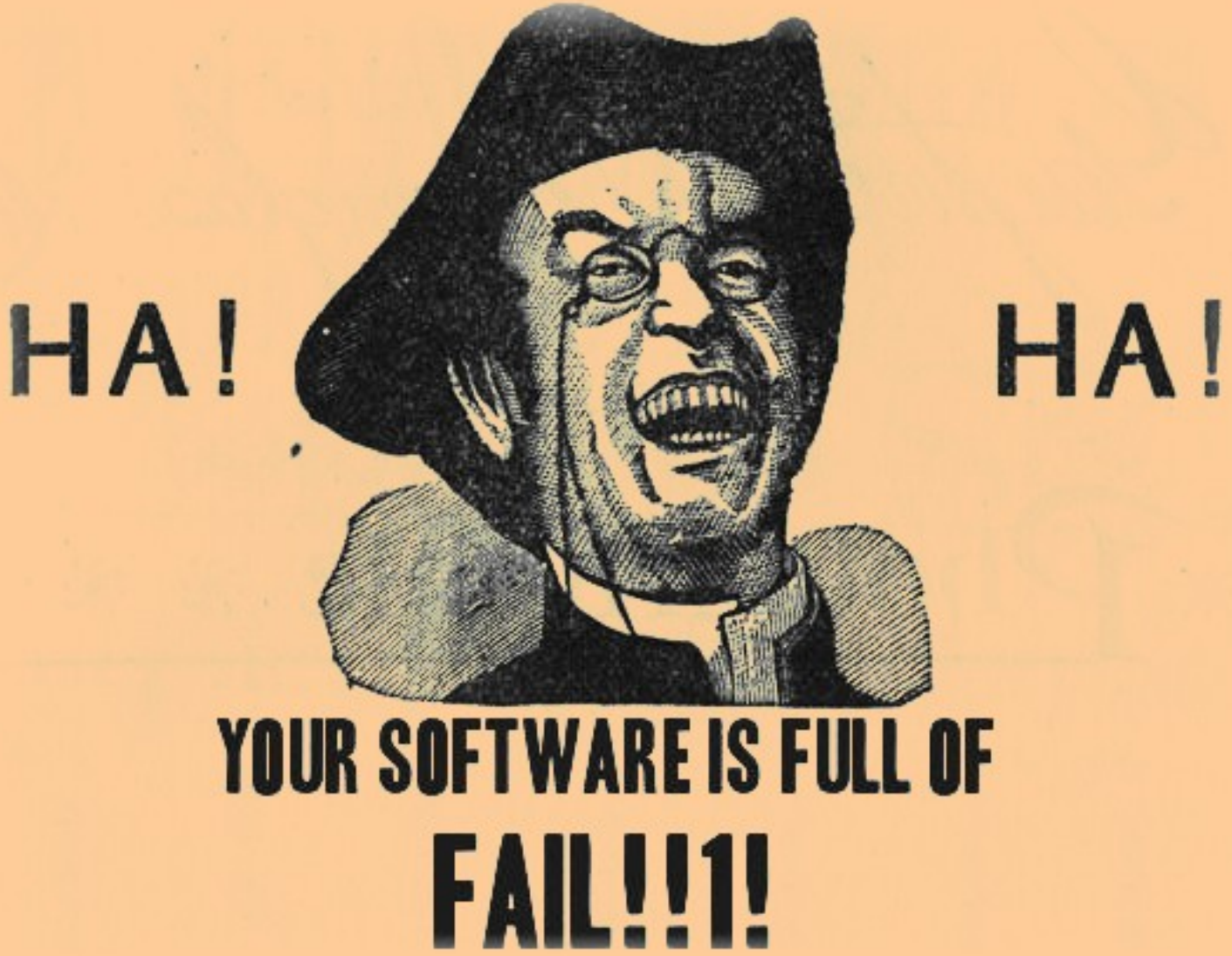
zzuf – multiple purpose fuzzer



input fuzz testing

- The idea
  - randomly alter a program’s input
- Expose bugs
  - user-contributed data (intarweb, e-mail)
  - file parsers, interpreters...
  - security implications more than often
- No magical solution
  - only finds simple bugs, not all of them

what zzuf does

- Input corruption
  - randomly sets or unsets bits
  - uses a random s
- Fully automated
  - can work on the fly
    - no costly file generation
    - works with DVDs, network, **`stdin`**
  - reproducible behaviour
    - on consecutive runs, with different programs

how zzuf works

- Controlling **`zzuf`** binary
  - forks tested program
  - checks **`stdout`**, exit value, signals...
- **`LD_PRELOAD`** mechanism
  - intercepts file reading functions
    - **`open()`**, **`read()`**, **`fopen()`**, **`fread()`**...
    - plans for zlib functions, too
  - also **`malloc()`** to check memory usage
  - more portable than **`ptrace`**, kernel land...

