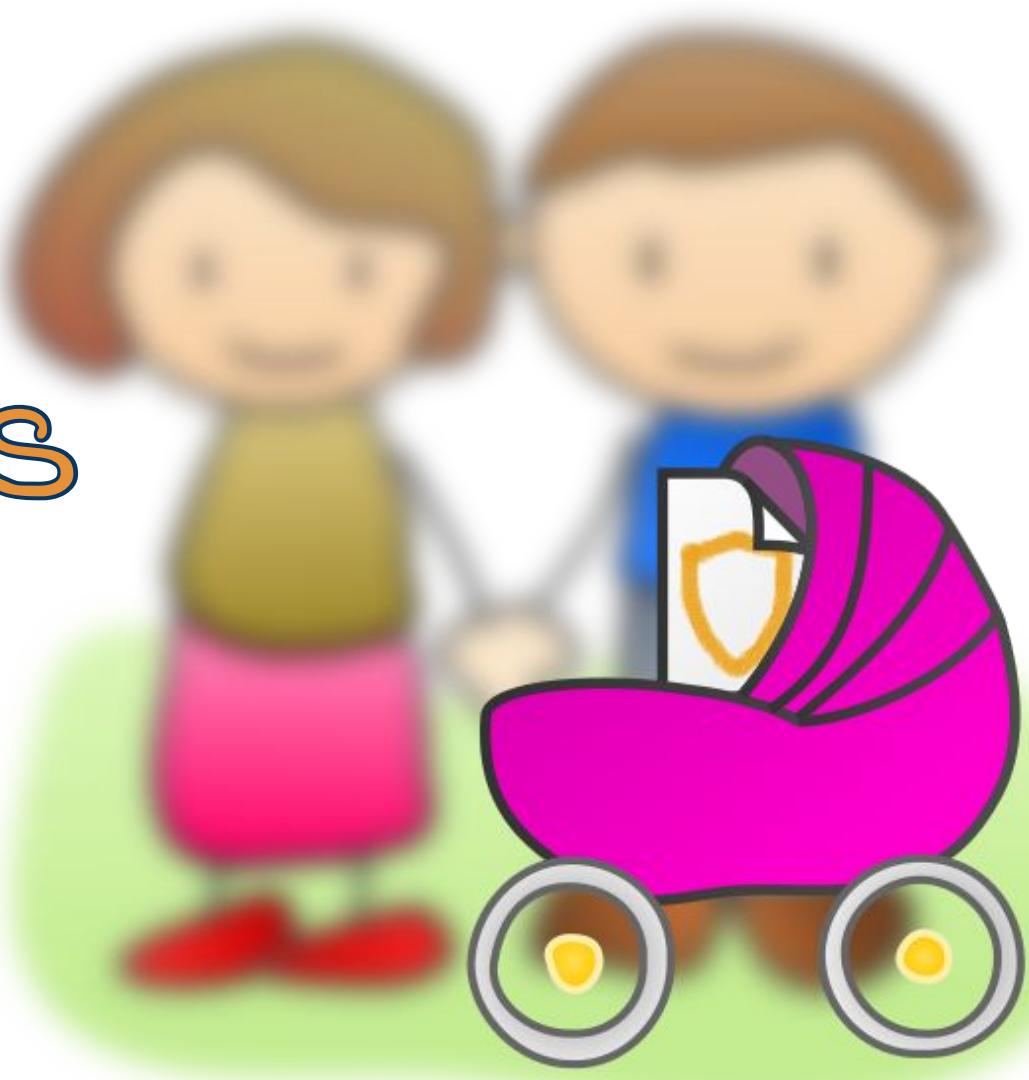


# Caring for file formats

Ange Albertini  
Troopers 2016



# TL;DR

- Attack surface with file formats is too big.
  - Specs are useless (just a nice ‘guide’), not representing reality.
  - We can’t deprecate formats because we can’t preserve and we can’t define how they *really* work
- 
- We need open good libraries to simplify landscape, and create a corpus to express the reality of file format, which gives us real “documentation”.
  - Then we can preserve and deprecate older format, which reduces attack surface.
  - From then on, we can focus on making the present more secure.
- 
- We don’t need “new” formats: we need ‘alive’ specs and files corpus. Otherwise specs will always diverge from reality.

# ANGE ALBERTINI

## reverse engineering

### VISUAL DOCUMENTATION

@angealbertini

ange@corkami.com

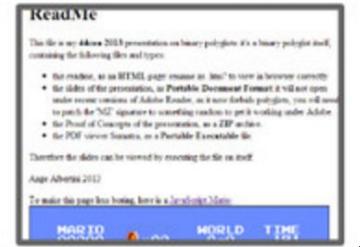
<http://www.corkami.com>

Welcome to my talk!

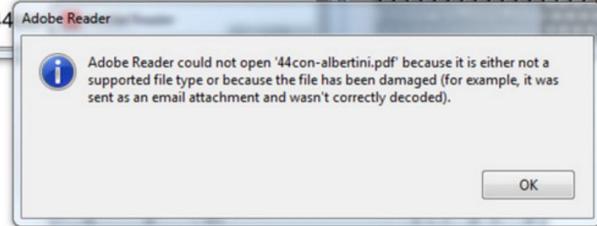
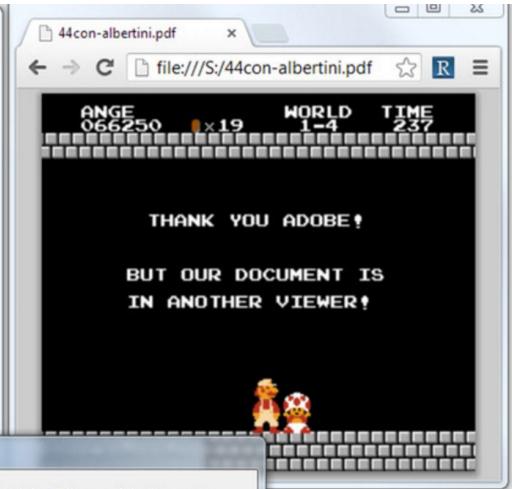




