcome to PyCon! =D =D so fun

```
bork@kiwi~> curl localhost:5000

    <html>
    <body>
    <h1>Bonjour, bienvenue à PyCon!</h1>
    </body>
    </html>
    ⏎
```

???

NETWORK SPYING TO THE RESCUE

```
sudo ngrep -d lo 5000
interface: lo (127.0.0.0/255.0.0.0)
match: 5000
####
T 127.0.0.1:45438 -> 127.0.0.1:5000 [AP]
  GET / HTTP/1.1..Host: localhost:5000..Connection:
keep-alive..Cache-Control: max-age=0..Accept:
text/html,application/xhtml+xml,application
/xml;q=0.9,image/webp,*/*;q=0.8..User-Agent: Mozilla/5.0 (X11; Linux
x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/41.0.2272.53 Sa
ari/537.36..DNT: 1..Accept-Encoding: gzip, deflate,
sdch..Accept-Language: en-US,en;q=0.8..Cookie:
username-localhost-8888="2|1:0|10:142841
1879|23:username-localhost-8888|48:MjYzMTc2NGMtYTA1MC00YjNkLTkyYTktNG
fab7ee279"....
#######################
T 127.0.0.1:45440 -> 127.0.0.1:5000 [AP]
  GET / HTTP/1.1..User-Agent: curl/7.22.0 (x86_64-pc-linux-gnu)
libcurl/7.22.0 OpenSSL/1.0.1 zlib/1.2.3.4 libidn/1.23
librtmp/2.3..Host: localhost:5000..Accept: */*....
##################
```

```
Accept-Language: en-US
```

```
bork@kiwi~> curl --header "Accept-Language: en-US" localhost:5000

    <html>
    <body>
    <h1>Hello, welcome to PyCon! =D =D so fun</h1>
    </body>
    </html>
    ⏎
```

NETWORK SPYING TOOLS

- ngrep
- tcpdump
- wireshark
- mitmproxy

CHAPTER 3: THE CASE OF THE SLOW PROGRAM

3 SLOW PROGRAMS

1. CPU time
2. too many writes
3. waiting for a slow server

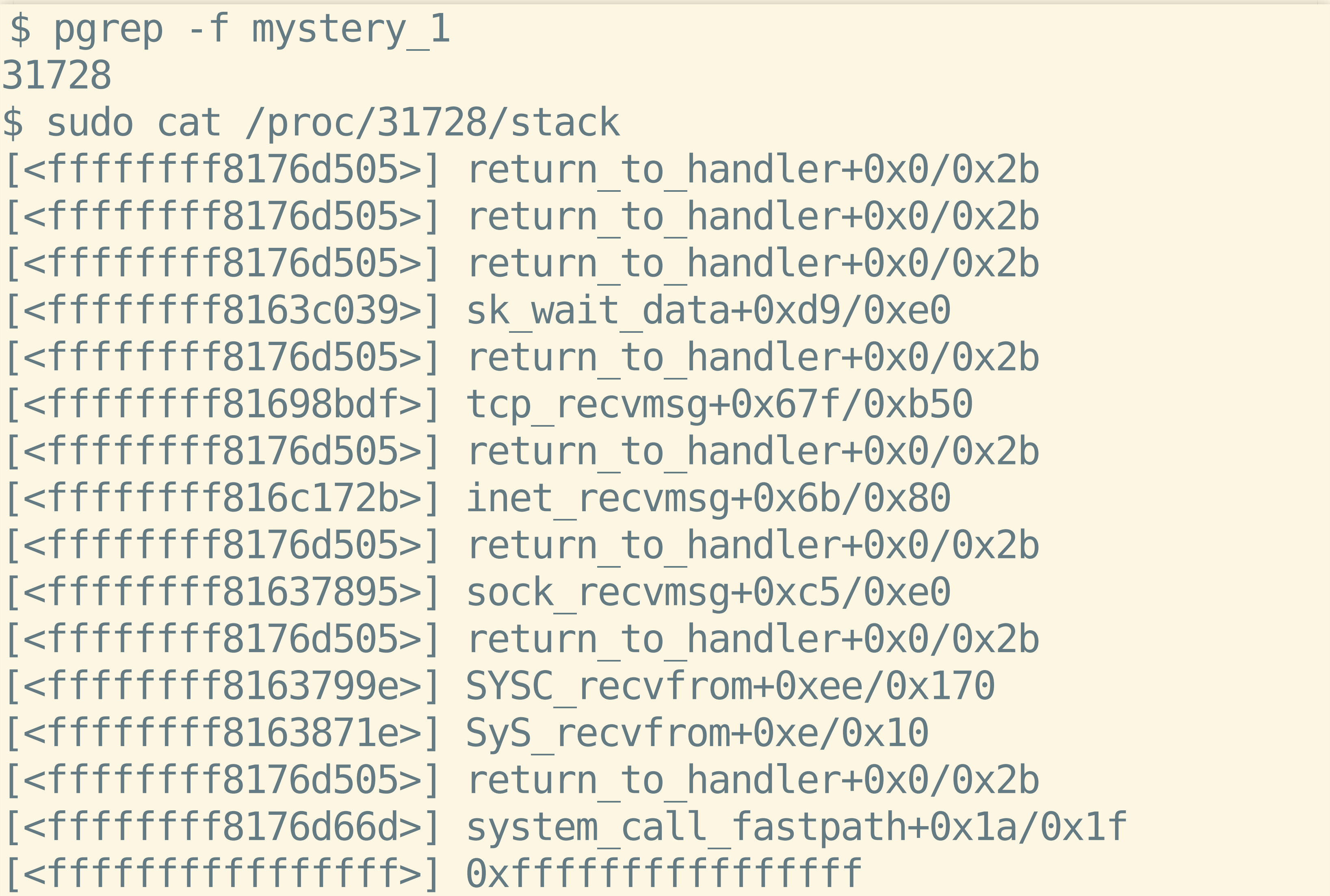
MYSTERY PROGRAM #1

```
$ time python mystery_1.py
0.09user 0.01system 0:02.11elapsed 5%C
```