example #1

- Using **`zzuf`** and **`cat`**

trivial use of `cat`

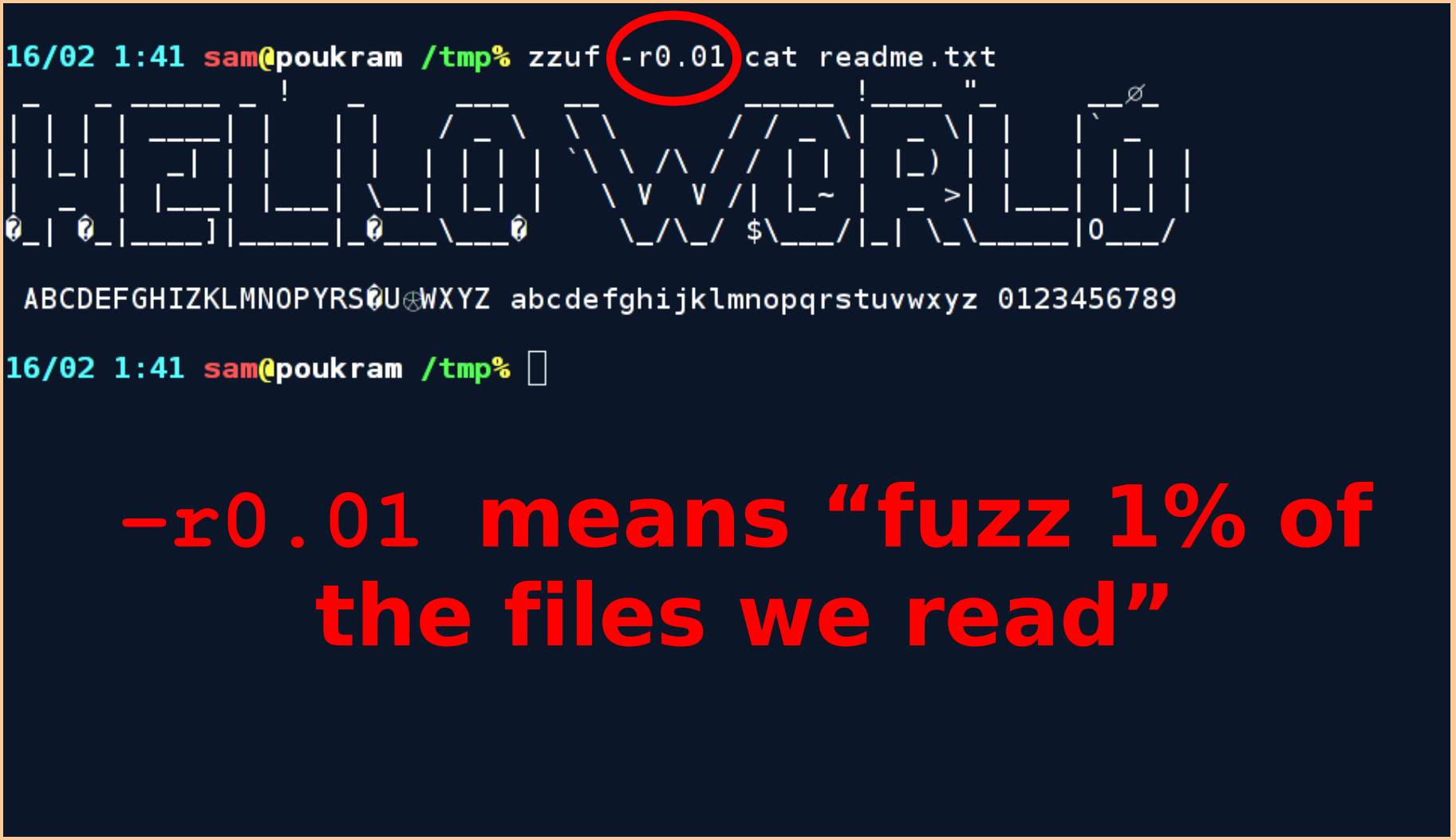
```
16/02 1:41 sam@poukram /tmp% cat readme.txt
 _    _ _____ _       _      ___   __        _____  ____  _     ____
| |  | | ____| |     | |    / _ \  \ \      / / _ \|  _ \| |   |  _ \
| |_| |  _| | |     | |   | | | |  \ \ /\ / / | | | |_) | |   | | | |
|  _  | |___| |___  | |__ | |_| |   \ V  V /| |_| |  _ <| |___| |_| |
|_| |_|_____|_____| |_____\___/     \_/\_/  \___/|_| \_\_____|____/

 ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz 0123456789

16/02 1:41 sam@poukram /tmp%
```