HTML

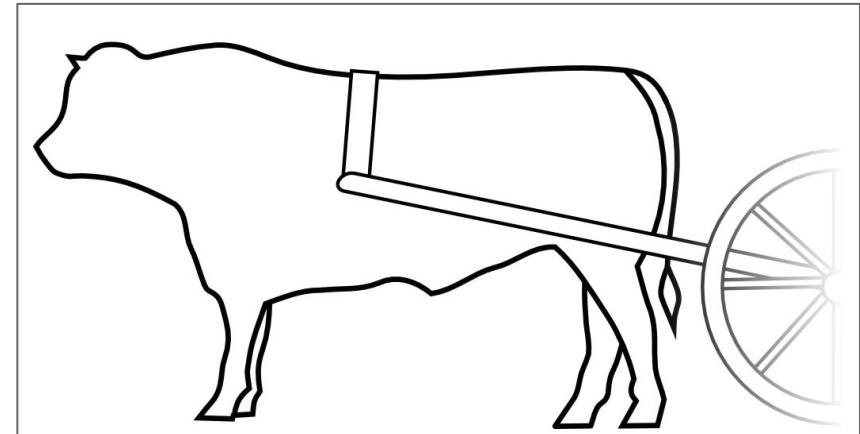
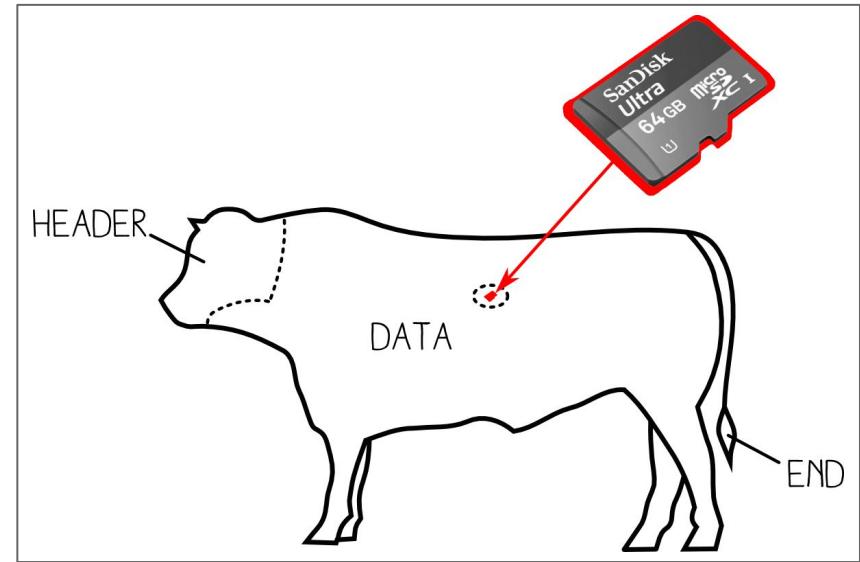
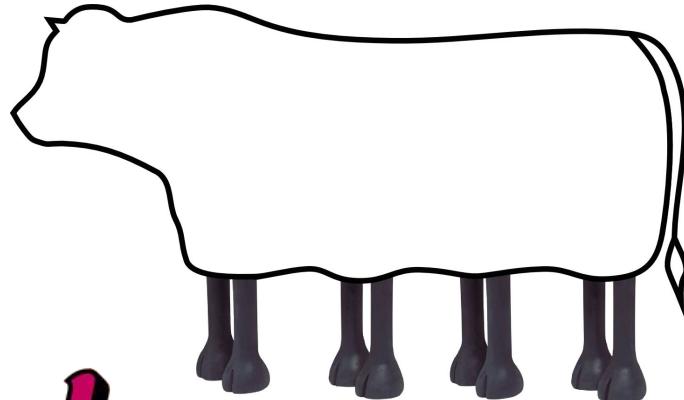


I make polyglots (multi-type files),  
schizophrenics (multi-behavior)...

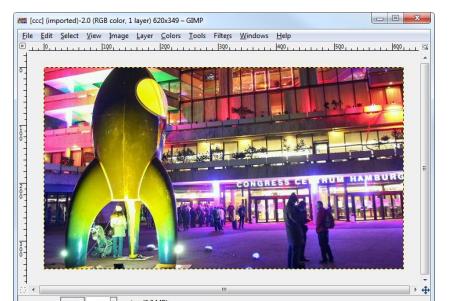


# Funky File Formats

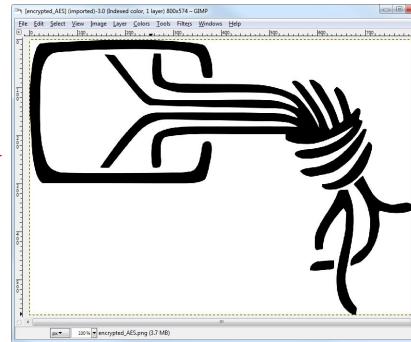
I tried to explain file formats with cows...  
But that didn't really tell why people should care.



JPG



$\rightarrow$   
 $AES_{K_1}$



PNG

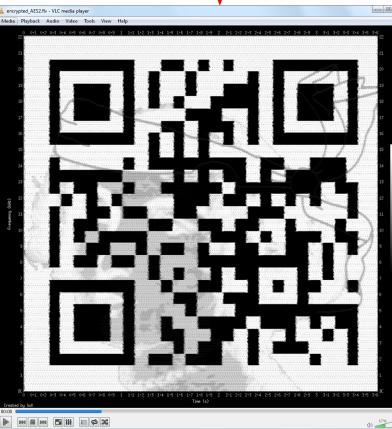
JAR  
(ZIP + CLASS)

```
>java -jar ccc.jpg  
Hello World! [Java]
```

$\rightarrow$   
 $AES_{K_2}$

3DES

PDF



FLV

I really like to play with file formats...

# PoC||GTFO

Preacherman

Editor of Last Resort

TeXnician

Editorial Whipping Boy

Funky File Supervisor

Assistant Scenic Designer

and sundry others

Manul Laphroaig

Melilot

Evan Sultanik

Jacob Torrey

Ange Albertini

Philippe Teuwen

I'm a part of PoC||GTFO,  
for which I'm a file format  
user and abuser.

# PoC||GTFO: many file formats

- Articles  
PDFLaTeX PDFBook Inkscape GhostScript Scribus Blender Gimp Fontforge  
PDFFont Mutool
- Proof of Concept  
Qpdf Xpdf Ruby Python Bash Truecrypt Wavpack Audacity Baudline Sox Tar  
Zip MkIsoFS LSnes PngOpt JpegSnoop AdvPNG Nasm Qemu BPGEnc

And *many* custom scripts handling file formats in unconventional ways...

I'm interested about hardware preservation



and digital preservation.

# My interests

- Using file formats
  - graphics, 3d, music...
- Abusing file formats
  - polyglot, schizophrenia, hash collisions...
- Preserving file formats
  - Retro-gaming, digital archeology...

What is a file format?

~~A miserable little pile of secrets~~

Not just a sequence of binary

If you [/your program] generate  
a picture of any kind,  
you might want to export  
the result to something  
that you can re-use later.  
(same for any form of information)

What is a file format?

A computer dialect  
to communicate  
between communities.

File formats are  
community connectors.

Don't think so?  
Try exporting everything as XML ;)

# Most people don't care about <actor>

They only care about <roles>  
We mostly care about the input/output.

Example:

# We don't care about GIF

We mostly care about its characteristics  
and how easy it is to use.

No need to be emotional,  
and stay in our comfort zone.

# We don't really care about file formats.

We care about their characteristics.

Not groundbreaking,  
but supported “everywhere”.

# Why should infosec **care**?

Fuzz formats. Blame “bad” devs.  
Collect CVEs. Boast your ego.

```
10 PRINT "SOLVED ANYTHING YET?"  
20 GOTO 10
```

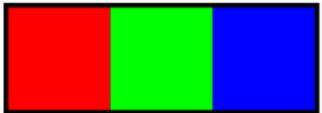
# Attack surface

- 1 OS = N supported formats
- For each format:
  - How many parsers?
  - For each parser:
    - Which version, compiler...