WHAT IS IT WAITING FOR?

LET'S LOOK INTO THE KERNEL'S SOUL

/PROC/PID/STACK



```
$ pgrep -f mystery_1
31728
$ sudo cat /proc/31728/stack
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff8163c039>] sk_wait_data+0xd9/0xe0
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff81698bdf>] tcp_recvmsg+0x67f/0xb50
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff816c172b>] inet_recvmsg+0x6b/0x80
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff81637895>] sock_recvmsg+0xc5/0xe0
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff8163799e>] SYSC_recvfrom+0xee/0x170
[<ffffffff8163871e>] SyS_recvfrom+0xe/0x10
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff8176d66d>] system_call_fastpath+0x1a/0x1f
[<ffffffffffffffff>] 0xffffffffffffffff
```

WE WIN! IT WAS THE NETWORK!

OUR SERVER

```
@app.route('/')
def slow():
    time.sleep(2)
    return "Hi!"
app.run()
```

MYSTERY PROGRAM #2

```
$ time python mystery_2.py
2.74user 0.00system 0:02.74elapsed 99%
```

USE A PYTHON PROFILER

```
total = 0
for i in xrange(14000000):
    total += i
```

MYSTERY PROGRAM #3

(REALLY A MYSTERY)

```
$ time python mystery_3.py
0:02.61elapsed 62%CPU
$ time python mystery_3.py
0:10.61elapsed 10%CPU
```

