Carnegie Mellon University

Dependency Management & Versioning

17-313 Spring 2023

S3D
Software and Societal Systems Department

Left-pad (March 22, 2016)

OBSESSIONS

QUARTZ

NPM ERR!

How one programmer broke the internet by deleting a tiny piece of code

THE VERGE TECH REVIEWS

REPORT TECH

How an irate developer briefly broke JavaScript

Unpublishing 11 lines of code brought down an open source house of cards

By Paul Miller | @futurepaul | Mar 24, 2016, 4:29pm EDT

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The Register

{ SOFTWARE }

How one developer just broke Node, Babel and thousands of projects in 11 lines of JavaScript

Code pulled from NPM – which everyone was using

Left-pad (March 22, 2016)

npmjs.org tells me that left-pad is not available (404 page) #4

Closed silkentrance opened this issue on Mar 22, 2016 · 193 comments

silkentrance commented on Mar 22, 2016

When building projects on travis, or when searching for left-pad on npmjs.com, both will report that the package cannot be found.

Here is an excerpt from the travis build log

```
npm ERR! Linux 3.13.0-40-generic
npm ERR! argv "/home/travis/.rvm/versions/node/v4.2.2/bin/node" "/home/travis/.rvm/versions/node/v4.2.2/bin/npm
npm ERR! node v4.2.2
npm ERR! npm  v2.14.7
npm ERR! code E404
npm ERR! 404 Registry returned 404 for GET on https://registry.npmjs.org/left-pad
npm ERR! 404
npm ERR! 404 'left-pad' is not in the npm registry.
npm ERR! 404 You should bug the author to publish it (or use the name yourself!)
npm ERR! 404 It was specified as a dependency of 'line-numbers'
npm ERR! 404
npm ERR! 404 Note that you can also install from a
npm ERR! 404 tarball, folder, http url, or git url.
npm ERR! Please include the following file with any support request:
npm ERR!     /home/travis/build/coldrye-es/pings/npm-debug.log
make: *** [deps] Error 1
```

And here is the standard npmjs.com error page https://www.npmjs.com/package/left-pad

However, if I remove left-pad from my local npm cache and then reinstall it using npm it will happily install left-pad@0.0.4.

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Left-pad (Docs)

left-pad

String left pad

build unknown

Install

```
$ npm install left-pad
```

Usage

```
const leftPad = require('left-pad')

leftPad('foo', 5)
// => "  foo"

leftPad('foobar', 6)
// => "foobar"

leftPad(1, 2, '0')
// => "01"

leftPad(17, 5, 0)
// => "00017"
```

Install

```
> npm i left-pad
```

Repository

github.com/stevemao/left-pad

Homepage

github.com/stevemao/left-pad#readme

Weekly Downloads

2,962,641

Version	License
1.3.0	WTFPL
Unpacked Size	Total Files
9.75 kB	10
Issues	Pull Requests
3	7

Last publish

4 years ago

Left-pad (Source Code)

17 lines (11 sloc) | 222 Bytes

```
1   module.exports = leftpad;
2
3   function leftpad (str, len, ch) {
4     str = String(str);
5
6     var i = -1;
7
8     if (!ch && ch !== 0) ch = ' ';
9
10    len = len - str.length;
11
12    while (++i < len) {
13      str = ch + str;
14    }
15
16    return str;
17  }
```


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See also: isArray

5 lines (4 sloc) | 133 Bytes

```
1  var toString = {}.toString;
2
3  module.exports = Array.isArray || function (arr) {
4    return toString.call(arr) === '[object Array]';
5  };
```

isarray

`Array#isArray` for older browsers and deprecated Node.js versions.

build passing downloads 227M/month

Just use Array.isArray directly, unless you need to support those older versions.

Usage

```
var isArray = require('isarray');

console.log(isArray([])); // => true
console.log(isArray({})); // => false
```

Install

```
> npm i isarray
```

Repository
github.com/juliangruber/isarray

Homepage
github.com/juliangruber/isarray

Weekly Downloads
50,913,317

Version	License
2.0.5	MIT

Unpacked Size	Total Files
3.43 kB	4

Issues	Pull Requests
4	3

Dependency Management

- It’s hard
- It’s mostly a mess (everywhere)
- But it’s critical to modern software development

What is a Dependency?