The PGM or PPM formats are the easiest way to convert any data in valid grayscale or RGB pictures.



<signature> <whitespace>  
P5 <width> <whitespace> <height> <whitespace>  
3 1 <max. value> <whitespace>  
255  
.ÿ  
<raw RGB values>  
00 80 FF



<signature> <whitespace>  
P6 <width> <whitespace> <height> <whitespace>  
3 1 <max. value> <whitespace>  
255  
ÿ ÿ ÿ  
<raw RGB values>  
FF 00 00 00 FF 00 00 00 FF

But most people don't know it's supported out of the box by many softwares.

We should reduce the attack surface.

How many unsuspected supported  
[sub-]formats and parsers?

<https://lcamtuf.blogspot.com/2014/10/psa-dont-run-strings-on-untrusted-files.html>

How many file formats supported  
by your browser ?

By your OS?

How many do you really need ?

Think “embedded”.

Capacity is still too cheap:  
we keep stacking formats/features,  
which doesn't solve anything.

It's a problem everywhere.  
We keep losing ground.

<!--

PoC||GTFO 10



ter looking at other options, we chose to use the Pokémon Red version, which uses a more reliable SGB detection routine that gets us access to the full SGB palette, a custom border, and consistent timing benefits we'll discuss later.<sup>7</sup> Using Pokémon Red also has another added benefit in that the entire game has been skillfully disassembled.<sup>8</sup>

### 3.3 The Emulator

When we started this project in August 2014, the only emulator capable of emulating an SGB inside of an SNES at a low enough level for our needs was the BSNES emulator. Unfortunately, although BSNES is very accurate at emulating an SNES, it doesn't do a very good job of emulating an SGB. The Gambarot Dot-Matrix Game Boy (DMG) emulator is likewise very accurate, but is unable to emulate an SGB on its own. Ilari was able to create a hybrid emulation core using BSNES to emulate the SNES↔DMG interface chip while using Gambarot for DMG emulation. This was a considerable undertaking, but in the end the emulator was very usable, albeit somewhat slow, as properly emulating the synchronization between the SNES CPU and the DMG CPU is a challenge. Ilari continued to provide emulator development and scripting support throughout the project.

### 3.4 The Hardware

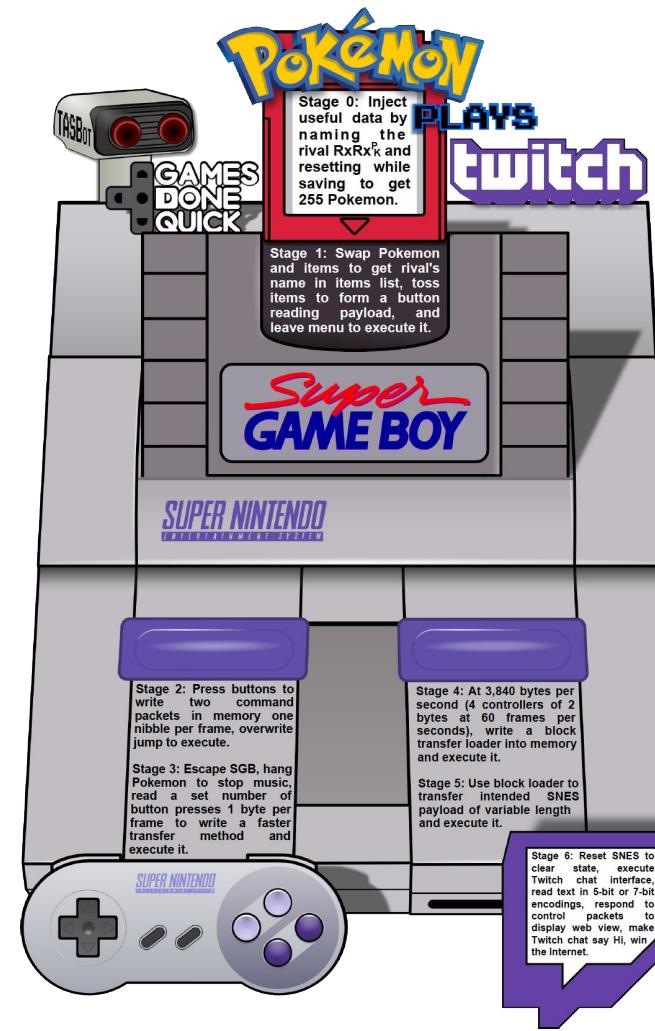
We didn't just want to exploit a game in the sandbox of a console emulator and call it a Proof of Concept. We wanted to do this properly and create an actual exploit that would work on real hardware. Only one member of our team (dwangoAC) had all the time and resources available to do this. After some discussion, he decided to build a TASBot, a serial-over-USB connected device, namely



Figure 1 – The legendary TASBot

### 3.5 The Plan

We were initially unsure what kind of payload to create once we had gained the ability to execute arbitrary code on the SNES. Initially we investigated methods of showing crude video, but abandoned it after spending far too much time failing to increase the framerate and running into limits with the processing speed of the SNES's 65C816 CPU. An IRC discussion about Twitch Plays Pokémon<sup>10</sup> led dwangoAC and p4plus2 to brainstorm what it would take to incorporate similar elements into our concept of *Pokémon Plays Twitch*. In the end, we took it to a chat interface on the SNES and giving TASBot, the robot holding the replay board, the ability to



# The file itself can perform the exploit (on the hardware or an emulator).



```
Loaded library C:\Users\Andrea\Downloads\pocorgtfo10\pocorgtfo10.lsmv
ROM Type Super Game Boy region NTSC
Rerecords 1654 length 08:11.425 (29534 frames)
Author: dwangoAC
Loaded 'C:\Users\Andrea\Downloads\pocorgtfo10\pocorgtfo10.lsmv' in 5311767 microseconds.
SNES reset
```

Beginning Page Up Line Up Line Down Page Down End

Isnes rr2-β23 [bsnes v085 / Gambatte r537]

File SGB Movie Speed Tools Configure Help

Ked also has another added benefit in that the entire game has been skillfully disassembled. unzip pocorgtfo10.pdf pokered-master.zip

RTC 20010909(Sun)T015428

P1 -----A-R-123

P2 --S---++XL-01--

P3 -----A-LR0-2-

P4 -----A-----

The emulator

When we started this project in August 2014, the only emulator capable of emulating an SGB inside of an SNES at a low enough level for our needs was the bsnes emulator.

Unfortunately, although bsnes is very accurate at emulating an SNES, it doesn't do a very good job of emulating an SGB. The Gambatte Dot-Matrix Game Boy (DMG) emulator is likewise very accurate, but is unable to emulate an SGB on its own. Ilari was able to create a hybrid emulation core using bsnes to emulate the SNES-DMG interface chip while using Gambatte for DMG emulation. This was a

Chat

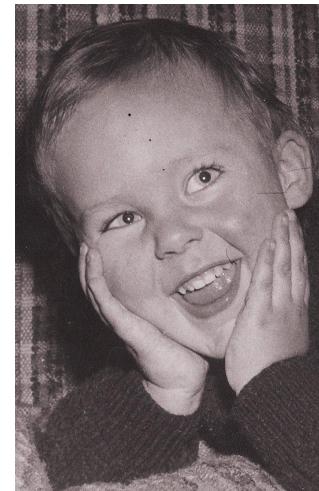
Frame: 28153/29534 Lag: 17231 Subframe: 0 Slot: 1 [Nonexistent] Speed: 110% Paused Playback

The payload displays the article.

