Designing a secure authentication package

(and the dangers of "there is ~~an app~~ a package for that")

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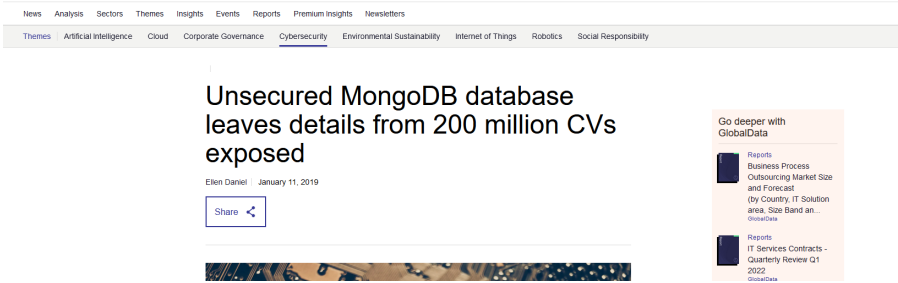
Outline

- Designing an authentication package
  - Design Goals
  - Lessons learned
- The TOTP "conspiracy"
  - Security in Open Source

Motivation

- Multiple projects all requiring authentication
- Code changes slightly per project, based on requirements
  - OpenID SSO via Google, Facebook, Microsoft, …
  - SAML SSO
  - Two-factor authentication
- Let’s standardize everything into a single package!

Goal 1 - Secure by default



- Package is secure by default
- Throw error if secrets are not provided or insecure
- Provide options to make it less secure (e.g. for test/dev environments)

Goal 2 - Hard to use wrong

- Use scary names for scary things
- Provide documentation for *why* they are scary
- e.g. `` `UnsafePbkdf2HashingAlgorithm` ``, `` `@UnsafeDisableCsrfCheckForNonGetMethods('We can disable the CSRF check here, because...')` ``
- Code reviews immediately show potential problems
- Forbid unsafe settings when `` `NODE_ENV=production` ``

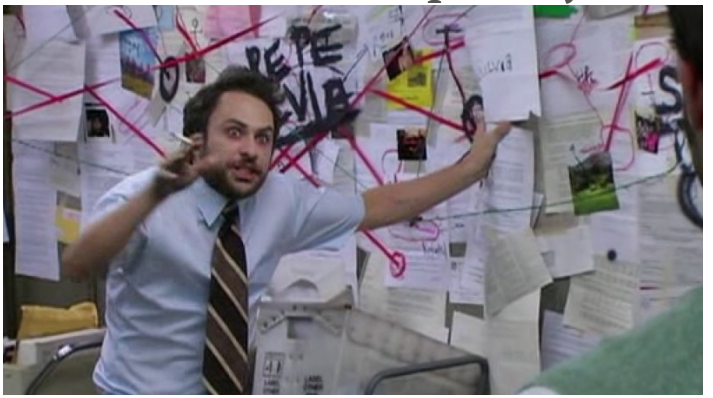
Goal 3 - Quick and easy to use

- Internal package allows us to tailor it to our common project architecture
- Package provides a NestJS module that can be imported and configured in <1h
- Extensive documentation - package will be used in *every* project!
- Proper releases, changelog, …

Development Strategy

- Pair Programming
- Research existing open source packages…
- …use them "under the hood" if feasible
- Use generic solutions if possible (e.g. one OpenID connector instead of Google/Microsoft/…)
  - …if they are spec compliant
  - (looking at you, LinkedIn!)

The TOTP "conspiracy"



Background

- Frequent advice: Use "battle-tested" package
  - many common bugs already fixed
  - many people verified the code
  - …but did they really?
- We wanted to use a totp package…
- …but then we checked the code

Speakeasy

speakeasy DT

2.0.0 • Public • Published 8 years ago

Readme | Code Beta | 1 Dependency | 363 Dependents | 7 Versions

Speakeasy

two-factor authentication for node.js

Jump to — Install · Demo · Two-Factor Usage · General Usage · Documentation · Contributing · License

Speakeasy is a one-time passcode generator, ideal for use in two-factor authentication, that supports Google Authenticator and other two-factor devices.

It is well-tested and includes robust support for custom token lengths, authentication windows, hash algorithms like SHA256 and SHA512, and other features, and includes helpers like a secret key generator.

