10 Dealing with Security

This chapter covers the following topics

- Injection
- Stress attacks
- Passive attacks
- Vulnerable configurations
- Path traversal
- Unicode exploits
- Escape sequences
- XSS, CSRF, DoS/DDoS
- DOR programmer error
- Server hardening
- Dependency auditing

Introduction

It's far from controversial to assert that security is paramount.

Nevertheless, as is evident from highly notable security breaches in recent years security mistakes are made all the time.

With a focus on handling adversarial input in a web application context, this chapter explores security fundamentals and good Node.js practices to help build more secure Node systems.

Detecting Dependency Vulnerabilities

Thanks to the wealth of modules on NPM, we're able to mostly focus on application logic, relying on the ecosystem for canned solutions. This does, however, lead to large dependency trees and security vulnerabilities can be discovered at any time, even for the most conscientious, mature and popular modules and frameworks.

In this recipe we demonstrate how to detect vulnerabilities in a projects dependency tree.

Getting Ready

We'll create a folder called `app`, initialize it as a package install `express`:

```
$ mkdir app
$ cd app
$ npm init -y
$ npm install express
```

We don't need to add any of our own code, since we're only checking dependencies.

How to do it

We're going to use `auditjs` to automatically check our dependency tree against vulnerability databases.

Let's install `auditjs` into our project `app` folder:

```
$ npm install --save-dev auditjs
```

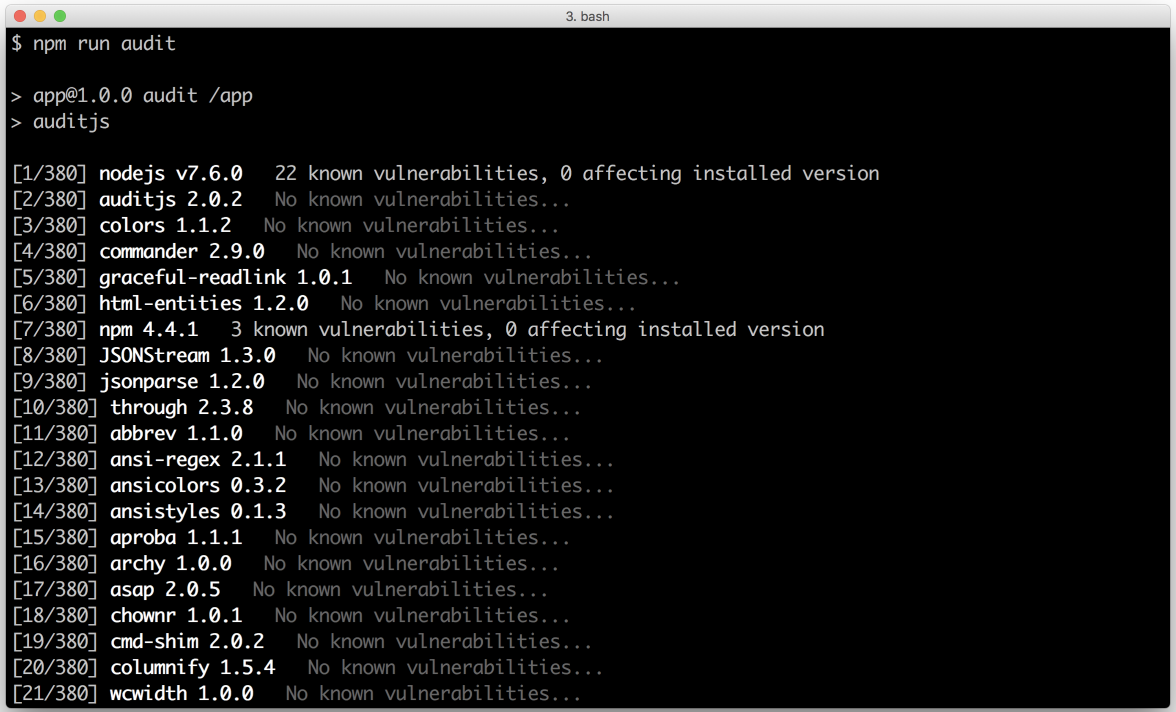
Now let's add a field to the `scripts` object in the `package.json` file:

```
  "scripts": {
    "test": "echo \"Error: no test specified\" && exit 1",
    "audit": "auditjs"
  },
```

Finally we can audit our dependencies with

```
$ npm run audit
```

This should output something like the following image.



