Exploiting Vulnerabilities in Media Software

iSEC Partners

https://www.isecpartners.com

Agenda

- Introduction
  - Why media software?
  - Why bugs are still out there
  - How we're going to bang them out
- Fuzzing techniques
  - Why/What/How
  - Fuzzbox
- Codecs to attack
  - Ogg Vorbis
  - MP3
  - FLAC
  - Speex
  - Raw formats: PCM/WAV, AIFF

Agenda

- Case studies: blown up software
- Demo
- Q&A

Introduction

- Hello
  - I'm a consultant for iSEC Partners
  - Focus on application security
  - UNIX grump
  - Audio hobbyist
- What's this all about?
  - The attack surface and potential of media codecs
  - Focus here is on audio, but that doesn't matter
  - Video works the same way, and uses the same container formats

Why this matters

- Omnipresent, and always on
  - Promiscuously shared, played, streamed
  - Come from extremely untrusted, often anonymous sources
  - Who thinks to refrain from playing “untrusted” sounds?
  - Most browsers will play automatically anyhow
- It's political
  - There are people out there who don't like you stealing music
  - Like me, for example
  - But mostly I mean the RIAA, and companies like Sony
  - Ripe for corporate abuse
- It's “rich”
  - Media playback software is excessively functional
  - Does tons of parsing
- It's underexplored!

Why underexplored?

- Modern codecs are designed to be resistant to corruption
  - Bit-flipping an ogg file, for example, will usually not work
  - Example: zzuf, a popular bit-flipping fuzzer, noted VLC as being “robust” against fuzzing of Vorbis, Theora, FLAC
  - As zzuf notes, this does not mean there are no bugs; we just need a targeted fuzzer
- Most exploits thus far have been simple
  - Attacks on players: long playlists, URL names, etc
  - Few attacks using media files themselves
  - Even fewer targeting things on the codec level

Fuzzing techniques: what to fuzz

- Two main areas are important here
  - Content metadata
    - ID3, APEv2, Vorbis comments, album art, etc.
- Frame data
  - We're mostly interested in the frame header
  - Contains structural data describing overall file layout
    - Sample rate, number of frames, frame size, channels
  - Can be multiple types of frame headers in a file, especially in the case of container formats

Fuzzing techniques: what to fuzz with

- Obviously, random strings
  - Repeating one random ASCII char to help us spot stack pointer overwrites
  - Throw in some random unicode, encoded in funny ways
  - Format strings
  - Just a bunch of %ns to give us some memory corruption
  - Random signed ints
  - Fencepost numbers
- HTML! More on this later.
- URLs – maybe we can catch some URL pingbacks

Fuzzing techniques: how to fuzz it

- Three possible approaches
  - Reach in and just mutate
    - Might work, might not
    - Works a sad amount of the time
- Use existing parsing libraries
  - Works well, but usually requires patching the libs
  - Built-in error handling will obviously trip us up
  - Metadata editing libraries don't always allow changing of data we want
  - Let's use this for basic stuff like ID3 tags and Vorbis comments
- Make your own frame parser
  - Sometimes quick and easy, sometimes painful
  - But turns up some great bugs

The toolbox

- A few tools to make fuzzing and parsing easier:

- Hachoir
  - Dissects many file types visually
- mutagen
  - Help in mangling audio tags and understanding file layout
- vbindiff
  - shows differences between fuzzed and non-fuzzed files
- bvi
  - a hex editor with keybindings similar to a certain one true editor
- gdb

Fuzzbox

- A multi-codec audio stream fuzzer, written in Python
- Targets specific codecs, no general file fuzzing
- Uses third party libs like py-vorbis and mutagen for metadata fuzzing
- Uses built-in frame parsing for frame fuzzing
- NOT another “fuzzing framework”
- An example of real-world fuzzers used in pen-testing: quick, dirty and targeted

