COMP9447 15s2

5A - Fuzzing

What is fuzzing?

- Software testing technique used to find bugs by feeding random/pseudo random or purposely bad data to an application
- Usually generated by another program (the fuzzer)
- If it crashes, then awesome. Save that ‘fuzz’ and move onto the next test

History of Fuzzing

- Barton Miller at University of Wisconsin "Operating System Utility Program Reliability - The Fuzz Generator“ - 1989
- Dave Aitel released two fuzzers in 2001 - SPIKE fuzzing framework, and sharefuzz. Spike in particular was the first block based fuzzer publicly known, and made fuzzing a huge thing in the security world – 2001
- Big gap there of nothing..
- Many fuzzing toolkits have been released since then

Benefits of fuzzing (pros) compared to more manual review

- Reappliable effort – Fuzzer creation is generally focused on protocol, file format, etc. – so you can take your PDF fuzzer and use it on every PDF parser, or take your SSL fuzzer and use it on every SSL implementation
- Write once, use many times
- Lower skill requirement than in-depth reverse engineering or source code review
- Bugs found are guaranteed to be reachable, if you are fuzzing from reachable interface
- Largely, better bang for back
- Can be used to estimate “watermark” of security – i.e. fuzzer library of common network protocols vs. firewall to see if the vendor has their SDLC act together
- Will find memory corruption, overflows, etc.

Cons

- Bugs are often shallow - Other people may find them. Now that exploit writing time is often very large (compared to vuln finding time)
- Hard to get full coverage of program – remember that the least used paths are more likely to be vulnerable
- Multistage vulns –I .e. those which require multiple concurrent things to happen to occur are hard to target – i.e. think about a network protoco, where if the first packet of a particular type of communication is slightly malformed in a certain way, and then the second packet is in a different way, then a bug occurs. Very hard to cover (but not impossible..)
- Will not find smarter things like backdoors or complex race conditions

Two Broad “Families” of Fuzzing + Targets

Families:

- **Generation Based:** The fuzzer itself generates the bad data
- **Mutation Based:** The fuzzer mutates good data in some way

Targets:

- Network protocols (server:apache/smb, client:browsers)
- File format (acrobat/office/flash – includes programming languages i.e. JavaScript)
- API (system calls)

Anatomy of a Fuzzer

- Fuzzing engine – creates the test cases either by generation or mutation
- Test harness
  - Process monitor
  - Starts the application each time
  - Feeds it the input
  - Rinse and repeat
  - Records the conditions under which a crash occurred
  - Tries to grab some useful diagnostic information to speed the bug hunt process up (or vuln verification process)
- Do not underinvest in your test harness!

