I Came to Drop Bombs

Auditing the Compression Algorithm Weapons Cache

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About Me

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  Pentested numerous networks, web applications, mobile applications, etc.
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What is a Decompression Bomb?

A decompression bomb is a file designed to crash or render useless the program or system reading it.

Vulnerable Vectors

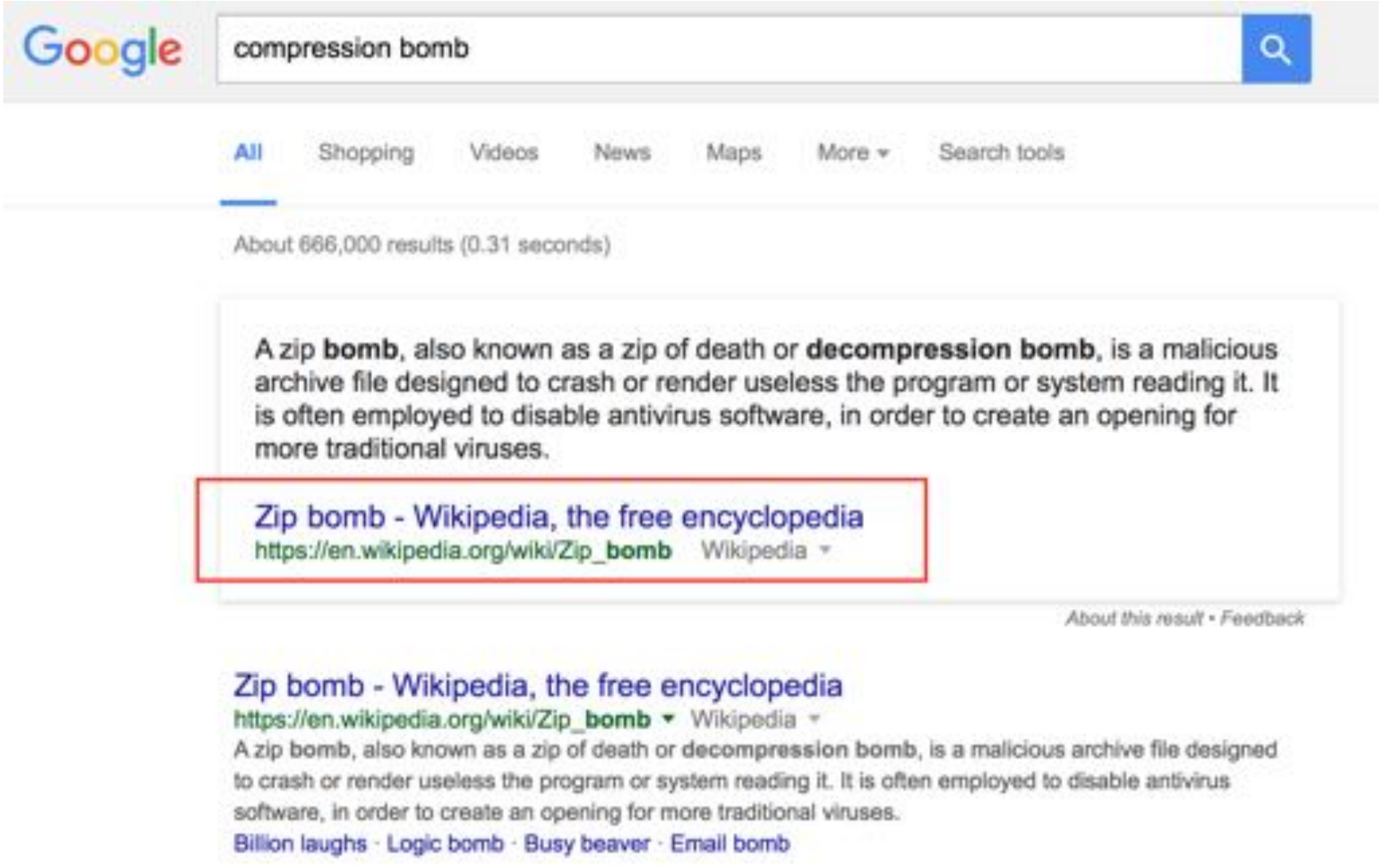
- Chat clients
- Image hosting
- Web browsers
- Web servers
- Everyday web-services software
- Everyday client software
- Embedded devices (especially vulnerable due to weak hardware)
- Embedded documents
- Gzip'd log uploads