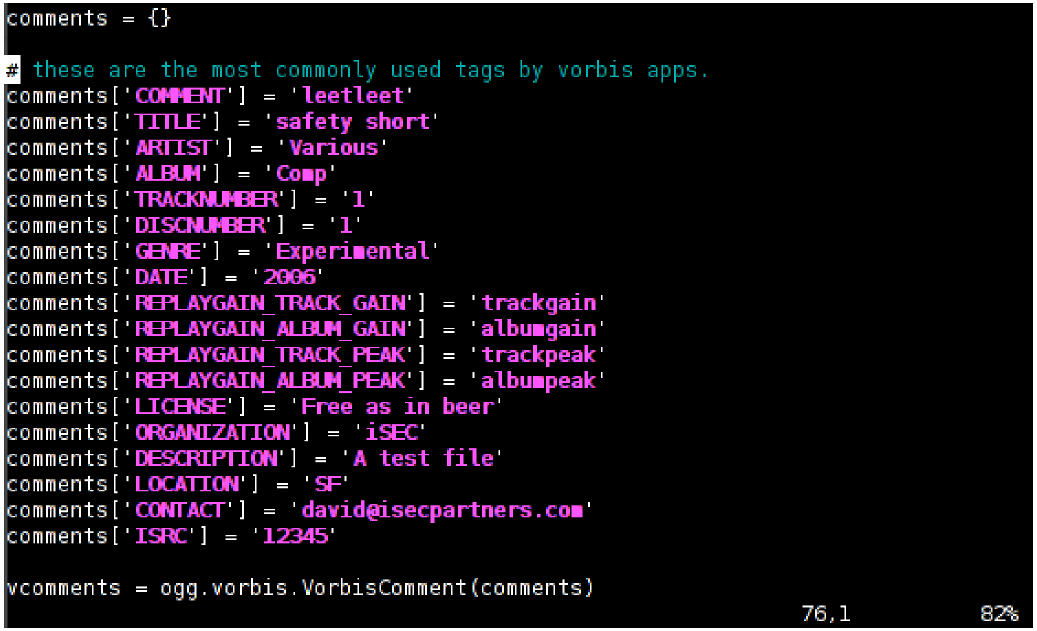
Ogg Frame Structure

- Case study: Ogg Vorbis
  - Excellent free codec
  - Well documented
  - Not just for hippies
  - Unencumbered status gets it into many things
  - Consists of an Ogg container:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1| Byte
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| capture_pattern: Magic number for page start "OggS"           | 0-3
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| version       | header_type   | granule_position              | 4-7
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               | 8-11
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               | bitstream_serial_number       | 12-15
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               | page_sequence_number          | 16-19
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               | CRC_checksum                  | 20-23
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               | page_segments | segment_table | 24-27
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| ...                                                           | 28-
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
```

Vorbis Frame Structure

- ...with a chewy Vorbis center
  - Contains channels, sample rate, etc
  - Also “Vorbis comments”
    - Simple name/value pairs – can be any length or content, but some have special meaning
    - Easiest to use existing libs for this – in this case, py-vorbis



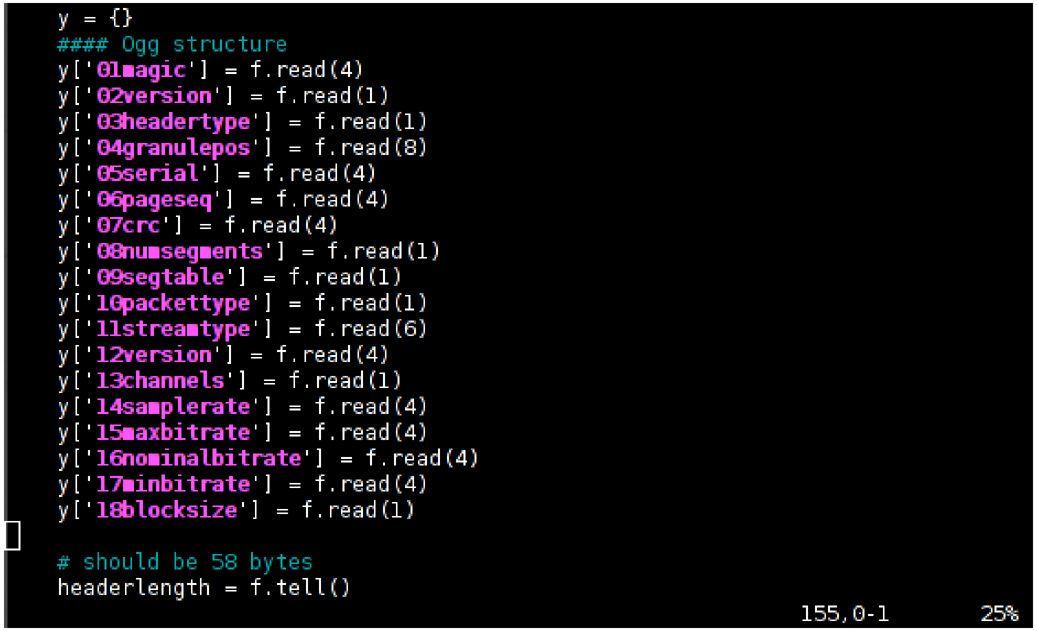
```
comments = {}

# these are the most commonly used tags by vorbis apps.
comments['COMMENT'] = 'leetleet'
comments['TITLE'] = 'safety short'
comments['ARTIST'] = 'Various'
comments['ALBUM'] = 'Comp'
comments['TRACKNUMBER'] = '1'
comments['DISCNUMBER'] = '1'
comments['GENRE'] = 'Experimental'
comments['DATE'] = '2006'
comments['REPLAYGAIN_TRACK_GAIN'] = 'trackgain'
comments['REPLAYGAIN_ALBUM_GAIN'] = 'albumgain'
comments['REPLAYGAIN_TRACK_PEAK'] = 'trackpeak'
comments['REPLAYGAIN_ALBUM_PEAK'] = 'albumpeak'
comments['LICENSE'] = 'Free as in beer'
comments['ORGANIZATION'] = 'iSEC'
comments['DESCRIPTION'] = 'A test file'
comments['LOCATION'] = 'SF'
comments['CONTACT'] = 'david@isecpartners.com'
comments['ISRC'] = '12345'