DEMO DEMO

WE WIN

YOUR PROGRAM

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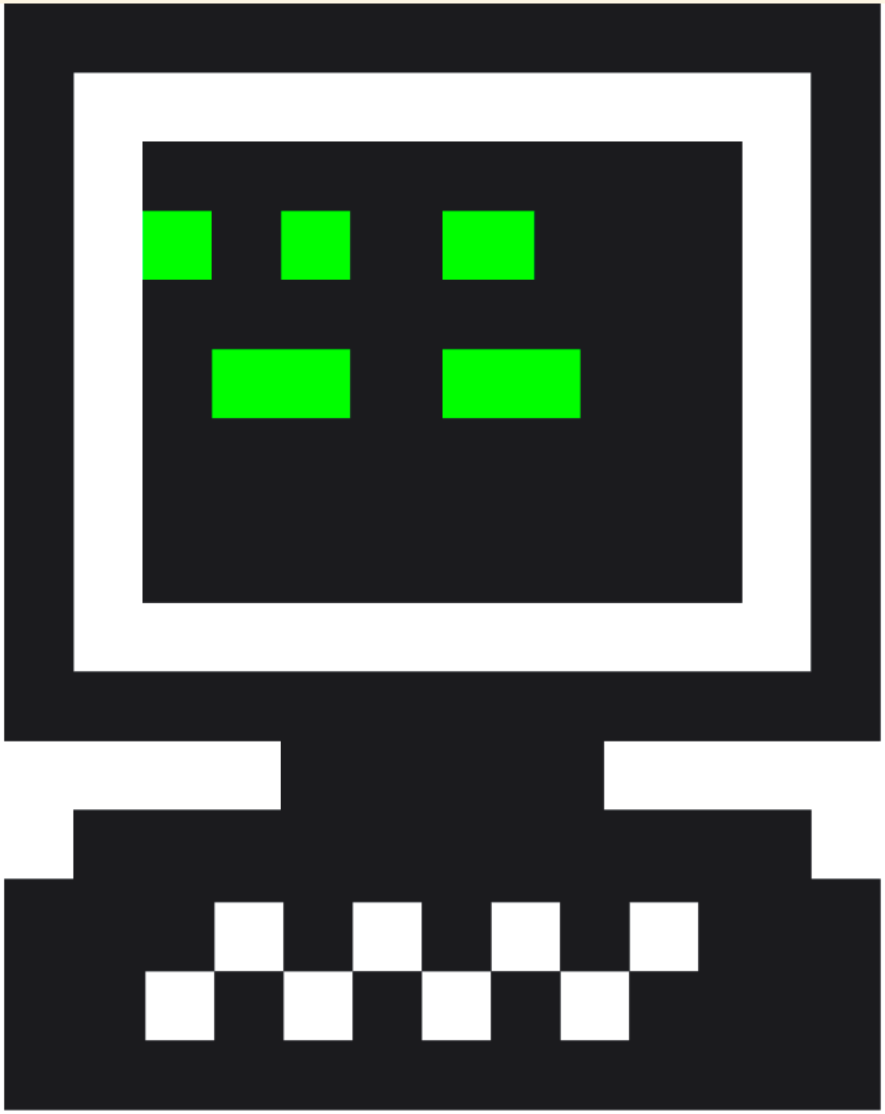

THANKS!

- Julia Evans
- twitter: @b0rk
- learn more by reading my blog: http://jvns.ca

Come get a strace zine!!!!!

```
.reveal pre code { font-family: andale mono; font-size: 1.7em; line-height: 1.2em; } .reveal pre b { color: yellow; }
```

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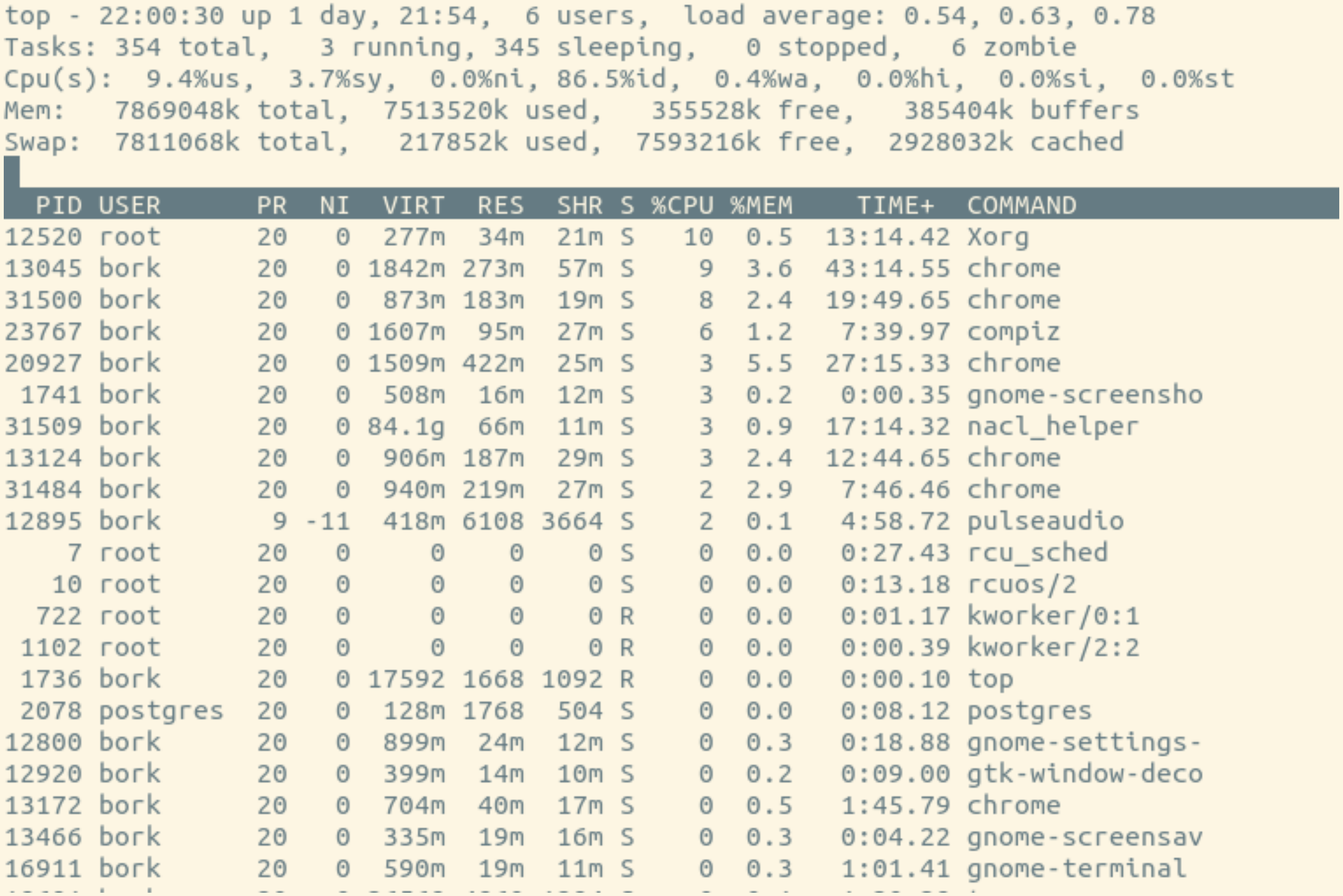