How it works

The `auditjs` tool traverses the entire dependency tree, and makes requests to the OSS Index which aggregates vulnerability announcemounts from npm, the Node Security Project, the National Vulnerability Database, and Snyk.io, and others.

The `auditjs` tool also checks the local version of `node` to see if it's secure, so it can be useful to run `auditjs` on a CI (Continuous Integration) machine that has the exact `node` version as used in production.

We install it as a development dependency, and then add it as an `audit` script in `package.json`. This means auditing comes "bundled" with our project whenever it's shared among multiple developers.

There's more

What other methods can we use to manage dependency security?

Module Vetting

We can arbitrarily check modules for vulnerabilities (at least the vulnerability database mantained by snyk.io) without installing them.

Let's install the `snyk` CLI tool:

```
$ npm install -g snyk
```

We need to run through an authentication process, let's run:

```
$ snyk wizard
```

And follow the steps that the wizard takes us through.

Once complete we can check any module on npm for vulnerabilities using the `snyk test` command.

We could test the Hapi framework (which we haven't used at all in our project), for instance:

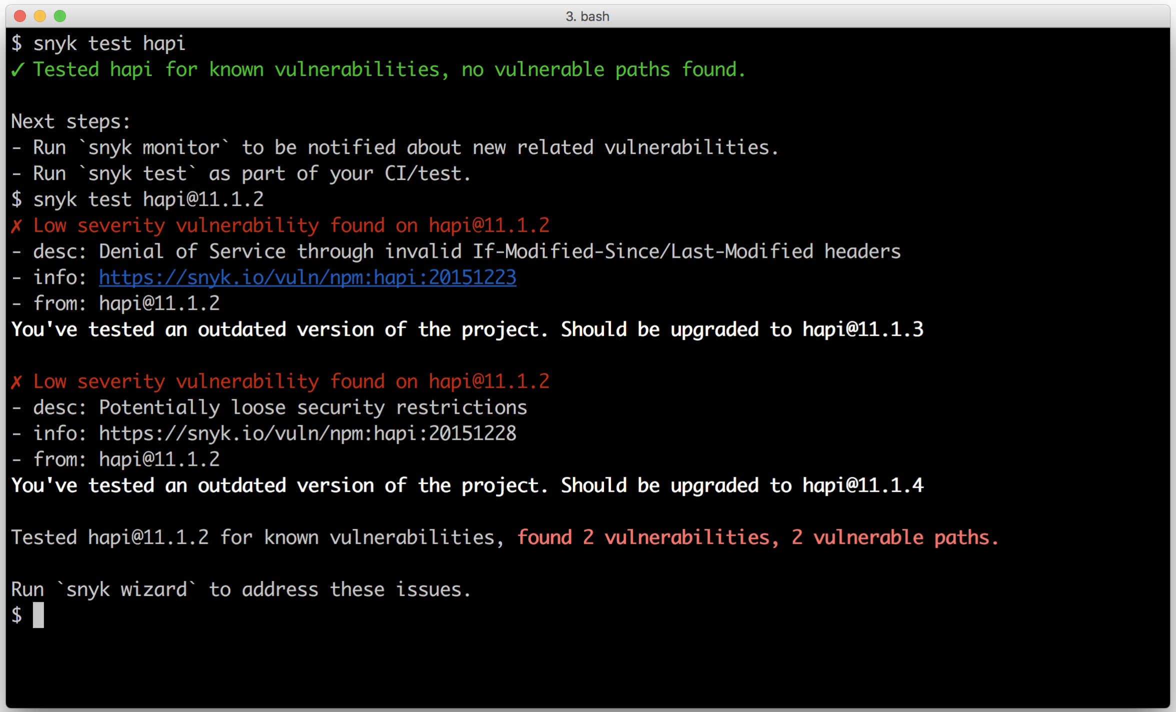
```
$ snyk test hapi
```

That should (hopefully!) pass with without vulnerabilities.

