Final Thoughts on the semester

17-313 Fall 2023

Foundations of Software Engineering

https://cmu-313.github.io

Andrew Begel and Rohan Padhye and **Michael Hilton**

Administrivia

- Final Exam time and Location: Tuesday, December 12

  05:30pm-08:30pm □n Person PH 100

- Snack Survey to be released tomorrow

Today- JIT Topic Selection:

- I have a set of topics I could present today, but I would like to ask you what you would like to hear about:
  - Grad School
  - ML Fairness Types
  - Dependency Management + SemVer
  - Software Patents
  - Decision Calculus

Grad School

Not All Grad School Programs are created equal

- PhD - Researched Focused
- Masters programs - A wide variety of programs with different goals
  - 5th year masters
  - Research Masters
  - Full/Part time Masters
  - Immigration Concerns
  - Breadth vs Depth

The PhD in CS:
Getting There and Being Successful

More Great Reasons to Pursue a Ph.D.

Gain Opportunities to Teach and Mentor

Pursuing a Ph.D. provides you with a unique opportunity to teach and mentor

Satisfy Your Intellectual Curiosity

- *Discover new things*
- *Identify new problems*
- *Develop creative solutions*
- *Push the boundary of knowledge*
- *Develop a habit of lifelong learning*

Get Paid to Learn!

Many students don’t realize that most C.S. Ph.D. programs pay a comfortable stipend. But note, there are opportunity costs.

The CS Doctorate (Ph.D.) in a Nutshell

Timeline

- Variable; average 6-7 years from Bachelor’s
- Depending on school, starting with a Master’s degree may shorten timeline

Coursework

- Typically “next level” CS foundations and (more) advanced electives

Research

- Dissertation (aka Doctoral Thesis)
- Oral/Written Exam along the way (e.g., qualifying exam)

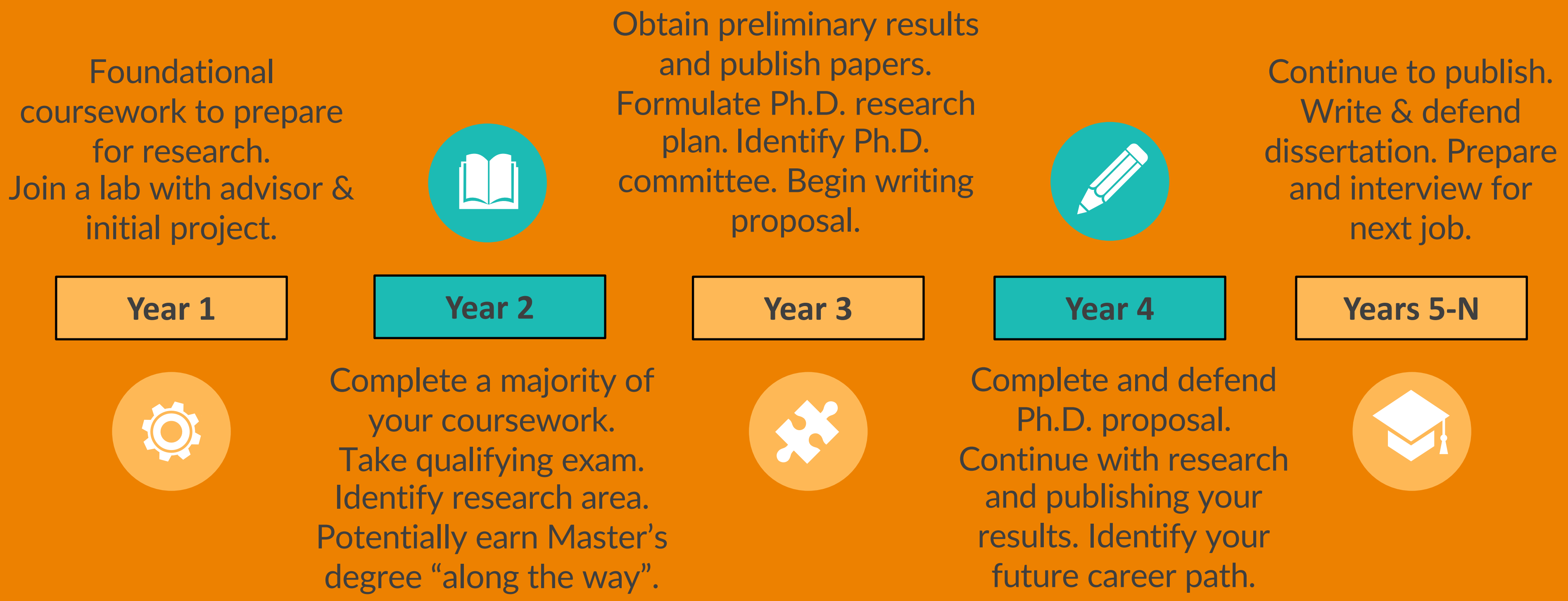
Tuition & Stipend (Get paid to learn!)

- Generally ***tuition is waived*** and you typically receive ***a stipend and health insurance*** from a teaching or research assistantship or fellowship

Career Paths

- Academia (e.g., a professor)
- Industrial, NPO, or government researcher or engineer
- Entrepreneur (e.g., a start-up)
- Higher-level development/leadership positions

Typical Timeline for a Ph.D. Program



Year 1

Foundational coursework to prepare for research.
Join a lab with advisor & initial project.

Year 2

Complete a majority of your coursework.
Take qualifying exam.
Identify research area.
Potentially earn Master's degree "along the way".

Year 3

Obtain preliminary results and publish papers. Formulate Ph.D. research plan. Identify Ph.D. committee. Begin writing proposal.

Year 4

Complete and defend Ph.D. proposal.
Continue with research and publishing your results. Identify your future career path.

Years 5-N

Continue to publish.
Write & defend dissertation. Prepare and interview for next job.

How a Ph.D. differs from an M.S. Degree

Academic Master's Program

3-4 courses/term in first year.
1-2 courses/term with a research and MS thesis or project in second year.
Not always funded, but there is the potential to serve as a teaching assistant.

Professional Master's Program

3-4 courses/term for 1.5– 2 years.
Geared towards industrial careers.
Typically not funded by the school, but could be funded by a company you work for.

Doctoral (Ph.D) Program

Similar to Academic Master's in the first 2 years. In years 3+, primarily research.
Typically includes additional duties such as teaching assistant or research assistant.

The PhD in CS: Getting There and Being Successful

November 1st, 2021

Dr. Michael Hilton
Associate Teaching Professor
Carnegie Mellon University

Dr. Janet Davis
Associate Professor
Whitman College

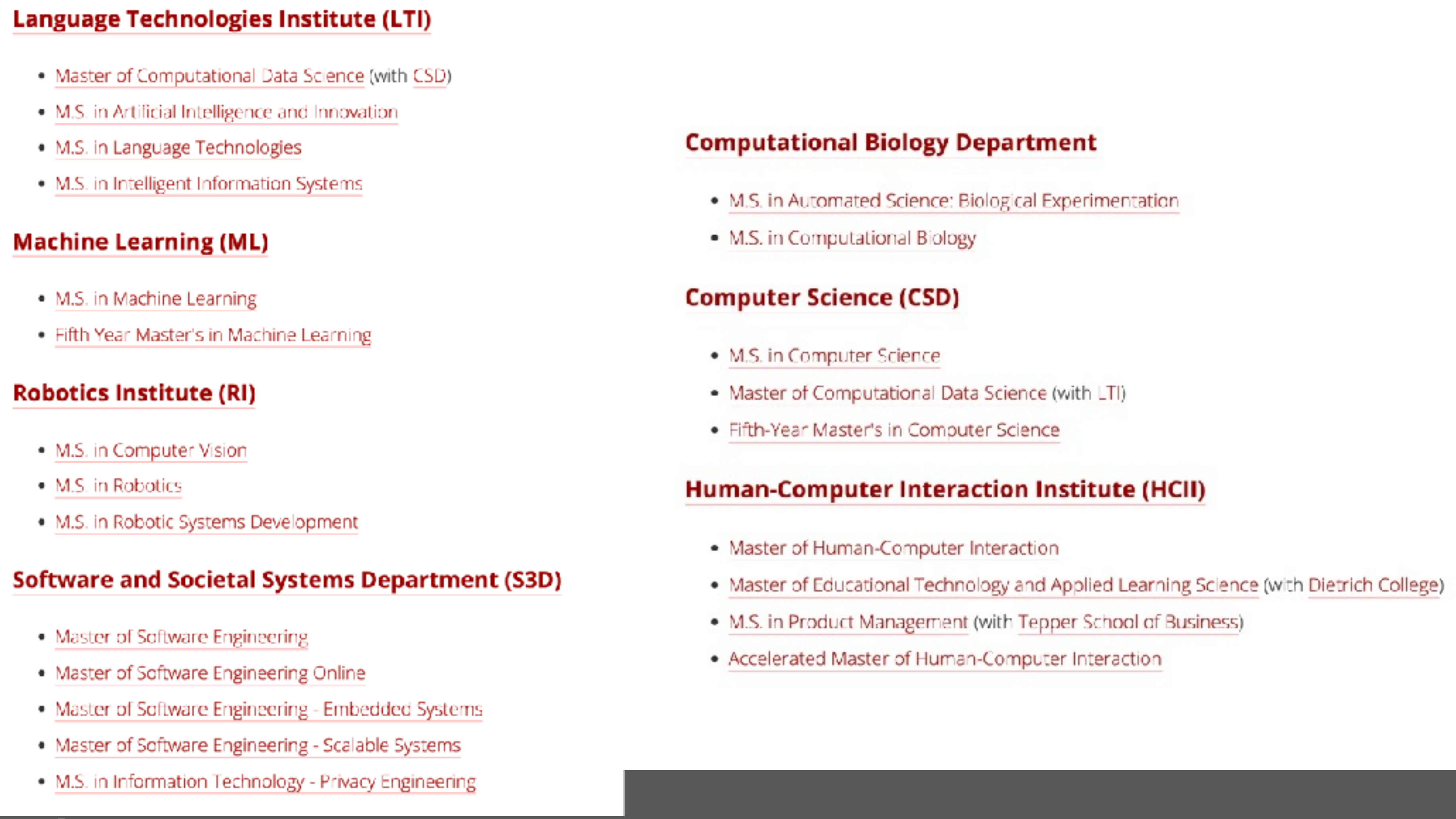
Ian Ludden
PhD Student
University of Illinois Urbana-Champaign

CRA-E
Computing Research Association
Education

https://www.youtube.com/watch?v=Qn7eUeNw6vI

Masters Programs

MS Diversity - This is just SCS MS Programs in SCS



Language Technologies Institute (LTI)

- Master of Computational Data Science (with CSD)
- M.S. in Artificial Intelligence and Innovation
- M.S. in Language Technologies
- M.S. in Intelligent Information Systems

Machine Learning (ML)

- M.S. in Machine Learning
- Fifth Year Master's in Machine Learning

Robotics Institute (RI)

- M.S. in Computer Vision
- M.S. in Robotics
- M.S. in Robotic Systems Development

Software and Societal Systems Department (S3D)

- Master of Software Engineering
- Master of Software Engineering Online
- Master of Software Engineering - Embedded Systems
- Master of Software Engineering - Scalable Systems
- M.S. in Information Technology - Privacy Engineering

Computational Biology Department

- M.S. in Automated Science: Biological Experimentation
- M.S. in Computational Biology

Computer Science (CSD)

- M.S. in Computer Science
- Master of Computational Data Science (with LTI)
- Fifth-Year Master's in Computer Science

Human-Computer Interaction Institute (HCII)

- Master of Human-Computer Interaction
- Master of Educational Technology and Applied Learning Science (with Dietrich College)
- M.S. in Product Management (with Tepper School of Business)
- Accelerated Master of Human-Computer Interaction

Some Programs of Interest

- MSE - Masters of Software Engineering
- MSE - AMP
- SCS 5th Year Master’s Program
- 5th-Year Master’s in ML
- MBA/Part Time

Reasons to Consider a Master's Degree

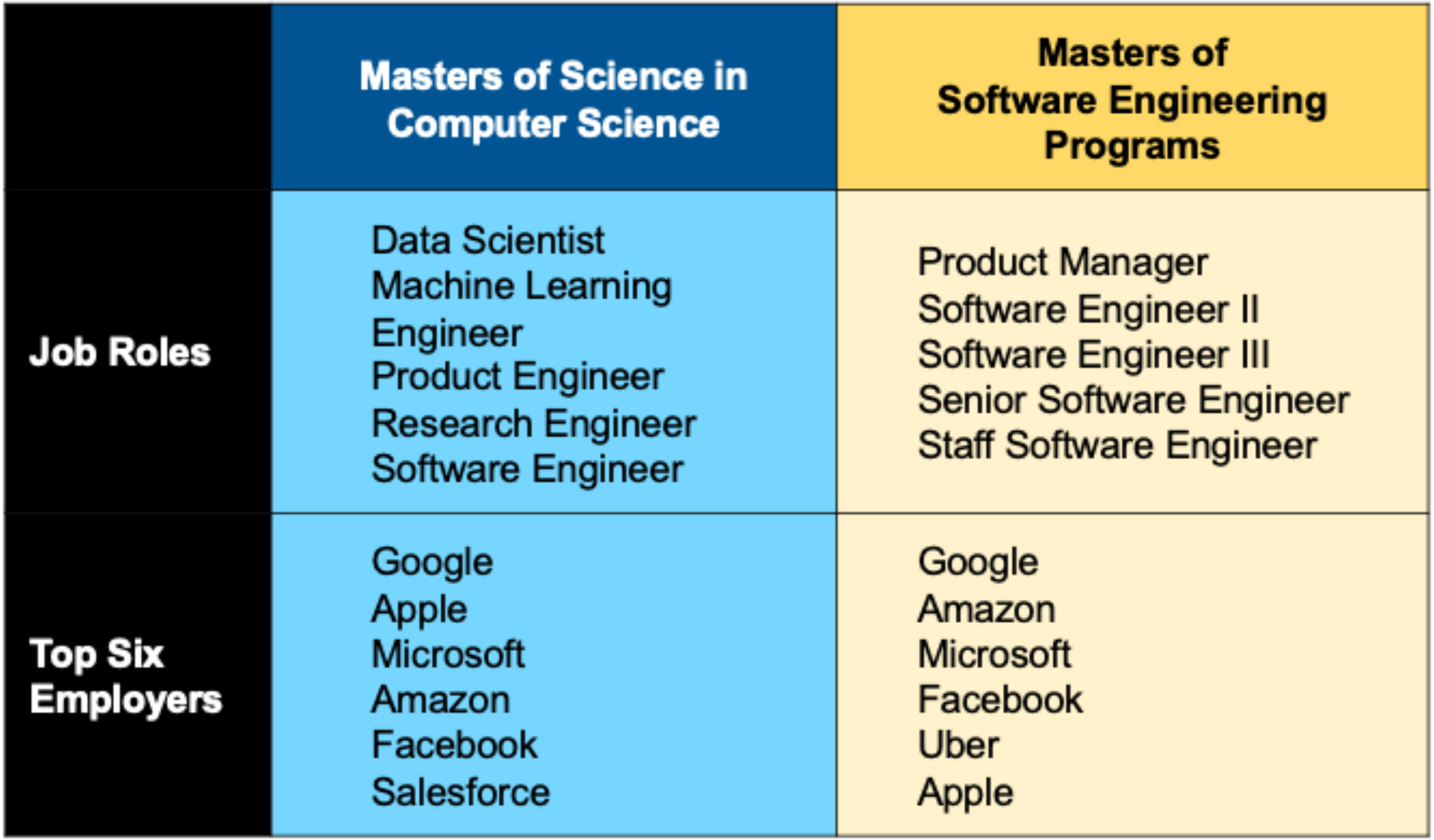
- Entry into the US Labor Force
- Extension of Student Visa
- Breadth
- Depth
- Credentials
- Curiosity of Learning
- ???

Master’s of Software Engineering

MSE Degree Programs

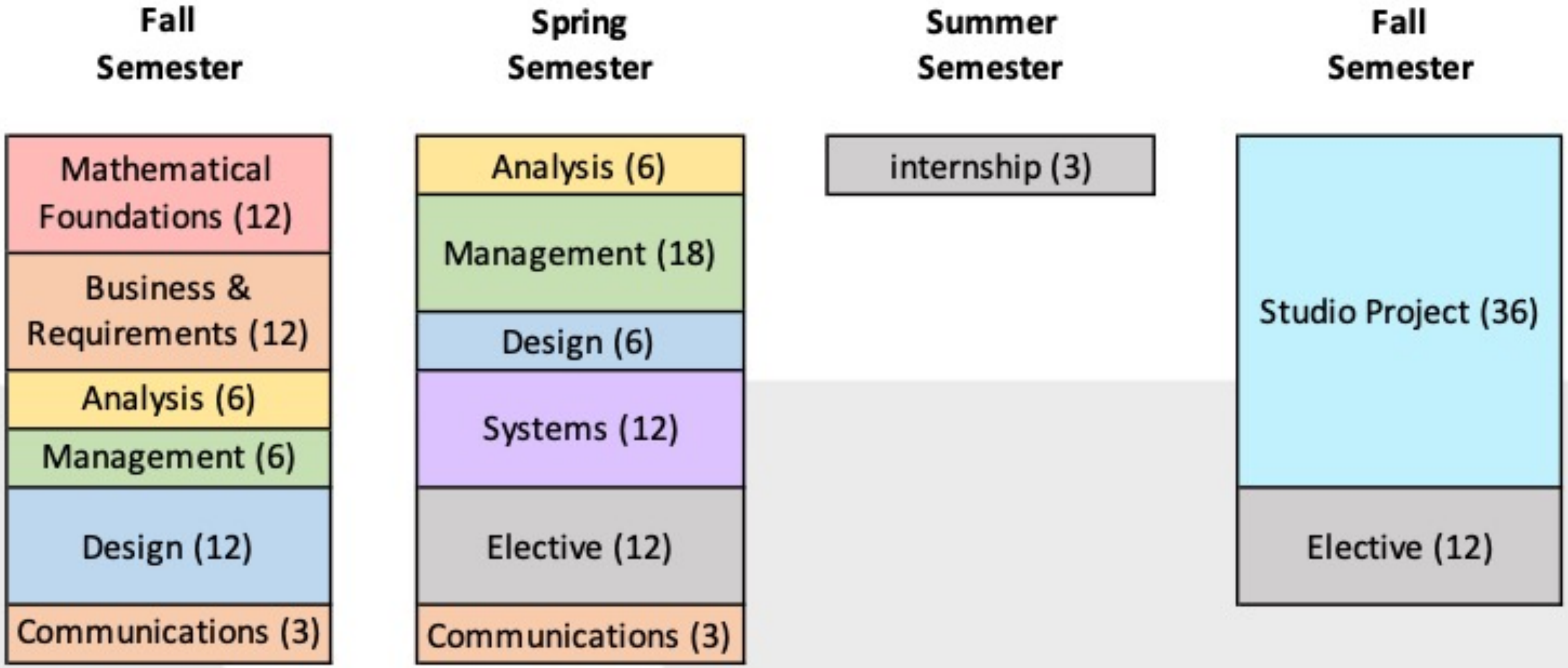
The Masters of Software Engineering (MSE) is five programs:

- **MSE for professionals** with >2 years of software engineering experience
    - MSE Campus is a four semester full-time program, graduates in 1.5 years
    - MSE/MBA dual degree program with Tepper School of Business
    - MSE Online is a 6-8 semester part-time program, graduates in 2-3 years
- **MSE for recent grads** with <2 years of related experience, consisting of two programs or tracks:
    - Scalable Systems (SS) – distributed and data-intensive systems
    - Embedded Systems (ES) – robotics, sensors and wearables



	Masters of Science in Computer Science	Masters of Software Engineering Programs
Job Roles	Data Scientist Machine Learning Engineer Product Engineer Research Engineer Software Engineer	Product Manager Software Engineer II Software Engineer III Senior Software Engineer Staff Software Engineer
Top Six Employers	Google Apple Microsoft Amazon Facebook Salesforce	Google Amazon Microsoft Facebook Uber Apple

MSE-SS/-ES – Plan of Study



Fall Semester

- Mathematical Foundations (12)
- Business & Requirements (12)
- Analysis (6)
- Management (6)
- Design (12)
- Communications (3)

Spring Semester

- Analysis (6)
- Management (18)
- Design (6)
- Systems (12)
- Elective (12)
- Communications (3)

Summer Semester

- internship (3)

Fall Semester

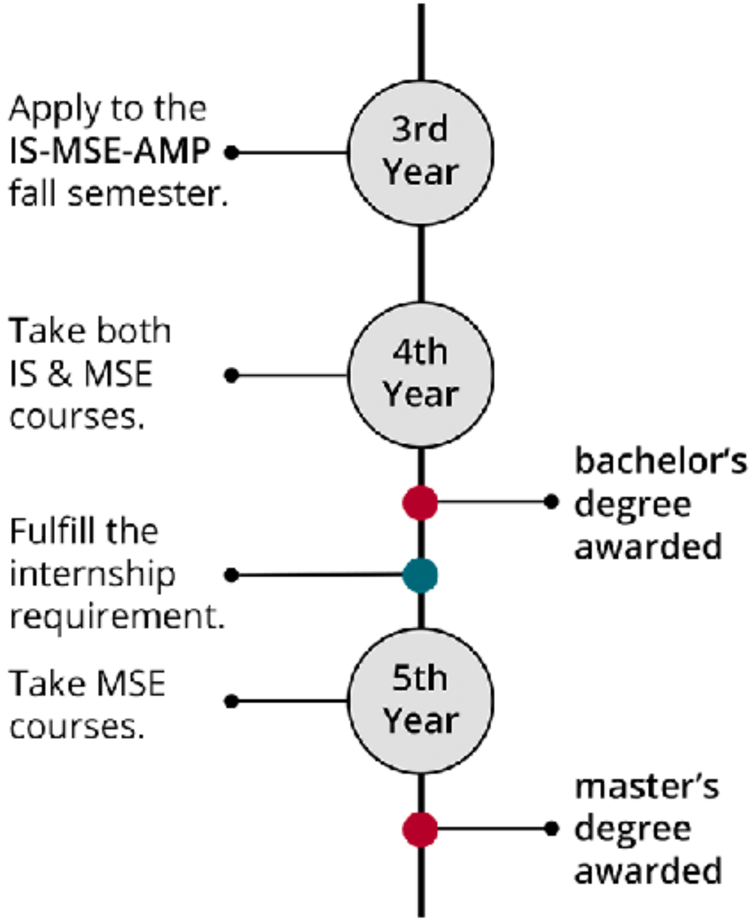
- Studio Project (36)
- Elective (12)

* 60 unit core, 6 units communication, 36 units project, required internship, 24 units electives

□S-MSE Accelerated Master's Program (AMP)

IS-MSE Accelerated Master's Program (AMP)

- 5th year master's program for undergraduate Information Systems majors in the Dietrich College of Humanities and Social Sciences at Carnegie Mellon.
- https://mse.isri.cmu.edu/applicants/mse-amp.html
- Application Deadline: December 12, 2022



3rd Year — Apply to the IS-MSE-AMP fall semester.