vcomments = ogg.vorbis.VorbisComment(comments)
                                                  76,1          82%
```

Ogg and Vorbis frame in Python

- Mercifully 8-bit aligned

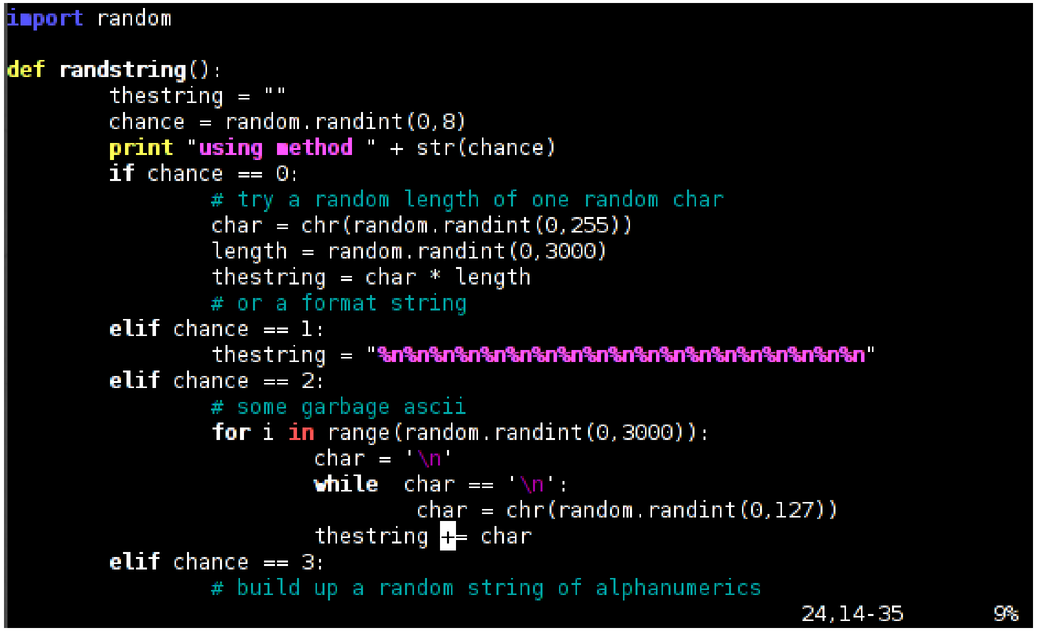


```
y = {}
#### Ogg structure
y['01magic'] = f.read(4)
y['02version'] = f.read(1)
y['03headertype'] = f.read(1)
y['04granulepos'] = f.read(8)
y['05serial'] = f.read(4)
y['06pageseq'] = f.read(4)
y['07crc'] = f.read(4)
y['08numsegments'] = f.read(1)
y['09segtable'] = f.read(1)
y['10packettype'] = f.read(1)
y['11streamtype'] = f.read(6)
y['12version'] = f.read(4)
y['13channels'] = f.read(1)
y['14samplerate'] = f.read(4)
y['15maxbitrate'] = f.read(4)
y['16nominalbitrate'] = f.read(4)
y['17minbitrate'] = f.read(4)
y['18blocksize'] = f.read(1)

# should be 58 bytes
headerlength = f.tell()
                                                  155,0-1        25%
```

Data loaded, feed to fuzzer

- Now we have comments and frame data
- Time to mangle them up
- Transforms are defined in randjunk.py:

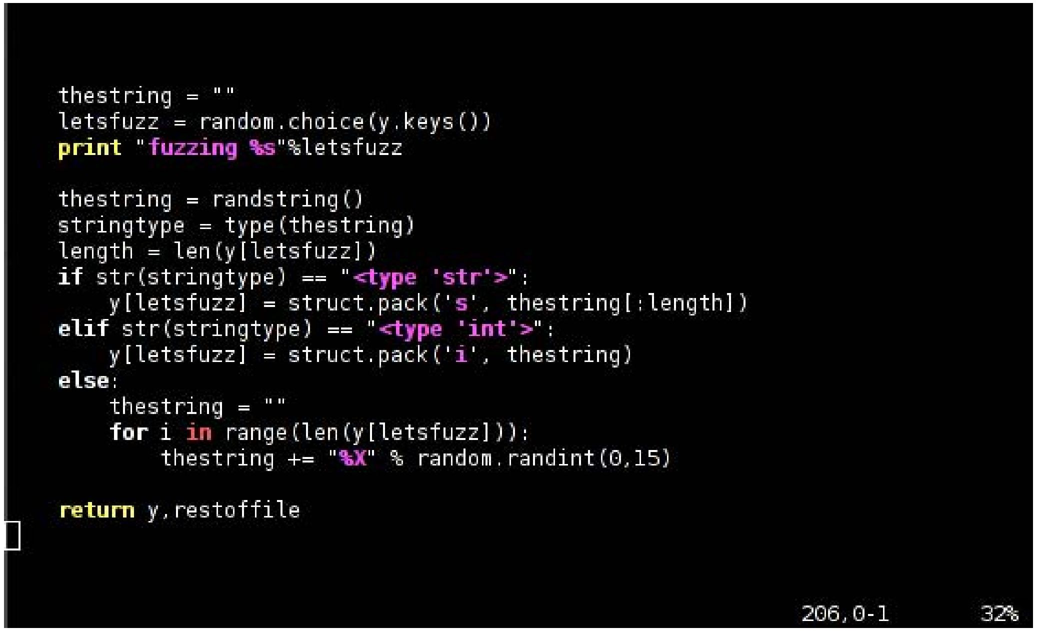