- Core of what most build systems do
  - “Compile” and “Run Tests” is just a fraction of their job
- Examples: Maven, Gradle, NPM, Bazel, …
- **Foo->Bar**: To build Foo, you may need to have a built version of Bar
- Dependency Scopes:
  - **Compile**: Foo uses classes, functions, etc. defined by Bar
  - **Runtime**: Foo uses an abstract API whose implementation is provided by Bar (e.g. logging, database, network or other I/O)
  - **Test**: Foo needs Bar only for tests (e.g. JUnit, mocks)
- Internal vs. External Dependencies
  - Is Bar also built/maintained by your org or is it pulled from elsewhere using a package manager?

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Dependencies: Example

```
<dependencyManagement>
  <dependencies>
    <dependency>
      <groupId>com.sismics.docs</groupId>
      <artifactId>docs-core</artifactId>
      <version>${project.version}</version>
    </dependency>

    <dependency>
      <groupId>com.sismics.docs</groupId>
      <artifactId>docs-web-common</artifactId>
      <version>${project.version}</version>
    </dependency>

    <dependency>
      <groupId>com.sismics.docs</groupId>
      <artifactId>docs-web-common</artifactId>
      <type>test-jar</type>
      <version>${project.version}</version>
    </dependency>

    <dependency>
      <groupId>com.sismics.docs</groupId>
      <artifactId>docs-webc</artifactId>
      <version>${project.version}</version>
    </dependency>

    <dependency>
      <groupId>org.eclipse.jetty</groupId>
      <artifactId>jetty-server</artifactId>
      <version>${org.eclipse.jetty.jetty-server.version}</version>
    </dependency>

    <dependency>
      <groupId>org.eclipse.jetty</groupId>
      <artifactId>jetty-webapp</artifactId>
      <version>${org.eclipse.jetty.jetty-webapp.version}</version>
    </dependency>
```

Package: git (1:2.17.1-1ubuntu0.9

fast, scalable, distributed revision control system

Other Packages Related to git

• depends ✦ recommends ■ suggests - enhances

• git-man (<< 1:2.17.0~) [not arm64, i386]
  fast, scalable, distributed revision control system (manual pages)

  git-man (<< 1:2.17.1~) [arm64, i386]

  git-man (>> 1:2.17.0) [not arm64, i386]

  git-man (>= 1:2.17.1) [arm64, i386]

• libc6 (>= 2.16) [not arm64, ppc64el]
  GNU C Library: Shared libraries
  also a virtual package provided by libc6-udeb

  libc6 (>= 2.17) [arm64, ppc64el]

• libcurl3-gnutls (>= 7.16.2)
  easy-to-use client-side URL transfer library (GnuTLS flavour)

• libperl-perl
  Perl module for error/exception handling in an OO-ish way

• libexpat1 (>= 2.0.1)
  XML parsing C library - runtime library

• libpcre3
  Old Perl 5 Compatible Regular Expression Library - runtime files

• perl
  Larry Wall's Practical Extraction and Report Language

• zlib1g (>= 1:1.2.0)
  compression library - runtime

✦ less
  pager program similar to more

✦ patch
  Apply a diff file to an original

✦ ssh-client
  virtual package provided by openssh-client

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Where are the dependencies hosted?

- Typically downloaded from dependency servers:
  - Maven Central (https://repo.maven.apache.org/maven2/)
  - Ubuntu Packages for Apt (https://packages.ubuntu.com/)
  - Python Package Index (https://pypi.org/)]
  - NPM Public Registry (https://registry.npmjs.org/)
- Packages need a unique identifier
  - Typically a package name (sometimes owner name) and version
- Custom repositories allowed by most package managers
  - Often used for company-internal packages or cache mirroring
  - Note problems with duplicates (same package name in different repositories; some priority order is needed)
- Somebody needs to manage repositories
  - Availability: Repository needs to be running
  - Access Control: Packages should only be published by owners
  - Integrity: Packages should be signed or otherwise verifiable
  - Uniqueness and archival: Only one artifact per version
  - Traceability: Packages can have metadata pointing to source or tests
  - Security: ???

Transitive Dependencies

Packages can depend on other packages

Q: Should Git be able to use exports of libSSL (e.g. certificate management) or zLib (e.g. gzip compression)?