4th Year — Take both IS & MSE courses.

bachelor's degree awarded

Fulfill the internship requirement.

5th Year — Take MSE courses.

master's degree awarded

CSD Fifth-year Master’s

CS 5th year's Master

- Fifth Year Master's program usually lasts 12 months, including one normal academic year and one summer
- Students will start working on a research project during the summer after their senior year, and continue that project while taking classes during the academic year.
- Students can only start the Fifth Year Master's program after they have received their B.S. in computer science or A□from CMU.
- "Students typically apply in their senior year"
- https://csd.cmu.edu/academics/masters/requirements

M.S. in Computer Science

M.S. in Computer Science

- Pass* 96 units in qualifying master’s courses from the curriculum list in the MSCS Handbook. This is typically eight courses.
- Pass 12 free-elective units.
- Pass one course from the available Systems courses. (May be used a qualifying course.)
- Pass one course from the available Theoretical Foundations courses. (May be used a qualifying course.)
- Pass one course from the available Theoretical Foundations courses. (May be used a qualifying course.)

- https://csd.cmu.edu/academics/masters/requirements

5th Year Master’s Machine Learning

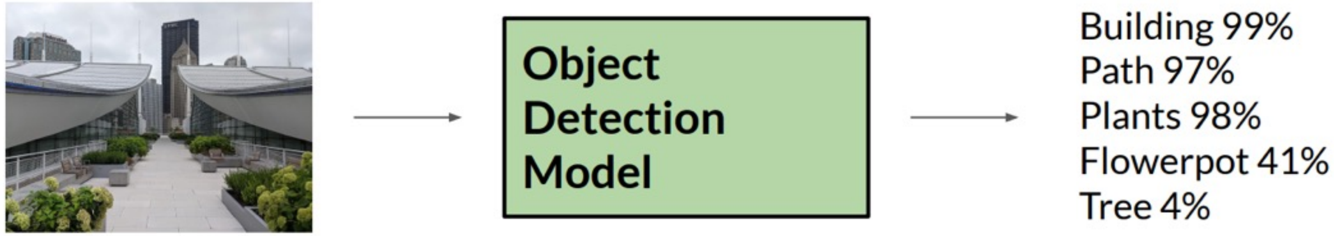
5th-Year Master's in Machine Learning

- The 5th-Year Master's in Machine Learning allows CMU students to complete a MS in Machine Learning in one additional year by taking some of the required courses as an undergraduate.
- □nterested students apply earlier in Senior year than the standard application deadline and receive the response earlier as well.
- Must take precisely 3 of the MS courses during their undergraduate years, passed with a B or better. (These courses may also count towards the Bachelor's degree.)
- https://www.ml.cmu.edu/academics/5th-year-ms.html

Questions?

ML Fairness

ML Model = Unreliable Function



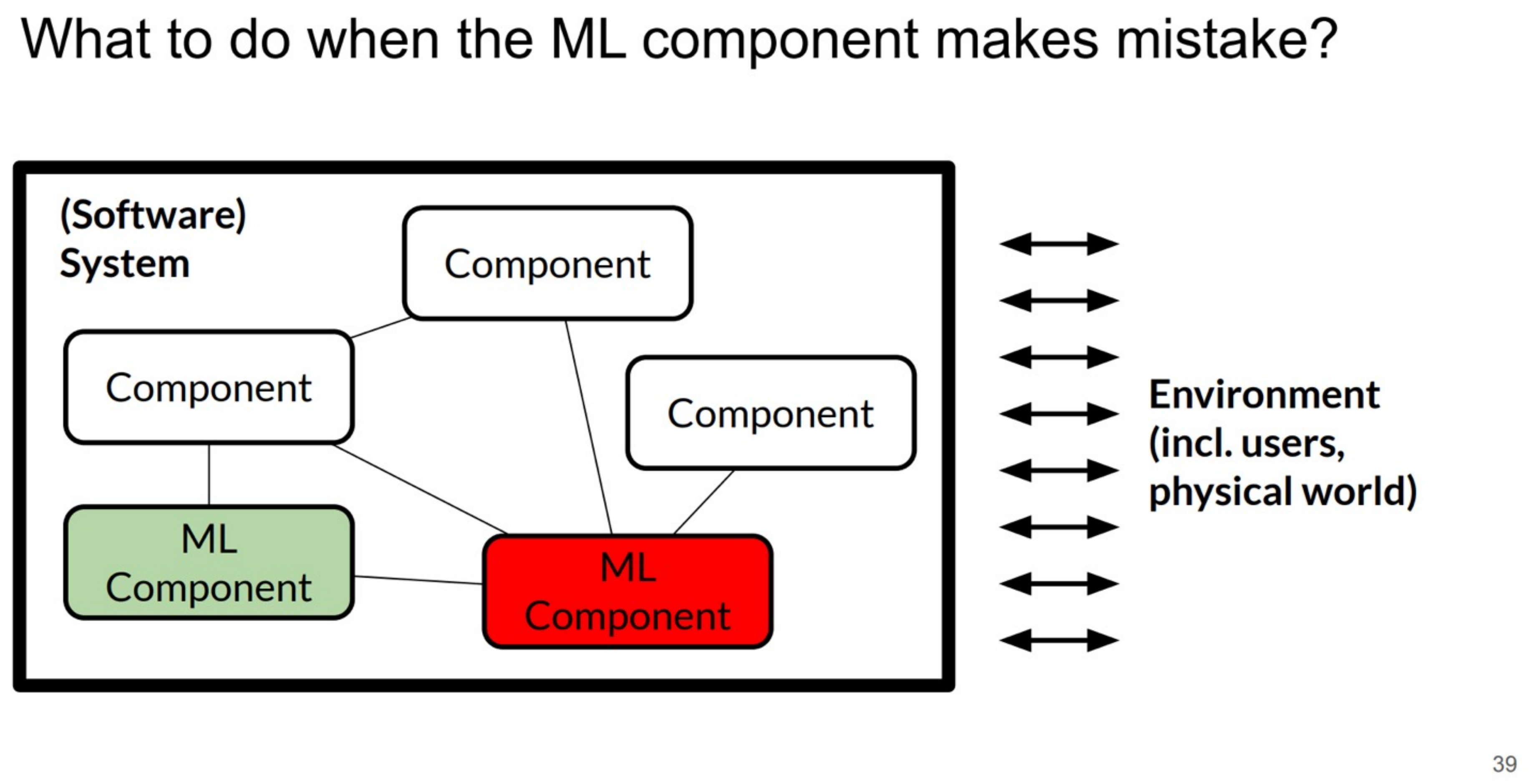
Object Detection Model

Building 99%
Path 97%
Plants 98%
Flowerpot 41%
Tree 4%

No guarantees, may make mistakes, confidence unreliable

Model often inscrutable, opaque

Evaluated in terms of accuracy, not correctness

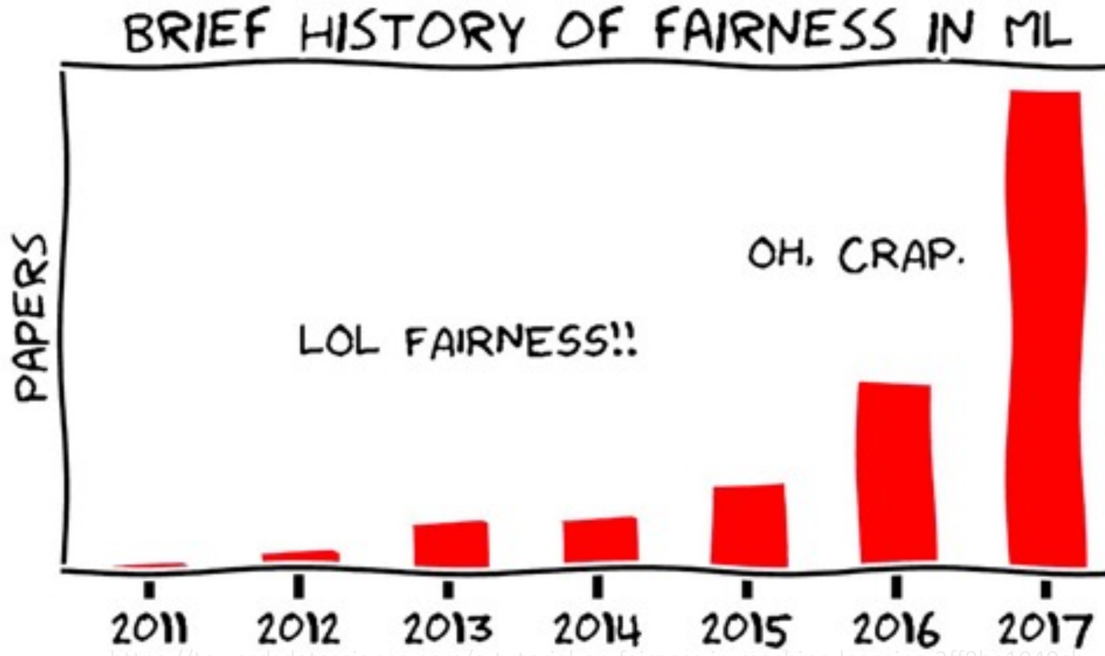


What to do when the ML component makes mistake?

Fairness

ML Fairness

- Getting answers is the easy part… Asking the right questions is the hard part.



https://towardsdatascience.com/a-tutorial-on-fairness-in-machine-learning-3ff8ba1040cb

Perception:

Unfair
Fair
JAKE-CLARK.TUMBLR

Life is often not this simple…

Fairness

- □s a deeply technical topic, but we will discuss it at a higher level of abstraction.
- The formulas are important, but knowing which formula to apply is MUCH more important
- This is a special case of how to to test when the desired outcome is hard to measure.

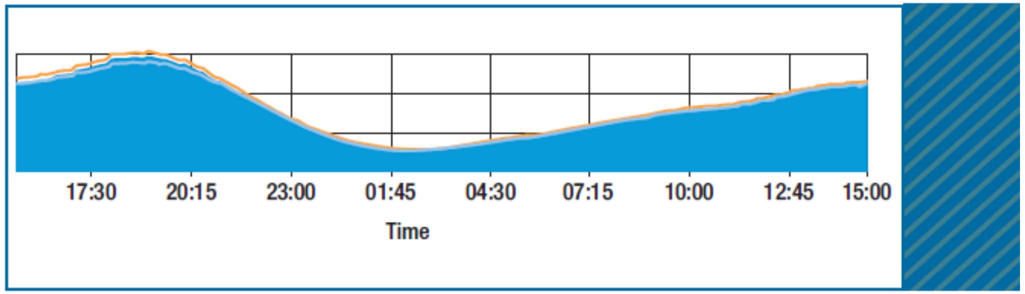


FIGURE 2. A graph of SPS ([stream] starts per second) over a 24-hour period. This metric varies slowly and predictably throughout a day. The orange line shows the trend for the prior week. The *y*-axis isn't labeled because the data is proprietary.

VS

What does ”fair” mean?

What is Fairness?

- Law
  - fairness includes protecting individuals and groups from discrimination or mistreatment with a focus on prohibiting behaviors, biases and basing decisions on certain protected factors or social group categories.
- Social Science
  - “often considers fairness in light of social relationships, power dynamics, institutions and markets.”3 Members of certain groups (or identities) that tend to experience advantages.

What is Fairness? continued

- Quantitative Fields
  - (i.e. math, computer science, statistics, economics): questions of fairness are seen as mathematical problems. Fairness tends to match to some sort of criteria, such as equal or equitable allocation, representation, or error rates, for a particular task or problem.
- Philosophy:
  - ideas of fairness “rest on a sense that what is fair is also what is morally right.” Political philosophy connects fairness to notions of justice and equity.

Fairness as QA

How can we define “fair”

- For the purposes of creating an oracle
- We must have a better definition than infamous 1964 Supreme Court obscenity test:
    - □shall not today attempt further to define [obscene material], and perhaps □could never succeed in intelligibly doing so. But □*know it when* □*see it*, and the motion picture involved in this case is not that.[

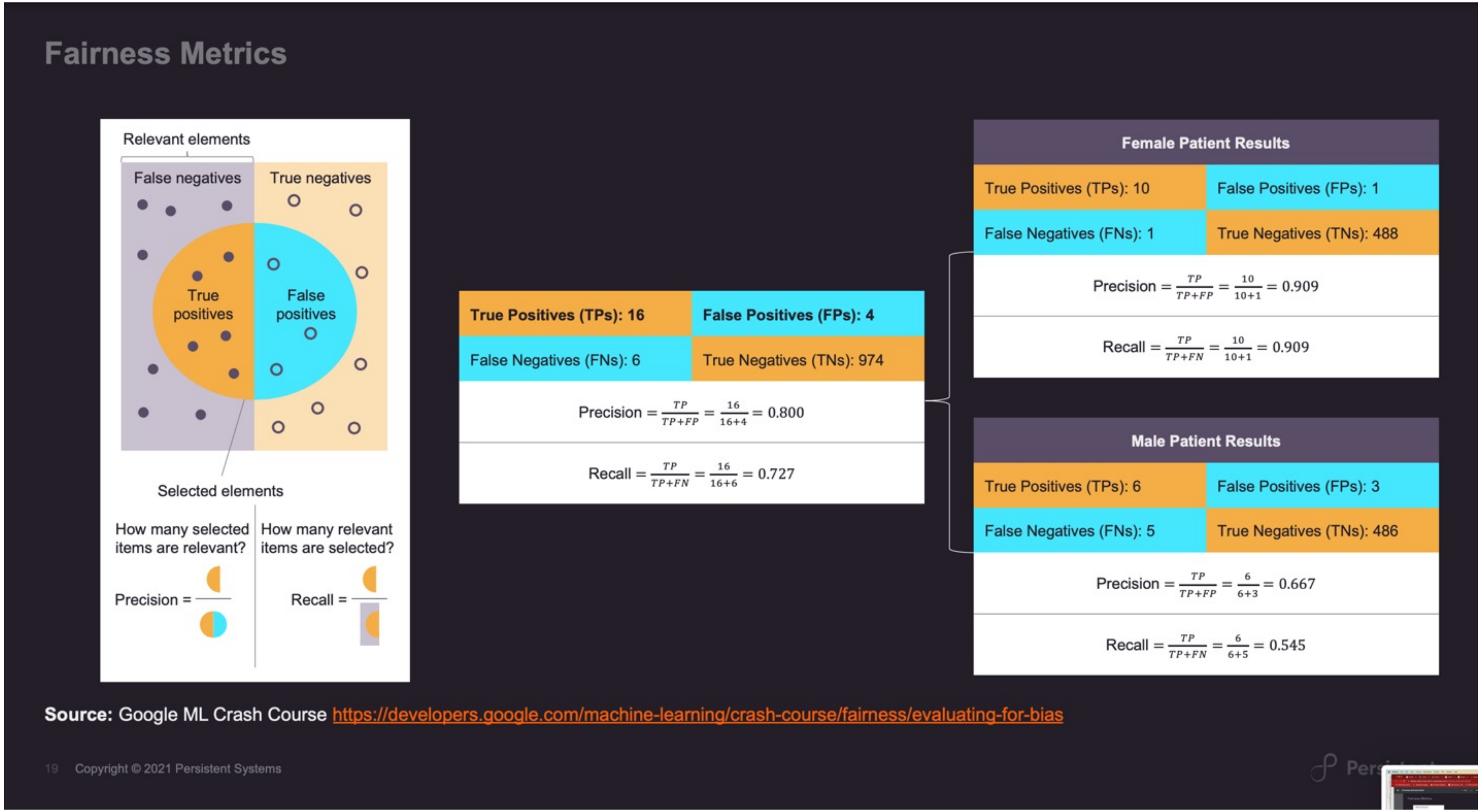
We don’t need to start from scratch…

What can we do?

What can we do?

- We can evaluate with different criteria (e.g., different admissions score thresholds).
- We can observe the outcome of changing thresholds, and we can set different thresholds for different groups. (e.g., different SAT scores for in-state or out-of-state admissions)
- We can observe the impact of these different thresholds across a variety of metrics for each group.

First, some definitions:



Fairness Metrics

True Positives (TPs): 16	False Positives (FPs): 4
False Negatives (FNs): 6	True Negatives (TNs): 974

$$\text{Precision} = \frac{TP}{TP+FP} = \frac{16}{16+4} = 0.800$$

$$\text{Recall} = \frac{TP}{TP+FN} = \frac{16}{16+6} = 0.727$$

Female Patient Results

True Positives (TPs): 10	False Positives (FPs): 1
False Negatives (FNs): 1	True Negatives (TNs): 488

$$\text{Precision} = \frac{TP}{TP+FP} = \frac{10}{10+1} = 0.909$$

$$\text{Recall} = \frac{TP}{TP+FN} = \frac{10}{10+1} = 0.909$$

Male Patient Results

True Positives (TPs): 6	False Positives (FPs): 3
False Negatives (FNs): 5	True Negatives (TNs): 486

$$\text{Precision} = \frac{TP}{TP+FP} = \frac{6}{6+3} = 0.667$$

$$\text{Recall} = \frac{TP}{TP+FN} = \frac{6}{6+5} = 0.545$$

Source: Google ML Crash Course https://developers.google.com/machine-learning/crash-course/fairness/evaluating-for-bias

19

https://dattaraj-public.s3.ap-south-1.amazonaws.com/AI-Fairness_26th+April_DR.pdf

Varieties of fairness (names vary)

- **Group unaware**
  - □gnore group data (one group could get excluded)
- **Group thresholds**
  - Different rules per group (rules differ by group)
- **Demographic parity**
  - Same percentage in pool as outcomes (might result in random selection)
- **Equal opportunity**
  - Equal chance out positive outcomes regardless of groups (focus on individual, rules differ per group)

Group unaware

- We use some criteria that is independent of the categories we are considering for fairness.
- Guarantees about outcomes: None. One group may be completely excluded

Group thresholds

- We create different criteria per group
- Guarantees about outcomes: candidates inside a group are evaluated by the same standard as others inside the same group.
- By definition, groups are evaluated to a different standard (e.g., different fitness standards by gender in US Military)

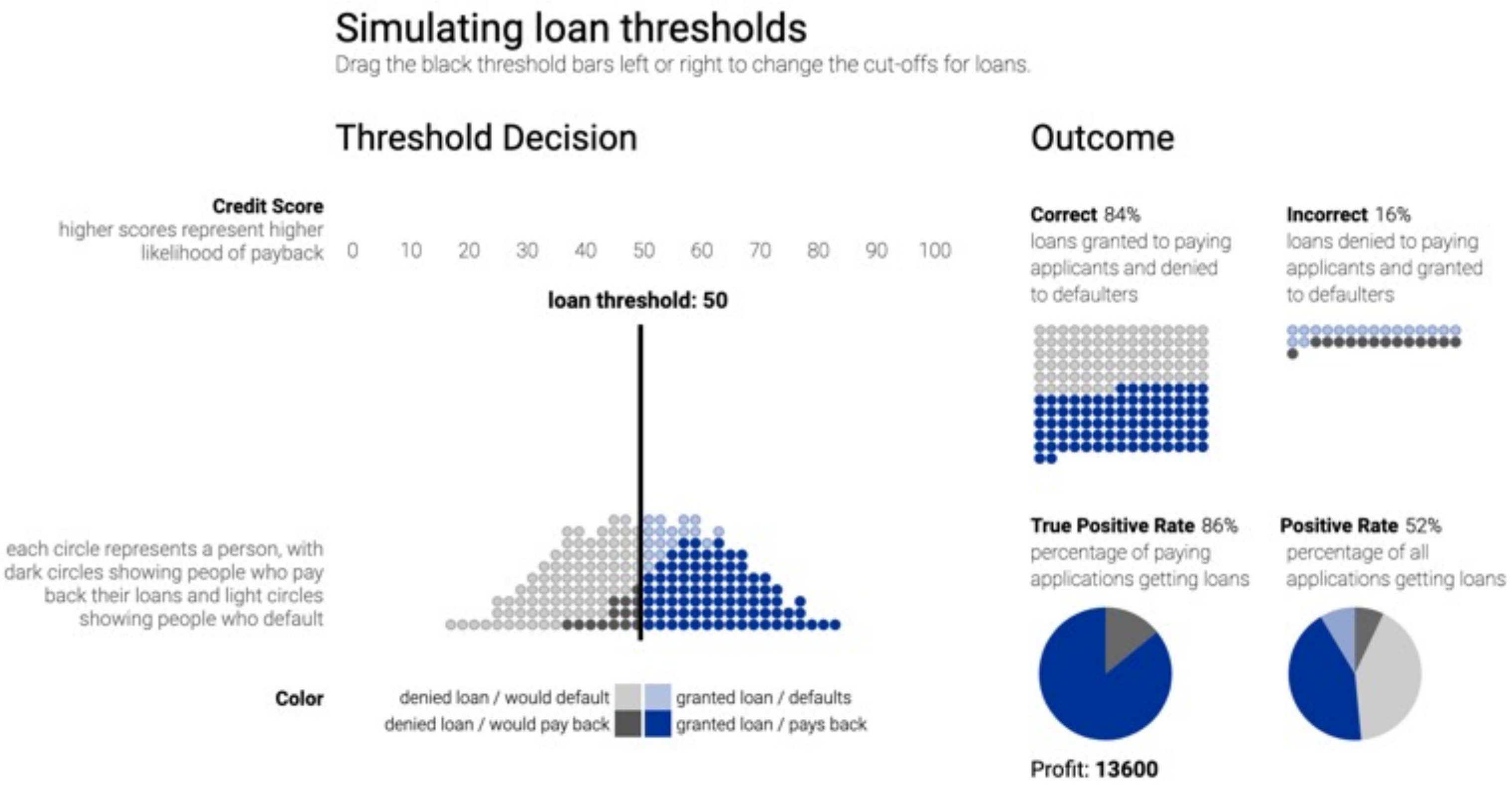
Demographic parity

- We create different criteria per group, with a goal of similar outcomes in a certain dimension.
- Guarantees about outcomes: The same percentage of each group will have a positive outcome. e.g., 25 % accepted from group A, 25% accepted from group B.
- However, can result in different true positive rates, (e.g., more “worthy” candidates denied in group A than group B.