```
import random

def randstring():
        thestring = ""
        chance = random.randint(0,8)
        print "using method " + str(chance)
        if chance == 0:
                # try a random length of one random char
                char = chr(random.randint(0,255))
                length = random.randint(0,3000)
                thestring = char * length
                # or a format string
        elif chance == 1:
                thestring = "%n%n%n%n%n%n%n%n%n%n%n%n%n%n%n%n%n%n%n"
        elif chance == 2:
                # some garbage ascii
                for i in range(random.randint(0,3000)):
                        char = '\n'
                        while  char == '\n':
                                char = chr(random.randint(0,127))
                        thestring += char
        elif chance == 3:
                # build up a random string of alphanumerics
                                                              24,14-35       9%
```

Data fuzzed, writing back out

- In the case of comments, we just write them back in
- For our frame data, we need to pack it:



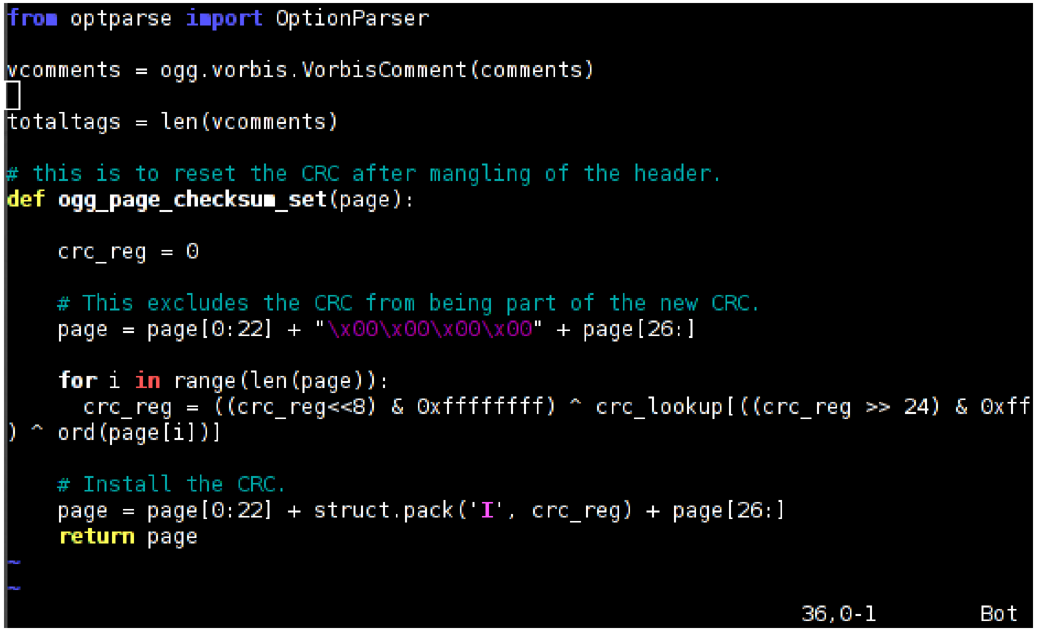
```
thestring = ""
letsfuzz = random.choice(y.keys())
print "fuzzing %s"%letsfuzz

thestring = randstring()
stringtype = type(thestring)
length = len(y[letsfuzz])
if str(stringtype) == "<type 'str'>":
    y[letsfuzz] = struct.pack('s', thestring[:length])
elif str(stringtype) == "<type 'int'>":
    y[letsfuzz] = struct.pack('i', thestring)
else:
    thestring = ""
    for i in range(len(y[letsfuzz])):
        thestring += "%X" % random.randint(0,15)

return y,restoffile
```

Fix the CRC