A History Lesson

early 90's	ARC/LZH/ZIP/RAR bombs were used to DoS FidoNet systems
2002	Paul L. Daniels publishes Arbomb (Archive "Bomb" detection utility)
2003	Posting by Steve Wray on FullDisclosure about a bzip2 bomb antivirus software DoS
2004	AERAsec Network Services and Security publishes research on the various reactions of antivirus software against decompression bombs, includes a comparison chart
2014	Several CVEs for PIL are issued – first release July 2010 (CVE-2014-3589, CVE-2014-3598, CVE-2014-9601)
2015	CVE for libpng – first release Aug 2004 (CVE-2015-8126)

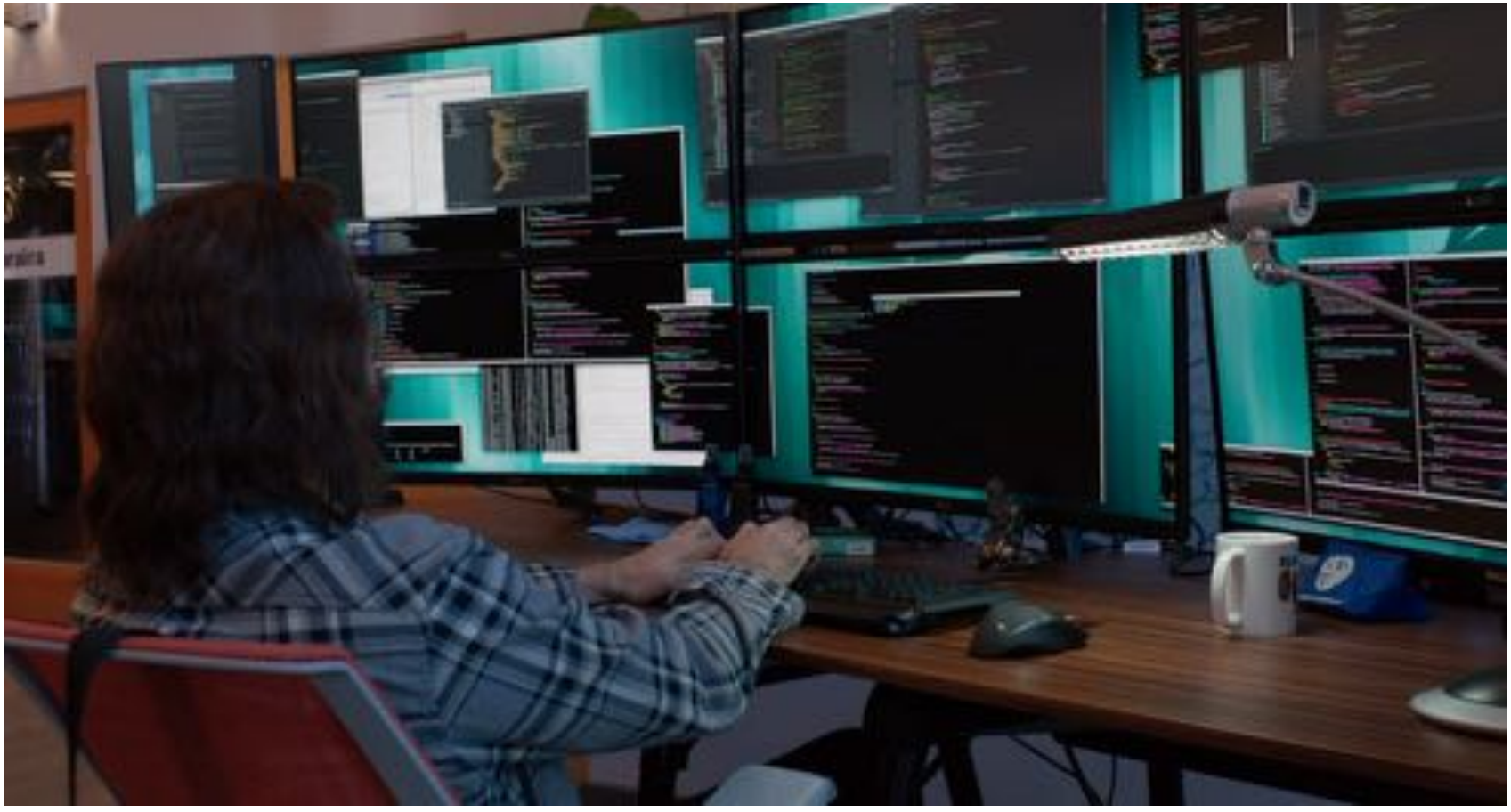
Why Are We Still Talking About This?!?

Why Are We Still Talking About This?!?