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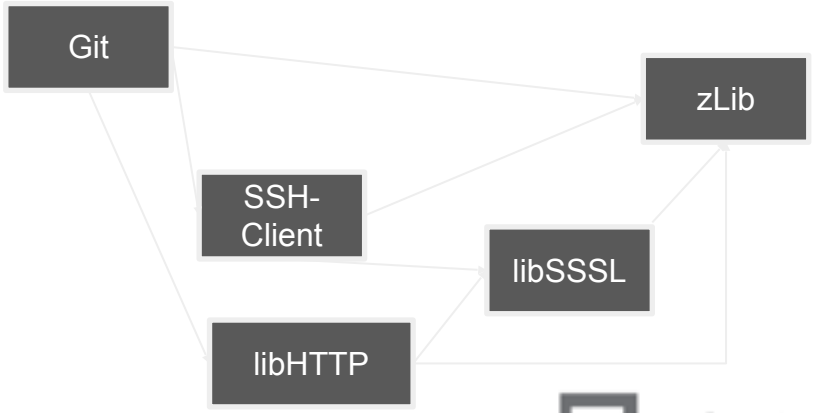
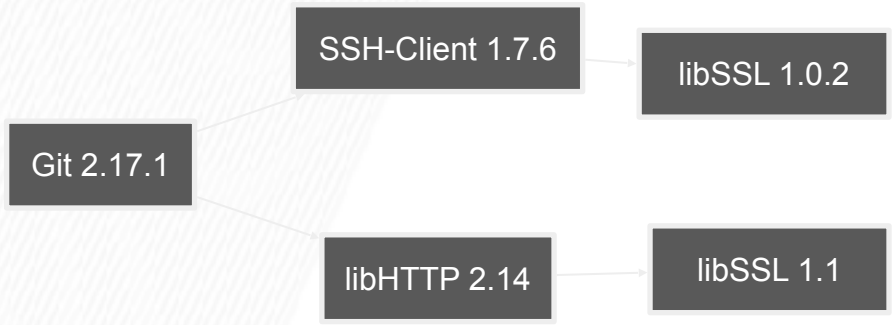
Diamond Dependencies

What are some problems when multiple intermediate dependencies have the same transitive dependency?



Diamond Dependencies

What are some problems when multiple intermediate dependencies have the same transitive dependency?



Resolutions to the Diamond Problem

1. Duplicate it!
   - Doesn't work with static linking (e.g. C/C++), but may be doable with Java (e.g. using ClassLoader hacking or package renaming)
   - Values of types defined by duplicated libraries cannot be exchanged across
2. Ban transitive dependencies; just use a global list with one version for each
   - Challenge: Keeping things in sync with latest
   - Challenge: Deciding which version of transitive deps to keep
3. Newest version (keep everything at latest)
   - Requires ordering semantics
   - Intermediate dependency may break with update to transitive
4. Oldest version (lowest denominator)
   - Also requires ordering semantics
   - Sacrifices new functionality
5. Oldest non-breaking version / Newest non-breaking version
   - Requires faith in tests or semantic versioning contract

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Semantic Versioning

- Widely used convention for versioning releases
  - E.g. 1.2.1, 3.1.0-alpha-1, 3.1.0-alpha-2, 3.1.0-beta-1, 3.1.0-rc1
- Format: {MAJOR} . {MINOR} . {PATCH}
- Each component is ordered (numerically, then lexicographically; release-aware)
  - 1.2.1 < 1.10.1
  - 3.1.0-alpha-1 < 3.1.0-alpha-2 < 3.1.0-beta-1 < 3.1.0-rc1 < 3.1.0
- Contracts:
  - MAJOR updated to indicate breaking changes
    - Same MAJOR version => backward compatibility
  - MINOR updated for additive changes
    - Same MINOR version => API compatibility (important for linking)
  - PATCH updates functionality without new API
    - Ninja edit; usually for bug fixes

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https://semver.org/

2.0.0 2.0.0-rc.2 2.0.0-rc.1 1.0.0 1.0.0-beta

Semantic Versioning 2.0.0

Summary

Given a version number MAJOR.MINOR.PATCH, increment the:

1. MAJOR version when you make incompatible API changes,
2. MINOR version when you add functionality in a backwards compatible manner, and
3. PATCH version when you make backwards compatible bug fixes.

Additional labels for pre-release and build metadata are available as extensions to the MAJOR.MINOR.PATCH format.