-->

PoC||GTFO 10 is a PoC-ception:

- a PDF article describing the exploit
- a file performing the exploit  
(to display the article)



# **“young celebs”**

What they were supposed to be  
doesn't really matter.

What file formats were supposed to be  
doesn't matter anymore,  
what they are now is all we care.

Security cares about current reality,  
not obsolete theory.

We can blame bad parsers.  
What about the file formats?

If the map is unclear enough, you'll get lost anyway.

A blurry file format will never lead to a clean parser.

2 ways to communicate

use a ready-made translator:  
an import/export library

Write your own:  
read the specs.

# Landscapes



```
>crypto_hash *
test0.jpg 13990732b0d16c3e112f2356bd3d0dad1...
test1.jpg 13990732b0d16c3e112f2356bd3d0dad1...
```

To exploit hash collisions, I abused JPEG.  
To abuse JPEG “everywhere”, just abuse LibJPEG.

μΣ 9 ▶ μ♦ . . ú  
ΔΦ L F T G R J N  
, c n 8 y â ♦ 2 % j j ð  
ò C V Y F c ] s a ÿ T R

```
JPEG signature   Chunk marker      Chunk length
                 - ff d8 in block 1  - c4 00 in block 1
                 - ff e6 in block 2  - e4 00 in block 2

: ff d8 ff e? ?4 00 39 54 ?? 6d 04 2e ?? b7 b2 ??  (contains no 0xff)
?? 08 cf ?? ?? 46 d4 ?? ?? 0a 05 ?? ?? cb e2 ?? 
?? 87 fc ?? 38 98 83 ?? ?? 32 ac ?? ?? 6a a8 ?? 
?? 43 1f ?? ?? 66 87 f5 ?? 85 f7 ?? ?? 1c a9 ?? 

: ff fe b5 e9      <COMMENT chunk covering Image 1>
: ff e0            <start of Image 1>

...
ff d9            <end of Image 1> <end of comment>
: ff e0            <start of Image 2>
: ff d9            <end of Image 2>
```