Compression is the New Hotness

Who This Is For



Who This Is For

The Archives

An archive bomb, a.k.a. zip bomb, is often employed to disable antivirus software, in order to create an opening for more traditional viruses

- Singly compressed large file
- Self-reproducing compressed files,
  i.e. Russ Cox's Zips All The Way Down
- Nested compressed files, i.e. 42.zip

The Archives

42.zip

42.zip (42.374B) is comprised of:

16 x 4294967295 = 68.719.476.720 (68GB)
16 x 68719476720 = 1.099.511.627.520 (1TB)
16 x 1099511627520 = 17.592.186.040.320 (17TB)
16 x 17592186040320 = 281.474.976.645.120 (281TB)
16 x 281474976645120 = 4.503.599.626.321.920 (4.5PB)

– Each containing a single 4.3GB file –

Compression Bombs

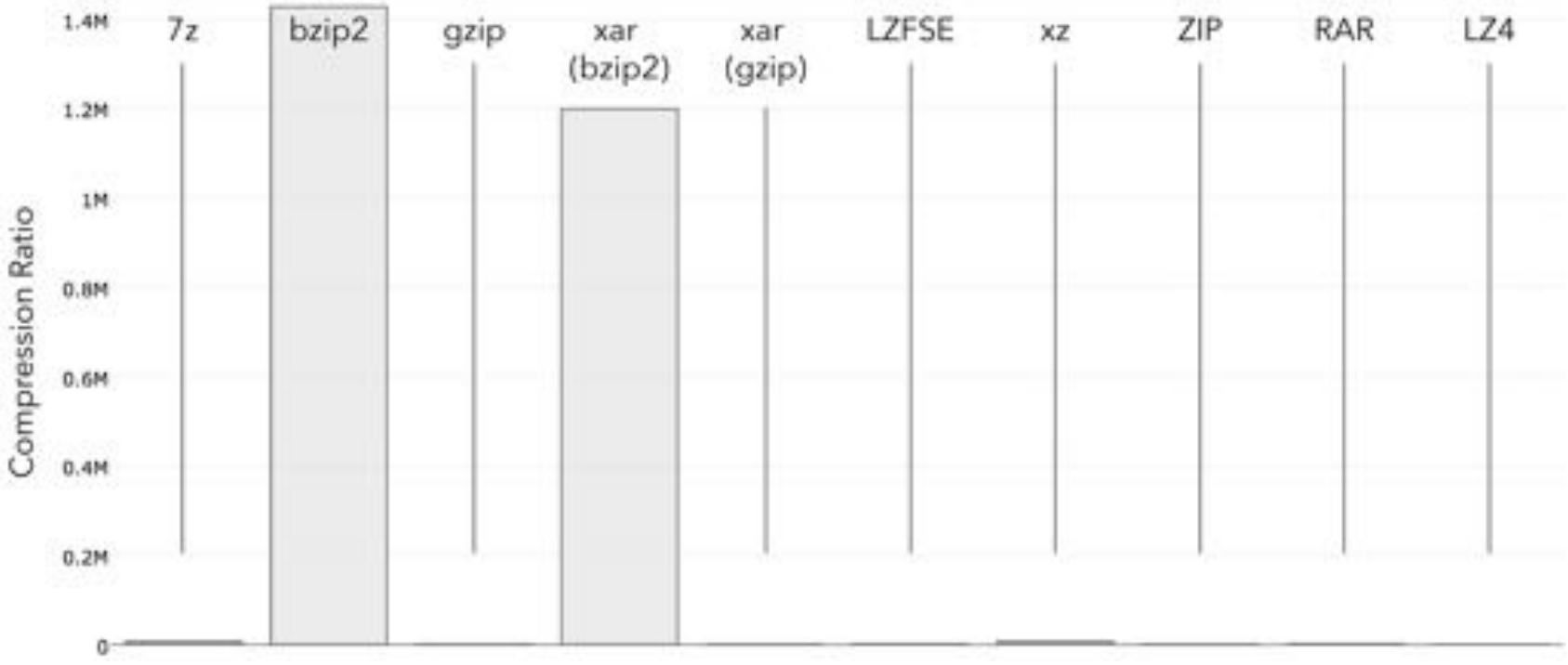
Ratio Calculation

$$\text{Compression Ratio} = \frac{\text{Uncompressed Content}}{\text{Compressed Content}}$$