Equal opportunity

- We create different criteria per group, with a goal of similar outcomes for similar individuals across groups.
- Guarantees about outcomes: The same number of true positives per group. e.g., 80% true positives in group A, 80% true positives in group B.
- However, can result in different positive rates across groups.

Explainability



Simulating loan thresholds

Drag the black threshold bars left or right to change the cut-offs for loans.

Threshold Decision

Credit Score
higher scores represent higher likelihood of payback

loan threshold: 50

each circle represents a person, with dark circles showing people who pay back their loans and light circles showing people who default

Color

denied loan / would default	○	○	granted loan / defaults
denied loan / would pay back	●	●	granted loan / pays back

Outcome

Correct 84%
loans granted to paying applicants and denied to defaulters

Incorrect 16%
loans denied to paying applicants and granted to defaulters

True Positive Rate 86%
percentage of paying applications getting loans

Positive Rate 52%
percentage of all applications getting loans

Profit: **13600**

https://research.google.com/bigpicture/attacking-discrimination-in-ml/

Activity

Consider the different approaches to fairness. Can you come up with different scenarios where each fairness approach might or might not be appropriate?

Remember the fairness approaches are:

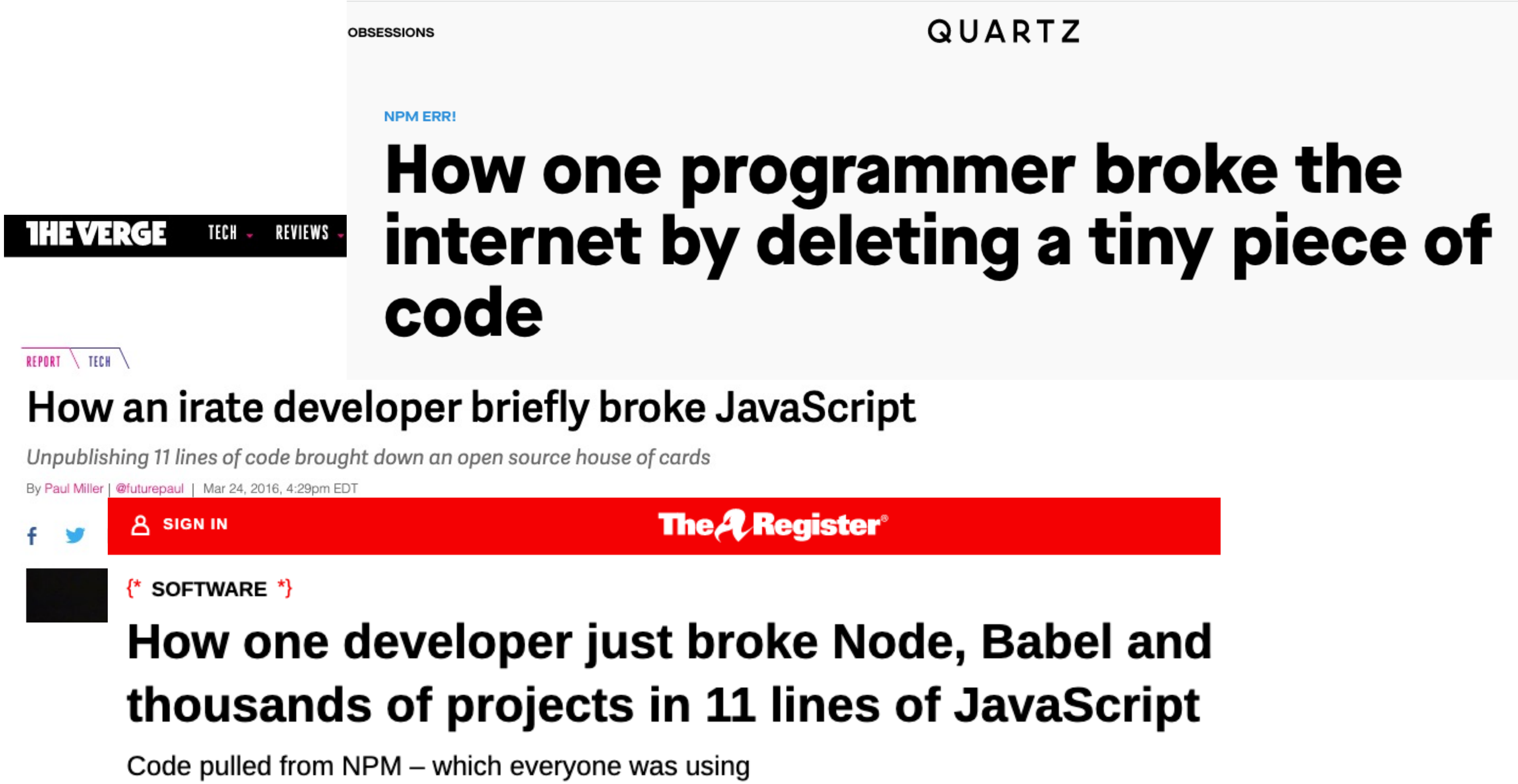
- Group unaware
- Group thresholds
- Demographic parity
- Equal opportunity

Resources

- Fairness Textbook:
- https://fairmlbook.org/testing.html

Dependency Management

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

SIGN IN

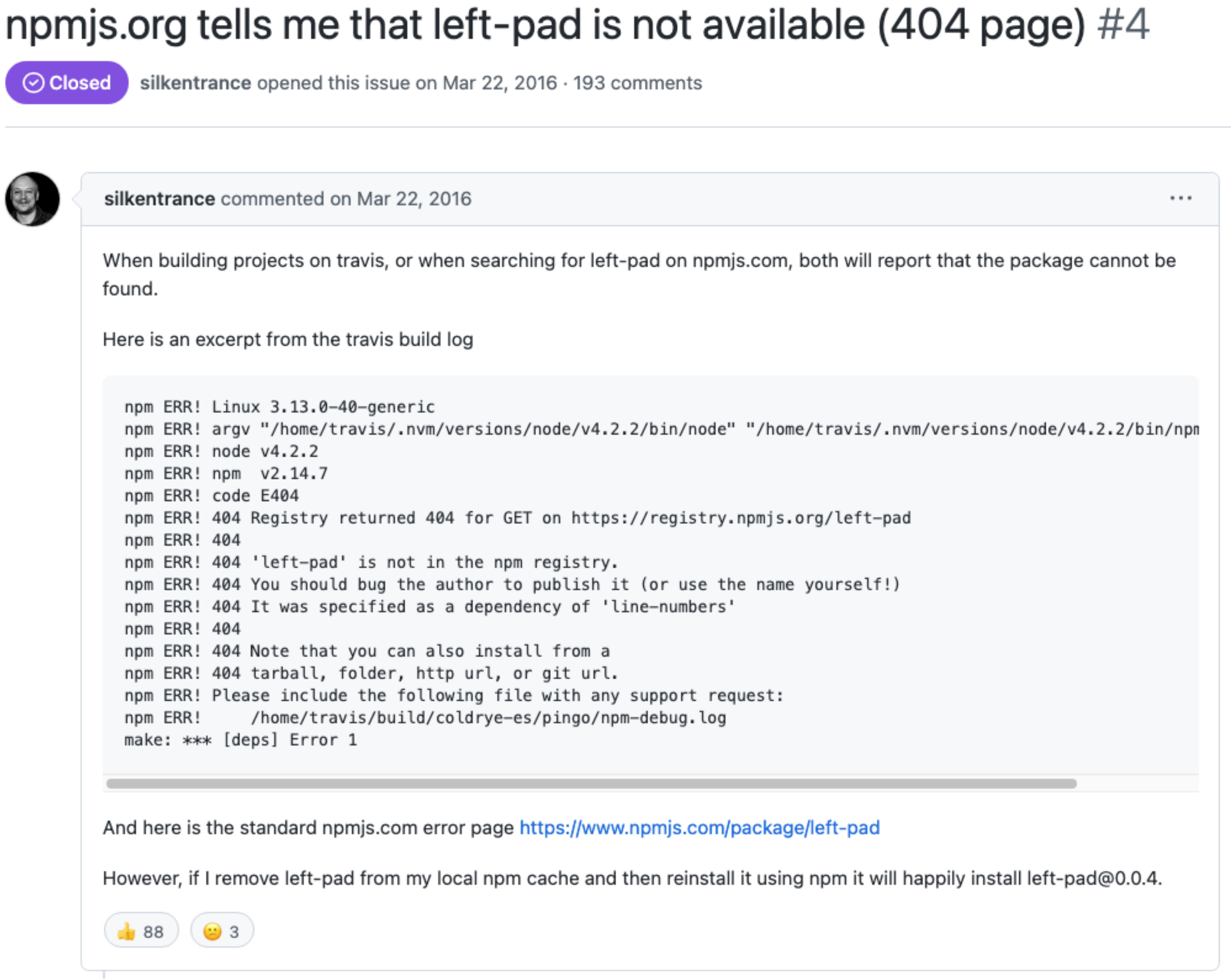
The Register®

{* 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

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

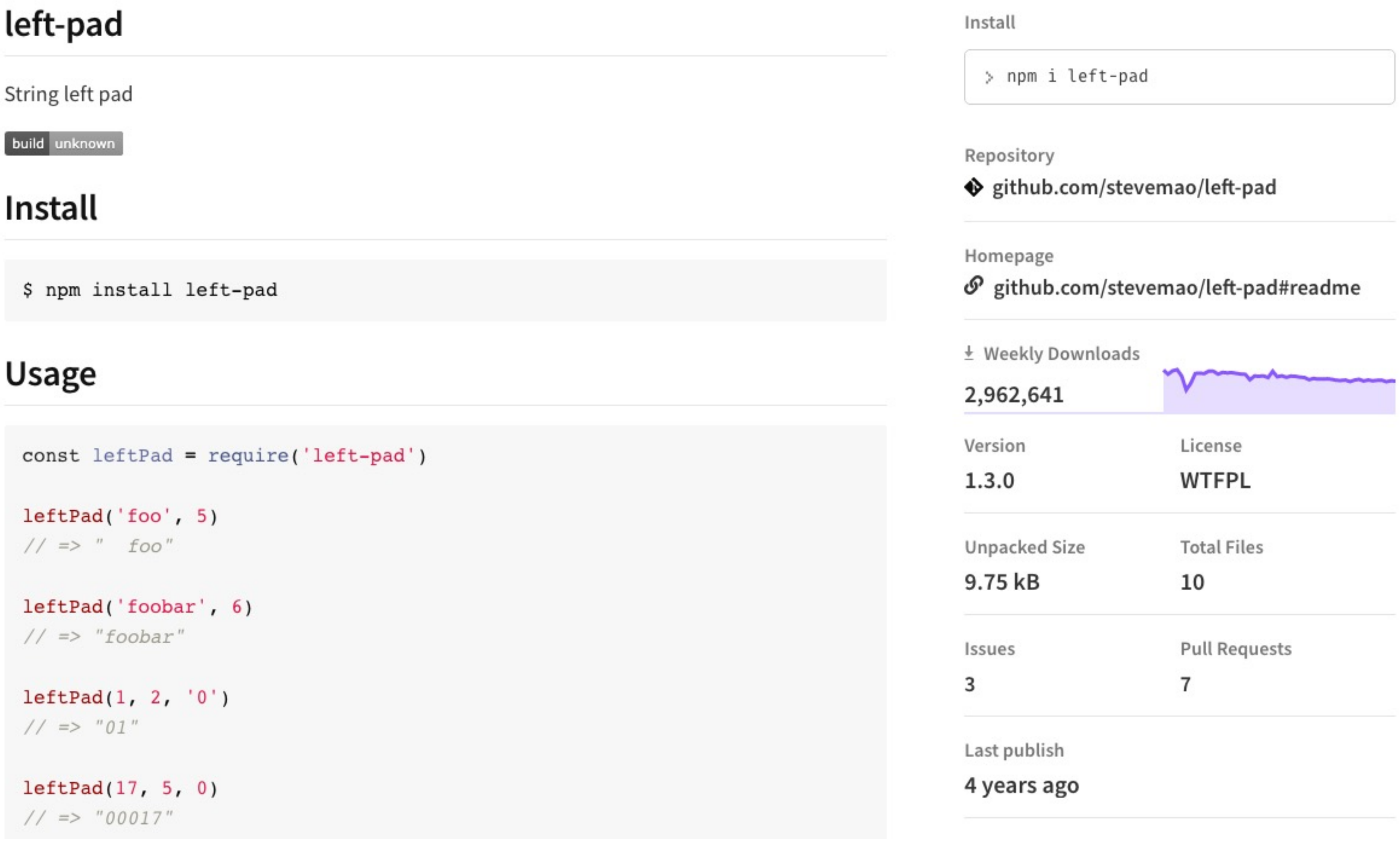
```
npm ERR! Linux 3.13.0-40-generic
npm ERR! argv "/home/travis/.nvm/versions/node/v4.2.2/bin/node" "/home/travis/.nvm/versions/node/v4.2.2/bin/npm
npm ERR! node v4.2.2
npm ERR! npm  v2.14.7
npm ERR! code E404
npm ERR! 404 Registry returned 404 for GET on https://registry.npmjs.org/left-pad
npm ERR! 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/pingo/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.

👍 88 😕 3

Left-pad (Docs)



left-pad

String left pad

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

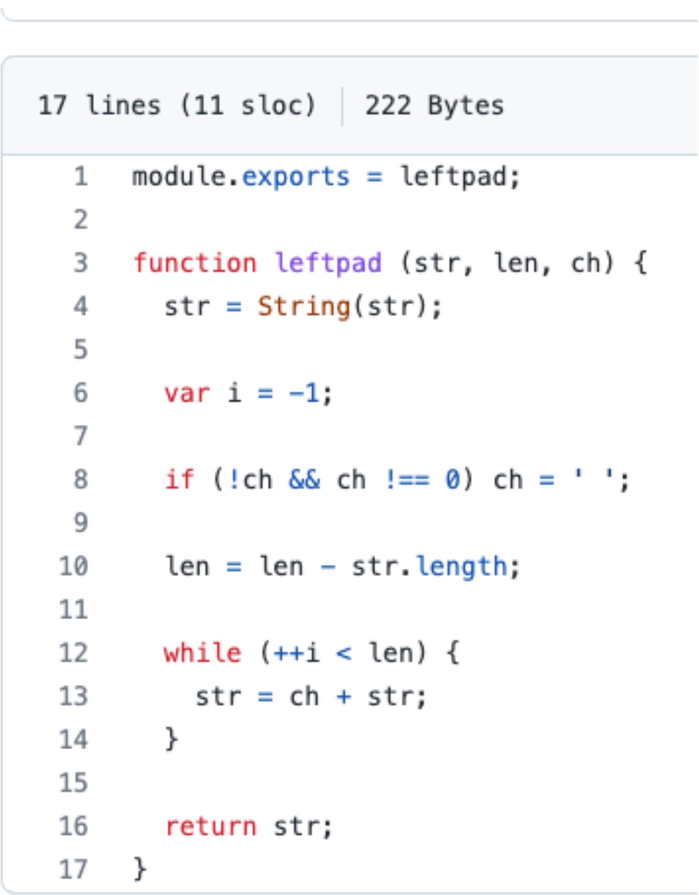
Homepage
github.com/stevemao/left-pad#readme

Weekly Downloads
2,962,641

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

Last publish
4 years ago

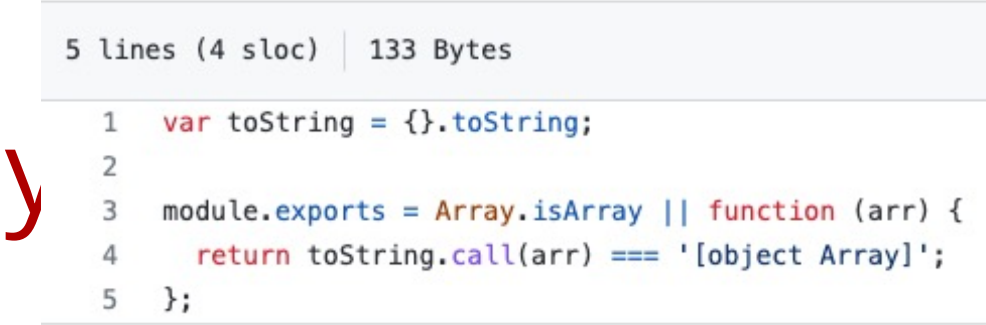
Left-pad (Source Code)



17 lines (11 sloc) | 222 Bytes

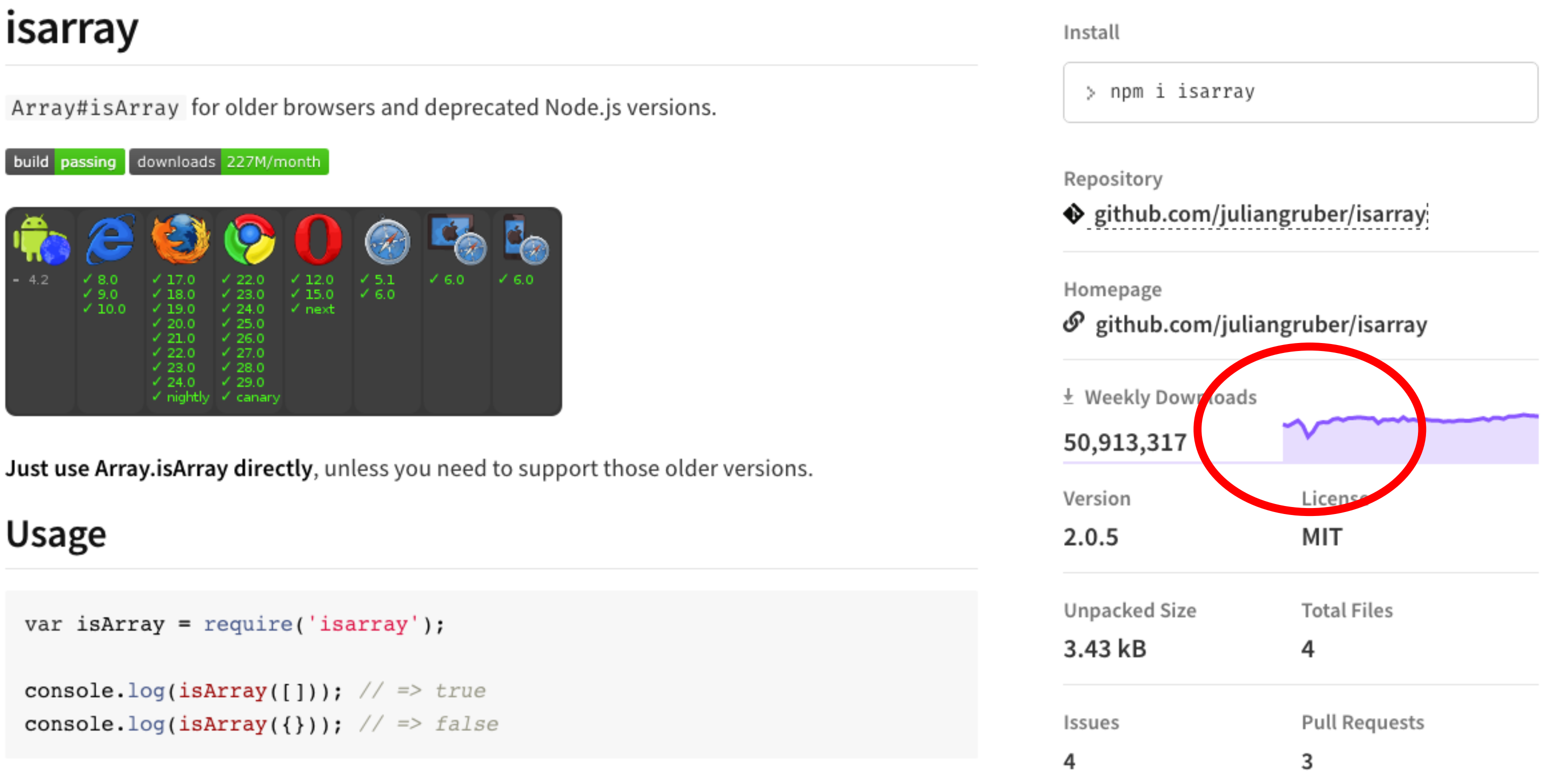
```
module.exports = leftpad;