# SHA-1 backdooring EXPLOITATION

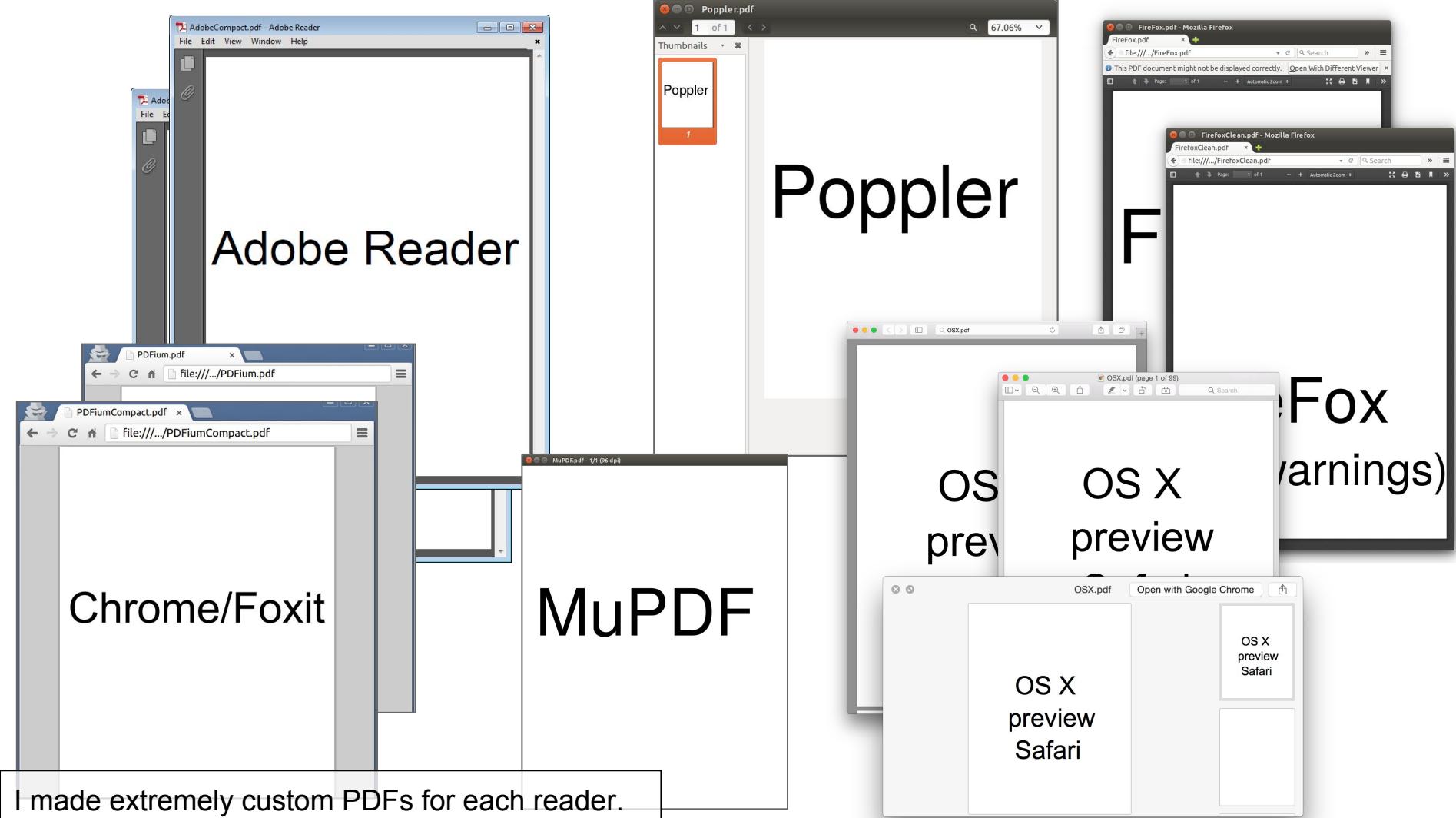
# JPEG format's landscape

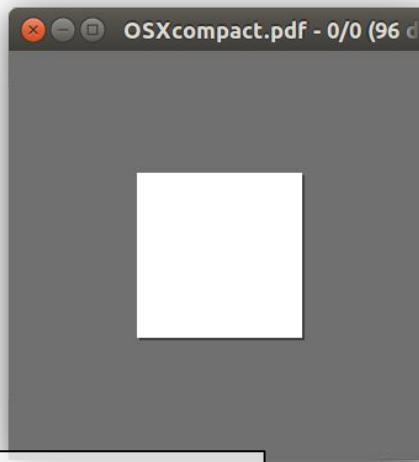
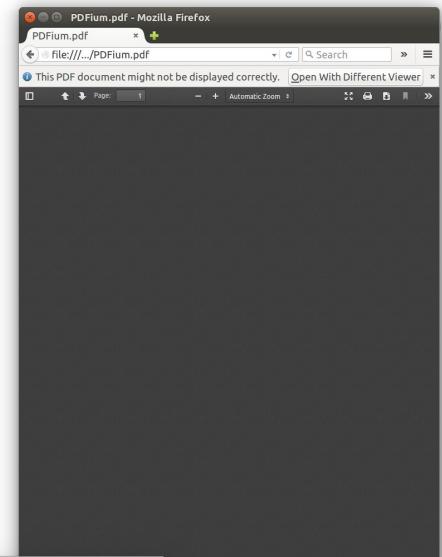
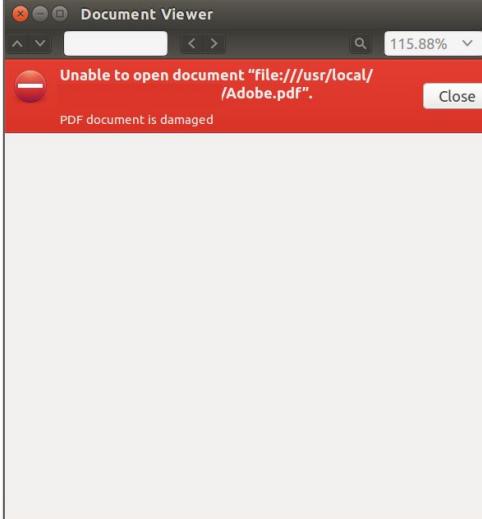
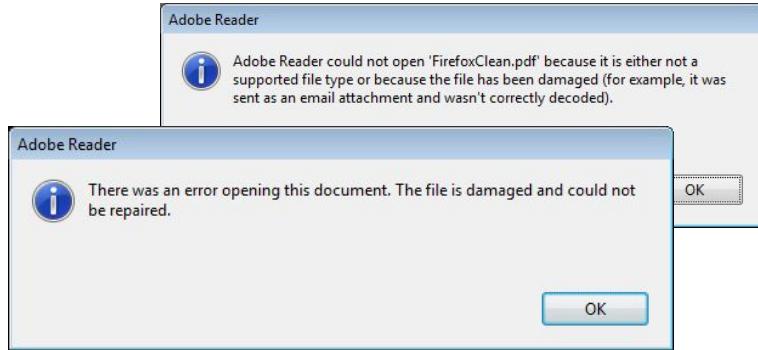
in practice, JPEG is LibJPEG turbo v6

- de facto standard
  - later versions not used (different API)

Even if you create your own JPEG library,  
you want to have full LibJPEG compatibility.

JPEG format is defined by LibJPEG.





These "extreme" PDFs fail on any other reader.

# PDF's current landscape

PDF: 6 interpretations of the specs

- specs are even more useless

# One good open library: a unified attack surface

Fuzz it, pwn everyone ?  
True, but also fixed for everyone!

Is diversity really good?  
We're all supposed to use the same file format.

# Diversity is good?

Attack surface is worse.  
Unofficial substandards.

# In any cases...

Specs are merely an introduction guide.  
A free set of examples w/ corner cases.  
A grammar ?



# PDF's future

PDF/E (engineer): 3d crap

PDF/A (archiving): already 8 flavours

Specs:

- specs are now commercial
- the main implementation is not open
- no set of free files.

And all countries preserve their culture with that format?!?!

We're waiting for a new disaster...

# **many file formats are abandoned**

One specs. then nothing.

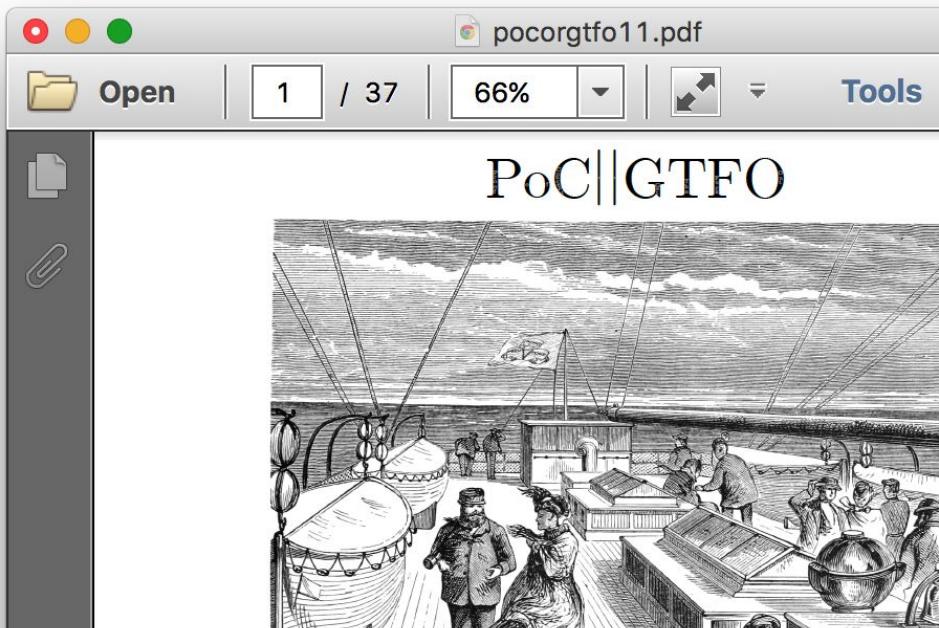
It's like knowing about someone  
only from a baby's picture.

<!--

PoC||GTFO 11

```
$ruby pocorgtfo11.pdf  
Listening for connections on port 8080.  
To listen on a different port,  
re-run with the desired port as a command-line argument
```

```
A neighbor at 127.0.0.1 is requesting /  
A neighbor at 127.0.0.1 is requesting /ajax/  
A neighbor at 127.0.0.1 is requesting /favicon
```



PoC||GTFO Issue 0x11 x

C 127.0.0.1:8080

# International Journal of PoC||GTFO Issue 0x11

IN A FIT OF STUBBORN OPTIMISM,  
**PASTOR MANUEL LAPHROAIG**  
AND HIS CLEVER CREW  
SET SAIL TOWARD  
WELCOMING SHORES OF  
THE GREAT UNKNOWN!

[Click here](#) to download the PDF!

|   |  |
|---|--|
| <a href="#">11.1Please Stand and Be Seated</a>              | <a href="#">11.6Phrasebook for ARM Cortex M</a>      |
| <a href="#">11.2In Praise of Junk Hacking</a>               | <a href="#">11.7Ghetto CFI for x86</a>               |
| <a href="#">11.3Emulating Star Wars on a Vector Display</a> | <a href="#">11.8Tourist's Guide to the MSP430</a>    |
| <a href="#">11.4Tron in 512 Bytes</a>                       | <a href="#">11.9This PDF is a Webserver</a>          |
| <a href="#">11.5Defeating the E7 Protection</a>             | <a href="#">11.10In Memoriam: Ben "bushing" Byer</a> |

This is an HTML/Ruby/PDF/ZIP polyglot. When interpreted by Ruby, it acts as a web server that serves this page. If the URL requested of the webserver matches a path inside the ZIP, that file is served. If loaded directly in a web browser, the file will render as this webpage, too, however, the link to the PDF download is hidden.