An old version of Hapi (version 11.1.2), will show vulnerabilities in the tree:

```
$ snyk test hapi@11.1.2
```

Running the above commands should look result in something like the following:



```
$ snyk test hapi
✓ Tested hapi for known vulnerabilities, no vulnerable paths found.

Next steps:
- Run `snyk monitor` to be notified about new related vulnerabilities.
- Run `snyk test` as part of your CI/test.
$ snyk test hapi@11.1.2
✗ Low severity vulnerability found on hapi@11.1.2
- desc: Denial of Service through invalid If-Modified-Since/Last-Modified headers
- info: https://snyk.io/vuln/npm:hapi:20151223
- from: hapi@11.1.2
You've tested an outdated version of the project. Should be upgraded to hapi@11.1.3

✗ Low severity vulnerability found on hapi@11.1.2
- desc: Potentially loose security restrictions
- info: https://snyk.io/vuln/npm:hapi:20151228
- from: hapi@11.1.2
You've tested an outdated version of the project. Should be upgraded to hapi@11.1.4

Tested hapi@11.1.2 for known vulnerabilities, found 2 vulnerabilities, 2 vulnerable paths.

Run `snyk wizard` to address these issues.
$
```

Restricting Core Module Usage

Some core modules are very powerful, and we depend on third party which may perform powerful operations with little transparency.

This could lead to unintended vulnerabilities where user input is passed through a dependency tree that eventually leads to shell commands that could inadvertently allow for malicious input to control our server. Whilst the chances of this happening seem rare, the implications are severe. Depending on our use case, if we can eliminate the risk, we're better off for it.

Let's write a small function which we can use to throw when a given core module is used thus allowing us to vet or at least monitor code (dependencies or otherwise) that uses the module.

To demonstrate, let's create a folder called `core-restrict` with an `index.js` file and an `example.js` file:

```
$ mkdir core-restrict
$ cd core-restrict
$ touch index.js example.js
```

In our `index.js` file we'll put the following code:

```
module.exports = function (name) {
  require.cache[name] = {}
  Object.defineProperty(require.cache[name], 'exports', {
   get: () => { throw Error(`The ${name} module is restricted`) }
  })
}
```

Now we can try it out with the `example.js` file:

```
const restrict = require('./')
restrict('child_process')

const cp = require('child_process')
```

If we run `example.js`:

```
$ node example.js
```

It should throw an error, stating "The child_process module is restricted".

This technique takes advantage of Node's module loading algorithm, it checks the loaded module cache (which we access through `require.cache`) for namespace before it attempts to load a built in module. We override the cache with that namespace and use `Object.defineProperty` to make a property definition on the `exports` key that throws an error when the key is accessed.

See also

- TBD

Hardening Headers in Web Frameworks

Due to Node's "batteries not included" philosophy, which has also influenced the philosophy of certain web frameworks (like Express), security features often tend to be a manual addon, or at least a matter of manual configuration.

In this recipe we'll show how to harden an Express web server (along with hardening servers built with other frameworks in the There's More section).

Getting Ready

We're going to use the official Express application generator because this definitively identifies the standard defaults of an Express project.

Let's install `express-genenerator` and use it to create an Express project named `app`:

```
$ npm install -g express-generator
$ express app
$ cp app
$ npm install
```

> ### Web Frameworks
>
> In this recipe we're hardening Express, in the There's More section we harden various other frameworks. For a comprehensive introduction to Web Frameworks see **Chapter 7 Working with Web Frameworks**

A final step to getting ready, since this book is written using StandardJS lint rules, is to automatically convert the generator to `standard` linting:

```
$ npm install -g standard
$ standard --fix
```

How to do it

Let's begin by starting our server, in the `app` folder we run:

```
$ npm start
```

Now in another tab, let's take a look at our Express apps default HTTP headers:

```
$ curl -I http://localhost:3000
```

If `curl` isn't installed in our system, we can achieve the same result with the following:

```
$ node -e "require('http').get({port: 3000, method: 'head'})
```

```
.on('socket', (socket) => socket.pipe(process.stdout))"
```

The response should look something like the following:

```
HTTP/1.1 200 OK
X-Powered-By: Express
Content-Type: text/html; charset=utf-8
Content-Length: 170
ETag: W/"aa-SNfgj6aecdqLGkiTQbf9lQ"
Date: Mon, 20 Mar 2017 11:55:42 GMT
Connection: close
```

Now let's install the `helmet` module.

```
$ npm install --save helmet
```

In our `app.js` file we'll require `helmet` at the end of the included modules, but before we require local files:

```
var express = require('express')
var path = require('path')
var favicon = require('serve-favicon')
var logger = require('morgan')
var cookieParser = require('cookie-parser')
var bodyParser = require('body-parser')
var helmet = require('helmet')
var index = require('./routes/index')
var users = require('./routes/users')
```

We can see `helmet` is required now, just above `index` and below `bodyParser`.