function leftpad (str, len, ch) {
  str = String(str);

  var i = -1;

  if (!ch && ch !== 0) ch = ' ';

  len = len - str.length;

  while (++i < len) {
    str = ch + str;
  }

  return str;
}
```

See also: isArray



5 lines (4 sloc) | 133 Bytes

```
var toString = {}.toString;

module.exports = Array.isArray || function (arr) {
  return toString.call(arr) === '[object Array]';
};
```



isarray

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

build passing | downloads 227M/month

- 4.2
✓ 8.0 ✓ 9.0 ✓ 10.0
✓ 17.0 ✓ 18.0 ✓ 19.0 ✓ 20.0 ✓ 21.0 ✓ 22.0 ✓ 23.0 ✓ 24.0 ✓ nightly
✓ 22.0 ✓ 23.0 ✓ 24.0 ✓ 25.0 ✓ 26.0 ✓ 27.0 ✓ 28.0 ✓ 29.0 ✓ canary
✓ 12.0 ✓ 15.0 ✓ next
✓ 5.1 ✓ 6.0
✓ 6.0
✓ 6.0

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

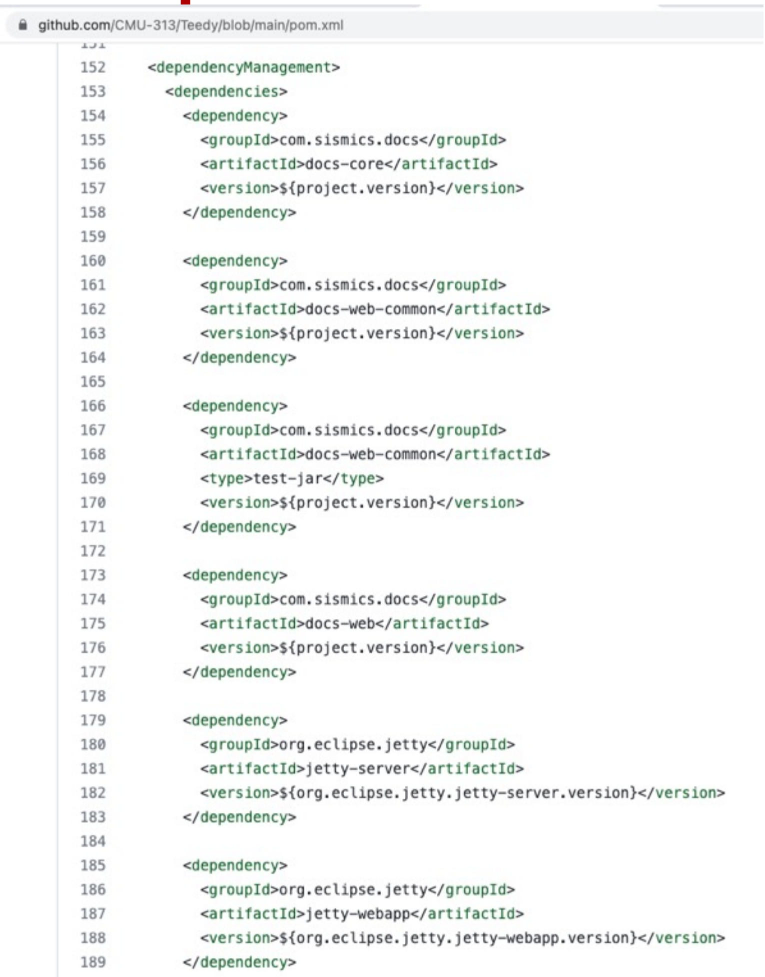
Dependency Management

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

What is a Dependency?

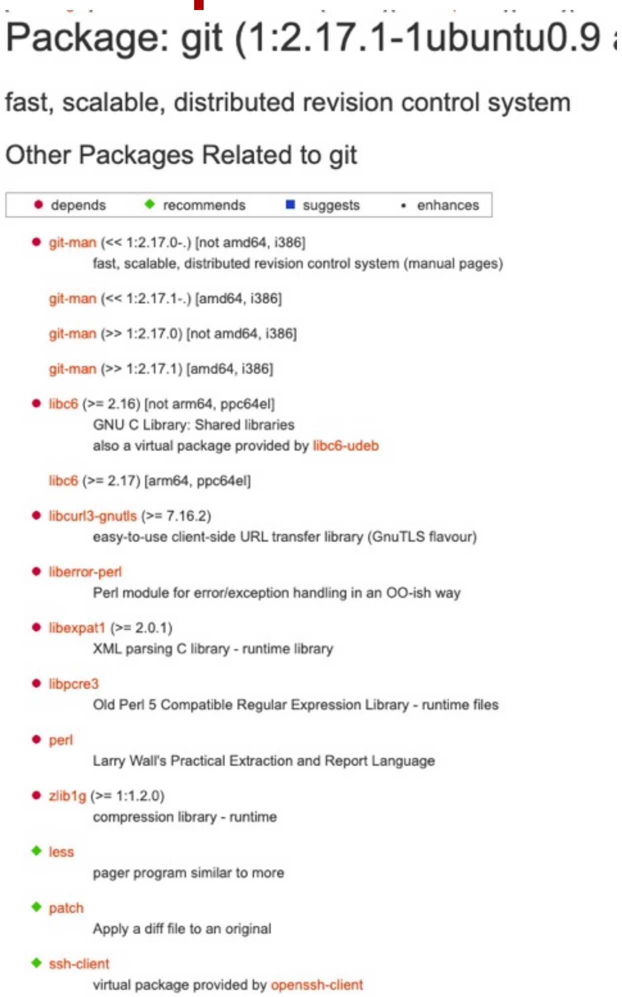
- Core of what most build systems do
  - “Compile” and “Run Tests” is just a fraction of their job
- Examples: Maven, Gradle, NPM, Bazel, …
- **Foo->Bar**: To build Foo, you may need to have a built version of Bar
- Dependency Scopes:
  - **Compile**: Foo uses classes, functions, etc. defined by Bar
  - **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?

Dependencies: Example



github.com/CMU-313/Teedy/blob/main/pom.xml

```
<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-web</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 amd64, i386]
  fast, scalable, distributed revision control system (manual pages)

  git-man (<< 1:2.17.1-.) [amd64, i386]

  git-man (>> 1:2.17.0) [not amd64, i386]

  git-man (>> 1:2.17.1) [amd64, i386]
- ● libc6 (>= 2.16) [not arm64, ppc64el]
  GNU C Library: Shared libraries
  also a virtual package provided by libc6-udeb

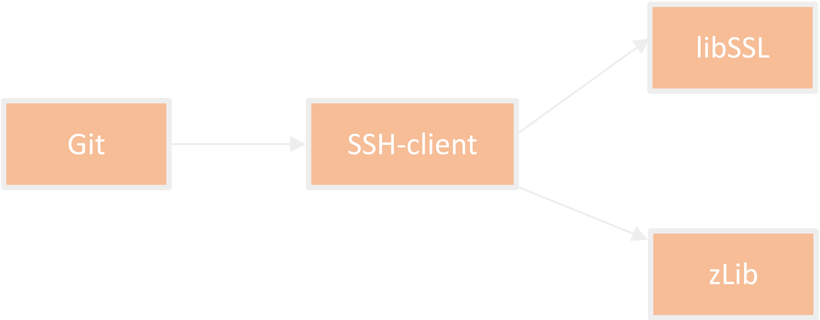
  libc6 (>= 2.17) [arm64, ppc64el]
- ● libcurl3-gnutls (>= 7.16.2)
  easy-to-use client-side URL transfer library (GnuTLS flavour)
- ● liberror-perl
  Perl module for error/exception handling in an OO-ish way
- ● libexpat1 (>= 2.0.1)
  XML parsing C library - runtime library
- ● libpcre3
  Old Perl 5 Compatible 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

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

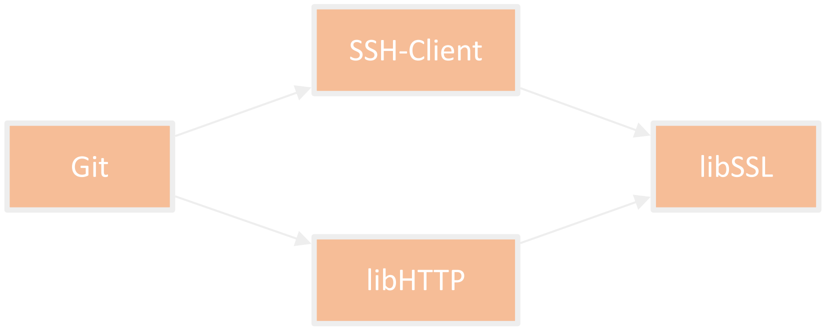
Packages can depend on other packages

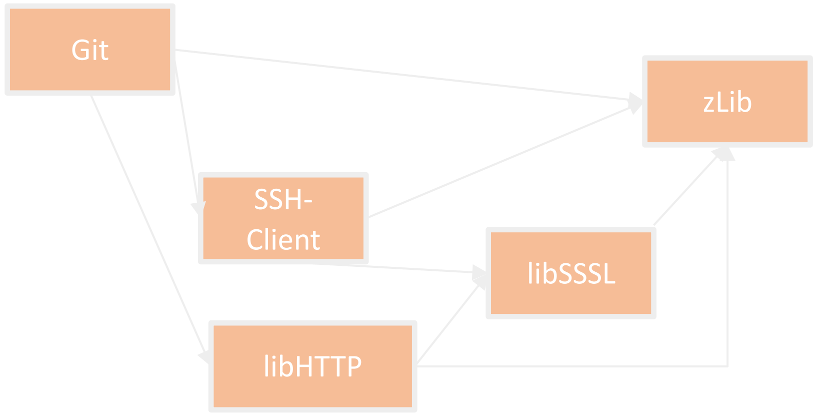


Q: Should Git be able to use exports of libSSL (e.g. certificate management) or zLib (e.g. gzip compression)?

Diamond Dependencies

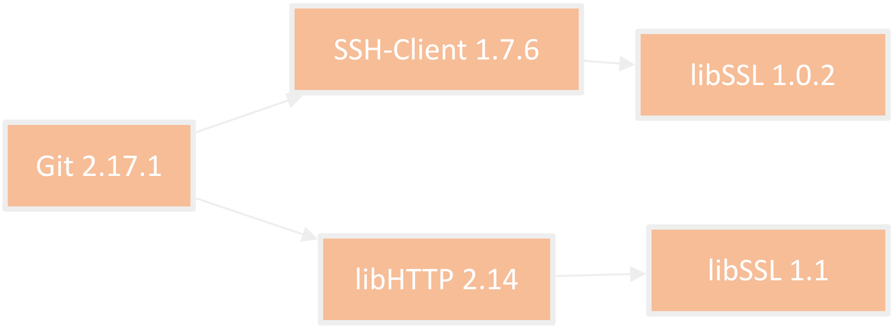
What are some problems when multiple intermediate dependencies have the same transitive dependency?





Diamond Dependencies

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



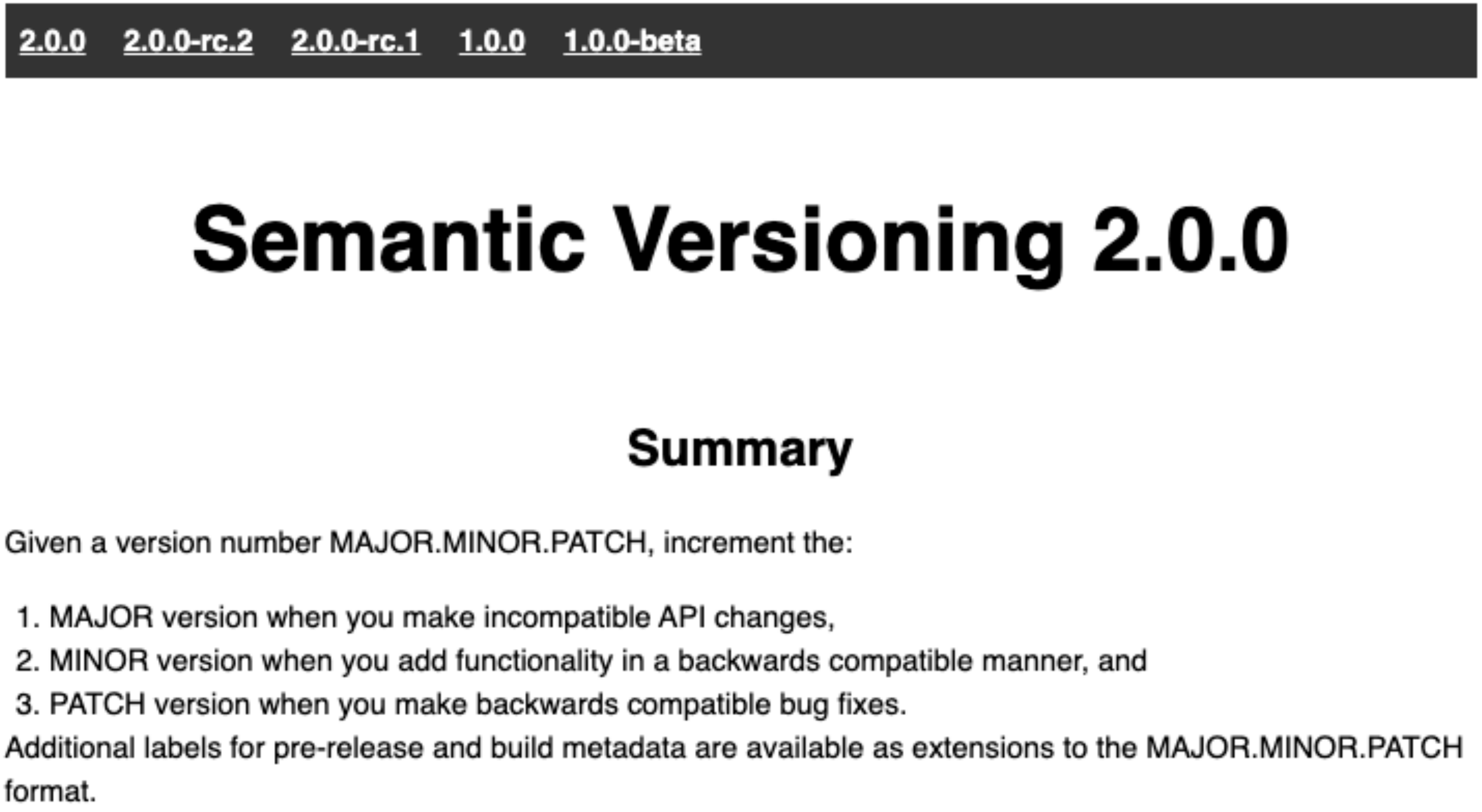
Resolutions to the Diamond Problem

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
   - ntermediate 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

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} . {M□NOR} . {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
    - M□NOR updated for additive changes
        - Same M□NOR version => AP□compatibility (important for linking)
    - PATCH updates functionality without new AP□
        - Ninja edit; usually for bug fixes

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

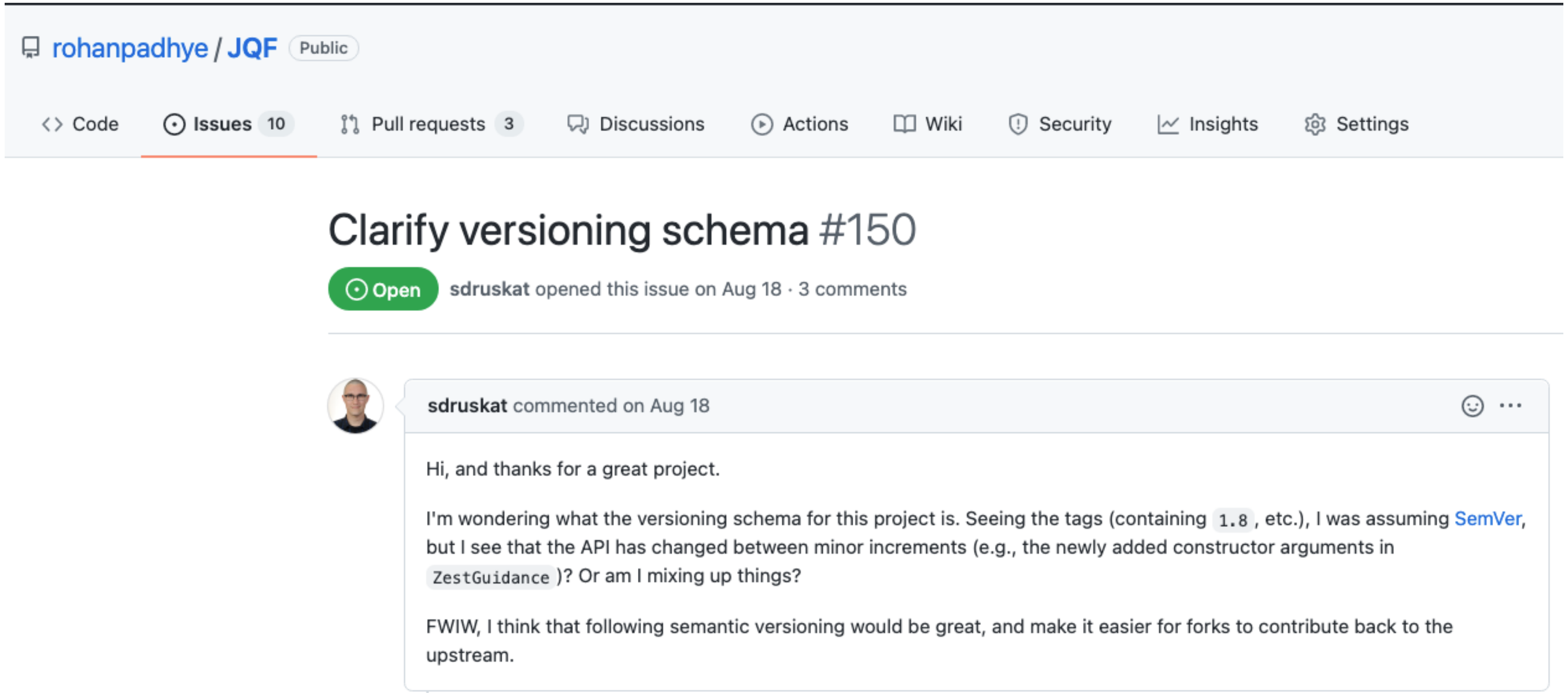
Summary

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.

People rely on SemVer contracts



Clarify versioning schema #150

Open sdruskat opened this issue on Aug 18 · 3 comments

sdruskat commented on Aug 18

Hi, and thanks for a great project.

I'm wondering what the versioning schema for this project is. Seeing the tags (containing `1.8`, etc.), I was assuming SemVer, but I see that the API has changed between minor increments (e.g., the newly added constructor arguments in `ZestGuidance`)? Or am I mixing up things?

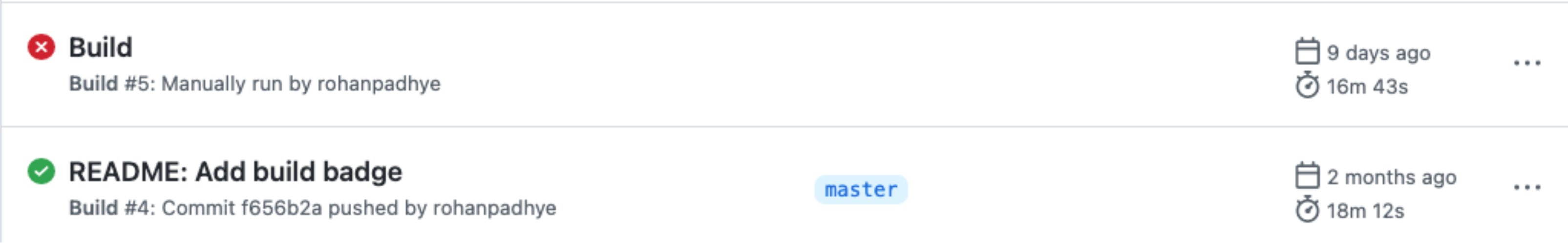
FWIW, I think that following semantic versioning would be great, and make it easier for forks to contribute back to the upstream.