- Every ogg frame has a CRC to prevent corruption
  - Also hides bugs :(
  - But, easy enough to fix



```
from optparse import OptionParser

vcomments = ogg.vorbis.VorbisComment(comments)

totaltags = len(vcomments)

# this is to reset the CRC after mangling of the header.
def ogg_page_checksum_set(page):

    crc_reg = 0

    # This excludes the CRC from being part of the new CRC.
    page = page[0:22] + "\x00\x00\x00\x00" + page[26:]

    for i in range(len(page)):
      crc_reg = ((crc_reg<<8) & 0xffffffff) ^ crc_lookup[((crc_reg >> 24) & 0xff
) ^ ord(page[i])]

    # Install the CRC.
    page = page[0:22] + struct.pack('I', crc_reg) + page[26:]
    return page
~
~
                                                               36,0-1        Bot
```

Other supported formats

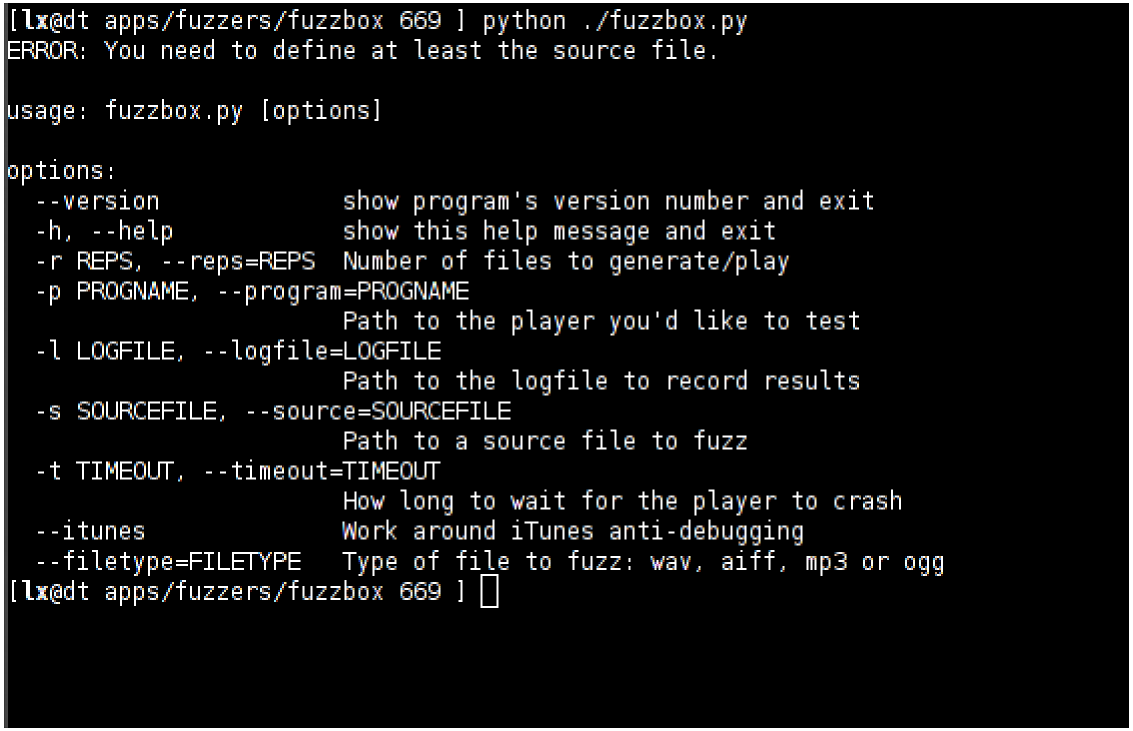
- MP3
  - Metadata with ID3
  - ID3v1
    - Length limited
    - Stored at end of file
    - Great for rewriting, awful for streaming
  - ID3v2
    - Massively structured and complex
    - Incompletely supported
    - I hope it dies
- FLAC
  - Lossless audio – uses Vorbis comments for metadata, can use Ogg as a container

Even more supported formats

- WAV and AIFF
  - What's to attack in raw audio?
  - Not much, but it still works
  - Sample width, framerate, frame number; all things that can expose integer bugs
  - WAV and AIFF parsing libraries are included with Python
- Speex
  - Optimized for speech
  - Used in several high-profile third-party products
  - Uses vorbis comments for metadata
  - Can be stored in an Ogg container

Setting up a fuzzer run

- Basic usage of fuzzbox