use `cat` through `zzuf`

```
16/02 1:42 sam@poukram /tmp% zzuf -r0.001 cat readme.txt
 _    _ _____ _       _      ___   __        _____  ____  _     ____
| |  | | ____| |     | |    / _ \  \ \      / / _ \|  _ \| |   |  _ \
| |_| |  _| | |     | |   | | | |  \ \ /\ / / | | | |_) | |   | | | |
|  _  | |___| |___  | |__ | |_| |   \ V  V /| |_| |  _ <| |___| |_| |
|_| |_|_____|_____| |_____\___/     \_/\_/  \___/|_| \_\_____|____/

 ABCDEFGXIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz 0123456789

16/02 1:42 sam@poukram /tmp%
```

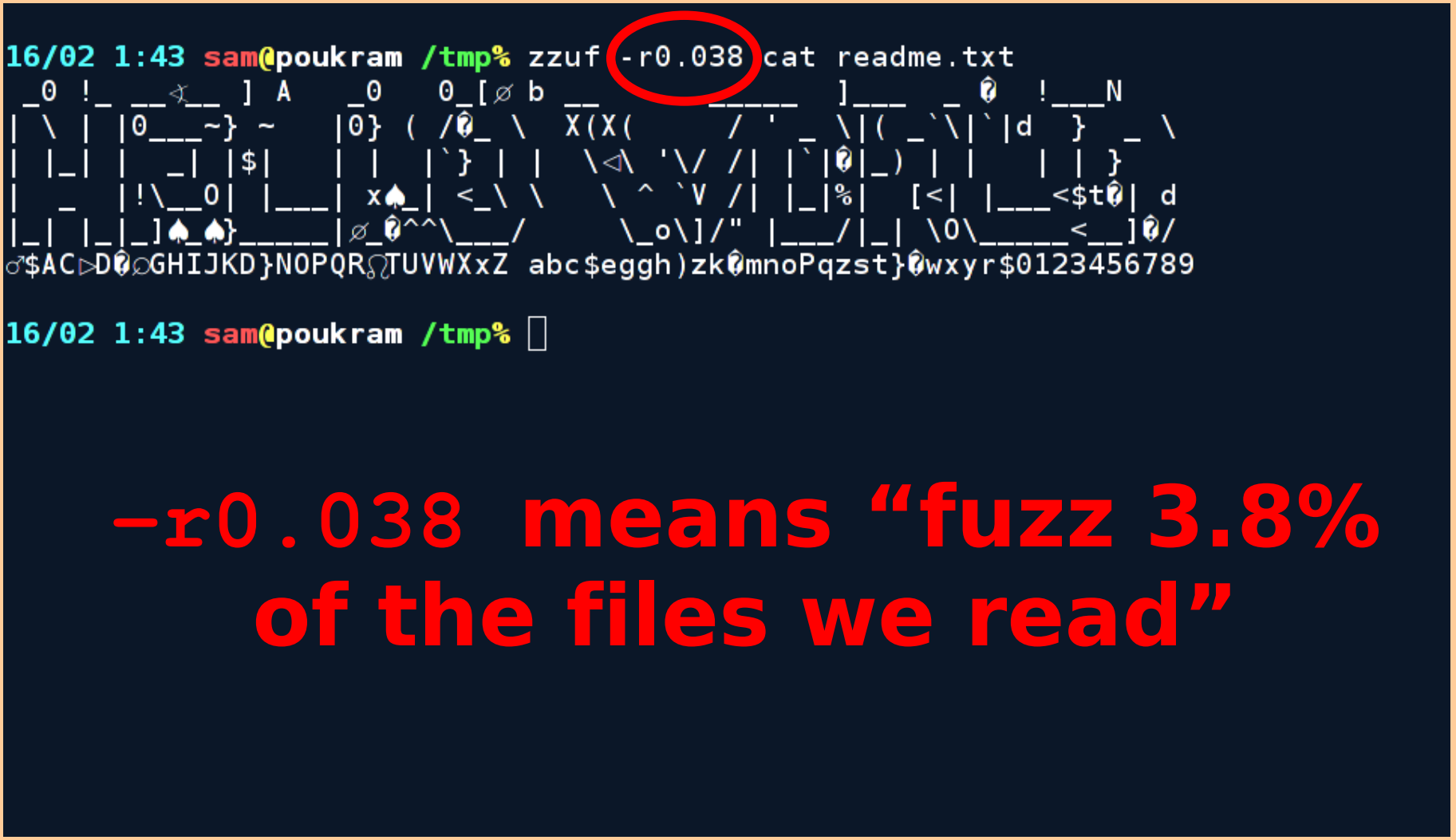
`-r0.001` means “fuzz 0.1% of the files we read”