Install

```
> npm i speakeasy
```

Repository

github.com/speakeasyjs/speakeasy

Homepage

github.com/speakeasyjs/speakeasy

Weekly Downloads

253 008

Version

2.0.0

License

MIT

Can you spot the bug?

```
553   /**
554    * Generates a key of a certain length (default 32) from A-Z, a-z, 0-9, and
555    * symbols (if requested).
556    *
557    * @param  {Integer} [length=32]  The length of the key.
558    * @param  {Boolean} [symbols=false] Whether to include symbols in the key.
559    * @return {String} The generated key.
560    */
561   exports.generateSecretASCII = function generateSecretASCII (length, symbols) {
562     var bytes = crypto.randomBytes(length || 32);
563     var set = '0123456789ABCDEFGHIJKLMNOPQRSTUVWXTZabcdefghiklmnopqrstuvwxyz';
564     if (symbols) {
565       set += '!@#$%^&*()<>?/[]{},.:;';
566     }
567
568     var output = '';
569     for (var i = 0, l = bytes.length; i < l; i++) {
570       output += set[Math.floor(bytes[i] / 255.0 * (set.length - 1))];
571     }
572     return output;
573   };
574
```

There are actually 3 bugs!

```
553   /**
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571     }
572     return output;
573   };
574
```
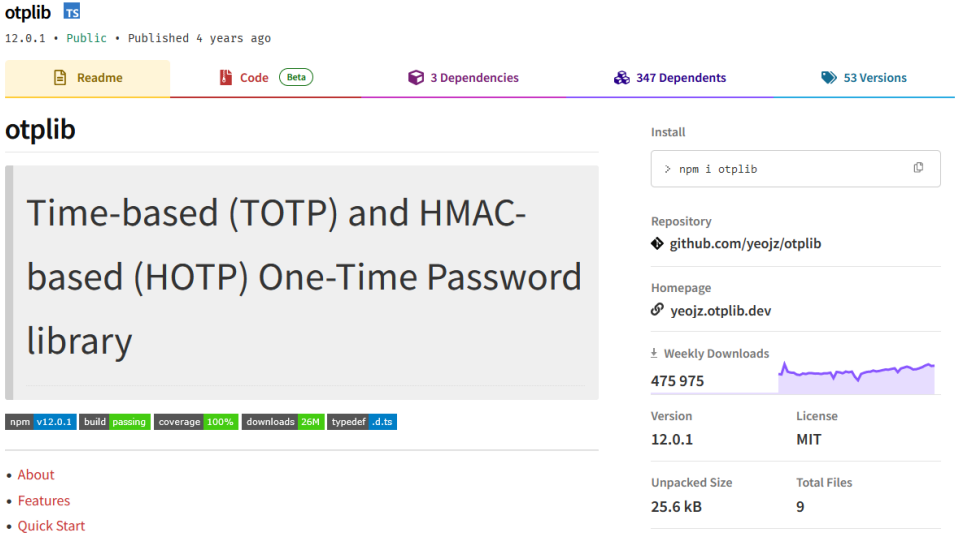

otplib


otplib
TS
12.0.1 • Public • Published 4 years ago
Readme
Code
Beta
3 Dependencies
347 Dependents
53 Versions
otplib
Time-based (TOTP) and HMAC-based (HOTP) One-Time Password library
npm v12.0.1
build passing
coverage 100%
downloads 26M
typedef .d.ts
• About
• Features
• Quick Start
Install
> npm i otplib
Repository
github.com/yeojz/otplib
Homepage
yeojz.otplib.dev
Weekly Downloads
475 975
Version
12.0.1
License
MIT
Unpacked Size
25.6 kB
Total Files
9

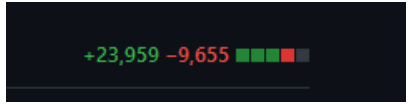
TOTP Algorithm Requirements

- RFC 4226

> R6 - The algorithm MUST use a strong shared secret. The length of the shared secret MUST be at least 128 bits. This document RECOMMENDs a shared secret length of 160 bits.

- 16 bytes minimum, 20 bytes recommended
- Secrets are base32 encoded (8 characters = 5 byte)
- Minimum: ~25 characters, recommended: 32 characters