Next we'll include `helmet` as middleware, at the top of the middleware stack:

```
app.use(helmet())
app.use(logger('dev'))
app.use(bodyParser.json())
app.use(bodyParser.urlencoded({ extended: false }))
app.use(cookieParser())
app.use(express.static(path.join(__dirname, 'public')))
```

Ok, let's press Ctrl+C to stop our server, and then start it again:

```
$ npm start
```

In another tab let's make the same HEAD request:

```
$ curl -I http://localhost:3000
```

Or the following in the absence of `curl`:

```
$ node -e "require('http').get({port: 3000, method: 'head'})
.on('socket', (socket) => socket.pipe(process.stdout))"
```

We should now see something like:

```
HTTP/1.1 200 OK
X-DNS-Prefetch-Control: off
X-Frame-Options: SAMEORIGIN
X-Download-Options: noopen
X-Content-Type-Options: nosniff
X-XSS-Protection: 1; mode=block
Content-Type: text/html; charset=utf-8
Content-Length: 170
ETag: W/"aa-SNfgj6aecdqLGkiTQbf9lQ"
Date: Mon, 20 Mar 2017 12:00:44 GMT
Connection: close
```

Note the removal of `X-Powered-By` and the addition of several new `X-` prefixed headers.

How it works

The `helmet` module is a collection of Express middleware, that provides some sane security defaults when included.

The first sane default is removing the `X-Powered-By` header.

In the previous recipe we saw an older version of Express, with several known, and public vulnerabilities.

Before we included `helmet` the header output contained:

```
X-Powered-By: Express
```

While there are other ways to identify an Express server, the first way we can harden our server, is to prevent it being a low hanging fruit for automated attacks.

This is purely obfuscation, but it makes our server statistically less vulnerable.

Next, `helmet` adds the `X-DNS-Prefetch-Control` with the value set to `off`. This instructs browsers not to prefetch DNS records for references within an HTML page (for instance, a link to a third party domain may cause a browser to trigger a lookup request to the domain). While this (and other types of prefetching) seems like a good idea (for client side performance), it does lead to privacy issues. For instance, a user on a corporate network may have appeared to access content that was only *linked* from a page. The `helmet` module disables this by default.

> ### `lusca`
>
> A popular alternative to `helmet` is [`lusca`](), it provides the same essential features as `helmet` and then some.

The next header, `X-Frame-Options: SAMEORIGIN` prevents iframe based Click Jacking where our site may be loaded in an `<iframe>` HTML element on a malicious site, but positioned behind other content that instigates a user click. This click can then be used in a "bait and switch" where click actually applies to an element on our site *within* the iframe. Setting `X-Frame-Options` to `SAMEORIGIN` instructs the browser to disallow the endpoint to be loaded in an iframe unless the iframe is hosted on the same domain.

The `X-Download-Options: noopen` is an archaic throwback that attempts to protect what remains of the Internet Explorer 8 user base (it may, by now, at time of reading, have been removed from `helmet` defaults). Internet Explorer 8, by default, opens downloaded files (such as HTML) with the authority of the site it was downloaded from. This header disables that behavior.

The MIME type of a document is important, it describes the structure of the content, for instance `text/css` and `application/javascript` have very different qualities, expectations and powers. Browsers can attempt to guess the MIME type of a document, and even in some cases (IE in particular), ignore the MIME type sent from the server. This opens up the possibility of attacks that bypass security mechanisms by veiling themselves in an alternative MIME type format, and then somehow switching back and being executed in their original format to run malicious code. A very sophisticated manifestation of this attack comes in the form of the Rosetta Flash attack created in 2004 to demonstrate the vulnerability. Setting the `X-Content-Type-Options` to `nosniff` instructs the browser to never guess and override the MIME type, rendering such attacks impossible.

The final `X-XSS-Protection` is supported in Internet Explorer and chrome. The name is very much a misnomer, since `X-XSS-Protection` provides very little protection from Cross Site Scripting. In fact, in Internet Explorer 8, when it was introduced, the `X-XSS-Protection` header *created* an XSS vulnerability. So this piece of `helmet` also performs User Agent detection and disables it for Internet Explorer 8.

> ### XSS
>
> We address Cross Site Scripting in detail in the **Guarding Against Cross Site Scripting (XSS)** recipe in this chapter.