The simplest possible form of a generation fuzzer

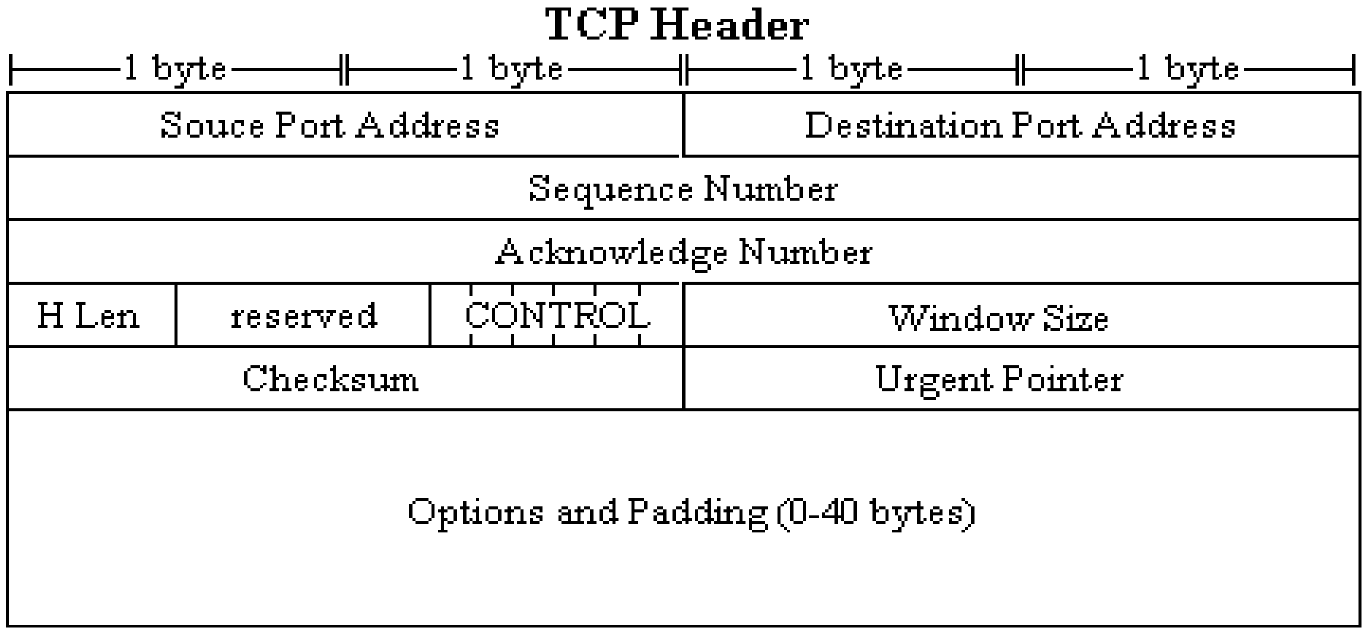
cat /dev/urandom | ./program

- Or even
  cat /dev/urandom | nc <ip> <port>
- Extremely basic
- Don't even need to know the protocol
- Need to get lucky - not very effective as most protocols/file formats need specific data in specific places (e.g. a header/footer/checksums)
- We have found real exploitable remote vulnerabilities doing this ;(
- Adding a header makes it a lot more productive ☺

i.e. { echo -n 'lol' & dd if=/dev/urandom bs=4 count=1 2>/dev/null ;} | nc <ip> <port>

Smarter Generational Fuzzing

- Attempt to model the protocol and then try your bad/random data in the most likely areas to cause a problem
- Most protocols are well defined, etc. or look at the code a little bit (to get headers for example)



Block / Based Fuzzers

Attempts to model a protocol in blocks.

Originally made public/popular with Spike in 2001, there's now a huge number.

"GET / HTTP/1.0" could be represented as:

```
s_string("GET");
space();
s_string("/");
space();
s_string("HTTP");
delimiter("/");
s_interger("1")
delimiter(".");
s_interger("0");
```

GET / HTTP/1.0

AAAAAAAAA / HTTP/1.0

BBBBBBBBBB / HTTP/1.0

%S%S%S%S%S / HTTP/1.0

../../../../../../ / HTTP/1.0

..

Later

GET %S%S%S%S%S HTTP/1.0

GET ../../../../../../../ HTTP/1.0

Later

GET / BBBBBBBBB/1.0

etc.

Slightly better, block-based, sulley example

- s_initialize
- s_initialize("HTTP")
- s_group("verbs", values=['GET','HEAD','POST','TRACE'])
- s_block_start("header", group="verbs")
- s_delim(' ')
- s_delim('/')
- s_string('index.html')
- s_delim(' ')
- s_string('HTTP')
- s_delim('/')
- s_string('1')
- s_delim('.')
- s_string('1')
- s_static('\r\n\r\n')
- s_block_end()

Block-Based Fuzzers

- The better you can map a protocol (in particular multi packet exchanges) the more likely you are to succeed
- Enrich your data set as much as possible. Example here is HTTP request header, i.e.