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}

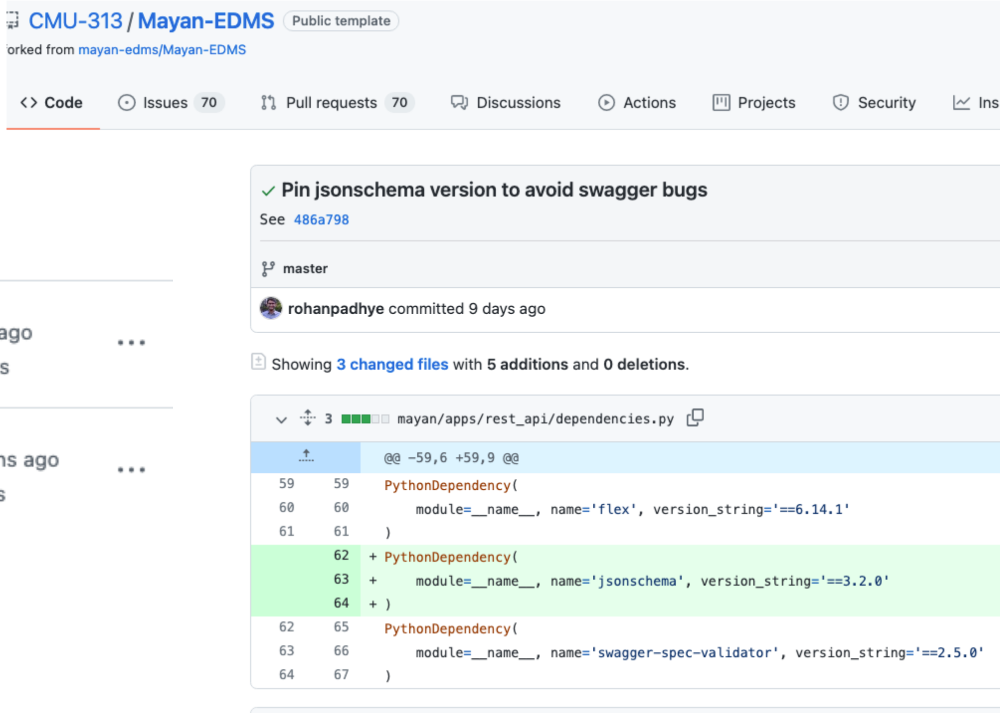
Semantic Versioning Contracts

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



☒ **Build**
Build #5: Manually run by rohanpadhye
9 days ago
16m 43s
...

✓ **README: Add build badge**
Build #4: Commit f656b2a pushed by rohanpadhye
master
2 months ago
18m 12s
...



CMU-313 / Mayan-EDMS Public template
orked from mayan-edms/Mayan-EDMS

✓ **Pin jsonschema version to avoid swagger bugs**
See 486a798

master

rohanpadhye committed 9 days ago

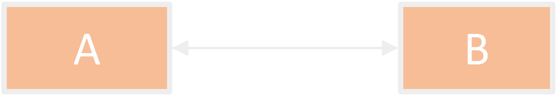
Showing **3 changed files** with **5 additions** and **0 deletions**.

3 mayan/apps/rest_api/dependencies.py

```
@@ -59,6 +59,9 @@
  PythonDependency(
      module=__name__, name='flex', version_string='==6.14.1'
  )
+ PythonDependency(
+     module=__name__, name='jsonschema', version_string='==3.2.0'
+ )
  PythonDependency(
      module=__name__, name='swagger-spec-validator', version_string='==2.5.0'
  )
```

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

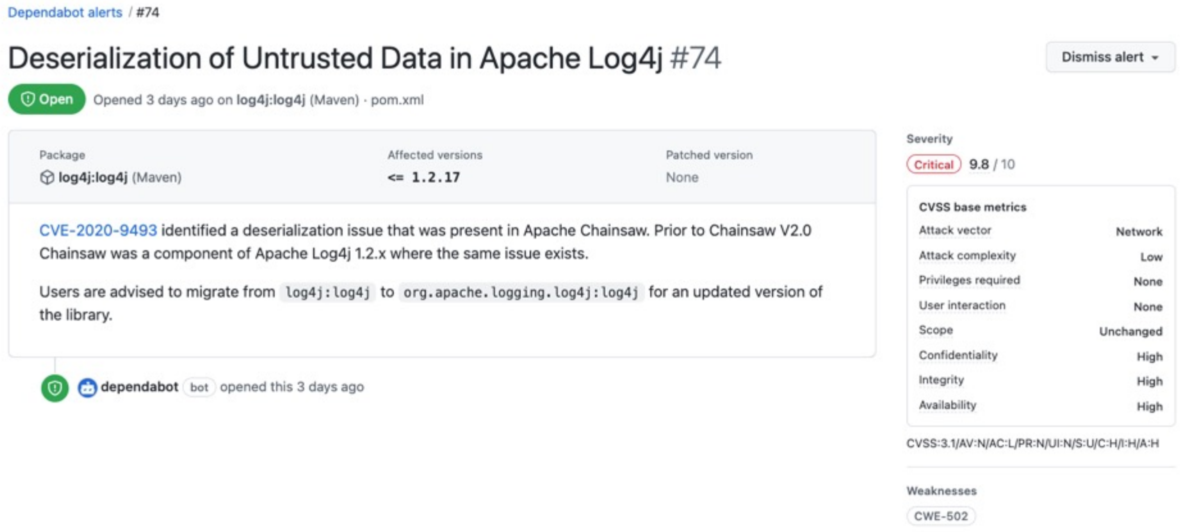


Cyclic Dependencies

- 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



Dependabot alerts / #74

Deserialization of Untrusted Data in Apache Log4j #74

Open Opened 3 days ago on log4j:log4j (Maven) · pom.xml

Package	Affected versions	Patched version
log4j:log4j (Maven)	<= 1.2.17	None

CVE-2020-9493 identified a deserialization issue that was present in Apache Chainsaw. Prior to Chainsaw V2.0 Chainsaw was a component of Apache Log4j 1.2.x where the same issue exists.

Users are advised to migrate from `log4j:log4j` to `org.apache.logging.log4j:log4j` for an updated version of the library.

dependabot bot opened this 3 days ago

Severity

Critical 9.8 / 10

CVSS base metrics	
Attack vector	Network
Attack complexity	Low
Privileges required	None
User interaction	None
Scope	Unchanged
Confidentiality	High
Integrity	High
Availability	High

CVSS:3.1/AV:N/AC:L/PR:N/UI:N/S:U/C:H/I:H/A:H

Weaknesses

CWE-502

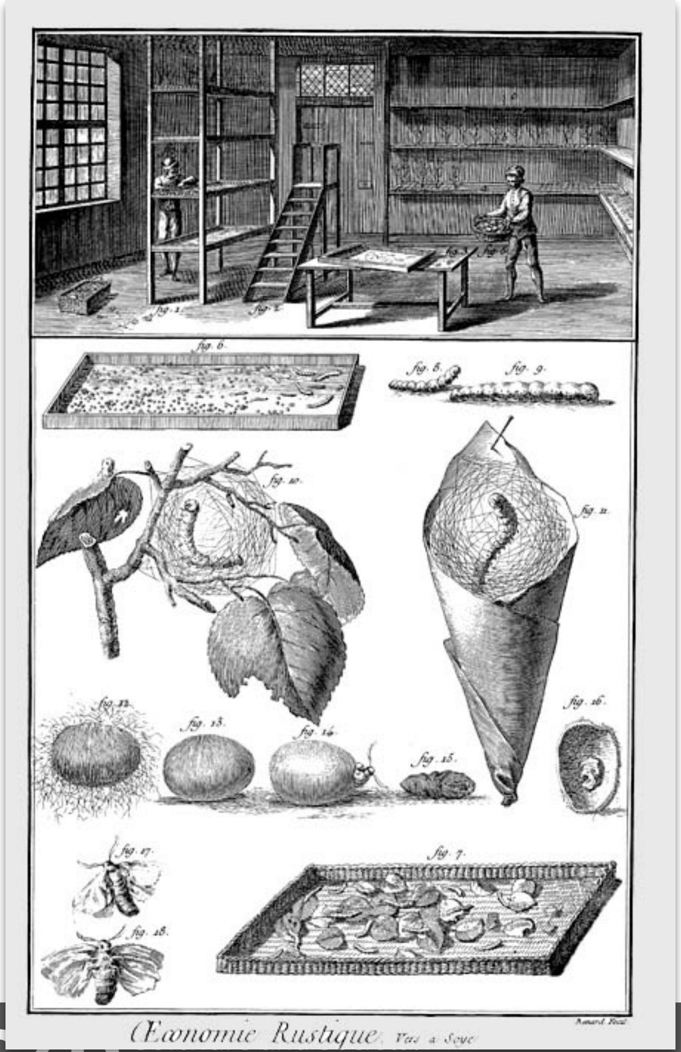
Takeaways

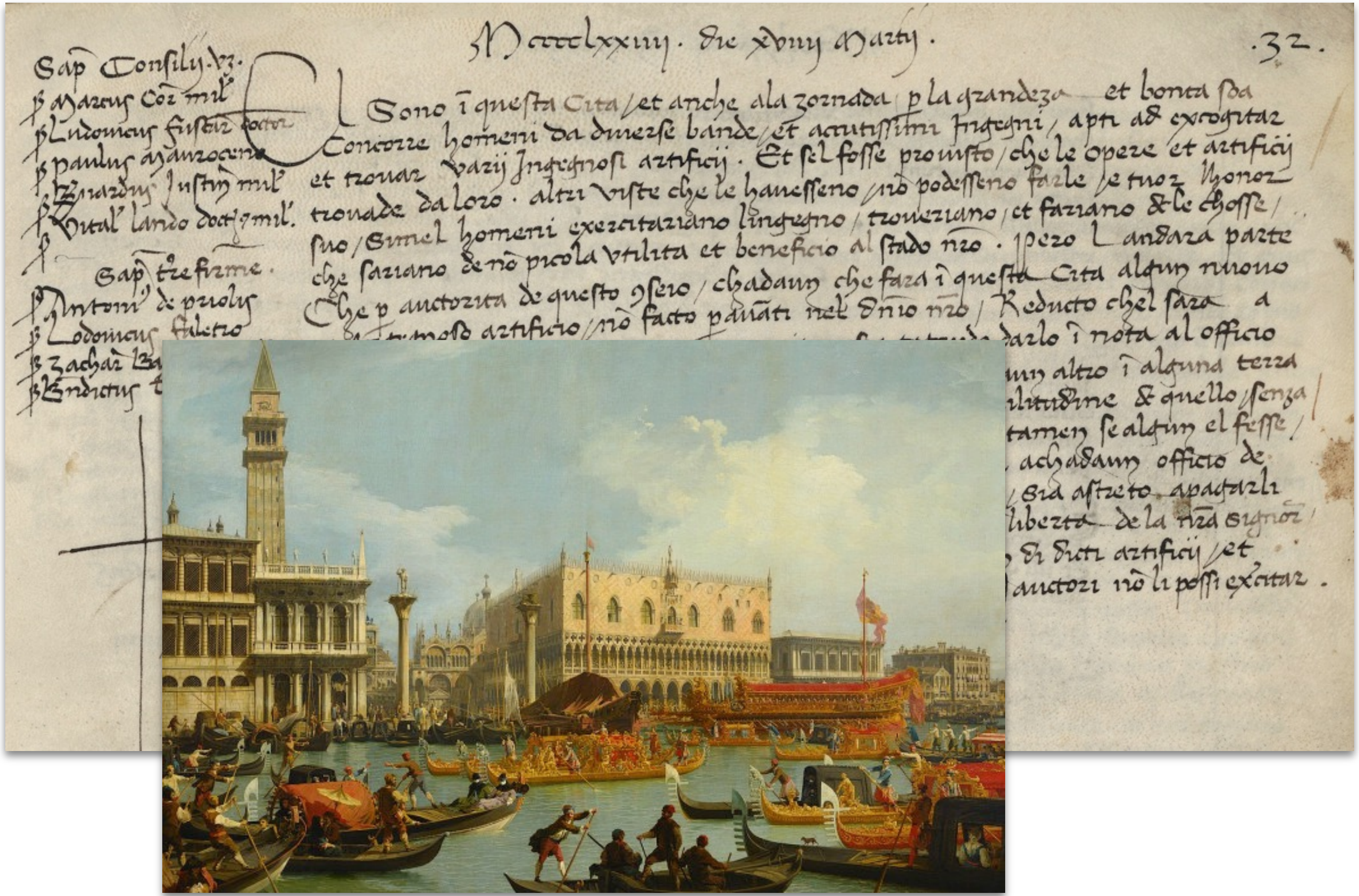
- Dependency management is hard.

Software Patents

Software Patents:
The Good, The Bad, and The Ugly

Venice, 1474





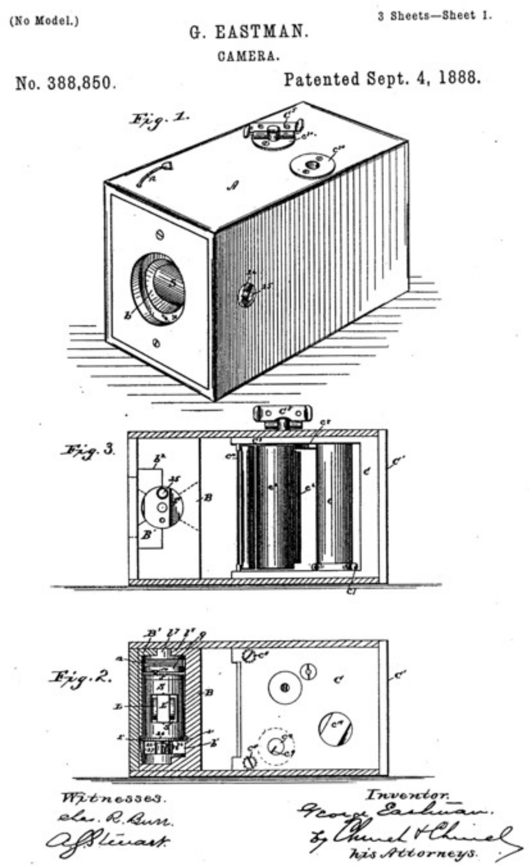
Mcccclxxiiij. die xviiij Martij. .32.

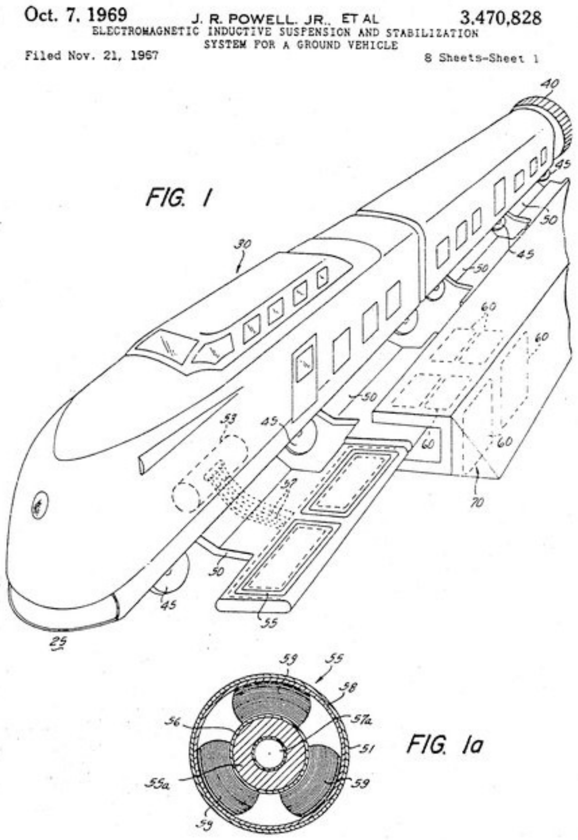
Sap Consilij. v3.
ß Marcus Cor mil
ß Ludovicus Fuscar doctor
ß Paulus Mauroceno
ß Bernardus Justin mil
ß Vital Lando doct et mil.
ß
Sap terre firme.
ß Antoni de Priolis
ß Lodovicus Faletro
ß Zachar Ba
ß Benedictus t

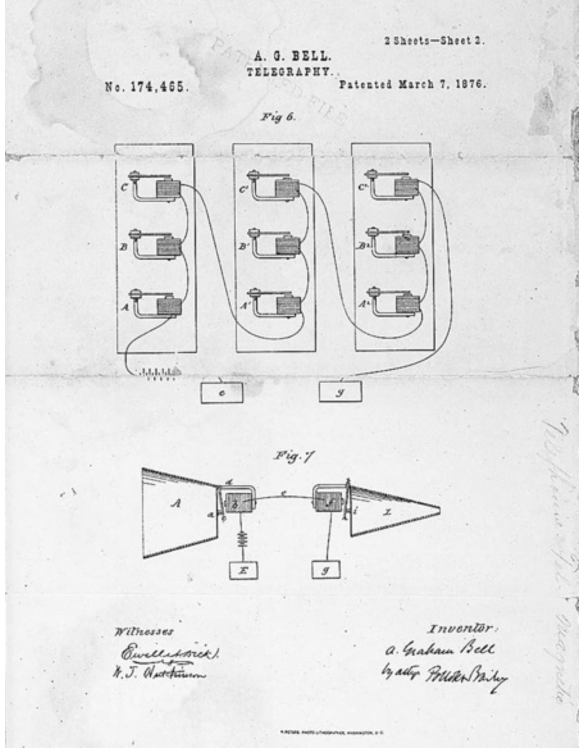
El Sono i questa Cita, et anche ala zornada p la grandeza et bonta soa
Concorre homeni da diverse bande, et acutissimi ingegni, apti ad excogitar
et trovar varij Ingegniosi artificij. Et sel fosse provisto, che le opere et artificij
trovade da loro. altri viste che le havesseno, no podesseno farle, e tuor l'honor
suo, Simel homeni exercitariano lingegno, troveriano, et fariano de le chosse,
che sariano de no picola utilita et beneficio al stado nro. pero L andara parte
Che p auctorita de questo Conseio, chadaun che fara i questa Cita algun nuovo
et ingenioso artificio, no facto pavanti nel Dnio nro, Reducto chel sara a
tegnudo darlo i nota al officio
altro i alguna terra
similitudine & quello, senza
tamen se algun el fesse,
a chadaun officio de
sia astreto a pagarli
liberta de la nra signor
di diti artificij, et
auctori no li possi exercitar.

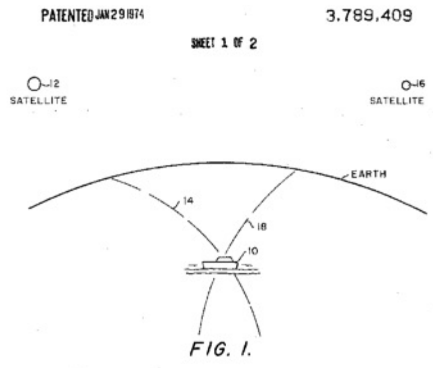
England, 1566

Today: USA









https://www.popularmechanics.com/technology/design/g20051677/patents-changed-the-world

What is a patent? New. Useful. Non-obvious.

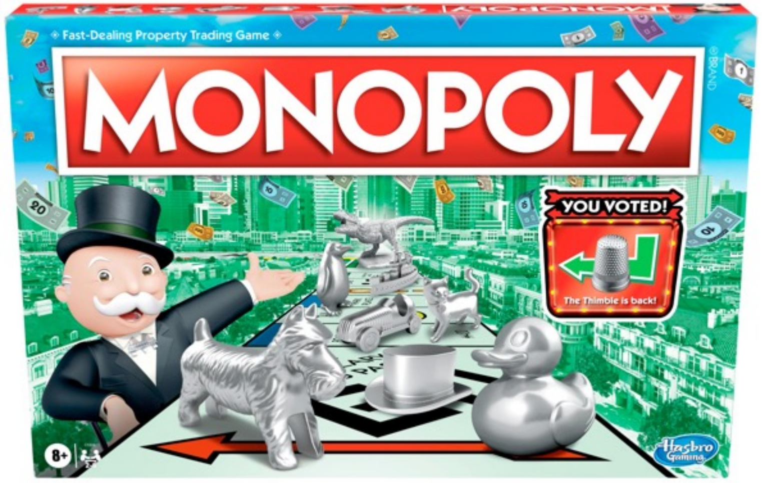
“A patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem. To get a patent, technical information about the invention must be disclosed to the public in a patent application.”