fuzz more bits (1%)



`-r0.01` means “fuzz 1% of the files we read”

fuzz even more bits (3.8%)



-r0.038 means “fuzz 3.8% of the files we read”

refuse non-printable bytes

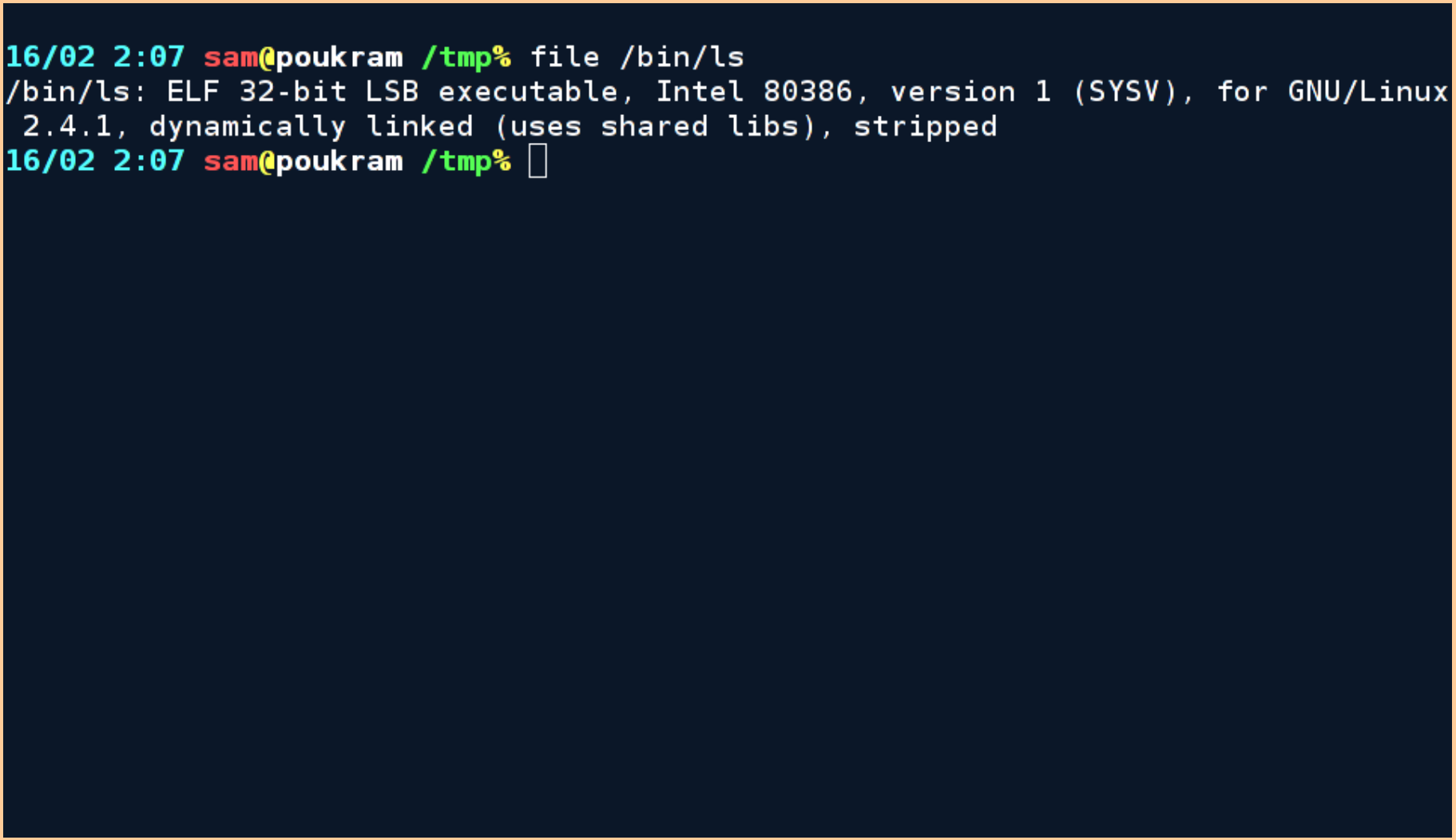
```
16/02 1:46 sam@poukram /tmp% zzuf -r0.038 -R '\x00-\x20\x7f-\xff' cat readme.txt

 _0 !_ _____ ] A    _0   0_[_ b __          _____  ]___  _    !___N
| \ | |0___~} ~   |0} ( /  _ \  X(X(     / '  _ \|( _`\|`|d  }  _ \
| |_| |  _| |$|   | |  |`} | |  \ \ '\ / / | |`| |_) | |   | | } |
|  _  |!\__O| |___| x__| <_\ \   \ ^ `V /| |_|%|  [ <| |___<$t_| d
|_| |_|_]___}_____|___^^\___/     \_o\]/" |___/|_| \O\_____<__]_/

$ACCDEFGHIJKD}NOPQRSTUVWXxZ abc$eggh)zklmnoPqzst}vwxyr$0123456789

16/02 1:46 sam@poukram /tmp%
```