Expect: AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

Cache-control: AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

Request fields list from Wikipedia: Good

Common non-standard request fields from Wikipedia: Better

Looking at the binary and stripping out all the requests fields it actually knows about, including some that aren’t on Wikipedia, and eliminating all the fields in protocol that it doesn’t support: Best

Look for the undocumented stuff

- Once again, you really want to search deep in the parts of the target that will not be exercised often
- This is even more so on closed-source things
- Open them up in IDA and look at string collections (i.e. for example above, all the HTTP request headers) and see if there are any that are unused
- Then dig around where they are used, and see what kind of stuff is going on

Mutation / Mangling

- Taking an existing file/packet, mangling it, feeding it back to the program
- Usually done with file formats
- Started with literally, flip a random of bit in a valid file.
- Will only fuzz the features in the initial file
- Hopefully with enough initial files you can fuzz all features!
- Lazy way of doing it as you don’t have to learn the file format / protocol
- Still get owned by crc/checksums

Mangling continued

- Still finds bugs!
- Charlie Miller found tonnes of bugs in real software in 2010 with 5 lines of python – still works now too
- Babysitting my army of Monkeys: https://fuzzinginfo.files.wordpress.com/2012/05/cmiller-csw-2010.pdf
- Very reliant on the initial files chosen

Charlie Millie Corpus Technique

- You need to build a good “corpus” of data/files to fuzz, generally based on code coverage
- Directly copy and pasted from the monkey pack:
- Example PDF:
  - Found 80,000 PDF’s on Internet
  - Used Adobe Reader + Valgrind in Linux to measure code coverage
  - Reduced to 1,515 files of ‘equivalent’ code coverage
  - Same bang as fuzzing all 80k in 2% of the time

Maximizing Code Coverage

- A good fuzzer will maximize how many code paths are executed
- You generally do this via instrumenting the target and watching which basic blocks it triggers
- You will find that some input files and paths hit supersets of others; you can remove the ones which don’t add anything new

Harden the client + Useful tools

- You want to detect any corruption or badness as soon as possible
- Thus, you want to turn memory protections all the way up on the system your target is on (i.e. the target)
- Grsecurity with all memory protections
- Guard pages/something to catch access violations – i.e. libgmalloc, libefence, memcheck

- There are tools like !exploitable as part of windbg which will tell you if something is likely exploitable

Picking bad data

- Certain kinds of data (and certain lengths of data) are more likely to trigger bugs
- Searching a 4-byte int for 1-0xFFFFffff takes too long. The best values are all of the powers of 2, plus or minus {1..5}.
- i.e. 1024, 1023, 1022, 1021, 1020, 1019, 1025, 1026, 1027, 1028, 1029.
- 2048, 2047, 2046, 2045, 2044, 2043, 2049, etc.
- It is also a very good idea on mutagenic fuzzers to rather than pick a completely random value, modify the existing value in a certain way, i.e. add 1 or 2 or 3 or 4 to it, or double it, or double it and add one.
- Research on mutagenic stuff (what works)

http://lcamtuf.blogspot.com.au/2014/08/binary-fuzzing-strategies-what-works.html

Picking bad data - Strings

All the usual suspects:

- AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
- PPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
- Ppppppppppppppppppppppppppppppp
- PPpppPppPpppPppPPppPPpPPPpPpPpPpppppP
- 3333333333333333333333333333333333333
- :::
- \/
- ..\
- \`/sbin/sudo /sbin/halt\`
- \`halt\`

Retrospective Selection

- Retrospective selection is important when making a fuzzer – particularly generation based fuzzers.
- What this means is basically, make sure that all the actual vulnerabilities identified in the target protocol can be found with your tool
- I.e. if you are writing a HTTP server fuzzer, look at all the reported vulnerabilities that a fuzzer could find (i.e. memory corruption) in the last several years, and make sure your fuzzer can find them.
- If not, add the bits to your fuzzer that mean it can.
- Repeat. :-)

Jones

- Proxy block based fuzzer fionnbharr wrote which had some success
- Pulls packets off the wire
- If they match a pattern -> pull them apart based off the matched class
- Fuzz particular variables, fix up checksums/lengths/whatever
- Inject it back into the stream
- Fixes the problem of having to create the whole conversation\

There's now an open-source version similar to this called proxyfuzz which has found some good bugs