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OPEN

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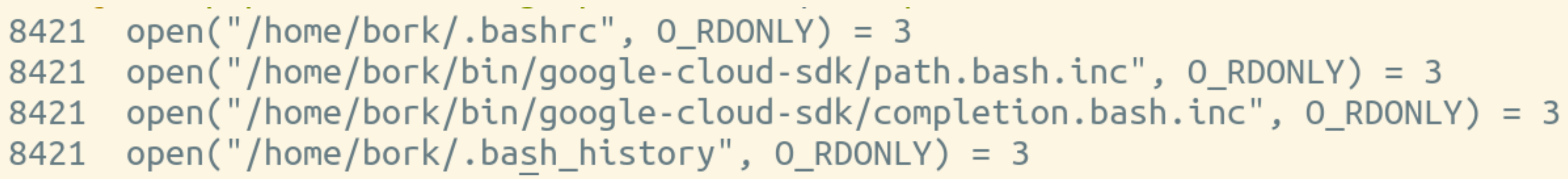
strace -e open bash
```



```
8421  open("/home/bork/.bashrc", O_RDONLY) = 3
8421  open("/home/bork/bin/google-cloud-sdk/path.bash.inc", O_RDONLY) = 3
8421  open("/home/bork/bin/google-cloud-sdk/completion.bash.inc", O_RDONLY) = 3
8421  open("/home/bork/.bash_history", O_RDONLY) = 3
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BASHRC WINS!