Setting the `X-XSS-Protection` header to `1; mode=block` instructs the browser to refuse to render when it detects a Reflected XSS attack (e.g. a non-persistent attack, such as crafting a URL with a query parameter the executes JavaScript). However this shouldn't be relied on as full XSS protection, since there are other types of XSS attacks and the ability for a browser to detect a reflected XSS attack in the first place is non-trivial (and has been inneffective in the past).

One other header that `helmet` sets by default is the `Strict-Transport-Security` which is only enabled for HTTPS requests. Since we don't have HTTPS implemented,
we don't see this header in output. Once a browser visits a site over HTTPS using the `Strict-Transport-Security` that browser becomes locked-in to using HTTPS, every subsequent visit must use HTTPS.

> ### Other `helmet` extras
>
> The `helmet` library can also enable a few other headers. In some cases, we may wish to disable client caching. The `helmet.noCache` middleware will set a variety of headers so that caching is eradicated from old and new browsers alike, as well instructing Content Delivery Networks (CDNs) to drop the cache. The `helmet.referrerPolicy` restricts the `Referrer` header, which privacy conscious users may appreciate. The `helmet.hkpk` middleware sets the `Public-Key-Pins` header, which we have to supply with a public key that appears in a sites SSL certificate chain. This causes the browser to store the key, and compare it on subsequent requests thus securing against the the

> possibility of a rogue Certificate Authority (CA) (or other SSL based Person in the Middle attack) Finally there's the `helmet.contentSecurityPolicy` middleware which we'll explore in more detail in the **Guarding Against Cross Site Scripting (XSS)** recipe in this chapter.

There's more

Let's explore the other ways a potential attacker might identify our server, and how to apply `helmets` sane defaults to other Web Frameworks (and even with Node's `http` core module). Additionally, we'll also discuss the non-default security headers `helmet` can set.

Avoiding fingerprinting

The `X-Powered-By` is one way vulnerability scanners will use to fingerprint a server, but other heuristics are employed by more sophisticated bots.

For instance, Node servers in general have a tendency towards lower case HTTP headers, the more lower case headers that appear the more likely a server is to be running Node. The only way to avoid this is to ensure that when our code (or our dependencies code) set's a header, it uses more typical casing.

Another case is the session cookie name, which in `express-session` (the official middleware for Express sessions) defaults to `connect.sid`.

In Hapi, with the `hapi-auth-cookie` plugin, the default is `sid` or with the `yar` plugin the default is `session`. These are slightly more generic, but still identifiable, especially given the way case is used (again lowercase is a give away). In all cases, the session name is configurable, and we might want to set it to something like `SESSIONID`.

The format of the ETag header is another consideration. Since ETag generation is unspecified in the HTTP specification, the format of header is often unique to the framework that generates it. In the case of Express, ETag output has changed between major versions, so it's possible to parse ETag headers to identify the version of Express a server is using.

Finally there's error pages (such as 404 or 500 page), the wording, html structure, styling can all help to identify the server.

Hardening a core `http` server

The `helmet` module is just set of useful Express middlewares. It provides sane defaults. All of the `helmet` library's default enabled middleware simply modifies the response header. Now that we're aware of the sane defaults, we can do the same with an HTTP server written entirely with the core HTTP module.

Let's create a folder called `http-app` and create `index.js` file in it.

Let's open `index.js` in our favorite editor, and write the following:

```
const http = require('http')

const server = http.createServer((req, res) => {
  secureHeaders(res)
  switch (req.url) {
    case '/': return res.end('hello world')
    case '/users': return res.end('oh, some users!')
    default: return error('404', res)
  }
})

function secureHeaders (res) {
  res.setHeader('X-DNS-Prefetch-Control', 'off')
  res.setHeader('X-Frame-Options', 'SAMEORIGIN')
  res.setHeader('X-Download-Options', 'noopen')
  res.setHeader('X-Content-Type-Options', 'nosniff')
  res.setHeader('X-XSS-Protection', '1; mode=block')
}

function error(code, res) {
  res.statusCode = code
  res.end(http.STATUS_CODES[code])
}

server.listen(3000)
```

Here we emulate the fundamental functionality from our main recipe. The `secureHeaders` function simply takes the response object, and calls `setHeader` for each of the headers discussed in the main recipe.

Hardening Koa

> ### Web Frameworks
>
> Due to Koa's use of ES2015 `async/await` this example will only run in Node 8 or higher.