WIPO
WORLD
INTELLECTUAL PROPERTY
ORGANIZATION

https://www.wipo.int/patents/en

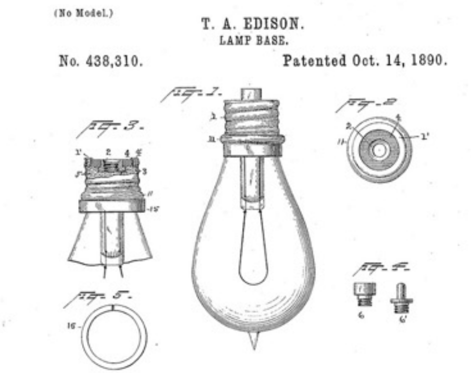
What rights do patents grant?

- Patents don’t give you the right to make, use, or sell an invention.
- Patents do give you the right to exclude others from making, using, and selling an invention for the term of a patent (20 years)
    - stop or sue others
    - licensing and royalties



What’s the difference? Patents vs. Copyright

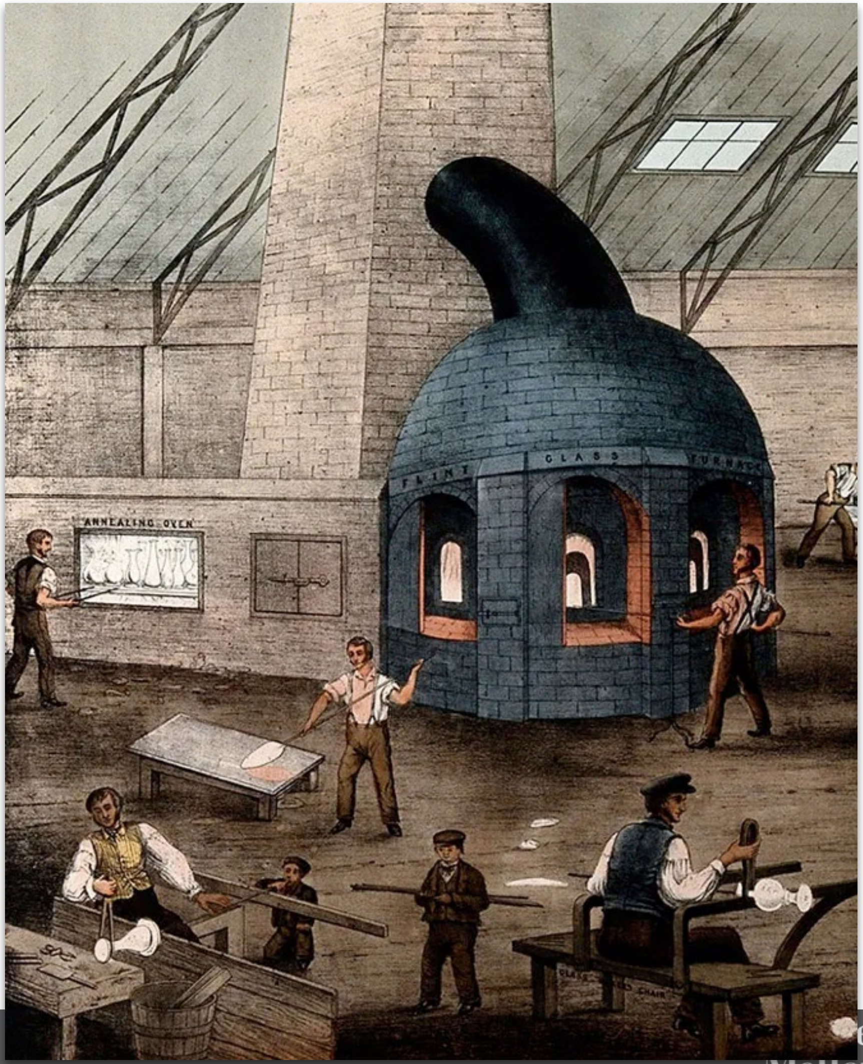
- Copyrights cover the details of expression of a work
- Copyrights don't cover any ideas
  Patents only cover ideas and the use of ideas
- Copyrights happen automatically.
  Patents are issued by a patent office in response to an application.



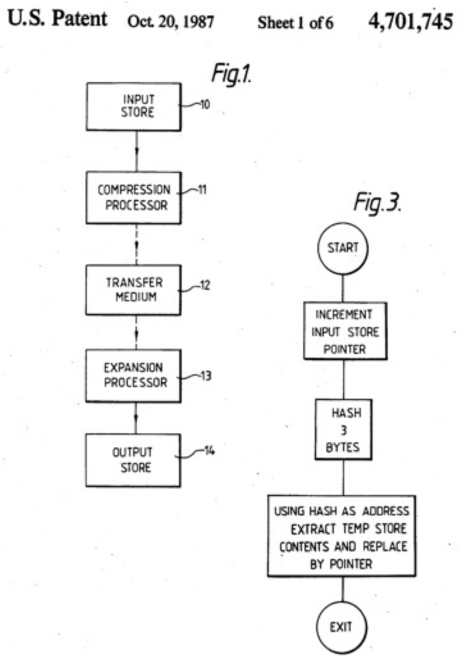
©

Why do patents exist?

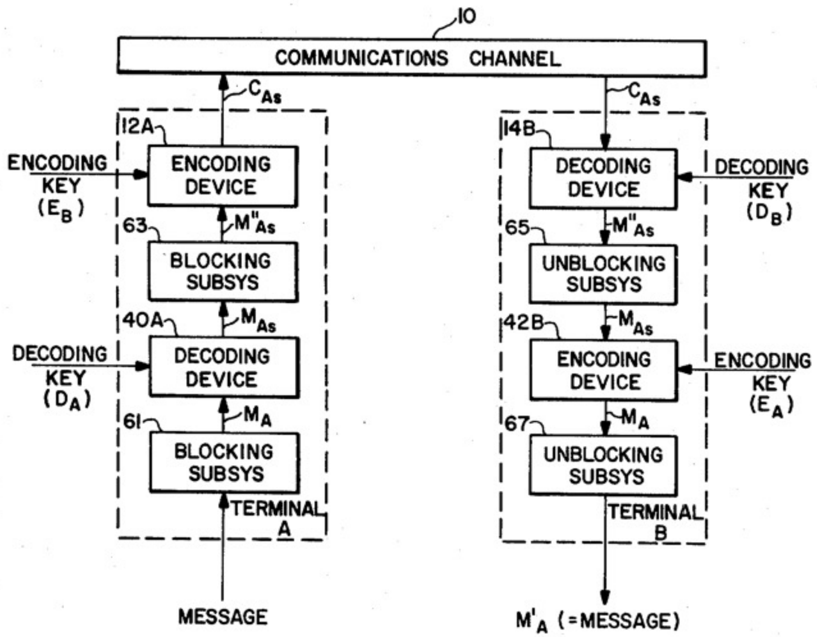
- Encourage disclosure of inventions
- Reward invention and creativity
- Protect investment of capital into R&D
- Encourage the market to “design around”
- Protect small companies from large ones

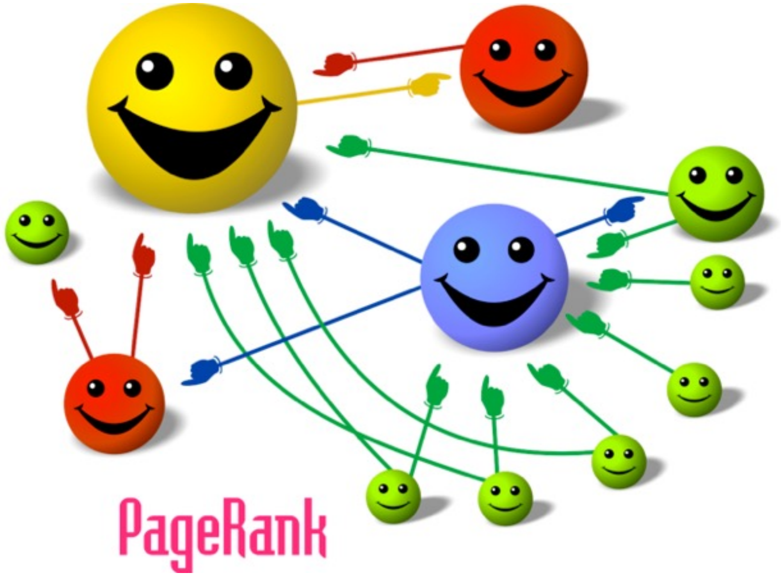


Software Patents



U.S. Patent Oct. 20, 1987 Sheet 1 of 6 4,701,745
Fig.1.
INPUT STORE
10
COMPRESSION PROCESSOR
11
TRANSFER MEDIUM
12
EXPANSION PROCESSOR
13
OUTPUT STORE
14
Fig.3.
START
INCREMENT INPUT STORE POINTER
HASH 3 BYTES
USING HASH AS ADDRESS EXTRACT TEMP STORE CONTENTS AND REPLACE BY POINTER
EXIT





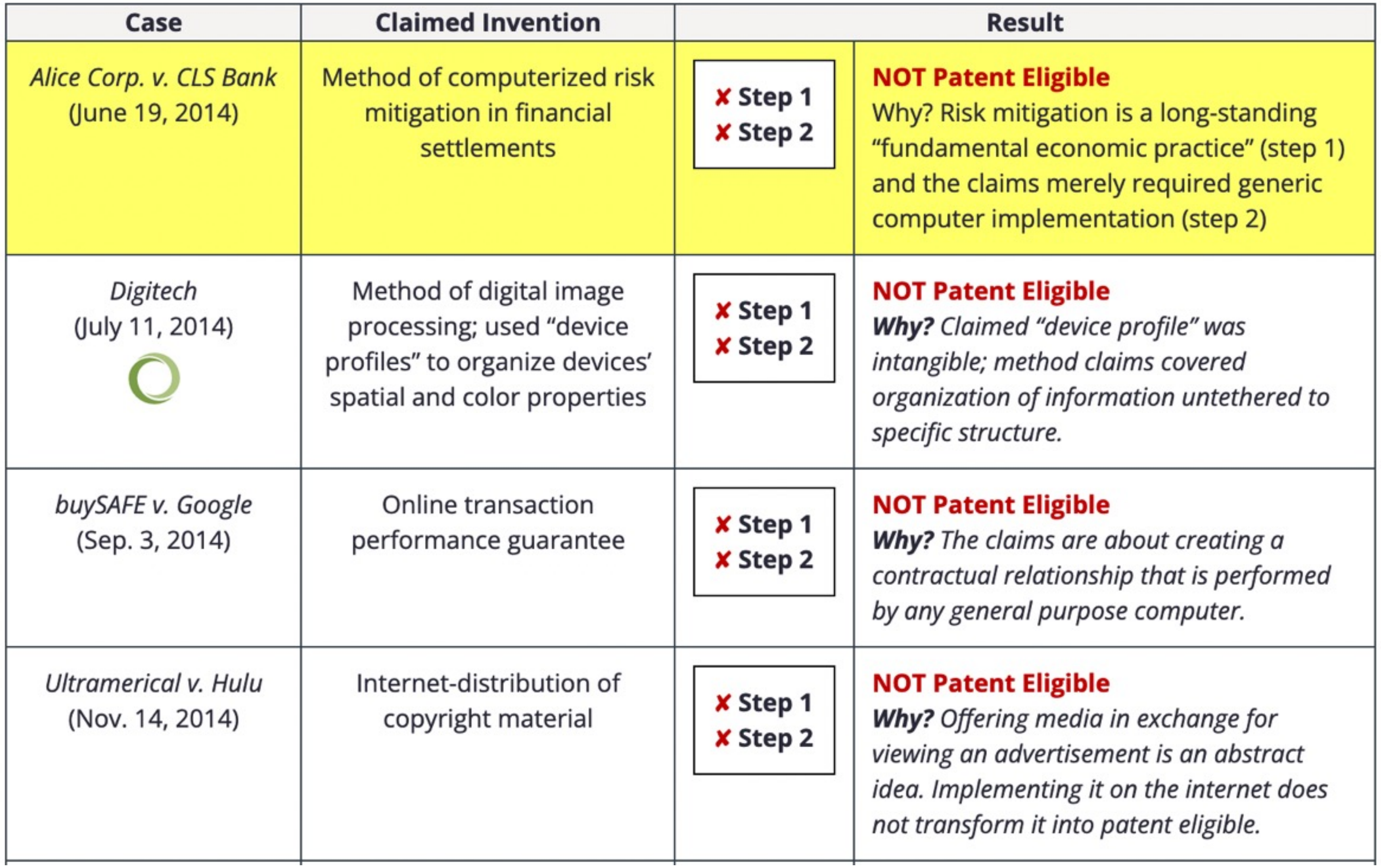
Patent or not?

Patent or not?

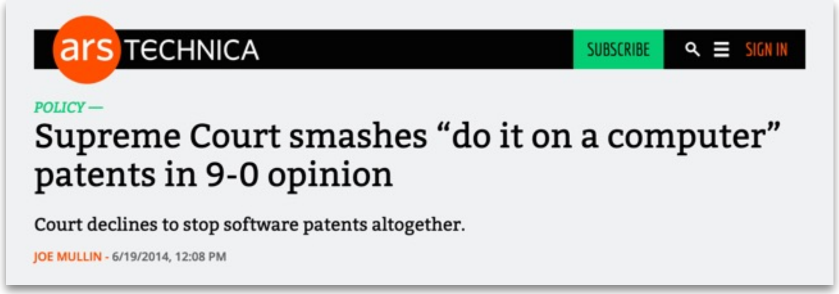
1. Running bingo on a computer
2. Using a computer to help users plan meals while achieving diet goals
3. Using a computer to order a pizza with customized toppings
4. Prompting a user before establishing a new network connection
5. Automatically notifying users when an item is picked up or delivered
6. Using a computer network to ask people to complete tasks and then wait for them to do them
7. Using SMS to perform tasks (e.g., checking bank balance)
8. Selecting ALL images in a CAPTCHA that match a given text

The software patent system is broken!

Alice vs. CLS Bank (2014)



Case	Claimed Invention	Result	
Alice Corp. v. CLS Bank (June 19, 2014)	Method of computerized risk mitigation in financial settlements	✘ Step 1 ✘ Step 2	**NOT Patent Eligible** Why? Risk mitigation is a long-standing "fundamental economic practice" (step 1) and the claims merely required generic computer implementation (step 2)
Digitech (July 11, 2014)	Method of digital image processing; used "device profiles" to organize devices' spatial and color properties	✘ Step 1 ✘ Step 2	**NOT Patent Eligible** ***Why?*** *Claimed "device profile" was intangible; method claims covered organization of information untethered to specific structure.*
buySAFE v. Google (Sep. 3, 2014)	Online transaction performance guarantee	✘ Step 1 ✘ Step 2	**NOT Patent Eligible** ***Why?*** *The claims are about creating a contractual relationship that is performed by any general purpose computer.*
Ultramerical v. Hulu (Nov. 14, 2014)	Internet-distribution of copyright material	✘ Step 1 ✘ Step 2	**NOT Patent Eligible** ***Why?*** *Offering media in exchange for viewing an advertisement is an abstract idea. Implementing it on the internet does not transform it into patent eligible.*

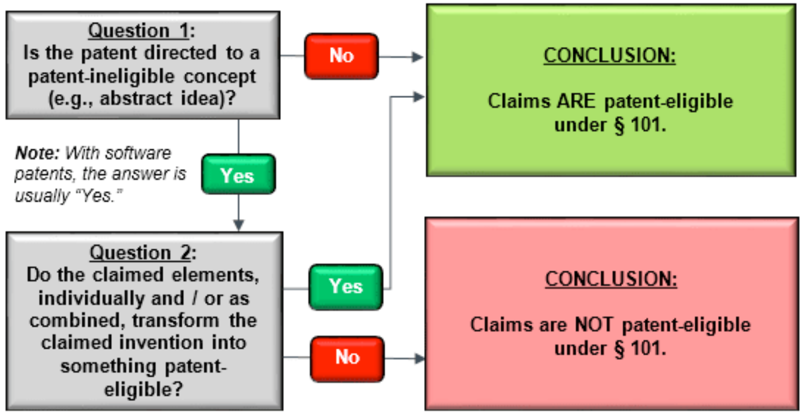


POLICY —

Supreme Court smashes "do it on a computer" patents in 9-0 opinion

Court declines to stop software patents altogether.

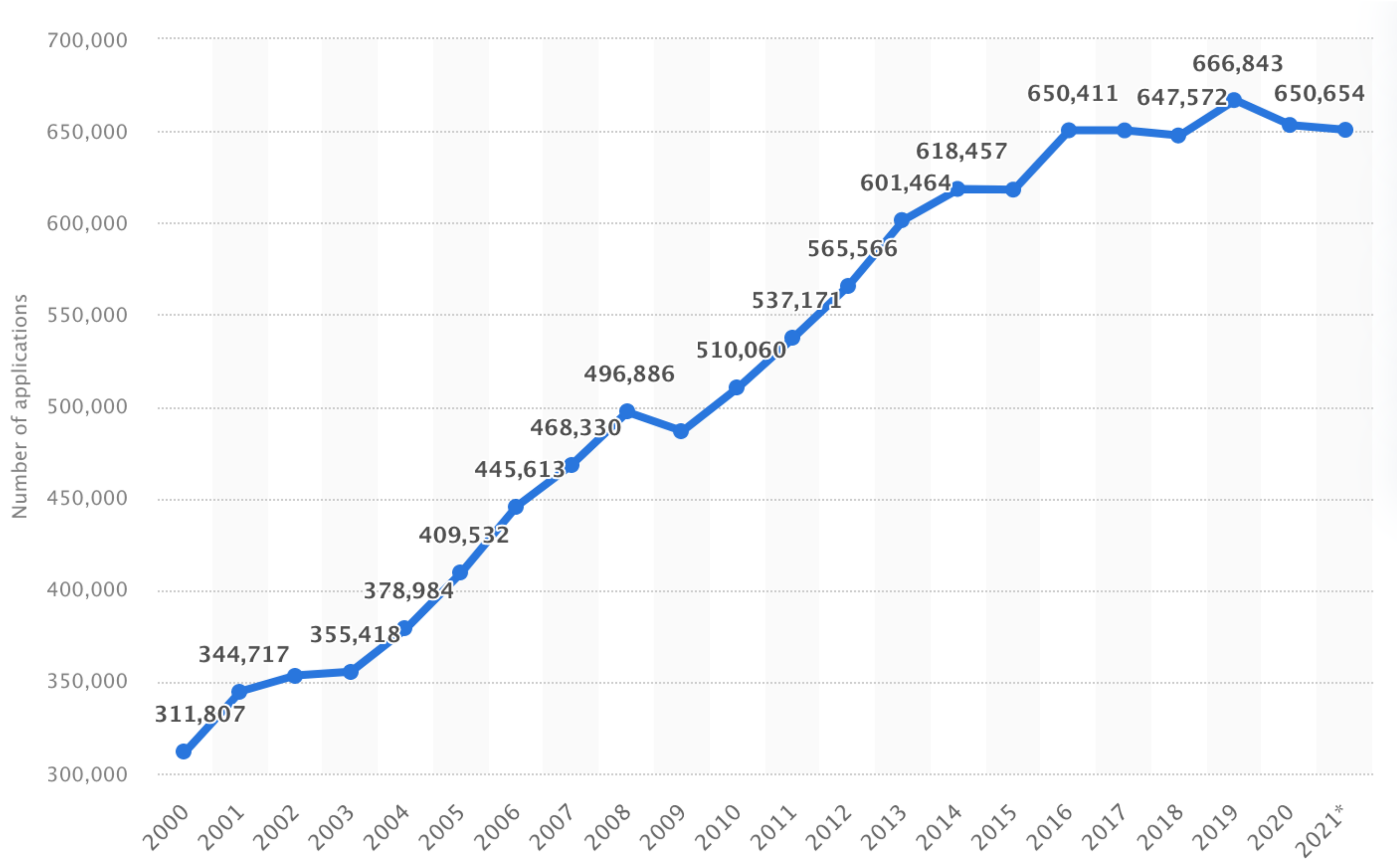
JOE MULLIN - 6/19/2014, 12:08 PM



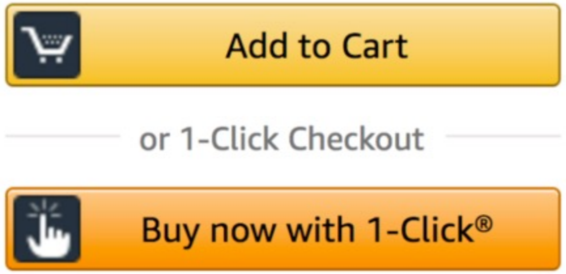
Question 1:
Is the patent directed to a patent-ineligible concept (e.g., abstract idea)?
No
Yes
Note: With software patents, the answer is usually "Yes."
Question 2:
Do the claimed elements, individually and / or as combined, transform the claimed invention into something patent-eligible?
Yes
No
CONCLUSION:
Claims ARE patent-eligible under § 101.
CONCLUSION:
Claims are NOT patent-eligible under § 101.

https://www.orrick.com/Articles/The-Effect-of-the-Alice-Decision-on-Software-and-3D-Printing-Patents