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- `write` for log files
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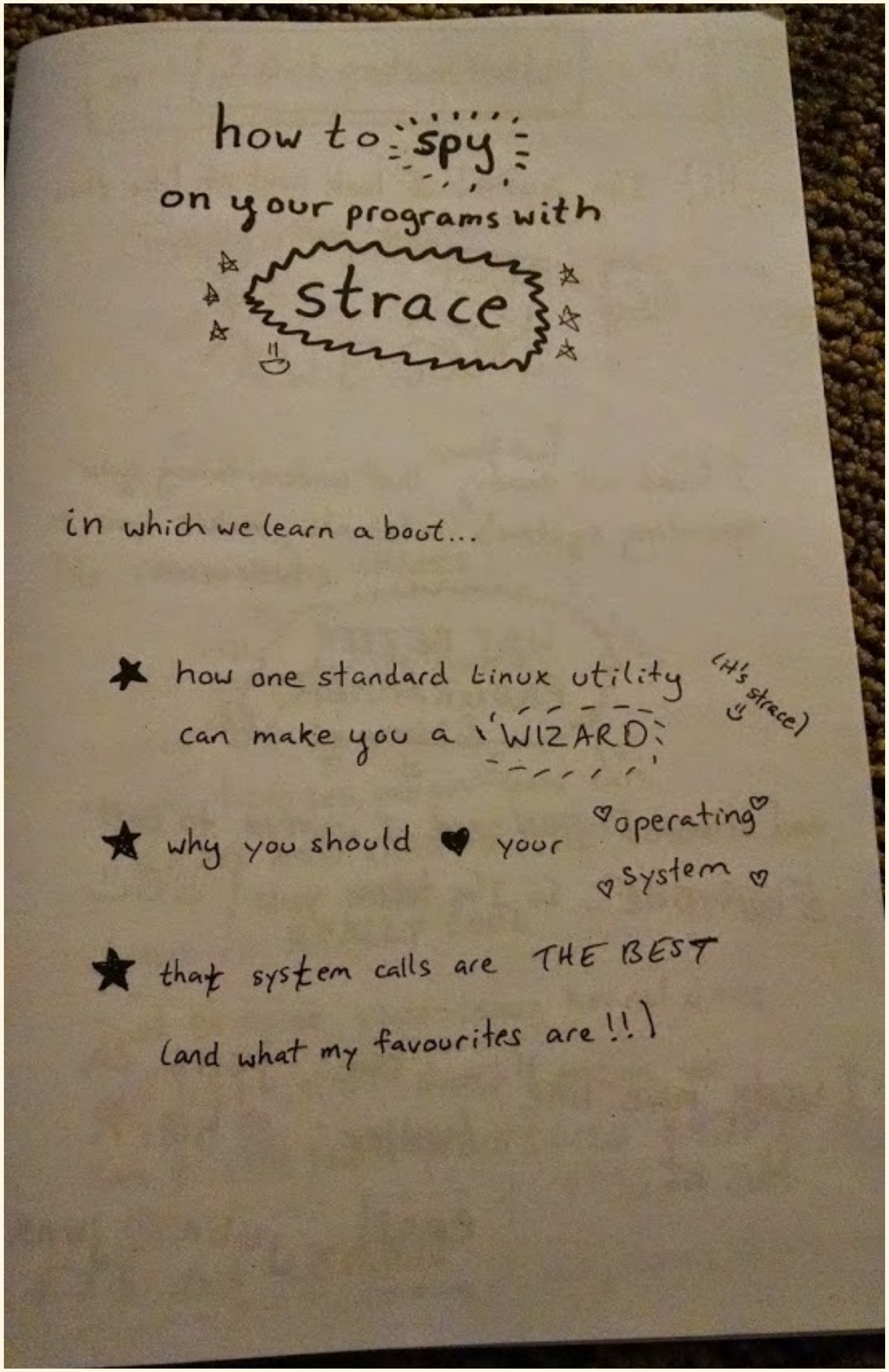