-R\x00-\x20 means “do not generate characters in the range 0x00 to 0x20”

example #2

- Using **`zzuf`** and **`file`**

trivial use of `file`

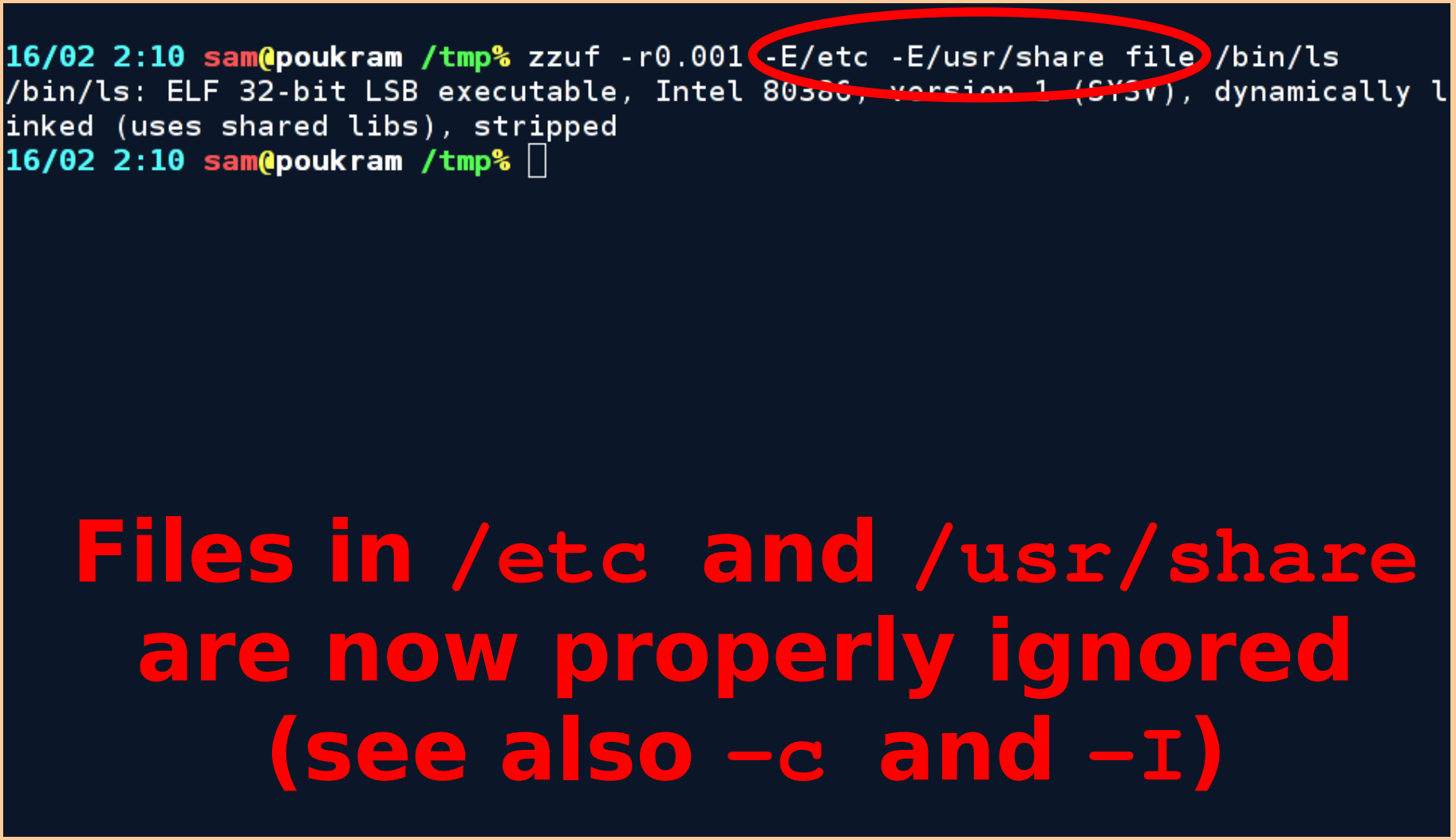


Using -d (debug)

```
16/02 2:09 sam@poukram /tmp% zzuf -d -r0.001 file /bin/ls
** zzuf debug ** libzzuf initialised for PID 27060
** zzuf debug ** fopen64("/etc/magic", "r") = [3]
** zzuf debug ** fgets(0xbfbea6ef, 8192, [3]) = 0xbfbea6ef
** zzuf debug ** fgets(0xbfbea6ef, 8192, [3]) = 0xbfbea6ef
** zzuf debug ** fgets(0xbfbea6ef, 8192, [3]) = 0xbfbea6ef
** zzuf debug ** fgets(0xbfbea6ef, 8192, [3]) = NULL
** zzuf debug ** fclose([3]) = 0
** zzuf debug ** open64("/usr/share/file/magic.mgc", 0) = 3
** zzuf debug ** mmap64(NULL, 1012224, 3, 2, 3, 0) = 0xb792b008 "\x1c\x04\x1e\xf
1...
** zzuf debug ** close(3) = 0
** zzuf debug ** open64("/bin/ls", 0) = 3
** zzuf debug ** read(3, 0xb78e3008, 262144) = 77352 "\x7fELF...
** zzuf debug ** close(3) = 0
/bin/ls: ERROR: cannot happen: invalid relation `\x1c'
16/02 2:09 sam@poukram /tmp%
```

Files in /etc and /usr/share should not be fuzzed

Using -E (exclude)



Using -s (seed)

```
16/02 2:30 sam@poukram /tmp% zzuf -s0:5 -r0.01 -E/etc -E/usr/share file /bin/ls
/bin/ls: ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), dynamically l
inked (uses shared libs), corrupted section header size
/bin/ls: ELF 32-bit LSB executable, (SYSV), statically linked (uses shared libs)
, stripped
/bin/ls: data
/bin/ls: data
/bin/ls: ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), bad note name
 size 0x80000061, dynamically linked, stripped
16/02 2:30 sam@poukram /tmp%
```

-s0:5 means “use random seeds 0, 1, 2, 3 and 4”