---

## Feelies

- [index.txt](#) — a text version of this feelies index
- [issues.txt](#) — about all issues of PoC||GTFO
- [issues.bib](#) — a BibTeX file containing references for all issues of PoC||GTFO
- [batteryfirmware.pdf](#) — Battery Firmware Hacking - Charlie Miller
- [vst.tar.bz2](#) — v.st vector board sources
- [vectormame.diff](#) — diff for Mame (see Star Wars article)

-->

PoC||GTFO 11 is self-aware:  
a PDF that serves itself (HTTP quine),  
parses its own ZIP to serve its archived feelies.

# Important question

Do you still sleep  
with a teddy bear?



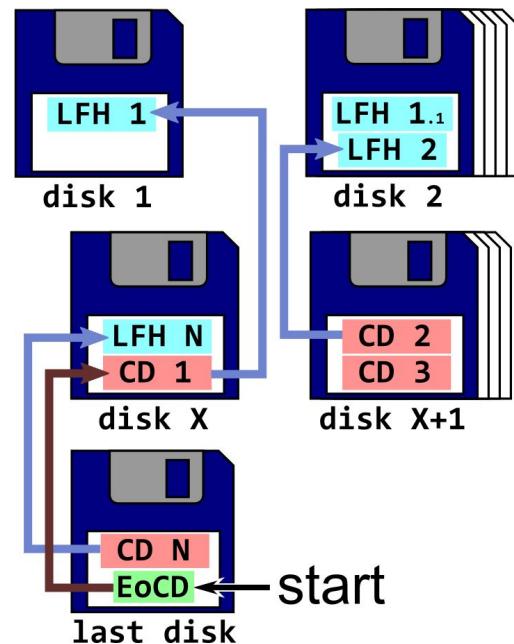
# Kids really deprecate stuff

Our computers still handle always more  
and more file formats.

⇒ The attack surface just keeps growing.

# Obsolete formats are still omnipresent

Formats, sub-formats, features...

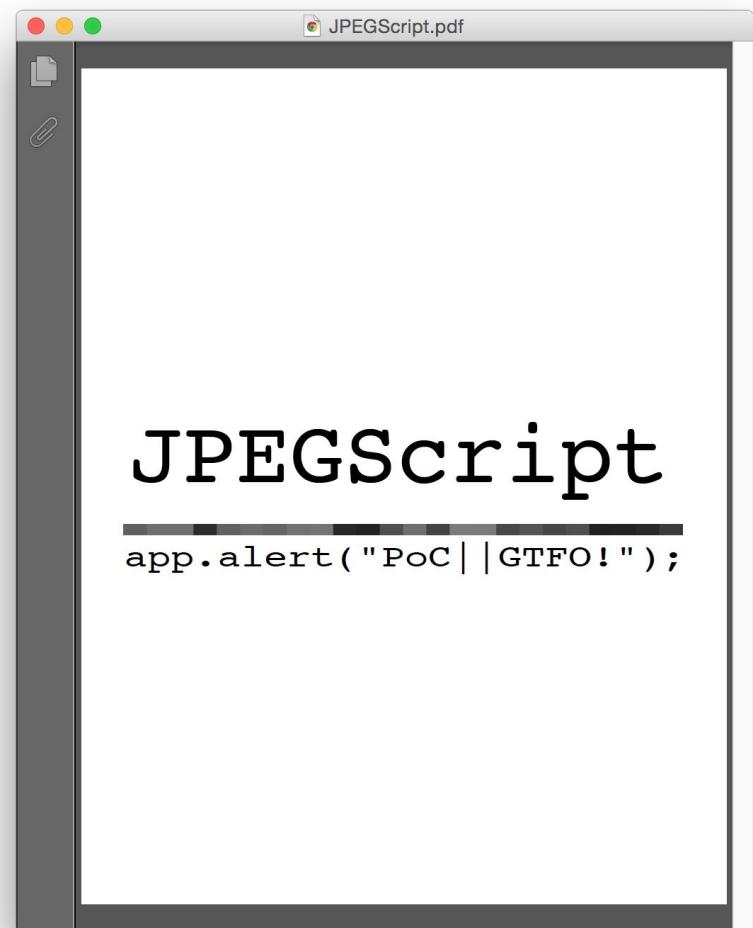


Because it's unclear  
if we can go back.

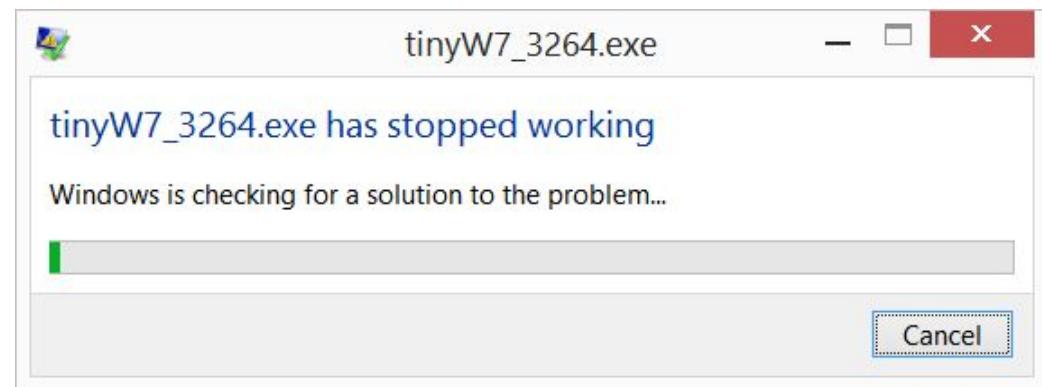
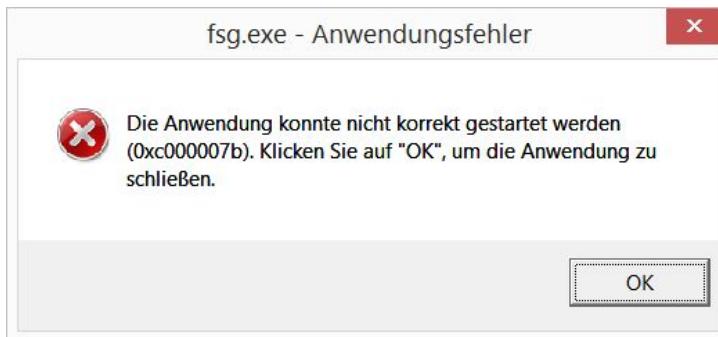
We'd be too afraid to deprecate them.

# Yet we deprecate for security.

Example for PDF:  
JPEG-compressed text  
is not supported anymore  
(it could bypass security).



# Windows PE format becomes stricter (deprecates packers)



# Sometimes, it's not even for security reasons

For example,  
EPUB 3.1 suddenly killed  
backward compatibility.