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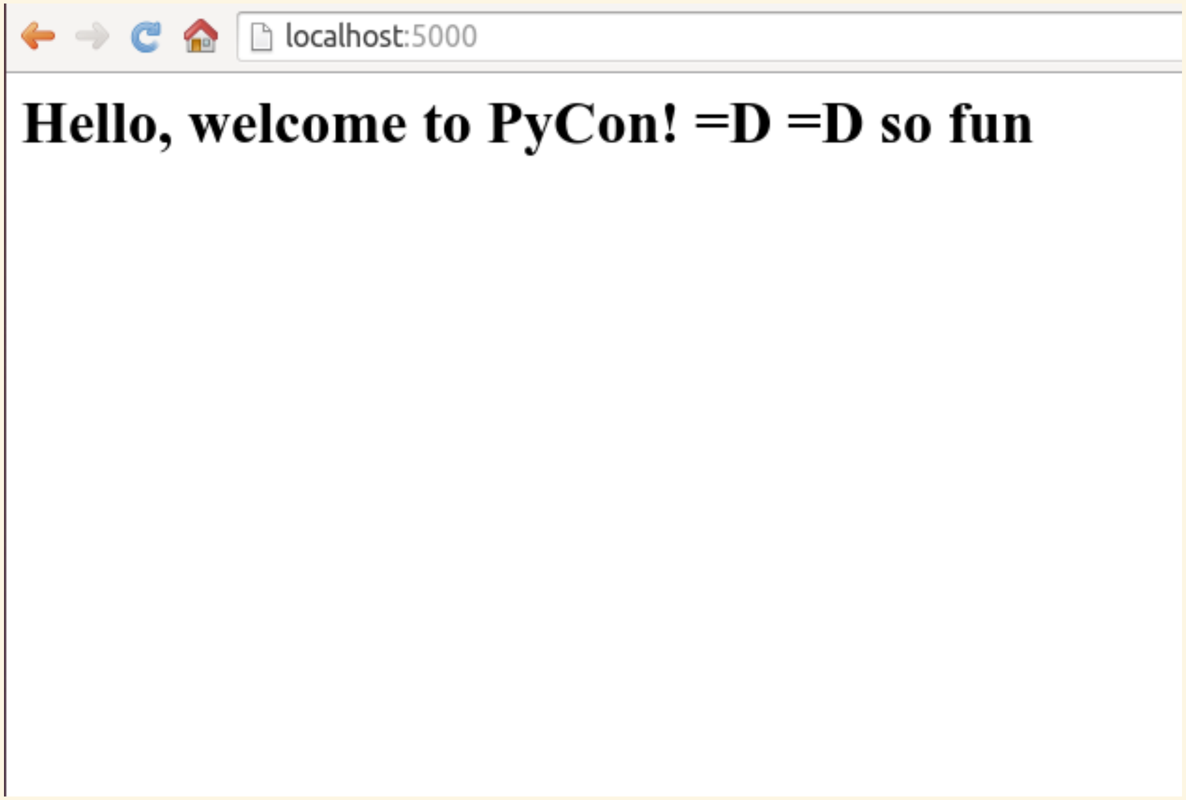

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```
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    ⏎
```

???

NETWORK SPYING TO THE RESCUE

```
sudo ngrep -d lo 5000
interface: lo (127.0.0.0/255.0.0.0)
match: 5000
####
T 127.0.0.1:45438 -> 127.0.0.1:5000 [AP]
  GET / HTTP/1.1..Host: localhost:5000..Connection:
keep-alive..Cache-Control: max-age=0..Accept:
text/html,application/xhtml+xml,application
/xml;q=0.9,image/webp,*/*;q=0.8..User-Agent: Mozilla/5.0 (X11; Linux
x86_64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/41.0.2272.53 Sa
ari/537.36..DNT: 1..Accept-Encoding: gzip, deflate,
sdch..Accept-Language: en-US,en;q=0.8..Cookie:
username-localhost-8888="2|1:0|10:142841
1879|23:username-localhost-8888|48:MjYzMTc2NGMtYTA1MC00YjNkLTkyYTktNG
fab7ee279"....
#######################
T 127.0.0.1:45440 -> 127.0.0.1:5000 [AP]
  GET / HTTP/1.1..User-Agent: curl/7.22.0 (x86_64-pc-linux-gnu)
libcurl/7.22.0 OpenSSL/1.0.1 zlib/1.2.3.4 libidn/1.23
librtmp/2.3..Host: localhost:5000..Accept: */*....
##################
```