$$1048576 = \frac{10485760\text{KB } (10\text{GB})}{10\text{KB}}$$

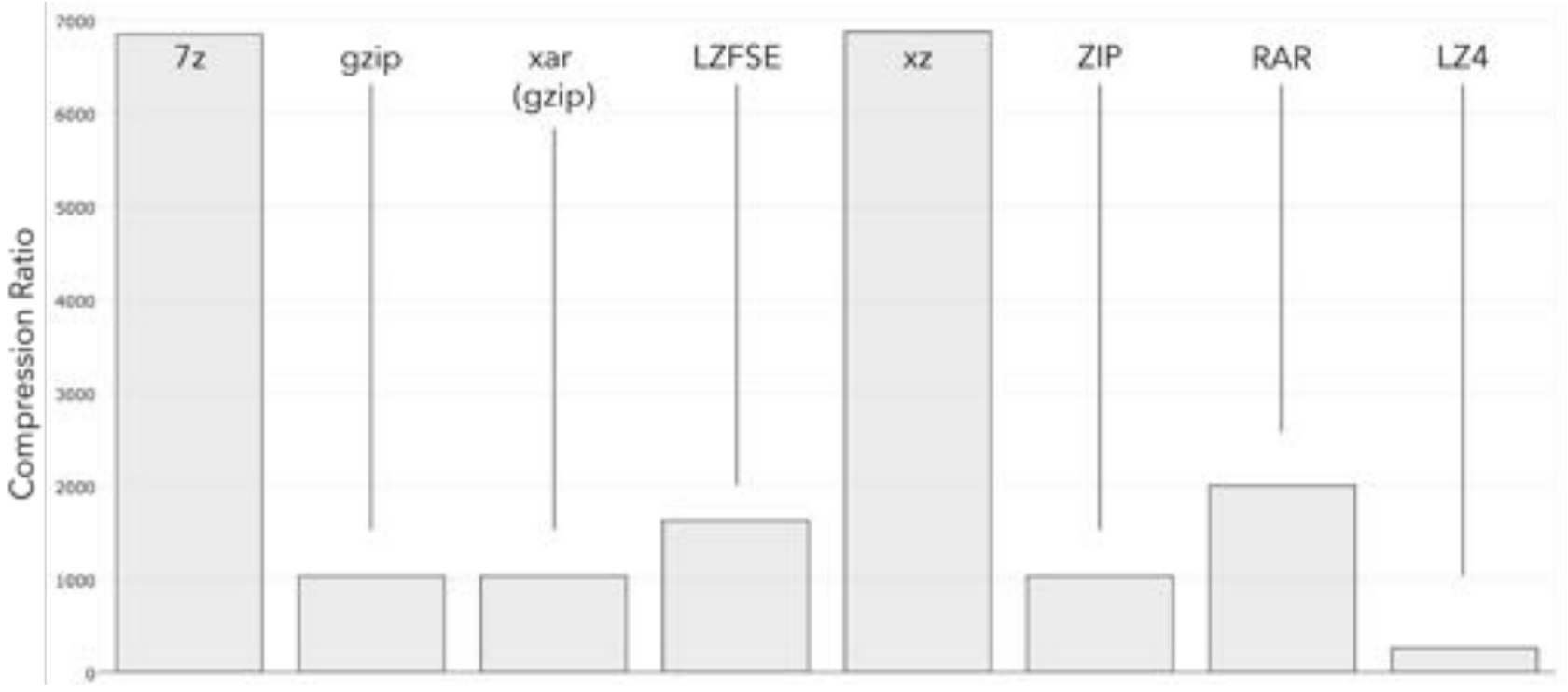
The Archives

Compression Ratio Graph



The Archives

Compression Ratio Graph (sans bzip2)



The Archives

Compression Ratios

Utility	Size	Compression Ratio	Algorithm
bzip2	7KB	~1427411:1	Burrows –Wheeler
xar (bzip2)	9KB	~1198921:1	Burrows –Wheeler
7z (gzip)	1.5MB	~6848:1	DEFLATE
xz	1.5MB	~6875:1	LZMA
RAR	5.2MB	~2003:1	LZSS/PPM
LZFSE	6.3MB	~1625:1	
gzip	10.2MB	~1029:1	DEFLATE
ZIP	10.2MB	~1029:1	DEFLATE
xar (default)	10.2MB	~1028:1	DEFLATE
LZ4	41.2MB	~258:1	LZ77

Ratios calculated from a zero-generated 10GB file

Mitigations

- Never rely on client-side checks for security
- Perform server-side checks to validate:
  - File format is expected for context
  - File size will not exceed maximum limit
  - File name is sane/safe
  - File names are validated to avoid symlink/hardlink or directory traversal attacks

Mitigations

The Archives

Limit the amount of resources available to the process and its children

- For Linux platforms, cgroups can and should be used to limit both CPU and memory usage
- In Python resource limits can be configured via the `resource` module's `setrlimit` and `RLIMIT*` directives:

```
import resource
rsrc = resource.RLIMIT_DATA
resource.setrlimit(rsrc, (1024000, hard)) # limit to 1MB
```