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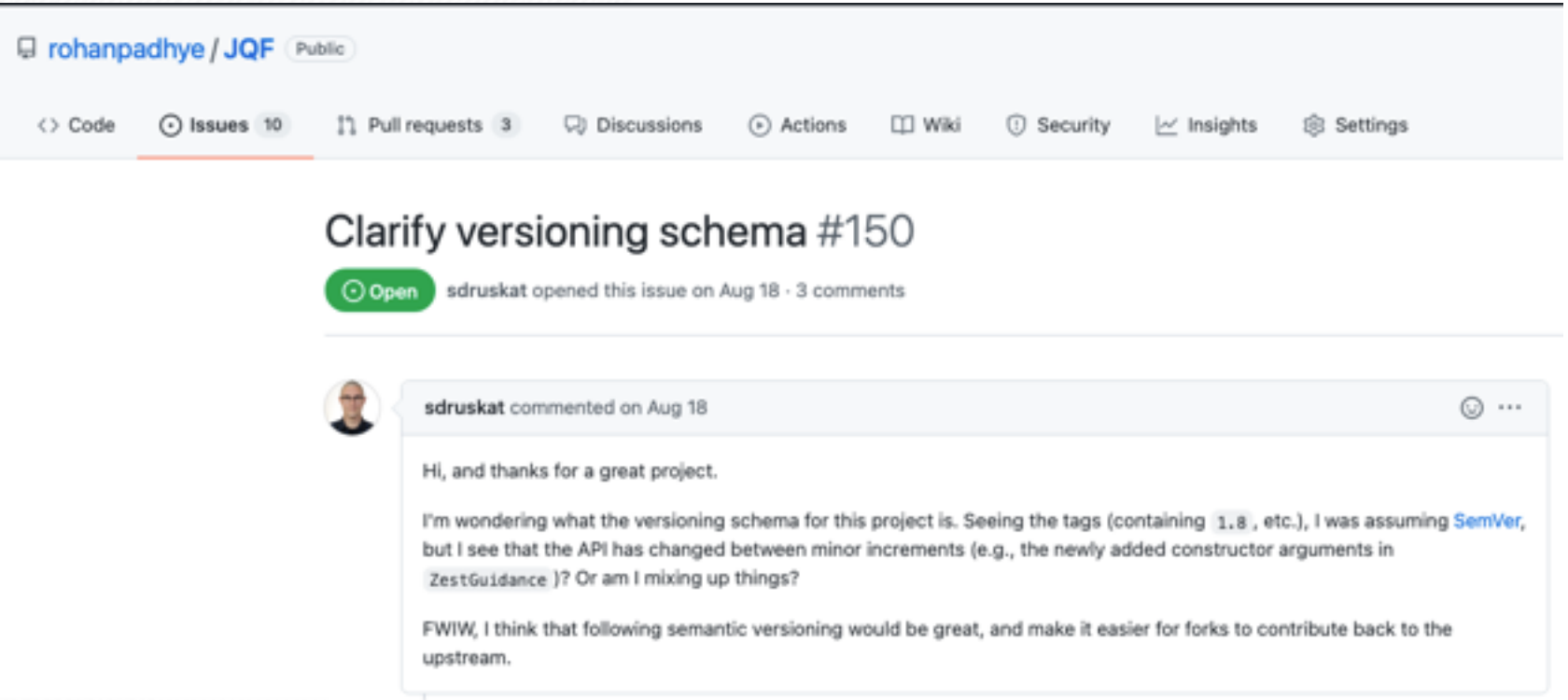
People rely on SemVer contracts



Dependency Constraints

- E.g. Declare dependency on ”Bar > 2.1”
  - Bar 2.1.0, 2.1.1, 2.2.0, 2.9.0, etc. all match
  - 2.0.x does NOT match
  - 3.0.x does NOT match
- Diamond dependency problem can be resolved using SAT solvers
  - E.g. Foo 1.0.0 depends on “Bar >= 2.1” and “Baz 1.8.x”
    - Bar 2.1.0 depends on “Qux [1.6, 1.7]”
    - Bar 2.1.1 depends on “Qux 1.7.0”
    - Baz 1.8.0 depends on “Qux 1.5.x”
    - Baz 1.8.1 depends on “Qux 1.6.x”
  - Find an assignment such that all dependencies are satisfied
    - Solution: Use Bar 2.1.0, Baz 1.8.1, and Qux 1.6.{latest}

