Reproducible Builds

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Linux Conf Australia 2016

Valerie Young

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- spectranaut on OFTC/freenode
- Studied physics and computer science at BU (2012)
- Programmer at athenahealth
- Ubuntu/Debian user since 2012
- Debian contributor since May 2016

…Thanks to Outreachy!

OUTREACHY

- **outreachy.gnome.org**
- Funding for women and minorities to work on free software
- 3 month projects (like Google summer of code)
- 3 month (and beyond) free software mentor
- Not limited to programming

Overview

1. What is “Reproducible Builds”?
2. Reproducible builds and software freedoms
3. Up-to-date history of reproducible builds efforts
4. What is left to do..?

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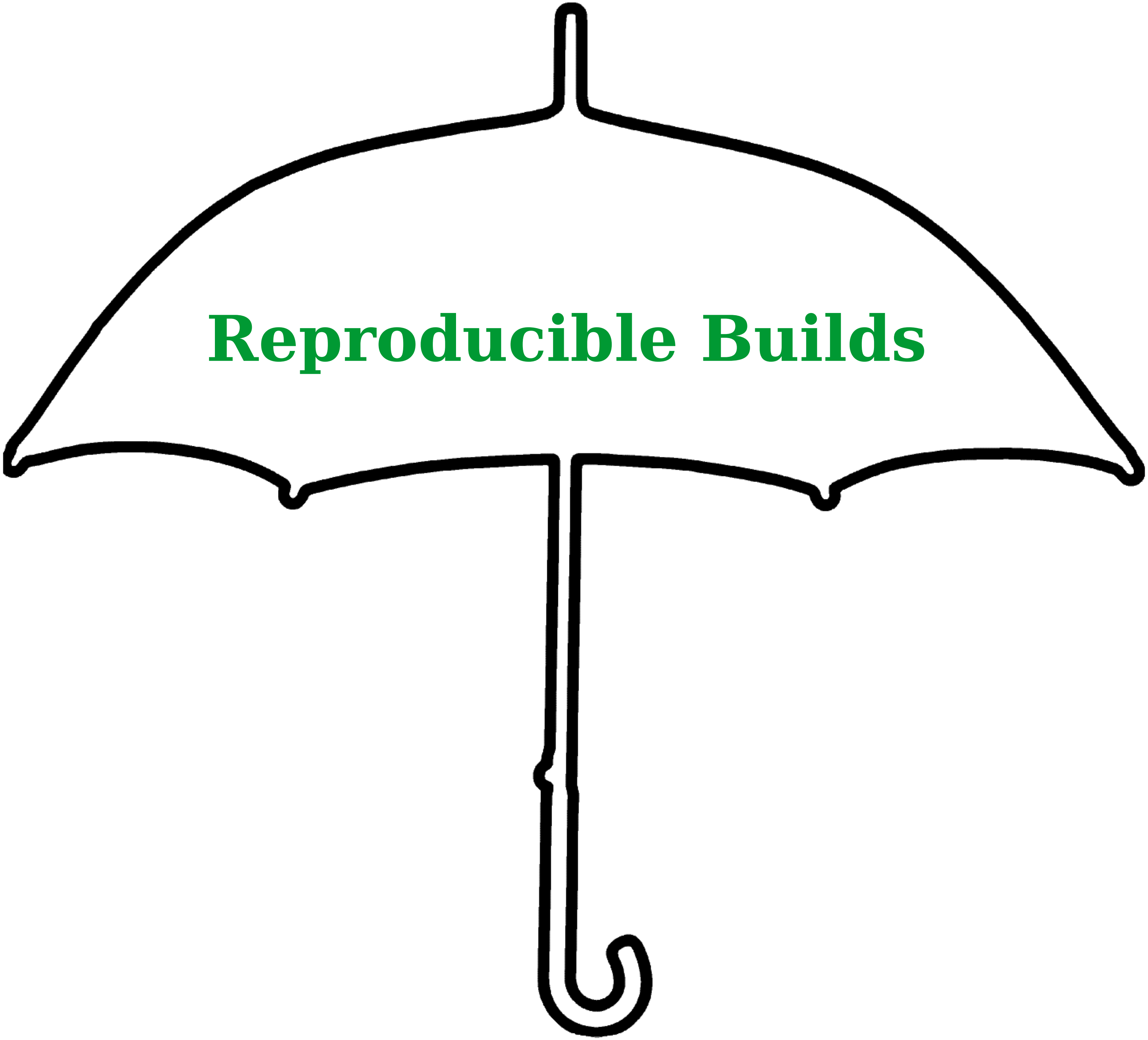
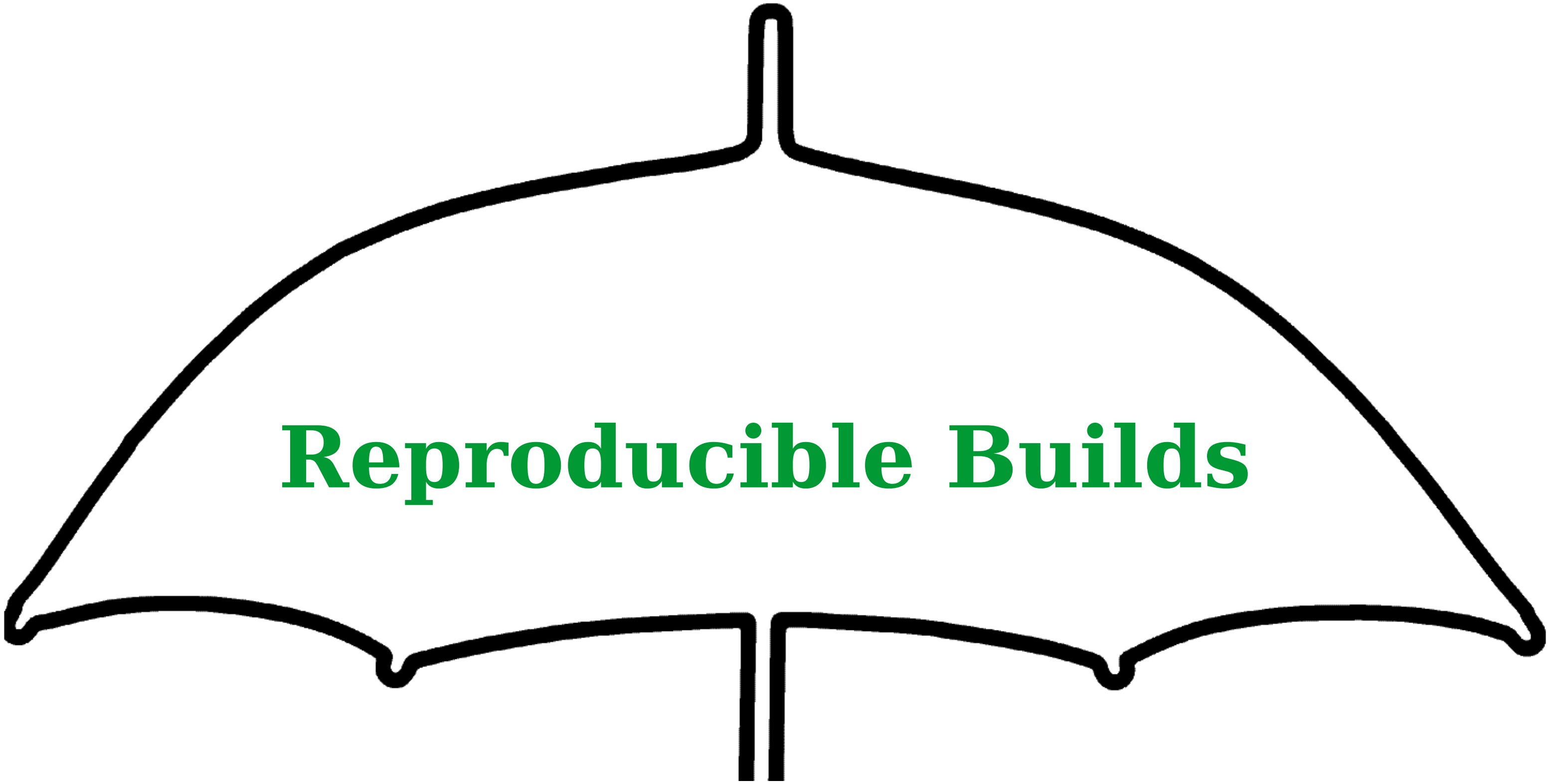