```
Accept-Language: en-US
```

```
bork@kiwi~> curl --header "Accept-Language: en-US" localhost:5000

    <html>
    <body>
    <h1>Hello, welcome to PyCon! =D =D so fun</h1>
    </body>
    </html>
    ⏎
```

NETWORK SPYING TOOLS

- ngrep
- tcpdump
- wireshark
- mitmproxy

CHAPTER 3: THE CASE OF THE SLOW PROGRAM

3 SLOW PROGRAMS

1. CPU time
2. too many writes
3. waiting for a slow server

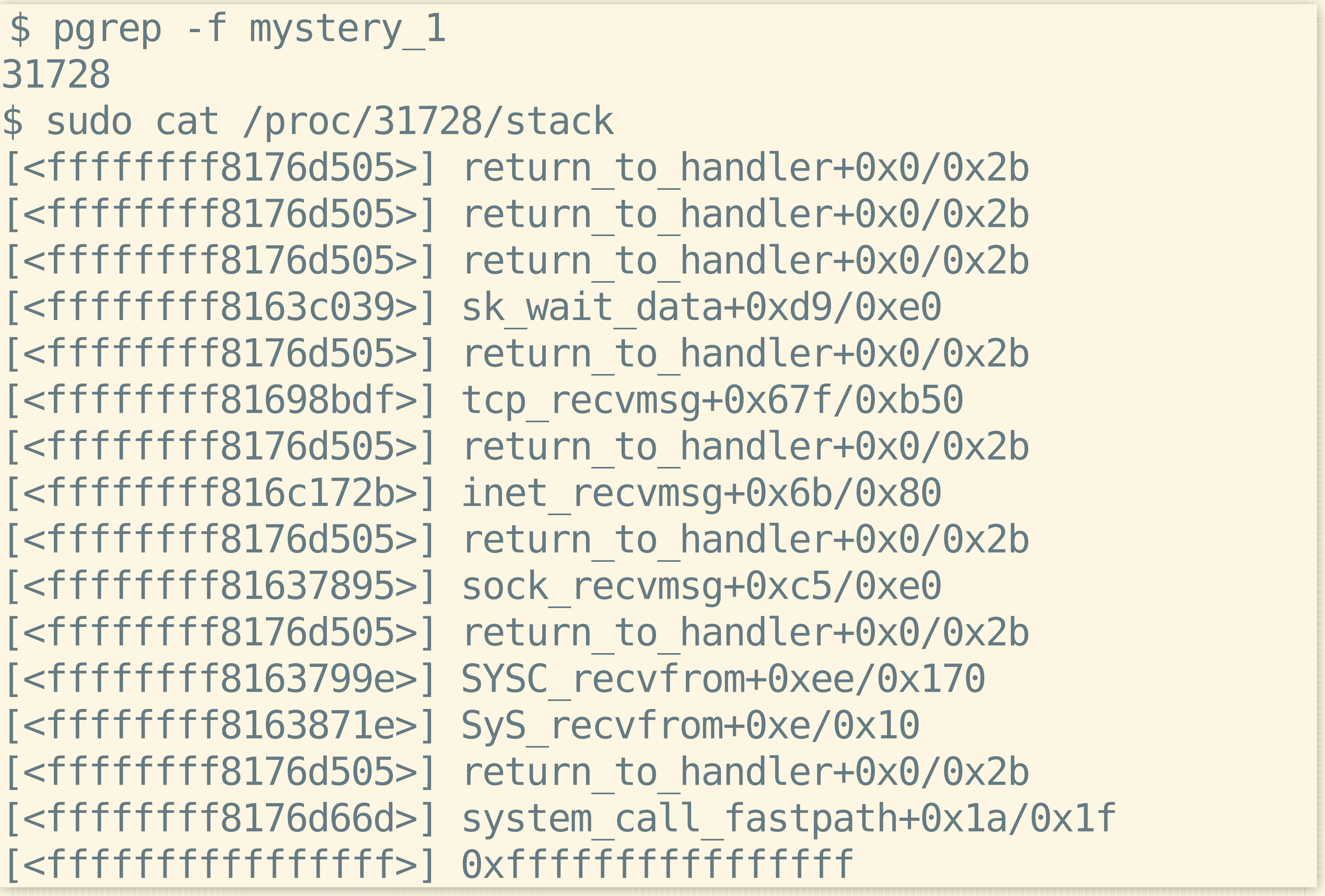
MYSTERY PROGRAM #1

```
$ time python mystery_1.py
0.09user 0.01system 0:02.11elapsed 5%C
```

WHAT IS IT WAITING FOR?

LET'S LOOK INTO THE KERNEL'S SOUL

/PROC/PID/STACK



```
$ pgrep -f mystery_1
31728
$ sudo cat /proc/31728/stack
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff8163c039>] sk_wait_data+0xd9/0xe0
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff81698bdf>] tcp_recvmsg+0x67f/0xb50
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff816c172b>] inet_recvmsg+0x6b/0x80
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff81637895>] sock_recvmsg+0xc5/0xe0
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff8163799e>] SYSC_recvfrom+0xee/0x170
[<ffffffff8163871e>] SyS_recvfrom+0xe/0x10
[<ffffffff8176d505>] return_to_handler+0x0/0x2b
[<ffffffff8176d66d>] system_call_fastpath+0x1a/0x1f
[<ffffffffffffffff>] 0xffffffffffffffff
```

WE WIN! IT WAS THE NETWORK!

OUR SERVER

```
@app.route('/')
def slow():
    time.sleep(2)
    return "Hi!"
app.run()
```

MYSTERY PROGRAM #2