Mycotoxin

- A client modification fuzzer I wrote whilst pretty drunk
- Requires you to recompile any client with –oS (so all instructions use stack)
- It then does random interchanges (i.e. wait a random number of syscalls, step a random number of instructions, and change the currently being pushed integer or string to a fuzz value)
- Defeats compression, encryption etc. etc.
- Found some decent bugs I was too lazy to do anything about
- Code is available if anyone wants to rewrite it in C

american fuzzy lop

American fuzzy lop is a security-oriented fuzzer that employs a novel type of compile-time instrumentation and genetic algorithms to automatically discover clean, interesting test cases that trigger new internal states in the targeted binary. This substantially improves the functional coverage for the fuzzed code. The compact synthesized corpora produced by the tool are also useful for seeding other, more labor- or resource-intensive testing regimes down the road.

http://lcamtuf.coredump.cx/afl/

IJG jpeg [1]	libjpeg-turbo [1,2]	libpng [1]
libtiff [1,2,3,4,5]	mozjpeg [1]	PHP [1,2,3,4]
Mozilla Firefox [1,2,3,4]	Internet Explorer [1,2,3,4]	Apple Safari (1) (2)
Adobe Flash / PCRE [1,2]	sqlite [1,2,3,4]...	OpenSSL [1,2,3,4]
LibreOffice [1,2,3,4]	poppler [1]	freetype [1,2]
GnuTLS [1]	GnuPG [1,2,3,4]	OpenSSH [1,2,3]
bash (post-Shellshock) [1,2]	tcpdump [1,2,3,4,5,6,7,8]	JavaScriptCore [1,2,3,4]
pdfium [1,2]	ffmpeg [1,2,3,4]	libmatroska [1]
libarchive [1,2,3,4,5,6] ...	wireshark [1,2]	ImageMagick [1,2,3,4,5,6,7,8] ...
BIND [1]	QEMU [1,2]	lcms [1]
Oracle BerkeleyDB [1,2]	Android / libstagefright [1,2]	iOS / ImageIO [1]
FLAC audio library [1,2]	libsndfile [1,2,3]	less / lesspipe [1,2,3]
strings (+ related tools) [1,2,3,4,5,6,7]	file [1,2,3,4]	dpkg [1]
rcs [1]	systemd-resolved [1,2]	libyaml [1]
Info-Zip unzip [1,2]	libtasn1 [1,2]	OpenBSD pfctl [1]
NetBSD bpf [1]	man & mandoc [1,2,3,4,5] ...	IDA Pro [reported by authors]