Using `-r` with ranges

```
16/02 2:34 sam@poukram /tmp% zzuf -s0:5 -r0.001:0.05 -E/etc -E/usr/share file /b
in/ls
/bin/ls: ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), dynamically l
inked (uses shared libs), stripped
/bin/ls: data
/bin/ls: ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), dynamically l
inked (uses shared libs), stripped
/bin/ls: ELF 32-bit LSB executable, Intel 80386, version 1 (SYSV), corrupted pro
gram header size, stripped
/bin/ls: data
16/02 2:34 sam@poukram /tmp%
```

`-r0.001:0.05` means "choose fuzzing ratios in the 0.1% - 5% range"

example #3

- Finding real bugs

giftopnm

```
16/02 9:13 sam@poukram /tmp% zzuf -q -s0:1000 -r0.001:0.1 giftopnm image.gif
zzuf[s=19,r=0.001:0.1] signal 11 (SIGSEGV)
[1]    5328 exit 1     zzuf -q -s0:1000 -r0.001:0.1 giftopnm image.gif
16/02 9:13 sam@poukram /tmp% zzuf -s19 -r0.001:0.1 < image.gif > fuzzed.gif
16/02 9:13 sam@poukram /tmp% giftopnm fuzzed.gif
[1]    5389 segmentation fault  giftopnm fuzzed.gif
16/02 9:13 sam@poukram /tmp%
```

Use `-q` to avoid flooding

Use the same `-r` and `-s` flags to generate a file that reproduces the behaviour

antiword

```
16/02 9:06 sam@poukram /tmp% zzuf -C10 -q -s0:10000 -r0.001:0.02 -M1000 antiword
 worddocument.doc
*** glibc detected *** double free or corruption (!prev): 0x0807a020 ***
zzuf[s=19,r=0.001:0.02]: signal 6 (SIGABRT)
zzuf[s=98,r=0.001:0.02]: signal 11 (SIGSEGV)
zzuf[s=109,r=0.001:0.02]: signal 11 (SIGSEGV)
*** glibc detected *** double free or corruption (out): 0x0807a020 ***
zzuf[s=140,r=0.001:0.02]: signal 6 (SIGABRT)
*** glibc detected *** double free or corruption (out): 0x0807a020 ***
zzuf[s=188,r=0.001:0.02]: signal 6 (SIGABRT)
zzuf[s=214,r=0.001:0.02]: signal 9 (memory exceeded?)
*** glibc detected *** double free or corruption (!prev): 0x0807a020 ***
zzuf[s=256,r=0.001:0.02]: signal 6 (SIGABRT)
zzuf[s=269,r=0.001:0.02]: signal 11 (SIGSEGV)
zzuf[s=270,r=0.001:0.02]: signal 9 (memory exceeded?)
zzuf[s=283,r=0.001:0.02]: signal 9 (memory exceeded?)
[1]    2818 exit 1     zzuf -C10 -q -s0:10000 -r0.001:0.02 -M1000 antiword wordd
ocument.doc
16/02 9:06 sam@poukram /tmp%
```

Many different ways to crash

mplayer/ffmpeg

```
16/02 9:40 sam@poukram /tmp% zzuf -q -s0:1000 -r0.001:0.1 -S -c -b 1000000-12000
00 mplayer -- -ao null -vo null -benchmark -fps 1000 video.wmv
zzuf[s=1,r=0.001:0.1]: signal 11 (SIGSEGV)
[1]    10231 exit 1     zzuf -q -s0:1000 -r0.001:0.1 -S -c -b 1000000-1200000 mp
layer -- -ao null -vo
16/02 9:40 sam@poukram /tmp% zzuf -s1 -r0.001:0.1 -b 1000000-1200000 < video.wmv
 > fuzzed.wmv
16/02 9:40 sam@poukram /tmp%
```

Use -b to only fuzz parts of the input

Innocent-looking videos can cause a DoS or worse

other features

- Fork and parallelise (`-F`)
- Detect stuck processes
  - Set maximum memory allocation (`-M`)
  - Set maximum running time (`-T`)
  - Set maximum `stdout` output (`-B`)
- Fuzz network intput (`-n`)
- Fuzz `stdin` (`-i`)

zzuf's future

- Context-dependent fuzzing
  - ignore or recompute CRCs
  - divert the zlib library, too
- Finish the Windows® port
  - help needed
- Make it easier to test GUI applications
- Attach to a debugger

http://sam.zoy.org/zzuf/