```
$ time python mystery_2.py
2.74user 0.00system 0:02.74elapsed 99%
```

USE A PYTHON PROFILER

```
total = 0
for i in xrange(14000000):
    total += i
```

MYSTERY PROGRAM #3

(REALLY A MYSTERY)

```
$ time python mystery_3.py
0:02.61elapsed 62%CPU
$ time python mystery_3.py
0:10.61elapsed 10%CPU
```

DEMO DEMO

WE WIN

YOUR PROGRAM

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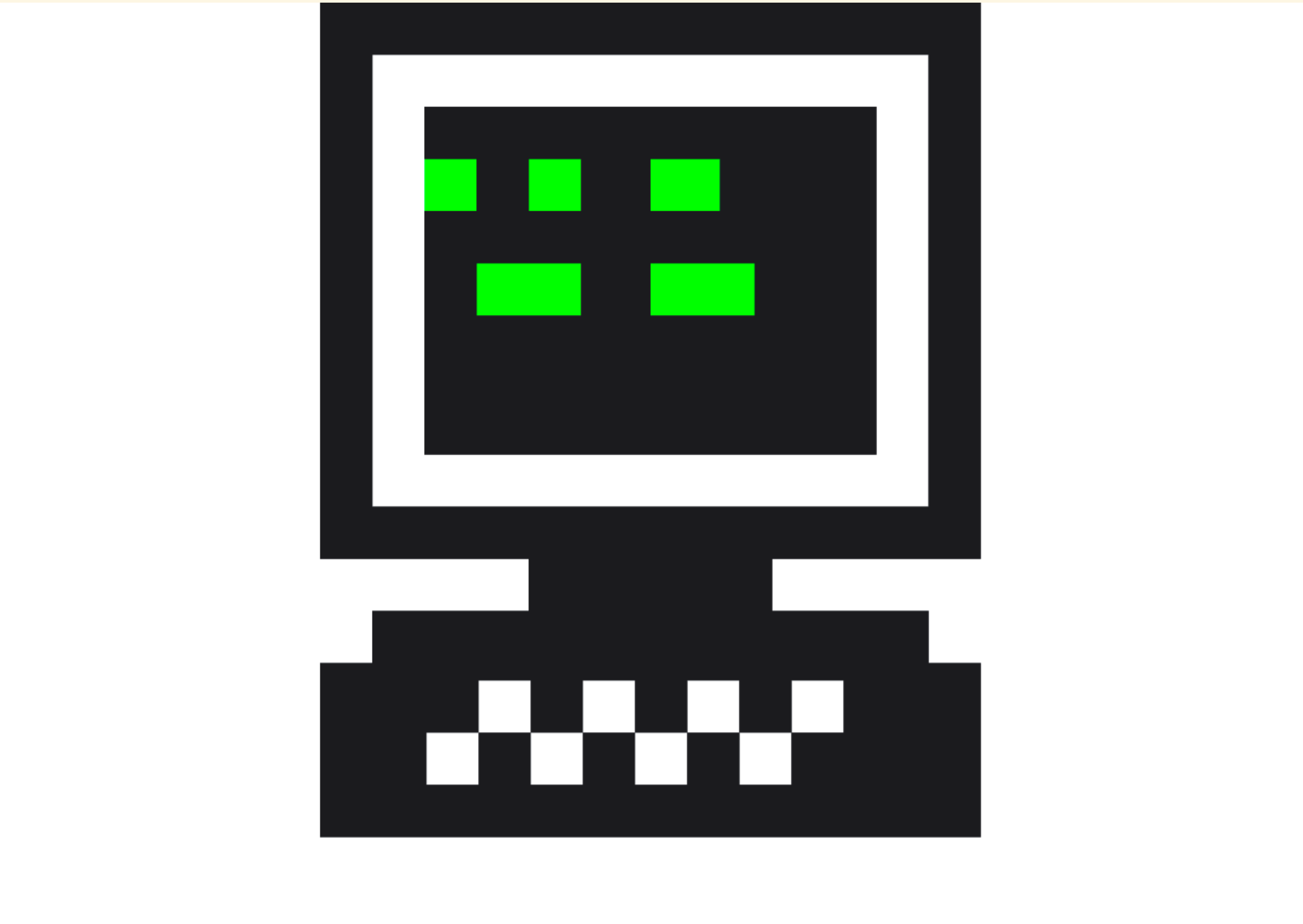

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