```
[lx@dt apps/fuzzers/fuzzbox 669 ] python ./fuzzbox.py
ERROR: You need to define at least the source file.

usage: fuzzbox.py [options]

options:
  --version             show program's version number and exit
  -h, --help            show this help message and exit
  -r REPS, --reps=REPS  Number of files to generate/play
  -p PROGNAME, --program=PROGNAME
                        Path to the player you'd like to test
  -l LOGFILE, --logfile=LOGFILE
                        Path to the logfile to record results
  -s SOURCEFILE, --source=SOURCEFILE
                        Path to a source file to fuzz
  -t TIMEOUT, --timeout=TIMEOUT
                        How long to wait for the player to crash
  --itunes              Work around iTunes anti-debugging
  --filetype=FILETYPE   Type of file to fuzz: wav, aiff, mp3 or ogg
[lx@dt apps/fuzzers/fuzzbox 669 ] 
```

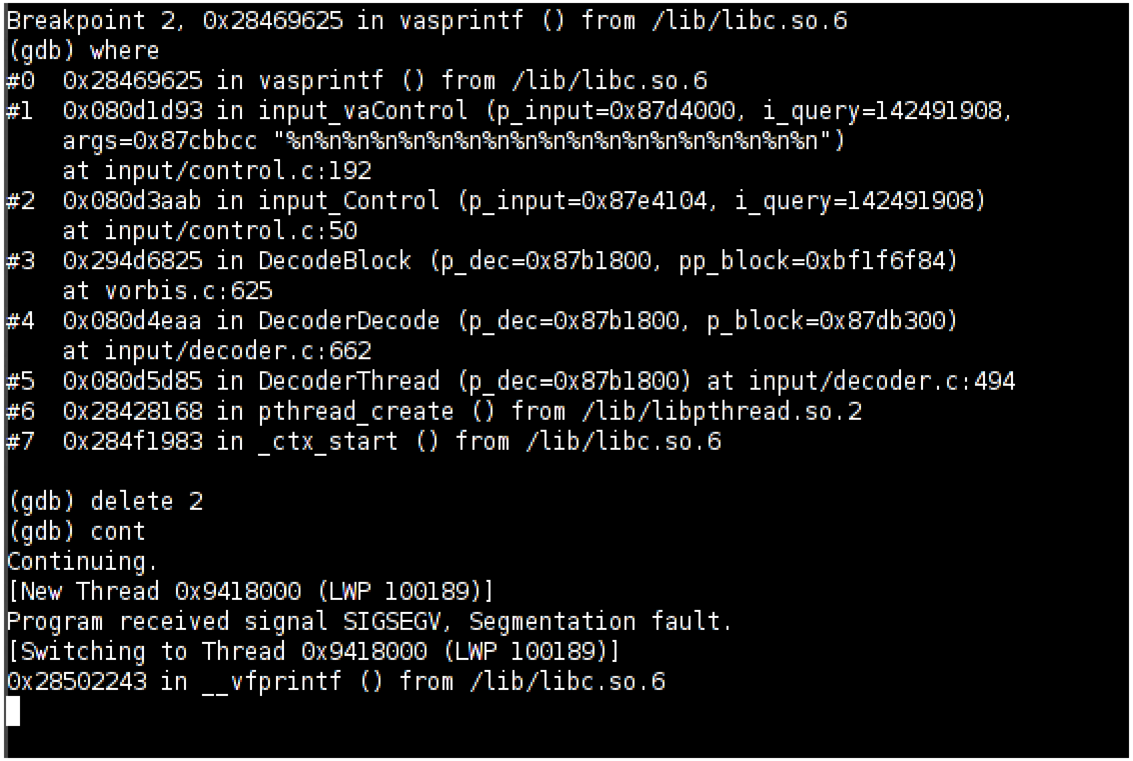
Demo

Nifty features

- Autoplay mode – kicks off a player of your choice under gdb
- Gathers backtraces, registers and resource usage
- iTunes anti-anti-debugging
- iTunes automation with AppleScript
- Kills off runaway apps

Fallout: VLC

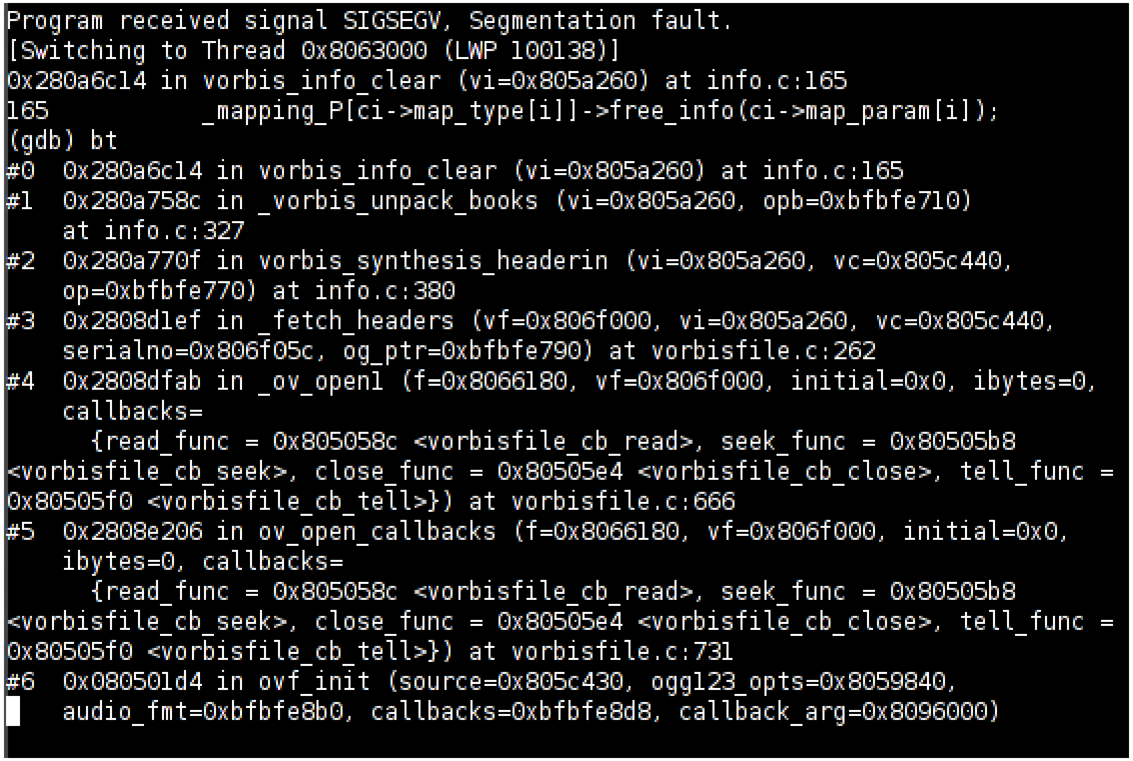
- Format string issues in Vorbis comments
  - Also CDDA, SAP/SDP – broadcast exploitation!