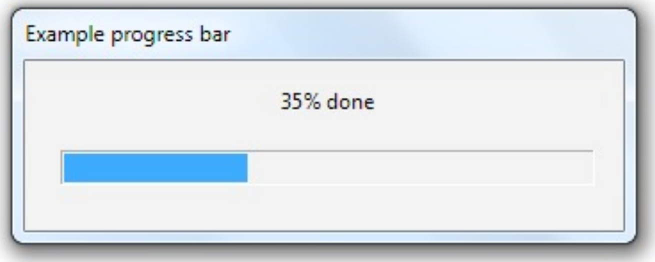
Problem: □nventive step and non-obviousness



https://www.statista.com/statistics/256554/number-of-patent-application-filings-in-the-us



US5960411A



US5301348A

Problem: Long patent pendencies and terms

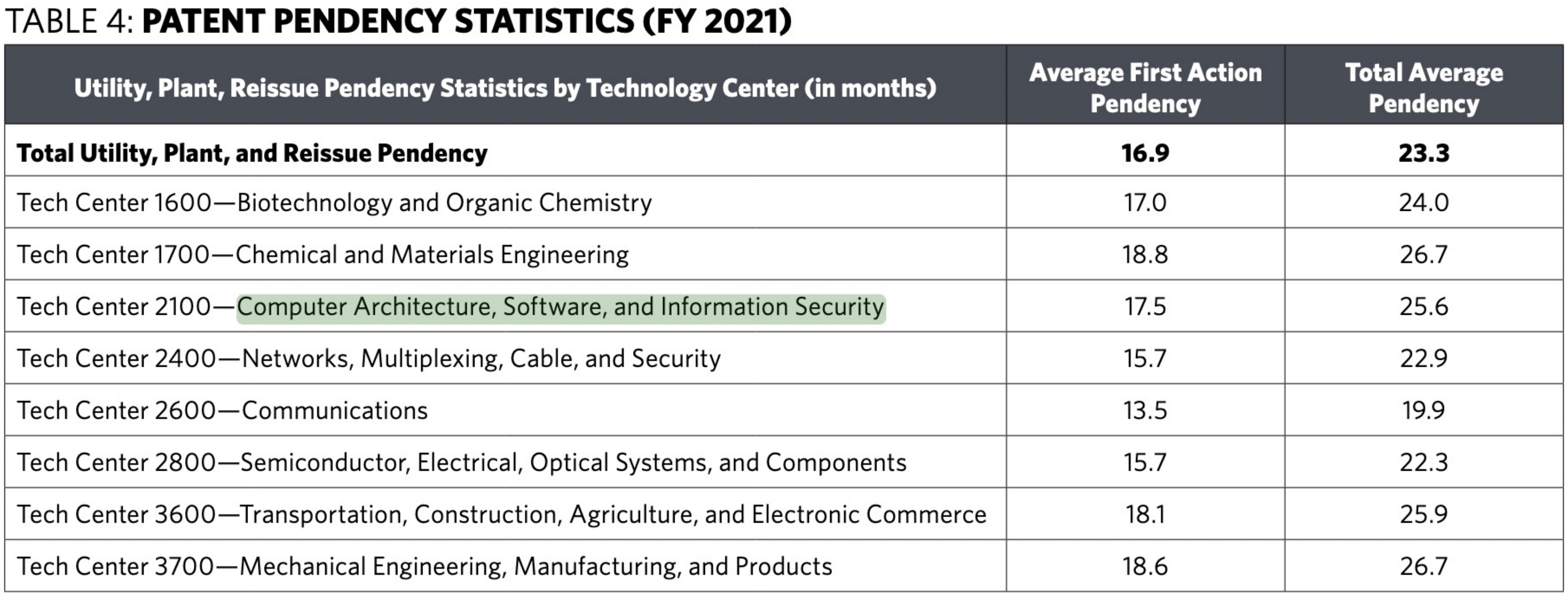


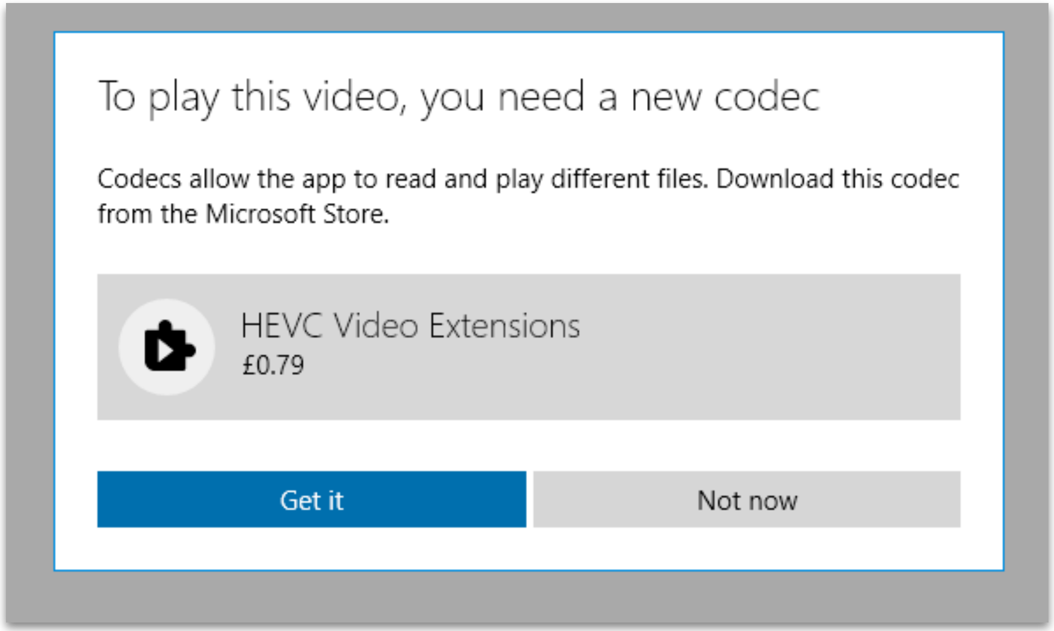
TABLE 4: **PATENT PENDENCY STATISTICS (FY 2021)**

Utility, Plant, Reissue Pendency Statistics by Technology Center (in months)	Average First Action Pendency	Total Average Pendency
Total Utility, Plant, and Reissue Pendency	**16.9**	**23.3**
Tech Center 1600—Biotechnology and Organic Chemistry	17.0	24.0
Tech Center 1700—Chemical and Materials Engineering	18.8	26.7
Tech Center 2100—Computer Architecture, Software, and Information Security	17.5	25.6
Tech Center 2400—Networks, Multiplexing, Cable, and Security	15.7	22.9
Tech Center 2600—Communications	13.5	19.9
Tech Center 2800—Semiconductor, Electrical, Optical Systems, and Components	15.7	22.3
Tech Center 3600—Transportation, Construction, Agriculture, and Electronic Commerce	18.1	25.9
Tech Center 3700—Mechanical Engineering, Manufacturing, and Products	18.6	26.7

https://www.uspto.gov/sites/default/files/documents/USPTOFY21PAR.pdf

Problem: Incompatibility

- PNG was invented to avoid GIF patent issues
- Opus is a patent-free MP3 alternative
- AV1 vs H265



To play this video, you need a new codec

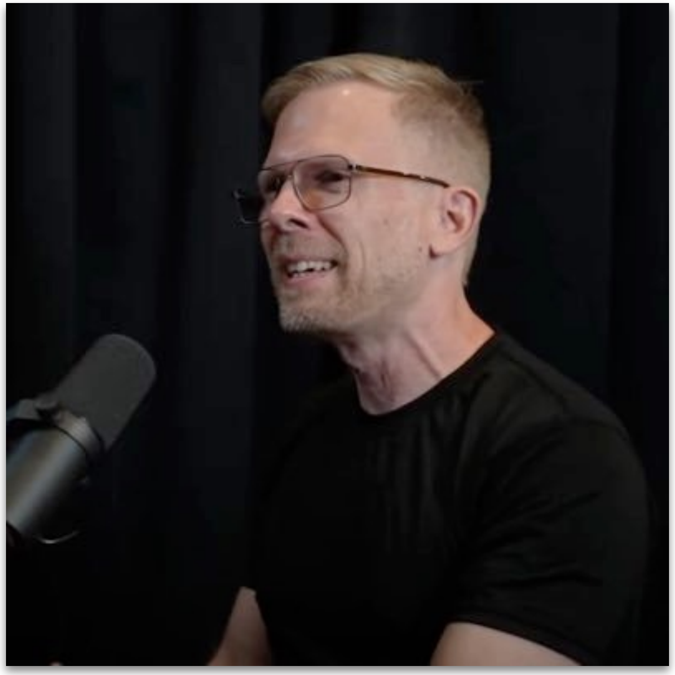
Codecs allow the app to read and play different files. Download this codec from the Microsoft Store.

HEVC Video Extensions
£0.79

Problem: Independent discovery doesn't matter!

"The idea that I can be presented with a problem, set out to logically solve it with the tools at hand, and wind up with a program that could not be legally used because someone else followed the same logical steps some years ago and filed for a patent on it is horrifying."

John Carmack



Problem: Only large organizations benefit

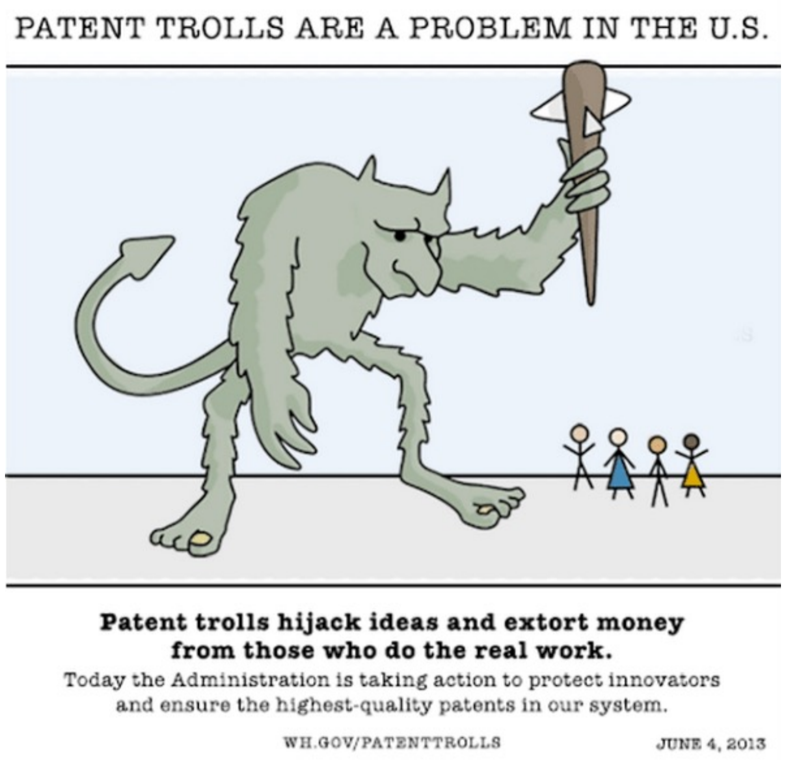
- The patent system relies on people to challenge bad patents
  - requires considerable time, money, and legal expertise
  - the US legal system requires both parties to pay legal fees (c.f., losers pay costs in Europe) *
- US software patents cost between $15,000 to $45,000!
  - that's before you even apply for international patents!

ELECTRONIC FRONTIER FOUNDATION'S PATENT BUSTING PROJECT

https://www.patenttrademarkblog.com/how-much-patent-costs

https://www.eff.org/issues/patent-busting-project

Problem: Non-Practicing Entities (Patent Trolls)

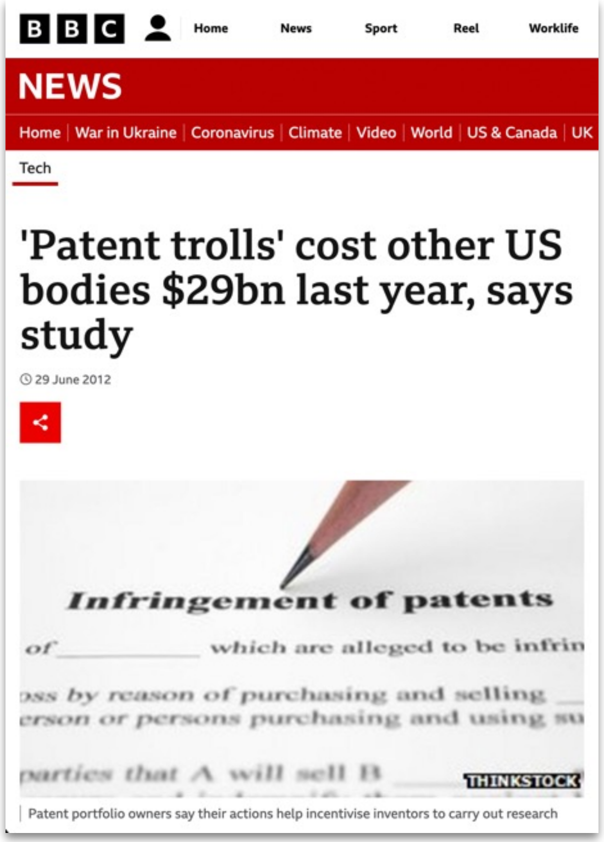


PATENT TROLLS ARE A PROBLEM IN THE U.S.

Patent trolls hijack ideas and extort money from those who do the real work.

Today the Administration is taking action to protect innovators and ensure the highest-quality patents in our system.

WH.GOV/PATENTTROLLS JUNE 4, 2013


BBC
Home
News
Sport
Reel
Worklife
NEWS
Home | War in Ukraine | Coronavirus | Climate | Video | World | US & Canada | UK
Tech

'Patent trolls' cost other US bodies $29bn last year, says study

29 June 2012

Infringement of patents
THINKSTOCK

Patent portfolio owners say their actions help incentivise inventors to carry out research

Problem: Innovation is Stifled

"As a developer for a small startup, absurd software patents are a constant worry. Stories abound of people like us getting pressured out of existence over the use of incredibly vague, basic interface elements and system components."

"Software patents are generally written in vague and nontechnical legal language, which obfuscates the patent in question . . . and also makes it easy to dramatically extend the patent to elements not considered at all when the patent was originally filed."

Defend Innovation

How to Fix Our Broken Patent System

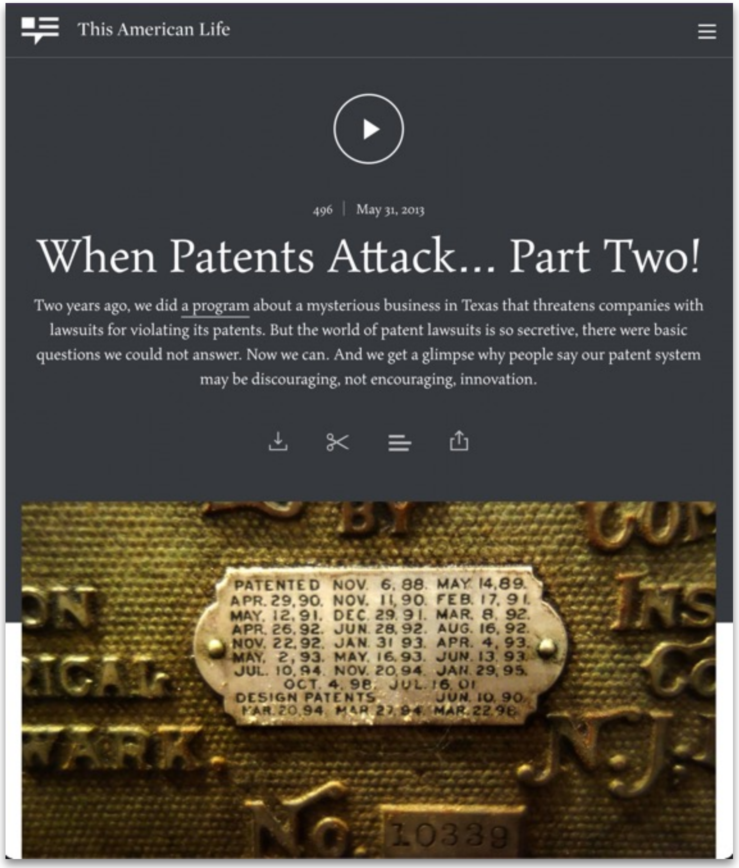
by Adi Kamdar, Daniel Nazer, Vera Ranieri

FEBRUARY 2015

ELECTRONIC FRONTIER FOUNDATION

This American Life: When Patents Attack!

- Innovatio sued libraries and coffee shops for providing WiFi in a public space
- Boadin has sued various media outlets, claiming that its patents are infringed whenever a word or phrase on your computer autocompletes
- NPHJ claims they hold a patent on “scanning and emailing documents”. They tried to sued non-profits for $1000 per employee in damages.

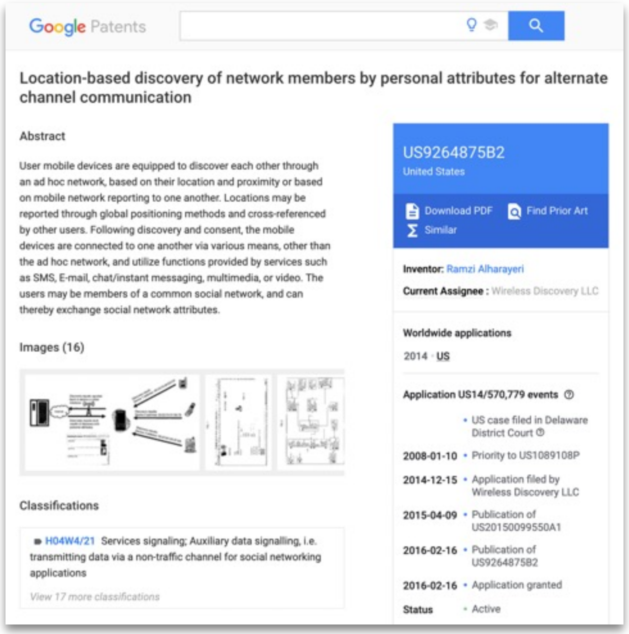


496 | May 31, 2013

When Patents Attack... Part Two!

Two years ago, we did a program about a mysterious business in Texas that threatens companies with lawsuits for violating its patents. But the world of patent lawsuits is so secretive, there were basic questions we could not answer. Now we can. And we get a glimpse why people say our patent system may be discouraging, not encouraging, innovation.

https://www.thisamericanlife.org/496/when-patents-attack-part-two



Google Patents

Location-based discovery of network members by personal attributes for alternate channel communication

Abstract

User mobile devices are equipped to discover each other through an ad hoc network, based on their location and proximity or based on mobile network reporting to one another. Locations may be reported through global positioning methods and cross-referenced by other users. Following discovery and consent, the mobile devices are connected to one another via various means, other than the ad hoc network, and utilize functions provided by services such as SMS, E-mail, chat/instant messaging, multimedia, or video. The users may be members of a common social network, and can thereby exchange social network attributes.

Images (16)

Classifications

H04W4/21 Services signaling; Auxiliary data signalling, i.e. transmitting data via a non-traffic channel for social networking applications

View 17 more classifications

US9264875B2
United States

Download PDF Find Prior Art Similar

Inventor: Ramzi Alharayeri

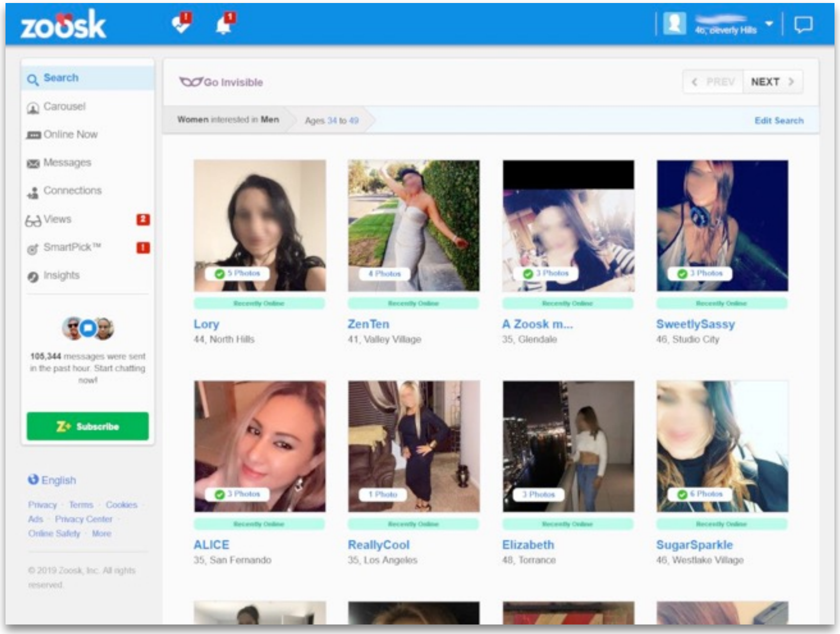
Current Assignee : Wireless Discovery LLC

Worldwide applications

2014 · US

Application US14/570,779 events

	US case filed in Delaware District Court
2008-01-10	Priority to US1089108P
2014-12-15	Application filed by Wireless Discovery LLC
2015-04-09	Publication of US20150099550A1
2016-02-16	Publication of US9264875B2
2016-02-16	Application granted
Status	Active



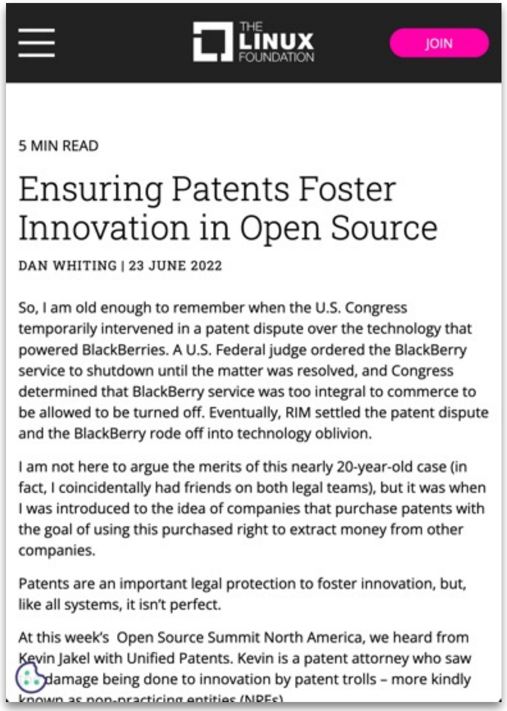
105,344 messages were sent in the past hour. Start chatting now!