otplib - PR#182



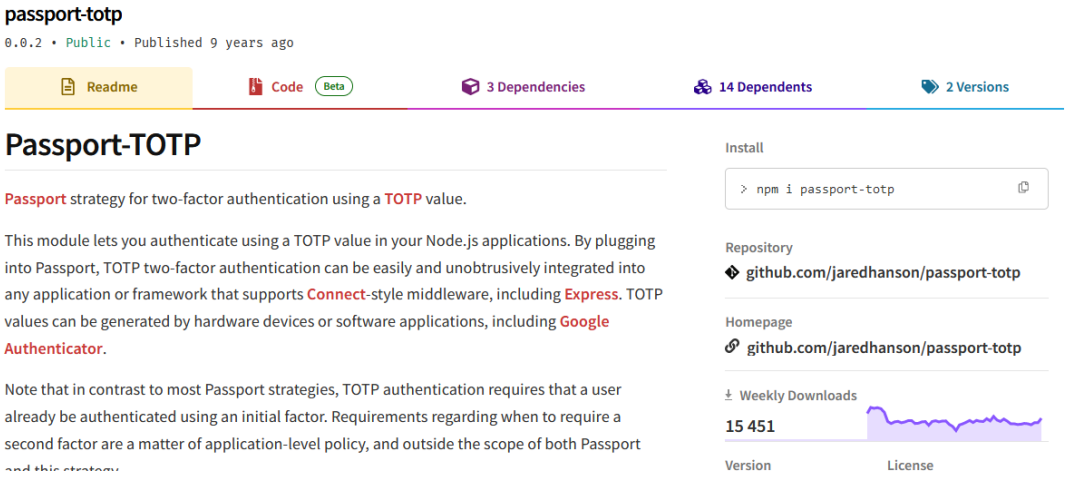
- A small change in those >30k changed lines...

```
/**
 * Generates and encodes a secret key
 *
 * @param {number} length - secret key length (not encoded key length)
 * @return {string}
 * @see {@link module:impl/authenticator/secretKey}
 * @see {@link module:impl/authenticator/encodeKey}
 */
generateSecret(len = 20) {
  if (!len) {
    return '';
  }
  const secret = secretKey(len, this.optionsAll);
  return encodeKey(secret);
}
```

```
/**
 * Reference: [[authenticatorGenerateSecret]]
 */
public generateSecret(numberOfBytes = 10): Base32SecretKey {
  return authenticatorGenerateSecret<T>(numberOfBytes, this.allOptions());
}
```

- ...no mention in the changelog...
- ...and no response from the maintainer since May 2022

passport-totp



passport-totp "complete, working example"

- Can you spot the bugs? (Usage: `` `utils.randomKey(10);` ``)

```
exports.randomKey = function(len) {
  var buf = []
    , chars = 'abcdefghijklmnopqrstuvwxyz0123456789'
    , charlen = chars.length;

  for (var i = 0; i < len; ++i) {
    buf.push(chars[getRandomInt(0, charlen - 1)]);
  }

  return buf.join('');
};

function getRandomInt(min, max) {
  return Math.floor(Math.random() * (max - min + 1)) + min;
}
```

passport-totp "complete, working example"

- There are a few...

```
exports.randomKey = function(len) {
  var buf = []
    , chars = 'abcdefghijklmnopqrstuvwxyz0123456789'
    , charlen = chars.length;

  for (var i = 0; i < len; ++i) {
    buf.push(chars[getRandomInt(0, charlen - 1)]);
  }

  return buf.join('');
};

function getRandomInt(min, max) {
  return Math.floor(Math.random() * (max - min + 1)) + min;
}
```

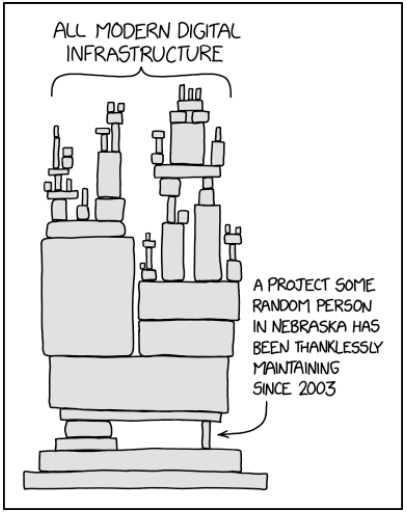
Debunking the "conspiracy" - why did this happen?

- Initial Google Authenticator libpam implementation used random 80 bit secrets
  - 80 bits in base32 result in 16 characters
  - Saving 16 characters in UTF-8 takes 16 bytes = 128 bit
  - …but that’s not the required 128 bits of randomness!
- Other packages copied this implementation (not reading RFC 4226)
- Google Authenticator fixed this in 2016

What can we do to prevent this?

- Verify dependencies yourself (especially if security-critical)
  - feasability with 1205 dependencies?
  - reduce dependencies?
- Use paid services (auth0, …) from specialized companies
  - Vendor lock-in?
  - closed source?
- Other ideas?

How many projects look like this?



Summary

- Re-usable packages are great, especially for security-critical code
  - even if "just" for specific internal use cases
  - Design goal 1: Secure by default
  - Design goal 2: Hard to use wrong
  - Design goal 3: Quick & easy to use
- TOTP "conspiracy"
  - "Battle tested" does not equal bug-free
  - Verify dependencies, especially if security-critical