If we're using Koa, we can avail of `koa-helmet`, which is, as the name suggests, `helmet` for `koa`.

To demonstrate, let's use the `koa-gen` tool to generate a Koa (v2) app:

```
$ npm install -g koa-gen
$ koa koa-app
```

Next let's install `koa-helmet`

```
$ npm i --save koa-helmet
```

Now we'll edit the `app.js` file, we'll add our dependency just above where `koa-router` is required:

```
const Koa = require('koa')
const app = new Koa()
const helmet = require('koa-helmet')
const router = require('koa-router')()
const views = require('koa-views')
```

Next we'll place the `koa-helmet` middleware at the top of the middleware stack:

```
// middlewares
app.use(helmet())
app.use(bodyparser())
app.use(json())
app.use(log4js.koaLogger(log4js.getLogger('http'), { level: 'auto' }))
app.use(serve(path.join(__dirname, 'public')))
```

Finally we'll start out server and check the headers:

```
$ npm start
```

Then with `curl`:

```
$ curl -I http://localhost:3000
```

Or without `curl`:

```
$ node -e "require('http').get({port: 3000, method: 'head'})
.on('socket', (socket) => socket.pipe(process.stdout))"
```

This should lead to something similar to the following output:

```
HTTP/1.1 200 OK
X-DNS-Prefetch-Control: off
X-Frame-Options: SAMEORIGIN
X-Download-Options: noopen
X-Content-Type-Options: nosniff
X-XSS-Protection: 1; mode=block
Content-Type: text/html; charset=utf-8
Content-Length: 191
Date: Mon, 20 Mar 2017 17:35:28 GMT
Connection: keep-alive
```

Hardening Hapi

We'll use a starter kit to quickly create a Hapi app:

```
$ git clone https://github.com/azaritech/hapi-starter-kit hapi-app
$ cd hapi-app
$ git reset --hard 5b6281
$ npm install
```

Hapi doesn't have an equivalent of `helmet` so we'll have to add the headers ourselves. The way to achieve this globally (e.g. across every request) is with the `onPreResponse` extension (Hapi terminology for a hook).

In the `index.js` file, just under the statement beginning `init.connections` we add:

```
server.ext('onPreResponse', (request, reply) => {
  var response = request.response.isBoom ?
    request.response.output :
    request.response;
  response.headers['X-DNS-Prefetch-Control'] = 'off';
  response.headers['X-DNS-Prefetch-Control'] = 'off';
  response.headers['X-Frame-Options'] = 'SAMEORIGIN';
  response.headers['X-Download-Options'] = 'noopen';
  response.headers['X-Content-Type-Options'] = 'nosniff';
  response.headers['X-XSS-Protection'] = '1; mode=block';
  reply.continue();
});
```

The function we supplied as the second argument to `server.ext` will be called prior to every response. We have to check for `Boom` objects (Hapi error objects) because error response object is located on `requests.response.output`. Other than we simply set properties on the `response.headers` and then call `reply.continue()` to pass control back to the framework.

If we hit our server with `curl`:

```
$ curl -I http://localhost:3000
```

Or with `node` instead of `curl`:

```
$ node -e "require('http').get({port: 3000, method: 'head'})
.on('socket', (socket) => socket.pipe(process.stdout))"
```

We should see something similar to:

```
HTTP/1.1 200 OK
X-DNS-Prefetch-Control: off
X-Frame-Options: SAMEORIGIN
X-Download-Options: noopen
X-Content-Type-Options: nosniff
X-XSS-Protection: 1; mode=block
cache-control: no-cache
content-type: text/html; charset=utf-8
content-length: 16
vary: accept-encoding
Date: Mon, 20 Mar 2017 19:28:59 GMT
Connection: keep-alive
```

See also

- TBD

Handling Parameter Poisoning

When it comes to handling parameters, in some frameworks there can be an unexpected type gotcha that opens us up to Denial of Service attacks (at the least).

In this recipe, we'll demonstrate and then tackle the issue of potential parameter poisoning.

Getting Ready

How to do it

How it works

There's more

See also

- TBD

Guarding Against Cross Site Scripting (XSS)

Getting Ready

How to do it

How it works

There's more

See also

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Preventing Cross Site Request Forgery

The browser security model, where a session cookie is valid among separate browser tabs/windows, enables a vast array of nefarious attacks on users.

Getting Ready

How to do it

How it works

There's more

See also

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Avoiding Timing Attacks

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How to do it

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