ELECTRONIC FRONTIER FOUNDATION

- Zoosk has a website that mobile devices can connect to
- Zoosk's server collects information from the mobile devices, including location and unique device identifiers
- Zoosk users can send and accept invitations to connect with and send messages to each other.
- Zoosk shares profile information of connected users, who are "members of a same social network" (i.e., they're on Zoosk)
- Zoosk can connect users who are in the immediate vicinity of each other, or a particular distance away

https://www.eff.org/deeplinks/2022/05/patent-troll-uses-ridiculous-people-finder-patent-sue-small-dating-companies

Problem: Open Source is under attack, too!



5 MIN READ

Ensuring Patents Foster Innovation in Open Source

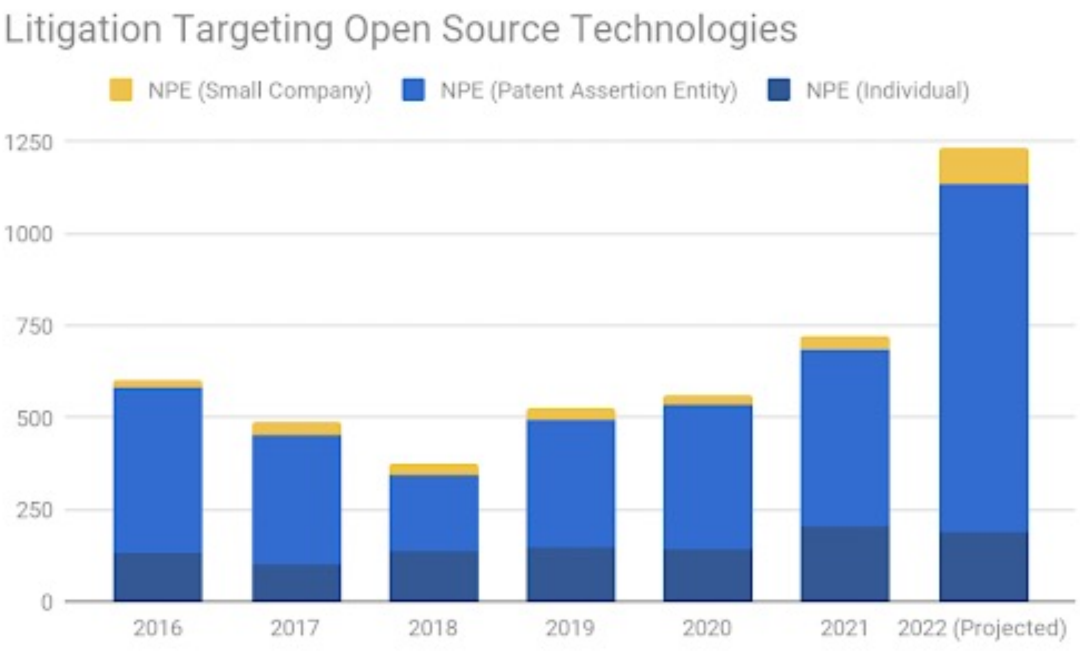
DAN WHITING | 23 JUNE 2022

So, I am old enough to remember when the U.S. Congress temporarily intervened in a patent dispute over the technology that powered BlackBerries. A U.S. Federal judge ordered the BlackBerry service to shutdown until the matter was resolved, and Congress determined that BlackBerry service was too integral to commerce to be allowed to be turned off. Eventually, RIM settled the patent dispute and the BlackBerry rode off into technology oblivion.

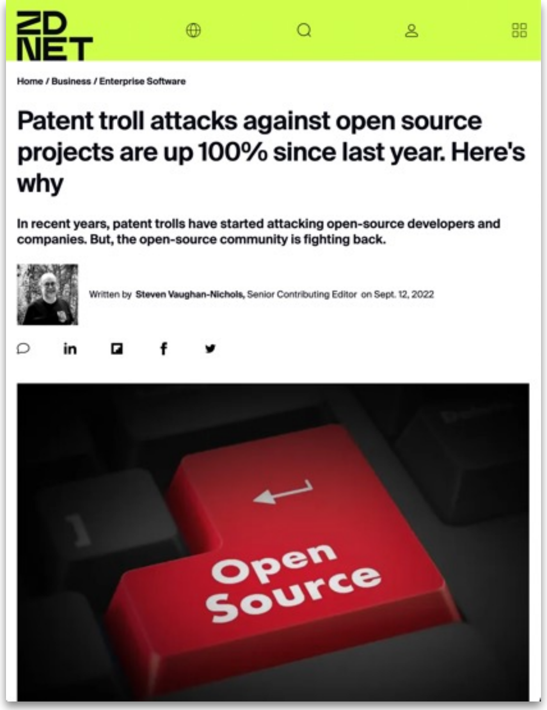
I am not here to argue the merits of this nearly 20-year-old case (in fact, I coincidentally had friends on both legal teams), but it was when I was introduced to the idea of companies that purchase patents with the goal of using this purchased right to extract money from other companies.

Patents are an important legal protection to foster innovation, but, like all systems, it isn't perfect.

At this week's Open Source Summit North America, we heard from Kevin Jakel with Unified Patents. Kevin is a patent attorney who saw damage being done to innovation by patent trolls – more kindly known as non-practicing entities (NPEs)



Data collected through June 6, 2022



Home / Business / Enterprise Software

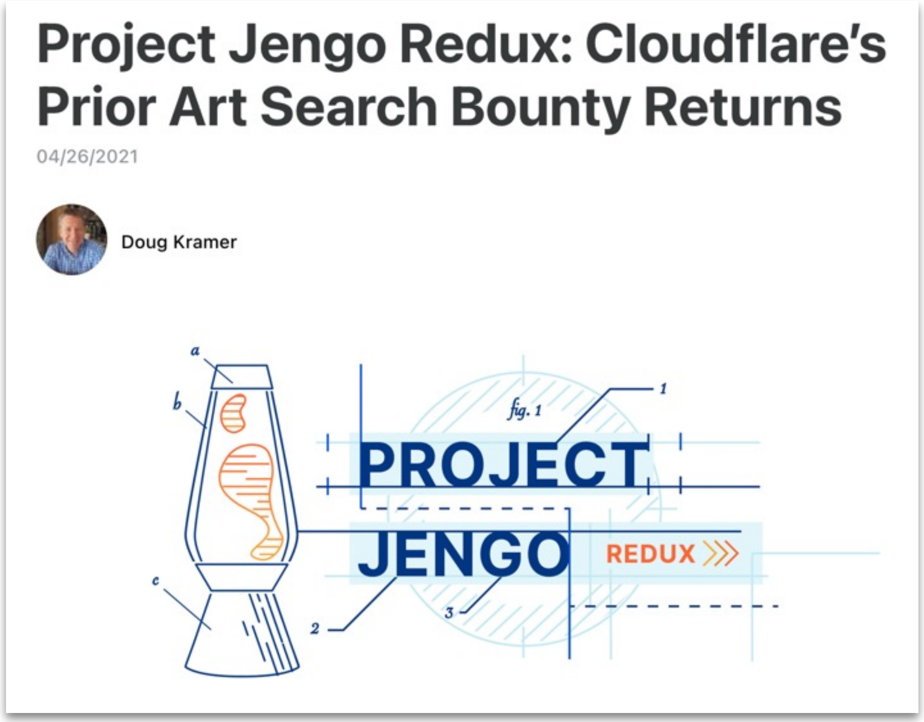
Patent troll attacks against open source projects are up 100% since last year. Here's why

In recent years, patent trolls have started attacking open-source developers and companies. But, the open-source community is fighting back.

Written by **Steven Vaughan-Nichols,** Senior Contributing Editor on Sept. 12, 2022

What next?

- Alternative licensing models
    - The Defensive Patent License (DPL)
    - The Open Invention Network (OIN)
    - License on Transfer (LOT)
- Bogus patent bounties
- [Unified Patents]
- Commonsense reform
- Abolish software patents?



Project Jengo Redux: Cloudflare's Prior Art Search Bounty Returns

04/26/2021

Doug Kramer

Decision Calculus

Life is all about tradeoffs

In this course, we have talked a lot about tradeoffs.

Some tradeoffs we have discussed:

Writing Tests vs writing more features

Choosing a familiar tech stack vs a “trendy one”

Other tradeoffs…?

Think about structured ways to make decisions

Do what is ethical, legal, moral, obvious

Sometimes, there are multiple (legitimate) options, that all seem to have positives and negatives.

What to do?

People have studied this before...

Economics

Biology + Microbiology

Sociology

Engineering

Computer Science

Strategy Games

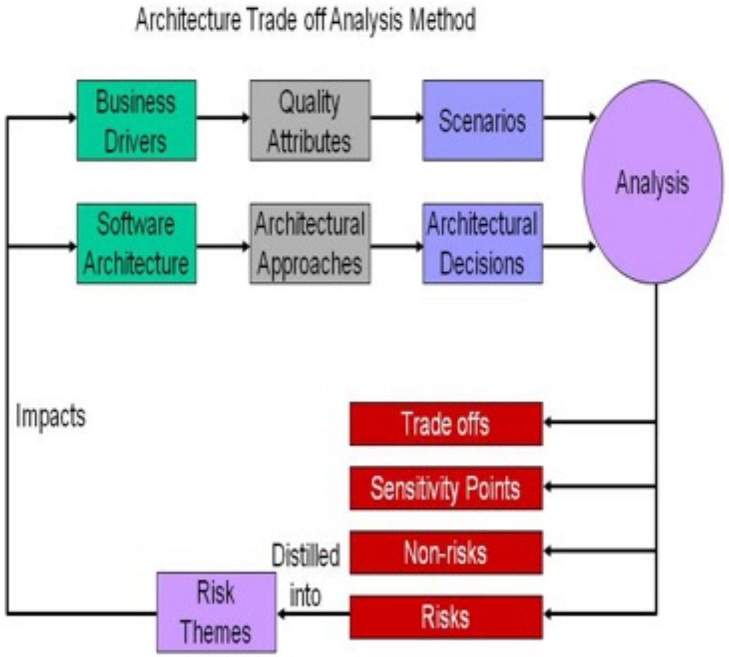
Ethics

Medicine

Politics

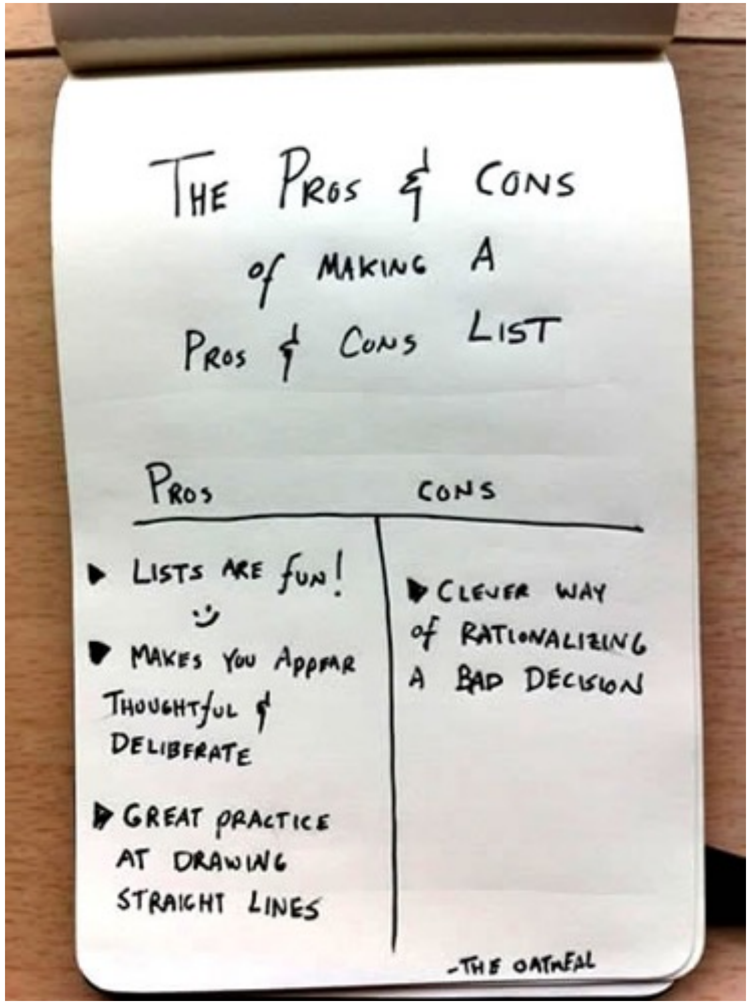
Architecture Tradeoff Analysis Method

1. Present the ATAM.
2. Present business drivers.
3. Present architecture.
4. Identify architectural approaches.
5. Generate quality attribute utility tree.
6. Analyze architectural approaches.
7. Brainstorm and prioritize scenarios.
8. Analyze architectural approaches



https://concisesoftware.com/architecture-tradeoff-analysis-method-atam/

Pros and cons



THE PROS & CONS
of MAKING A
PROS & CONS LIST

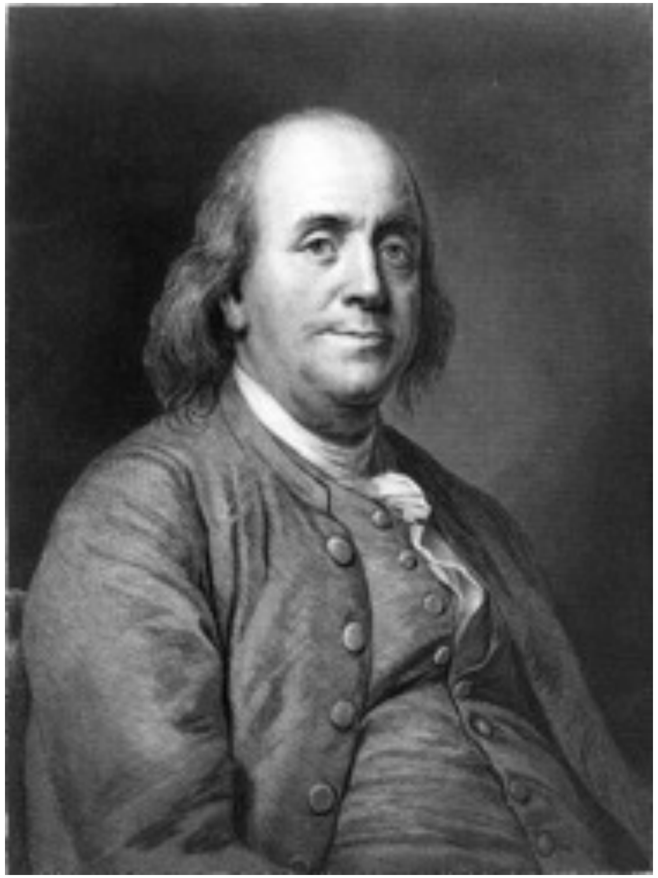
PROS	CONS
▶ LISTS ARE fun! :)	▶ CLEVER WAY of RATIONALIZING A BAD DECISION
▶ MAKES YOU APPEAR THOUGHTful & DELIBERATE	
▶ GREAT PRACTICE AT DRAWING STRAIGHT LINES	

-THE OATMEAL

https://theoatmeal.com/blog/pros_cons_list

Moral or Prudential Algebra

1. Make a list of Pros and Cons
2. Take a few days to think, forcing your brain to come up with all of the positive and negative aspects of taking the measure you're considering.
3. Assign weights to each item on your list depending on its importance.
4. When the weight of a item on your "pro" list is equal to the weight of an item on your "con" list, strike both of them out.
5. What is left in the balance is the choice you need to make. Wait a few more days and, if nothing new occurs to you, act on the decision you've made.



Even Swaps

Premise:

It is easy to make decisions when there is only one objective.

But having only one objective, as any decision maker knows, is a rare luxury.

Even swaps provides a practical way of making trade-offs among any set of objectives across a range of alternatives.

THE POLITICS OF E-MAIL PAGE 12

Harvard Business Review

MARCH-APRIL 1998

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Overview - 3 step process

1. Create a Consequences Table
2. Eliminate “Dominated” Alternatives
3. Make Even Swaps

Running Example from research paper

Example: Alan Miller is a computer scientist who started a technical consulting practice three years ago.

For the first year, he worked out of his home, but as his business grew he decided to sign a two-year lease on some space in the Pierpoint office park.

Now that lease is about to expire. He needs to decide whether to renew it or move to a new location.

Define the objectives

Alan defines five overriding objectives that he needs his office to fulfill:

1. a short commute from home
2. good access to his clients
3. good office services (clerical assistance, copiers and fax machines, and mail service)
4. sufficient space
5. low costs

He finds five viable alternatives: Parkway, Lombard, Baranov, Montana, and his current building, the Pierpoint.

Create Consequences Table

Objectives	Parkway	Lombard	Baranov	Montana	Pierpoint
Commute in Minutes	45	25	20	25	30
Customer Access (%)	50	80	70	85	75
Office Services	A	B	C	A	C
Office Size (Square Feet)	800	700	500	950	700
Monthly Cost ($)	1850	1700	1500	1900	1750

https://hbr.org/1998/03/even-swaps-a-rational-method-for-making-trade-offs

Create Ranking Table

Objectives	Parkway	Lombard	Baranov	Montana	Pierpoint
Commute in Minutes	45 (5th)	25 (2nd tie)	20 (1st)	25 (2nd tie)	30 (4th)
Customer Access (%)	50 (5th)	80 (2nd)	70 (4th)	85 (1st)	75 (3rd)
Office Services	A (1st tie)	B (3rd)	C (4th tie)	A (1st tie)	C (4th tie)
Office Size (Square Feet)	800 (2nd)	700 (3rd tie)	500 (5th)	950 (1st)	700 (3rd tie)
Monthly Cost ($)	1850 (4th)	1700 (2nd)	1500 (1st)	1900 (5th)	1750 (3rd)

https://hbr.org/1998/03/even-swaps-a-rational-method-for-making-trade-offs

Eliminate “Dominated” Alternatives

Objectives	Parkway	Lombard	Baranov	Montana	Pierpoint
Commute in Minutes	45 (5th)	25 (2nd tie)	20 (1st)	25 (2nd tie)	30 (4th)
Customer Access (%)	50 (5th)	80 (2nd)	70 (4th)	85 (1st)	75 (3rd)
Office Services	A (1st tie)	B (3rd)	C (4th tie)	A (1st tie)	C (4th tie)
Office Size (Square Feet)	800 (2nd)	700 (3rd tie)	500 (5th)	950 (1st)	700 (3rd tie)
Monthly Cost ($)	1850	1700	1500	1900	1750

https://hbr.org/1998/03/even-swaps-a-rational-method-for-making-trade-offs

Make Even Swaps

1. Determine the change necessary to cancel out an objective.
2. Assess what change in another objective would compensate for the needed change.
3. Make the even swap.
4. Cancel out the now-irrelevant objective.
5. Select the dominant alternative.

First Even Swaps

- For Baranov, swap 5 commute minutes, for 8% customer access.

Objectives	Lombard	Baranov	Montana
Commute in Minutes	~~25 (1st tie)~~	~~20~~ 25 (1st tie)	~~25 (1st tie)~~
Customer Access (%)	80	~~70~~ 78	85
Office Services	B	C	A
Office Size (Square Feet)	700	500	950
Monthly Cost ($)	1700	1500	1900

Second Even Swaps

- For Baranov, swap C->B, add $200, for Montana, swap A->B, reduce $100

Objectives	Lombard	Baranov	Montana
Commute in Minutes	~~25~~	~~25~~	~~25~~
Customer Access (%)	80	78	85
Office Services	~~B~~	~~C B~~	~~A B~~
Office Size (Square Feet)	700	500	950
Monthly Cost ($)	1700	~~1500~~ 1700	~~1900~~ 1800

Second Even Swaps

- For Lombard, swap 250 sq ft for $250

Objectives	Lombard	Montana
Commute in Minutes	~~25~~	~~25~~
Customer Access (%)	80	85
Office Services	~~B~~	~~B~~
Office Size (Square Feet)	~~700~~ ~~950~~	~~950~~
Monthly Cost ($)	~~1700~~ 1950	1800

Advice for swaps

- Make the easier swaps first
- Concentrate on the amount of the swap, not on the apparent importance of the overall objective.
- Remember that the value of an incremental change depends on what you start with.
- Make consistent swaps.
- Seek out solid information.