- Ruby's `Process` module has similar `RLIMIT` directives

Mitigations

The Archives

Restrict output file size and number of extracted files, and throw an exception if either of these limits are reached

```
import zlib
def decompress(data, maxsize=1024000):
    dec = zlib.decompressobj()
    data = dec.decompress(data, maxsize)
    if dec.unconsumed_tail:
        raise ValueError("Possible bomb")
    del dec
    return data
```

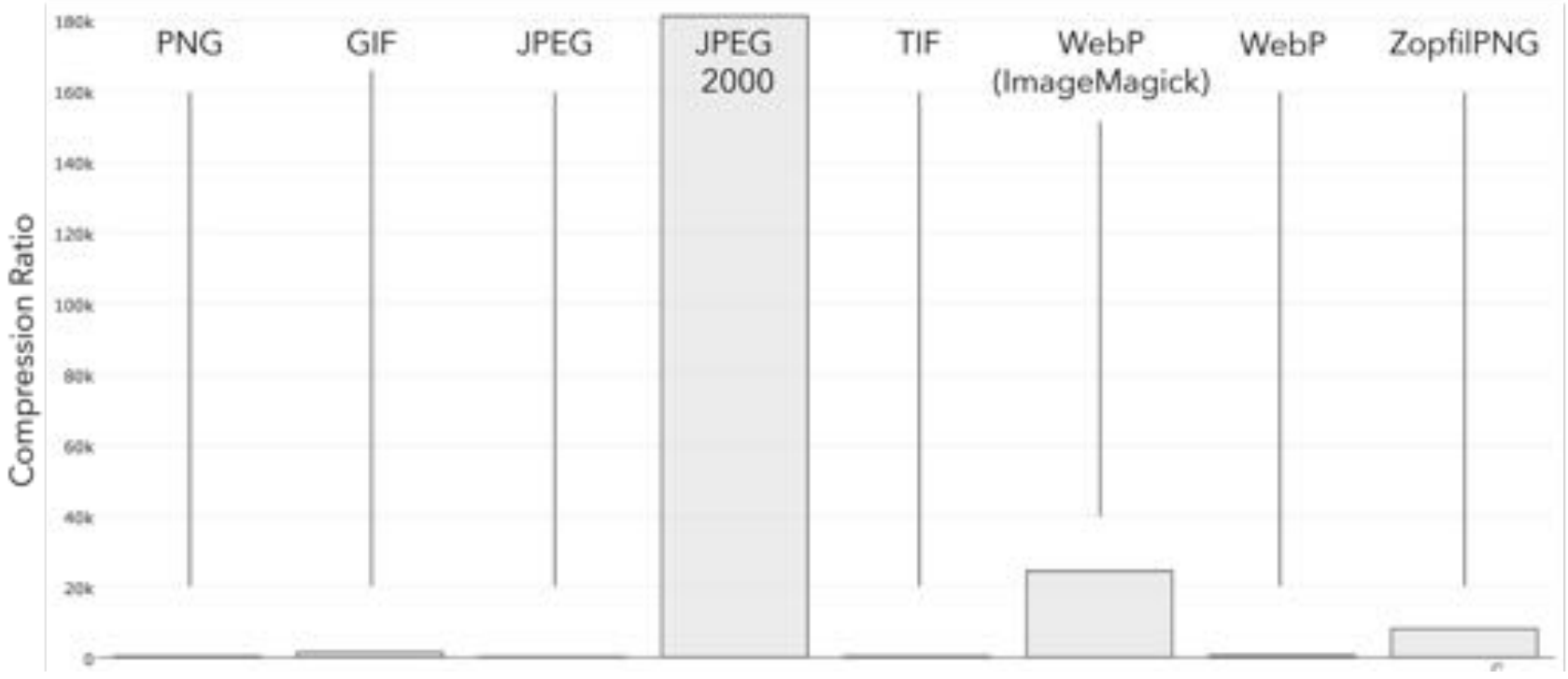
Not Just a Pretty Picture

Images can be highly effective in causing a denial of service for:

- Web servers and clients
- Mobile clients

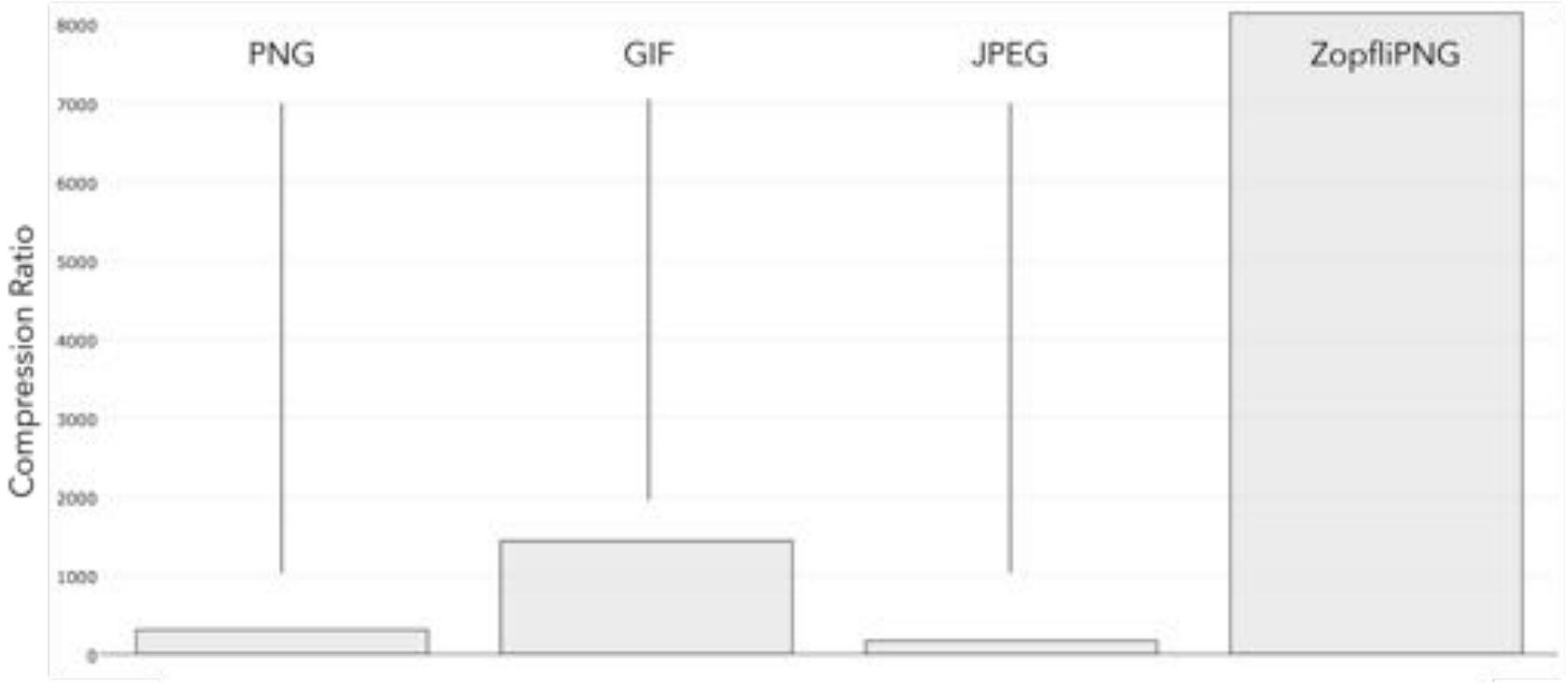
Not Just a Pretty Picture

Compression Ratio Graph



Not Just a Pretty Picture

Compression Ratio Graph (the Universals)



Not Just a Pretty Picture

Compression Ratios

Format	Size	Compression Ratio	Algorithm
JPEG 2000	552B	~181159:1	DWT
WebP*	4KB	~24414:1	LZ77
ZopfliPNG	12KB	~8138:1	WebP
GIF	68KB	~1436:1	LZW
WebP	177KB	~552:1	LZ77
TIF	292KB	~334:1	LZW
PNG	316KB	~309:1	DEFLATE
JPEG	586KB	~167:1	DCT

Ratios calculated from 10Kx10K, 8-bit single-color img (~95MB)

– WebP restricts image input to a maximum of 16383 pixels

* Initial WebP entry is the Imagemagick implementation

Mitigations

Not Just a Pretty Picture

Programmatically check image dimensions prior to processing

- libpng allows size limitations to be placed using `png_set_user_limits()`
  (the default is 1,000,000 by 1,000,000 pixels)
- For Python, this can be done using PIL's `Image` module:

```
from PIL import Image
im = Image.open(image_filename)
width, height = im.size
# Check image dimensions
if (width < MAX_IMAGE_WIDTH) and (height < MAX_IMAGE_HEIGHT):
    # do stuff
```

Mitigations

Not Just a Pretty Picture

- Use workers to perform process intensive tasks
- Limit the amount of resources available to the process and its children
  - libpng allows users to impose memory consumption and ancillary chunk limits via `png_set_chunk_malloc_max()` and `png_set_chunk_cache_max()`
- Contents are scrubbed to minimum required (exif data, avoiding image based XSS, etc.)