```
Breakpoint 2, 0x28469625 in vasprintf () from /lib/libc.so.6
(gdb) where
#0  0x28469625 in vasprintf () from /lib/libc.so.6
#1  0x080d1d93 in input_vaControl (p_input=0x87d4000, i_query=142491908,
    args=0x87cbbcc "%n%n%n%n%n%n%n%n%n%n%n%n%n%n%n%n%n%n%n")
    at input/control.c:192
#2  0x080d3aab in input_Control (p_input=0x87e4104, i_query=142491908)
    at input/control.c:50
#3  0x294d6825 in DecodeBlock (p_dec=0x87b1800, pp_block=0xbf1f6f84)
    at vorbis.c:625
#4  0x080d4eaa in DecoderDecode (p_dec=0x87b1800, p_block=0x87db300)
    at input/decoder.c:662
#5  0x080d5d85 in DecoderThread (p_dec=0x87b1800) at input/decoder.c:494
#6  0x28428168 in pthread_create () from /lib/libpthread.so.2
#7  0x284f1983 in _ctx_start () from /lib/libc.so.6

(gdb) delete 2
(gdb) cont
Continuing.
[New Thread 0x9418000 (LWP 100189)]
Program received signal SIGSEGV, Segmentation fault.
[Switching to Thread 0x9418000 (LWP 100189)]
0x28502243 in __vfprintf () from /lib/libc.so.6
```

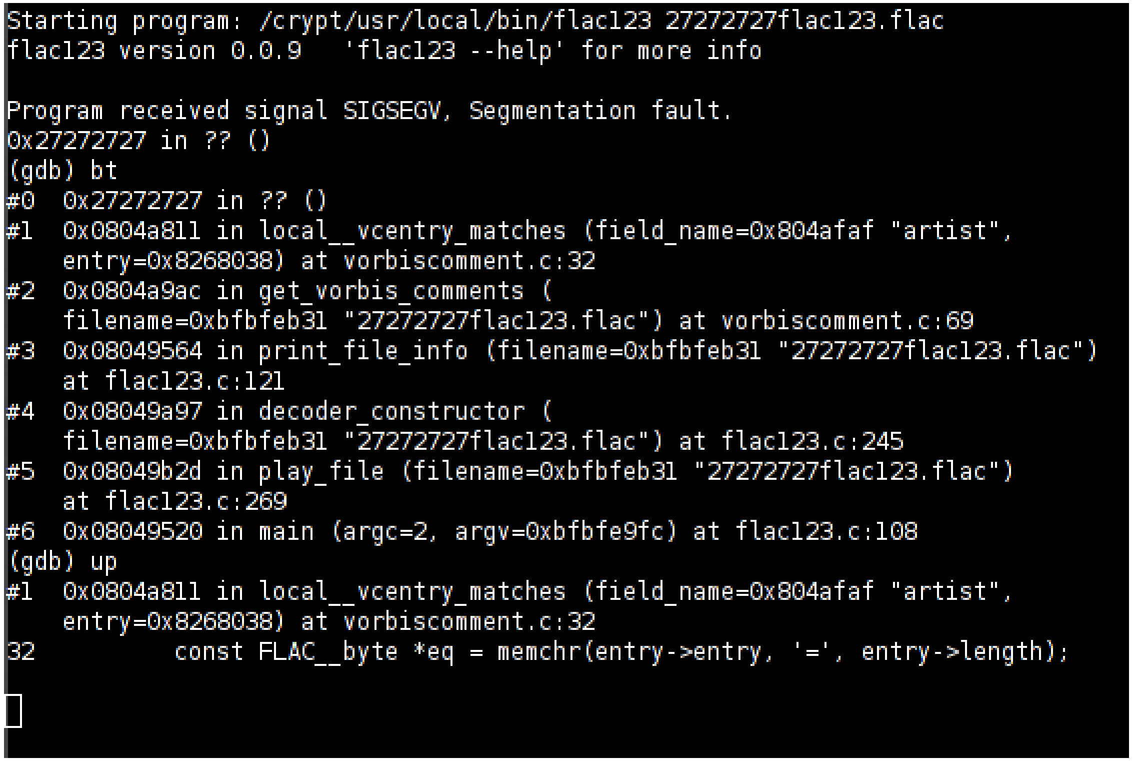
Fallout: libvorbis



```
Program received signal SIGSEGV, Segmentation fault.
[Switching to Thread 0x8063000 (LWP 100138)]
0x280a6c14 in vorbis_info_clear (vi=0x805a260) at info.c:165
165             _mapping_P[ci->map_type[i]]->free_info(ci->map_param[i]);
(gdb) bt
#0  0x280a6c14 in vorbis_info_clear (vi=0x805a260) at info.c:165
#1  0x280a758c in _vorbis_unpack_books (vi=0x805a260, opb=0xbfbfe710)
    at info.c:327
#2  0x280a770f in vorbis_synthesis_headerin (vi=0x805a260, vc=0x805c440,
    op=0xbfbfe770) at info.c:380
#3  0x2808d1ef in _fetch_headers (vf=0x806f000, vi=0x805a260, vc=0x805c440,
    serialno=0x806f05c, og_ptr=0xbfbfe790) at vorbisfile.c:262
#4  0x2808dfab in _ov_open1 (f=0x8066180, vf=0x806f000, initial=0x0, ibytes=0,
    callbacks=
      {read_func = 0x805058c <vorbisfile_cb_read>, seek_func = 0x80505b8
<vorbisfile_cb_seek>, close_func = 0x80505e4 <vorbisfile_cb_close>, tell_func =
0x80505f0 <vorbisfile_cb_tell>}) at vorbisfile.c:666
#5  0x2808e206 in ov_open_callbacks (f=0x8066180, vf=0x806f000, initial=0x0,
    ibytes=0, callbacks=
      {read_func = 0x805058c <vorbisfile_cb_read>, seek_func = 0x80505b8
<vorbisfile_cb_seek>, close_func = 0x80505e4 <vorbisfile_cb_close>, tell_func =
0x80505f0 <vorbisfile_cb_tell>}) at vorbisfile.c:731
#6  0x080501d4 in ovf_init (source=0x805c430, ogg123_opts=0x8059840,
█   audio_fmt=0xbfbfe8b0, callbacks=0xbfbfe8d8, callback_arg=0x8096000)
```

Fallout: flac-tools

- Stack overflow in metadata parsing



```
Starting program: /crypt/usr/local/bin/flac123 27272727flac123.flac
flac123 version 0.0.9   'flac123 --help' for more info