clamav [1,2,3,4,5]	libxml2 [1]	glibc [1]
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mutt [1]	procmail [1]	fontconfig [1]
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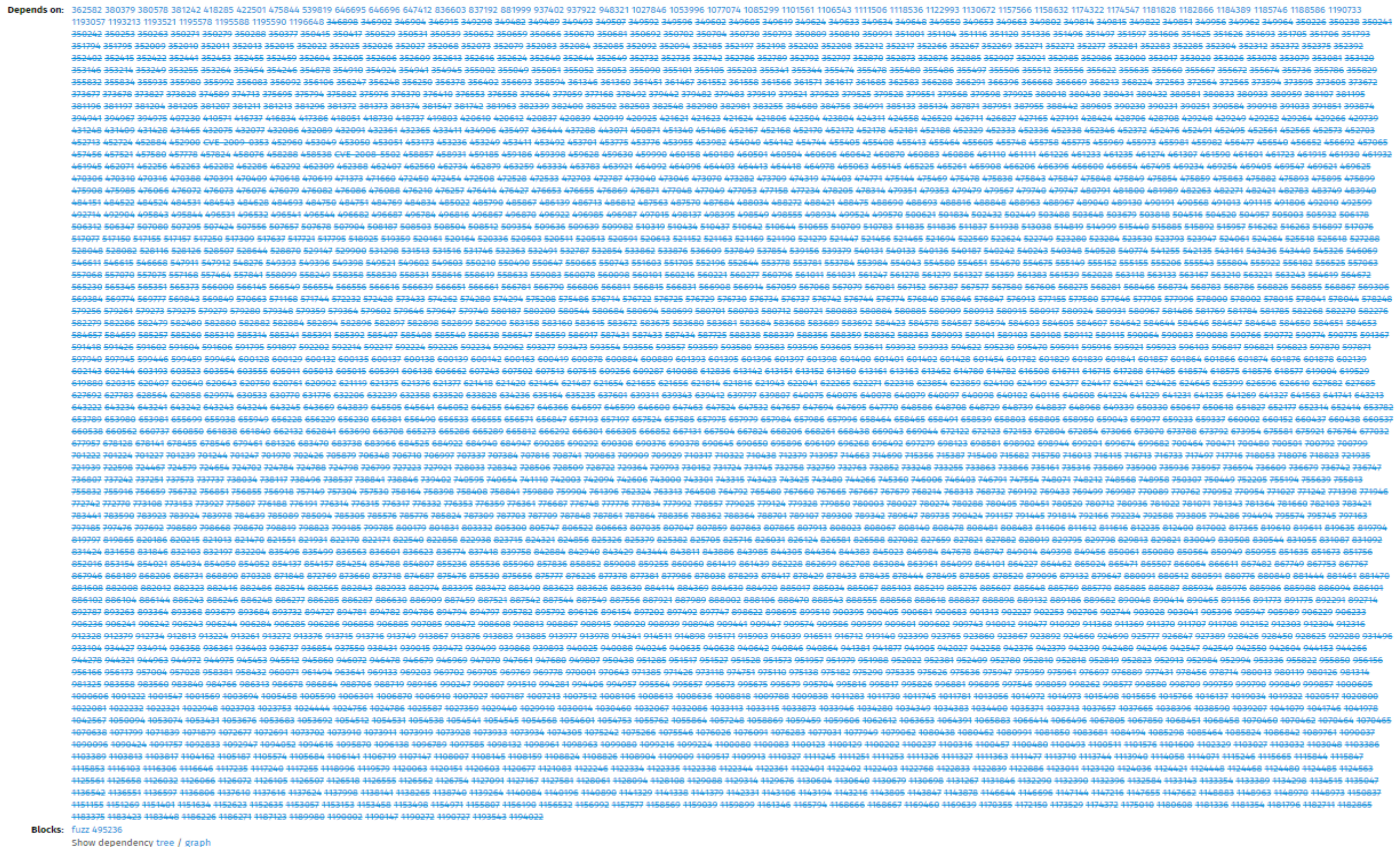
redis / lua-cmsgpack [1]	taglib [1,2,3]	privoxy [1]
perl [1,2,3,4,5,6,7]...	libxmp	radare2 [1,2]
SleuthKit [1]	fwknop [reported by author]	X.Org [1]
exifprobe [1]	jhead [?]	capnproto [1]
Xerces-C [1]	metacam [1]	djvulibre [1]
exiv [1]	Linux btrfs [1,2,3,4]	Knot DNS [1]
curl [1,2]	wpa_supplicant [1]	libde265 [reported by author]
dnsmasq [1]	libbpg (1)	lame [1]
libwmf [1]	uudecode [1]	MuPDF [1]
imlib2 [1]	libraw [1]	libbson [1]
libsass [1]	yara [1,2,3,4]	W3C tidy-html5 [1]
UPX [1]	FreeBSD syscons [1]	John the Ripper [1,2]

jsfunfuzz



Depends on: 362582 380379 380578 381242 418285 422501 475844 539819 646695 646696 647412 836603 837192 881999 937402 937922 948321 1027846 1053996 1077074 1085299 1101561 1106543 1111506 1118536 1122993 1130672 1157566 1158632 1174322 1174547 1181828 1182866 1184389 1185746 1188586 1190733
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Blocks: fuzz 495236
Show dependency tree / graph

GO FUZZ SOME STUFF