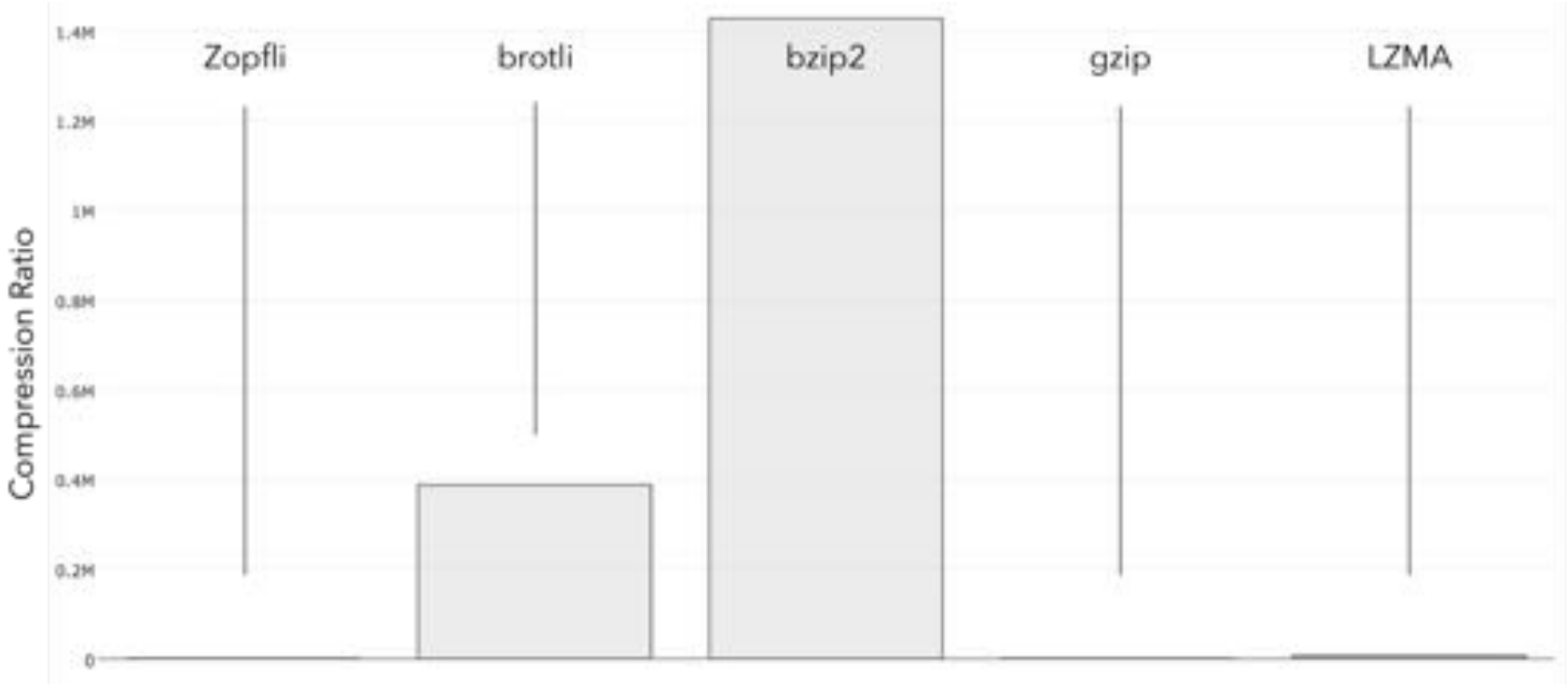
Bombs in Flight

HTTP bombs can be used to target:

- Web servers
- Web clients (includes mobile)
- Embedded devices

Bombs in Flight

Compression Ratio Graph



Bombs in Flight

Compression Ratios

Format	Size	Compression Ratio	Algorithm
Gzip	10.2MB	~1029:1	DEFLATE
Zopfli	10.3MB	~1017:1	DEFLATE
bzip2	7KB	~1427410:1	Burrows -Wheeler
brotli	27KB	~387844:1	LZ77
LZMA	1.5MB	~7089:1	

Ratios calculated from a zero-generated 10GB HTML file

- Zopfli binary restricts content to 2GB
- Bzip2 is supported by Lighttpd
- Brotli is supported in Firefox and Chrome (currently only for HTTPS)
- LZMA is supported in Opera beta 33