Program received signal SIGSEGV, Segmentation fault.
0x27272727 in ?? ()
(gdb) bt
#0  0x27272727 in ?? ()
#1  0x0804a811 in local__vcentry_matches (field_name=0x804afaf "artist",
    entry=0x8268038) at vorbiscomment.c:32
#2  0x0804a9ac in get_vorbis_comments (
    filename=0xbfbfeb31 "27272727flac123.flac") at vorbiscomment.c:69
#3  0x08049564 in print_file_info (filename=0xbfbfeb31 "27272727flac123.flac")
    at flac123.c:121
#4  0x08049a97 in decoder_constructor (
    filename=0xbfbfeb31 "27272727flac123.flac") at flac123.c:245
#5  0x08049b2d in play_file (filename=0xbfbfeb31 "27272727flac123.flac")
    at flac123.c:269
#6  0x08049520 in main (argc=2, argv=0xbfbfe9fc) at flac123.c:108
(gdb) up
#1  0x0804a811 in local__vcentry_matches (field_name=0x804afaf "artist",
    entry=0x8268038) at vorbiscomment.c:32
32          const FLAC__byte *eq = memchr(entry->entry, '=', entry->length);

```

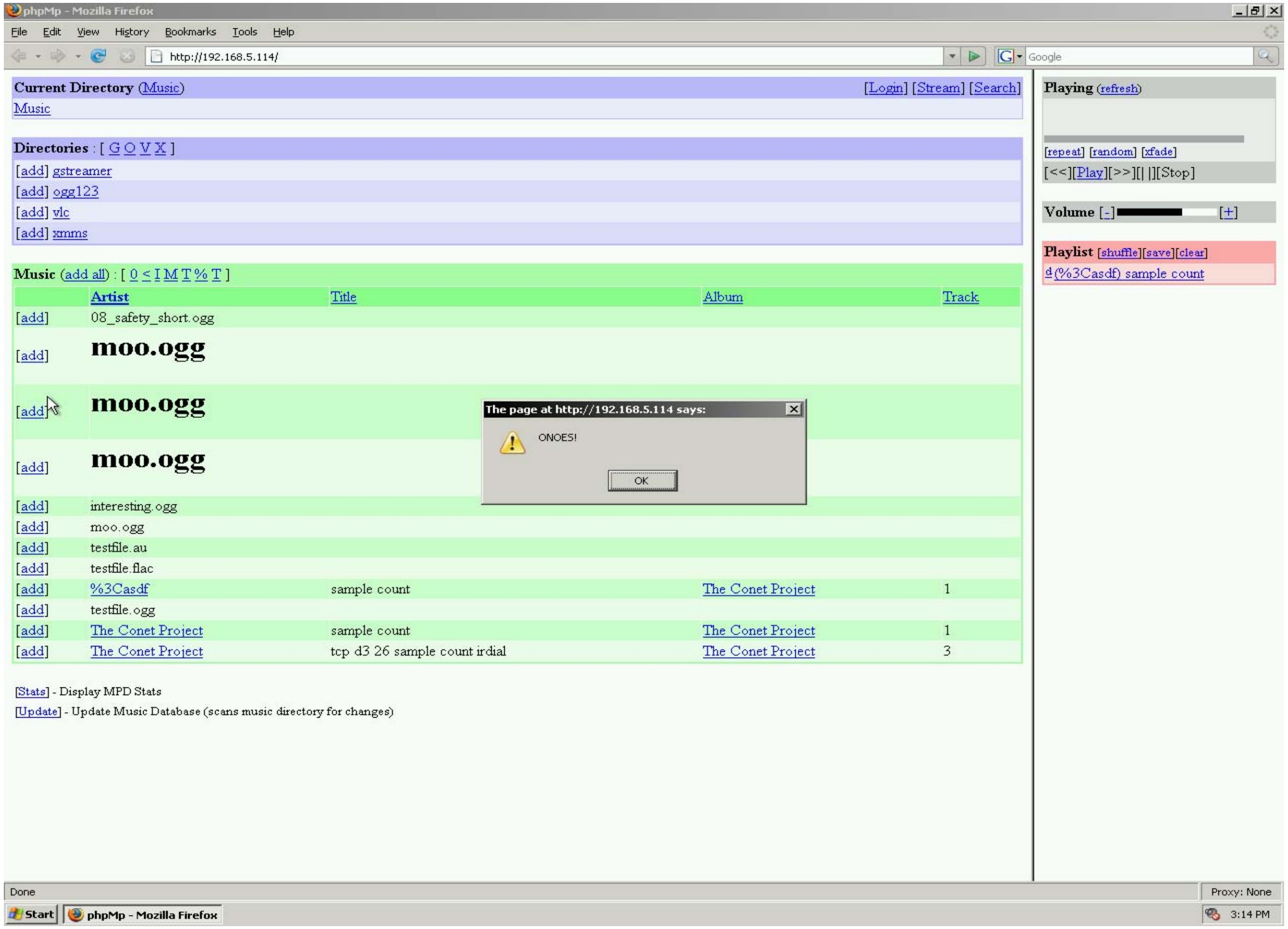
Demo

OMG!!1!

Collateral Damage

- Non-player apps, or “nobody uses Vorbis!”
  - As mentioned before, some of these codecs get around
  - Used in games – custom sounds downloaded with maps...
  - Asterisk does.
    - (O_o);;;
    - It also supports Speex, which is structurally very similar...
    - In other words, any DoS or code execution in Ogg/Vorbis means the same for Asterisk
- Web applications
  - Some apps aren't real careful about data parsed from media
  - Cool for CSRF, XSS or Javascript intranet scanning
- Indexing services and other parsers
  - Software like Beagle relies on media libraries to index
  - Exploits in these libraries affect the indexer
  - Can also be a venue for finding bugs in the indexer itself
  - Or its web interface

phpMp



Current Directory (Music) [Login] [Stream] [Search]

Music

Directories : [G O V X]

[add] gstreamer
[add] ogg123
[add] vlc
[add] xmms

Music (add all) : [0 < I M T % T]

	Artist	Title	Album	Track
[add]	08_safety_short.ogg			
[add]	**moo.ogg**			
[add]	**moo.ogg**			
[add]	**moo.ogg**			
[add]	interesting.ogg			
[add]	moo.ogg			
[add]	testfile.au			
[add]	testfile.flac			
[add]	%3Casdf	sample count	The Conet Project	1
[add]	testfile.ogg			
[add]	The Conet Project	sample count	The Conet Project	1
[add]	The Conet Project	tcp d3 26 sample count irdial	The Conet Project	3

The page at http://192.168.5.114 says:

ONOES!

OK

[Stats] - Display MPD Stats
[Update] - Update Music Database (scans music directory for changes)

Playing (refresh)

[repeat] [random] [xfade]

[<<][Play][>>][| |][Stop]

Volume [-] [+]

Playlist [shuffle][save][clear]

d (%3Casdf) sample count

Questions?

- Thanks for coming!
- Thanks to:
  - Chris Palmer, Jesse Burns, Tim Newsham

Q&A

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