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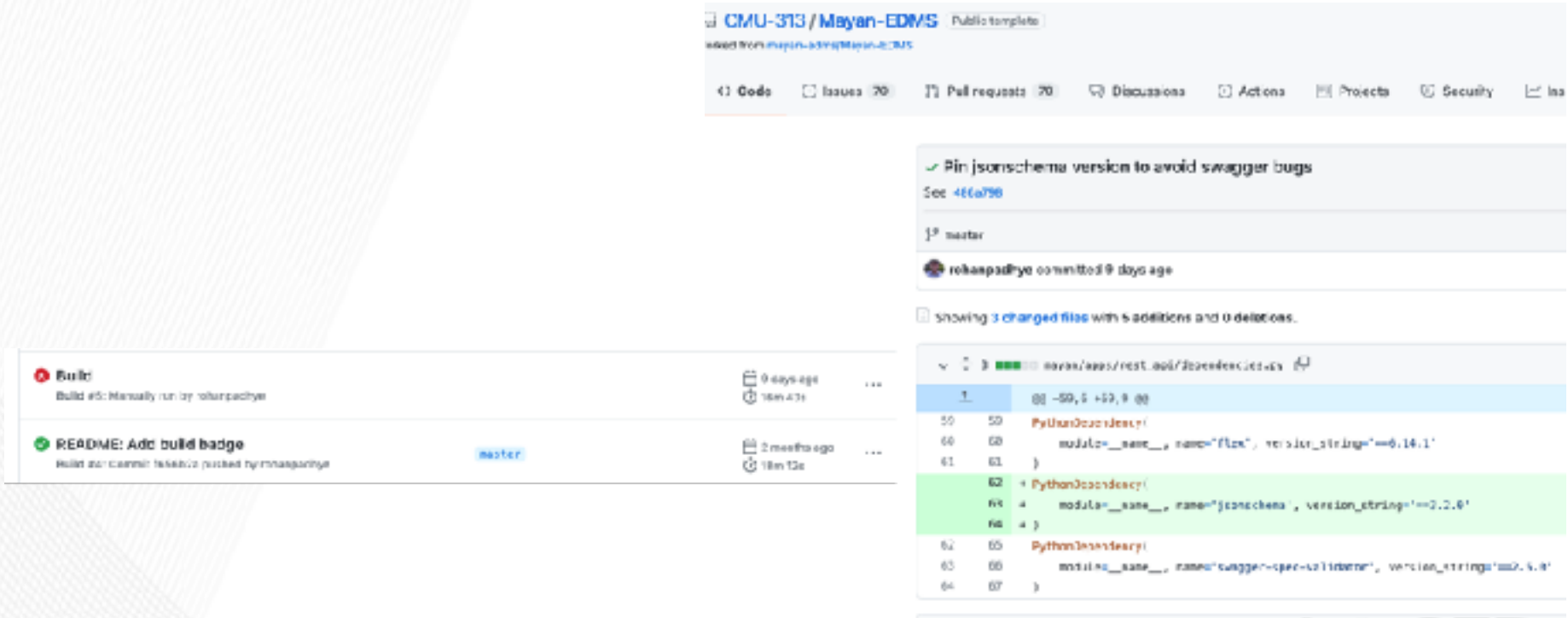
Semantic Versioning Contracts

- Largely trusting developers to maintain them
- Constrained/range dependencies can cause unexpected build failures
- Automatic validation of SemVer is hard



Cyclic Dependencies

- A very bad thing
- Avoid at all costs
- Sometimes unavoidable or intentional
  - E.g. GCC is written in C (needs a C compiler)
  - E.g. Apache Maven uses the Maven build system
  - E.g. JDK tested using JUnit, which requires the JDK to compile

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Cyclic Dependencies

- Bootstrapping: Break cycles over time
- Assume older version exists in binary (pre-built form)
- Step 1: Build A using an older version of B
- Step 2: Build B using new (just built) version of A
- Step 3: Rebuild A using new (just built) version of B
- Now, both A and B have been built with new versions of their dependencies
- Doesn't work if both A and B need new features of each other at the same time (otherwise Step 1 won't work)
  - Assumes incremental dependence on new features
- How was the old version built in the first place? (it's turtles all the way down)
  - Assumption: cycles did not exist in the past
  - Successfully applied in compilers (e.g. GCC is written in C)

Dependency Security

- Will you let strangers execute arbitrary code on your laptop?
  - Think about this every time you do “pip install” or “npm install” or “apt-get updgrade” or “brew updgrade” or whatever (esp. with sudo)
  - Scary, right? Who are you trusting? Why?
- Typo squatting (“pip install numpi”)
- Outright malice (remember the *event-stream* incident?)
- Genuine security vulnerabilities due to software bugs

Takeaways

- Dependency management is hard.

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