## EPUB 3.1 or EPUB 4.0?

By now it should be clear that the aggressive removal of features in EPUB 3.1 would have some far-reaching consequences. This is particularly true for the removal of the NCX, which would make EPUB 3.1 files incompatible with many existing E-ink readers. It would do this by ruling out the option to make backward-compatible “hybrid” files.

As Gary McGee pointed out earlier, introducing radical changes in what is essentially a minor version is pretty unusual practice for any standard. Nowadays, most software and file formats use some variation of **semantic versioning**, with version numbers that follow the general form MAJOR.MINOR.PATCH. Here, each component of the version number has a well-defined meaning:

1. MAJOR version is increased in case of incompatible API changes,
2. MINOR version is increased when functionality is added in a backwards-compatible manner, and
3. PATCH version is increased in case of backwards-compatible bug fixes.

Since the current draft includes multiple backward-incompatible changes, this makes

# We don't need new file formats.

It's the same problem again if  
eventually their specs stop reflecting reality.

Even dictionaries have regular updates, to reflect reality.



The screenshot shows a web browser window with the title "Recent updates to Oxford" and the URL "www.oxforddictionaries.com/words/what-s-new". The page header includes "GRAMMAR" and a search bar. On the right, there are social sharing icons for Facebook, Twitter, Google+, and a "SHARE THIS PAGE" button. The main content features a large heading "Recent updates to Oxford Dictionaries" and a paragraph explaining the site's purpose: "OxfordDictionaries.com is our free dictionary and language reference site. The site is updated regularly with new words and senses, special features on language change, revised encyclopedic entries, and improved functionality." Below this, instructions encourage users to visit the page for updates, sign up for newsletters, follow on Twitter, and read the blog. A section titled "August 2015" highlights new words like "cat café", "manspreading", and "Grexit". Another section discusses internet and gaming vocabulary additions like "YouTuber", "Reddit", and "pwn". A final section mentions food-related words like "beer o'clock" and "wine o'clock". At the bottom, a link points to a quiz about the new words.

Recent updates to Oxford Dictionaries

SHARE THIS PAGE

OxfordDictionaries.com is our free dictionary and language reference site. The site is updated regularly with new words and senses, special features on language change, revised encyclopedic entries, and improved functionality.

Visit this page to find out about the latest changes to the site. You can also keep up to date with all the latest news and developments by [signing up for our newsletter](#), following us on [Twitter](#), or [reading our blog](#).

August 2015

The latest update to Oxford Dictionaries sees almost 1,000 new words, phrases, and senses enter our English dictionary, including [cat café](#), [manspreading](#), and [Grexit](#).

Additions this quarter include slang terms such as [nuff said](#), [mic drop](#), and [awesomesauce](#). Many examples of internet and gaming vocabulary have been added, including [YouTuber](#), [Reddit](#), and [pwn](#).

Several fanciful words relating to food and drink have also entered the dictionary. Among these are [beer o'clock](#) and [wine o'clock](#), as well as [hangry](#) and [cakeage](#). As always, our update sees the inclusion of many topical terms, from [Grexit](#) and [Brexit](#) to [Mx](#).

[Read more about the new words in the August 2015 update](#), and find out how well you know our new words in our [quiz](#).

May 2015

# Story time

Digipres = PDF worshippers. 150 years of availability?

- Non free specs + closed source software?

Here comes the grim reaper:

- Fix your stuff or it will be killed (like Flash)

We store our knowledge. What about files born digital?

Not infosec, but worrying.

# veraPDF Corpus

The repository contains the veraPDF test corpus for PDF/A specifications (Versions 1B, 1A, 2B, 2U, 2A, 3B, 3U, 3A) as well as a number of additional tests files for ISO 32000-1.

This test suite complements [Isartor](#) and [Bavaria](#) test suites and follows their test file pattern:

- all test files are atomic;
- they are self-documented via the document outlines; and
- the naming pattern and the directory structure indicate relevant parts of ISO 19005-1 specification



© 2015 veraPDF Consortium



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# veraPDF and its test files: a great initiative.

## veraPDF-corpus / PDF\_A-1b / 6.1



DmitryRemezow Rename 6-1-12-t0

..

[veraPDF test suite 6-1-12-t01-fail-a.pdf](#)

[veraPDF test suite 6-1-12-t02-fail-a.pdf](#)

[veraPDF test suite 6-1-12-t02-fail-b.pdf](#)

[veraPDF test suite 6-1-12-t02-fail-c.pdf](#)

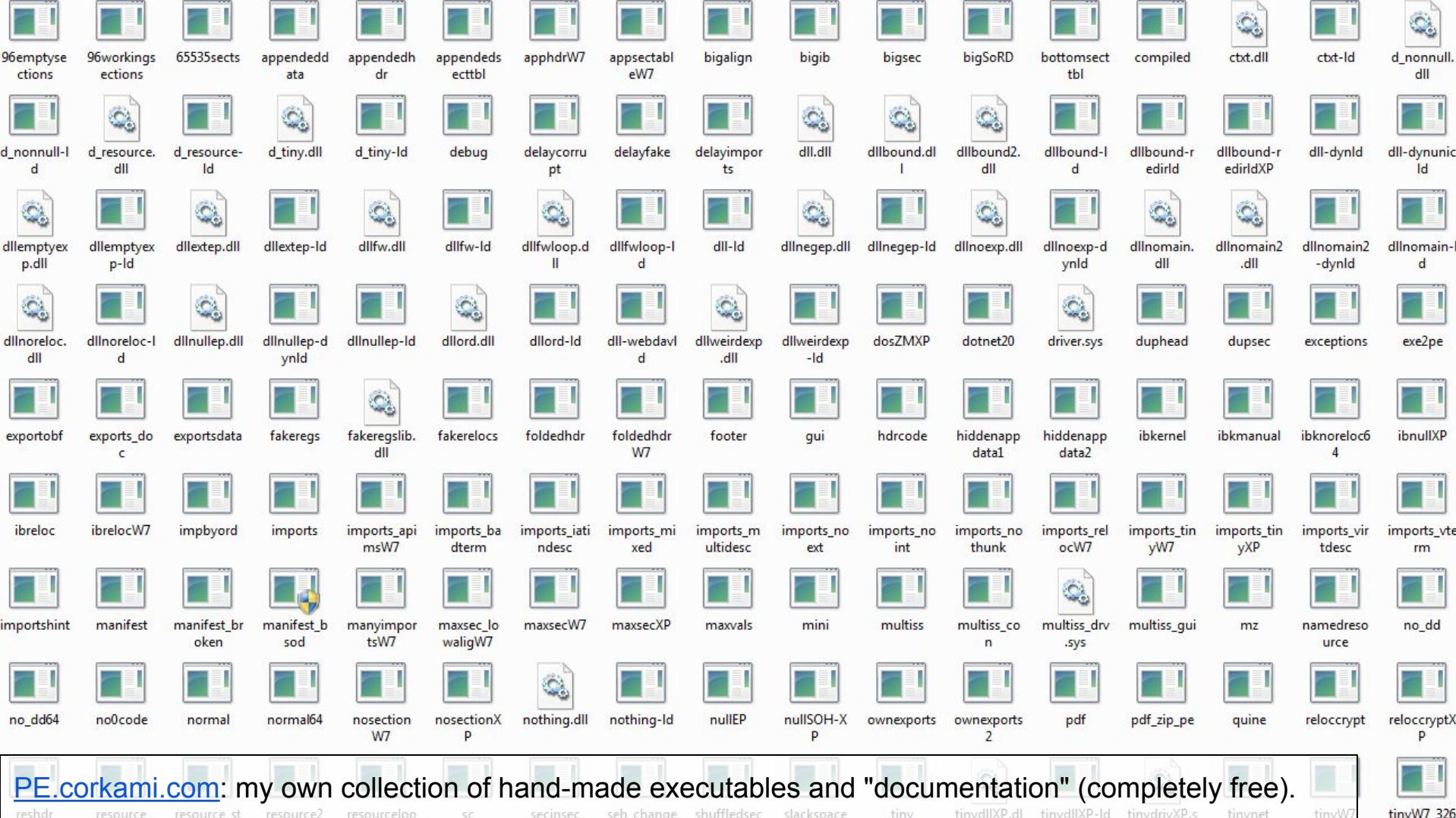
[veraPDF test suite 6-1-12-t02-fail-d.pdf](#)