Mitigations

Bombs in Flight

Limit the amount of resources available to the process and its children

- For Apache, use the `RLimit*` directives: `RLimitCPU`, `RLimitMEM`, and `RLimitNPROC`
- For Nginx, use the `worker_rlimit_core`, `worker_rlimit_nofile`, and `worker_processes` directives
- For Linux platforms, cgroups can be used to limit both CPU and memory usage

Mitigations

Bombs in Flight

- Limit request sizes
  - This can be done in Apache using the `LimitRequestBody` directive
  - For Nginx use the `client_max_body_size` directive
- Limit request compression ratios
  - For Apache, use `mod_deflate`'s `DeflateInflateRatioLimit`, `DeflateInflateRatioBurst`, and `DeflateWindowSize` directives

The Search Continues

- Various protocols, i.e. SSH, FTP
- Fonts
- Videos
- Embedded devices
- Version control systems, i.e. Git, SVN

Anything that makes use of compression is a potential vector for this type of attack.

Tools

- GzipBloat

  `https://github.com/cyberisltd/GzipBloat`
- Burp Image Size Extension

  `https://github.com/silentsignal/burp-image-size`
- bomb.codes

  `https://bomb.codes/`

Tools

GzipBloat

Common Test Cases:

- 1TB 'HTML response'*, Gzip encoded
- 1TB 'HTML response'* with 4 rounds of Gzip encoding
- 1TB file download with 4 rounds of Gzip encoding
- 1TB file download, Gzip encoded
- 1G 'HTML response'*, Gzip encoded
- 1G file download, Gzip encoded
- 10G 'HTML response'*, Gzip encoded
- 10G file download, Gzip encoded
- 10G 'HTML response'* with 2 rounds of Gzip encoding
- 10G file download with 2 rounds of Gzip encoding
- 1Tb SDCH dictionary

** Obviously this isn't really HTML content - it will extract to a file full of zeros.*

Tools

Image size matches request parameters

Issue:	**Image size matches request parameters**
Severity:	**Low**
Confidence:	**Firm**
Host:	**http://127.0.0.1:5000**
Path:	**/image.jpeg**

Note: This issue was generated by the Burp extension: Image size issues.

Issue detail

The size of the image returned in the HTTP response (32 by 64) matches exactly the values of client-supplied parameters **w** and **h**, respectively. This might mean that the server generates an image with dimensions specified by the client, which can lead to Denial of Service attacks if no limits are enforced.

Remediation detail

Limit the dimensions that can be requested as parameters of the request.

Issue background

While resizing images on the fly for generating thumbnails or previews might be useful, if the size is specified in parameters controlled by the client, an attacker can provide enormous numbers. While the attacker doesn't need to invest resources in such an attack, the server might allocate the required pixel buffer (resulting in out of memory situations) and/or perform calculations that scale with the size of the image (resulting in hogging the server CPU).

Tools

bomb.codes

View the Project on GitHub
bones-codes/bombs

Download ZIP File	Download TAR Ball	View On GitHub

License + Disclaimer

The whole project is available under MIT license, see LICENSE.

Use of these files is at your own risk — I am not responsible for any harm that these files cause your application, system, or anything else.

This project is maintained by bones-codes

Hosted on GitHub Pages — Theme by orderedlist
Support from NCC Group

A decompression bomb is a file designed to crash or render useless the program or system reading it, i.e. a denial of service. The following files can be used to test whether an application is vulnerable to this type of attack.

When testing, it's always better to start small and work your way up. Starting with the largest file available can seriously harm an application or system — so use these bombs with caution.

All files have been bzipped to work around Github's 50MB file upload restriction. Groups of files have been zipped then bzipped. Remove these additional encodings prior to testing.

> *"When you see something that is technically sweet, you go ahead and do it and you argue about what to do about it only after you have had your technical success. That is the way it was with the atomic bomb."*
>
> *– J. Robert Oppenheimer*

Archives

Format	10GB	30GB	50GB	100GB	200GB	300GB
7z	–	–	–	–	–	–
bzip2	–	–	–	–	–	–
Gzip	–	–	–	–	–	–
LZ4	–	–	–	–	–	–
LZFSE	–	–	–	–		
RAR	–	–	–	–	–	–

Mitigation Summary

- Restrict resources – place limits on processes and their children
- Don't rely on size alone – check image dimensions prior to rendering
- Restrict file size output – verify that the output file size won't max out storage
- Limit number of extracted files – calculate the file total to ensure that storage/processing power won't be overloaded
- Perform dynamic testing – always verify mitigations via manual testing to ensure that they are functioning properly

Archive bombs are decompression bombs,
but not all decompression bombs are archive bombs.

Questions?

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