[veraPDF test suite 6-1-12-t02-fail-e.pdf](#)

[veraPDF test suite 6-1-12-t02-fail-f.pdf](#)

[veraPDF test suite 6-1-12-t02-fail-l.pdf](#)

[veraPDF test suite 6-1-12-t02-pass-n.pdf](#)



96emptysections	96workingsections	65535sects	appendddata	appendddr	appenddsecttbl	apphdrW7	appseetableW7	bigalign	bigib	bigsec	bigSoRD	bottomsecttbl	compiled	ctxt.dll	cbtx-ld	d_nonnull.dll
dll_nonnull-ld	d_resource.dll	d_resource-ld	d_tiny.dll	d_tiny-ld	debug	delaycorrupt	delayfake	delayimports	dll.dll	dllbound.dll	dllbound-ld	dllbound-redirld	dllbound-redirldXP	dll-dynld	dll-dynamicld	dll-dynunicld
dllemptyexp.dll	dllemptyexp-ld	dllemptyexp-ld	dllextep.dll	dllextep-ld	dlfw.dll	dlfw-ld	dlfwloop.dll	dlfwloop-ld	dll-ld	dllegep.dll	dllegep-ld	dlinoexp.dll	dlinoexp-ld	dlloainmain.dll	dlloainmain2.dll	dlloainmain2-dynld
dllnoreloc.dll	dllnoreloc-ld	dllnullep.dll	dllnullep-ld	dllnullep-ld	dllord.dll	dllord-ld	dllwebdav.dll	dllweirdexp.dll	dosZMXP	dotnet20	driver.sys	duphead	dupsec	exceptions	exe2pe	
exportobf	exports_doc	exportsdata	fakereg	fakeregslib.dll	fakeloc	foldedhdr	foldedhdrW7	footer	gui	hdrcode	hiddenappdata1	hiddenappdata2	ibkernel	ibkmanual	ibknoreloc64	ibnullXP
ibreloc	ibrelocW7	impbyord	imports	imports_api_msW7	imports_baderm	imports_jatindesc	imports_mixed	imports_multidesc	imports_noext	imports_noint	imports_nothunk	imports_relocW7	imports_tinyW7	imports_tinyXP	imports_virtdesc	imports_vterm
importshint	manifest	manifest_broken	manifest_bsod	manyimportsW7	maxsec_lowaligW7	maxsecW7	maxsecXP	maxvals	mini	multiss	multiss_conn	multiss_drv.sys	multiss_gui	mz	namedresource	no_dd
no_dd64	no0code	normal	normal64	nosectionW7	nosectionXP	nothing.dll	nothing-ld	nullIEP	nullISOH-XP	ownexports	ownexports2	pdf	pdf_zip_pe	quine	relocrypt	relocryptXP
reshdr	resource	resource_st	resource2	resourcecomp	secincsec	seh_change	shuffledsec	slackspace	tiny	tinydllXP.dll	tinydllXP-ld	tinydrvXP.s	tinynet	tinyW7	tinyW7_326	

[PE.corkami.com](http://PE.corkami.com): my own collection of hand-made executables and "documentation" (completely free).

```
BFF9AF2770      mov      edi,07027AFF9 ;'p'
B068      3mov      al,068 ;'h'
AA        stosb
B800102900    mov      eax,000291000 --+4
AB        stosd
66B8C300      mov      ax,000C3 ;'P'
AA        stosb
89D8      mov      eax,ebx
0000      add      [eax],al
0000      add      [eax],al
```

Number	Name	VirtSize	RVA	PhysSize	Offset	Flag
65524		00007000	70226000	00000000	00280200	E00000C0
65525		00007000	7022D000	00000000	00280200	E00000C0
65526		00007000	70234000	00000000	00280200	E00000C0
65527		00007000	7023B000	00000000	00280200	E00000C0
65528		00007000	70242000	00000000	00280200	E00000C0
65529		00007000	70249000	00000000	00280200	E00000C0
65530		00007000	70250000	00000000	00280200	E00000C0
65531		00007000	70257000	00000000	00280200	E00000C0
65532		00007000	7025E000	00000000	00280200	E00000C0
65533		00007000	70265000	00000000	00280200	E00000C0
65534		00007000	7026C000	00000000	00280200	E00000C0
65535		00007000	70273000	00000000	00280200	E00000C0

```
0000          add      [eax],al  
Windows 7 x64  
>65535sects.exe  
* 65535 physically identical, virtually executed sections
```

```
Count of sections : 00000000 [00000000] Thu Jan 01 01:  
Symbol table 00000000 [00000000] Magic optional header  
Size of optional header 0000  
Linker version 0.00 OS version  
Entry point 00000000 System version  
Size of code 00000000
```

```
RE          ↳FRO ----- a64 PE+.0FFFFFFF'FFFF1000|  
EC28      sub    rsp, 028 ; '<'  
12000000  lea    ecx, [0FFFFFFF'FFFF101C] ; '* ke  
D8000000  call   printf
```

bknoreloc64.exe  
kernel IB + RIP-relative code (PE32+)

# Consequence of my PE page+corpus

- 'corkami-proof' software
- raises the bar for everyone
- become a hub of knowledge
  - "I can't share the sample", but from the knowledge, my own file will be shared  
⇒ even useful for the original contact

# Conclusion

# Attack surface

Too many (sub)formats

Too many parsers (= no good open lib)

# Specs

Specs shouldn't be a religious text

- Worshipped, but outdated and worthless

Specs should reflect reality (a law)

- updated, enforced, realistic, freely available

A good open lib

# Deprecation

Deprecation is a natural cycle, and yet...

We are afraid to deprecate because

***no*** file format is fully preserved:

- open, up to date specs
- free test coverage

# But it won't happen...

...until a great disaster ?

It ends up on CNN, with a logo & a website :)

# Ack

Phil Fabrice Travis Sergey  
Micah Kurt QKumba Hanno...

**Thank you!**

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corkami.com