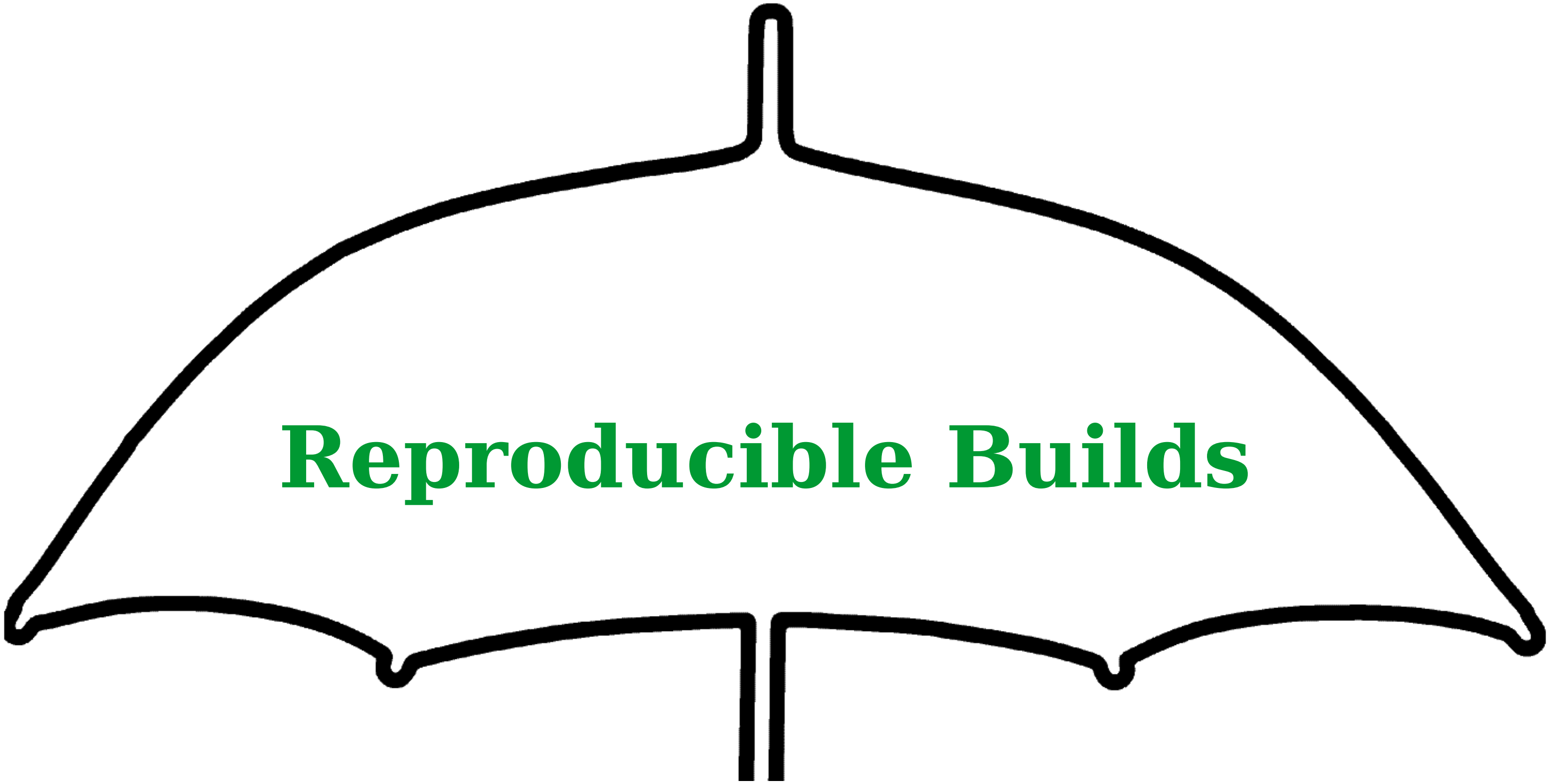
Reproducible Builds



Reproducible Builds

Goals:

1. Compilation of binary should be deterministic



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Review

Software Freedoms

- (0) The freedom to **run** the program for any purpose.
- (1) The freedom to **study** how the program works, and **change** it to your needs.
- (2) The freedom to **redistribute** copies so you can help your neighbor.
- (3) The freedom to improve the program, and **release your improvements** to the public, so that the whole community benefits.

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source build binary

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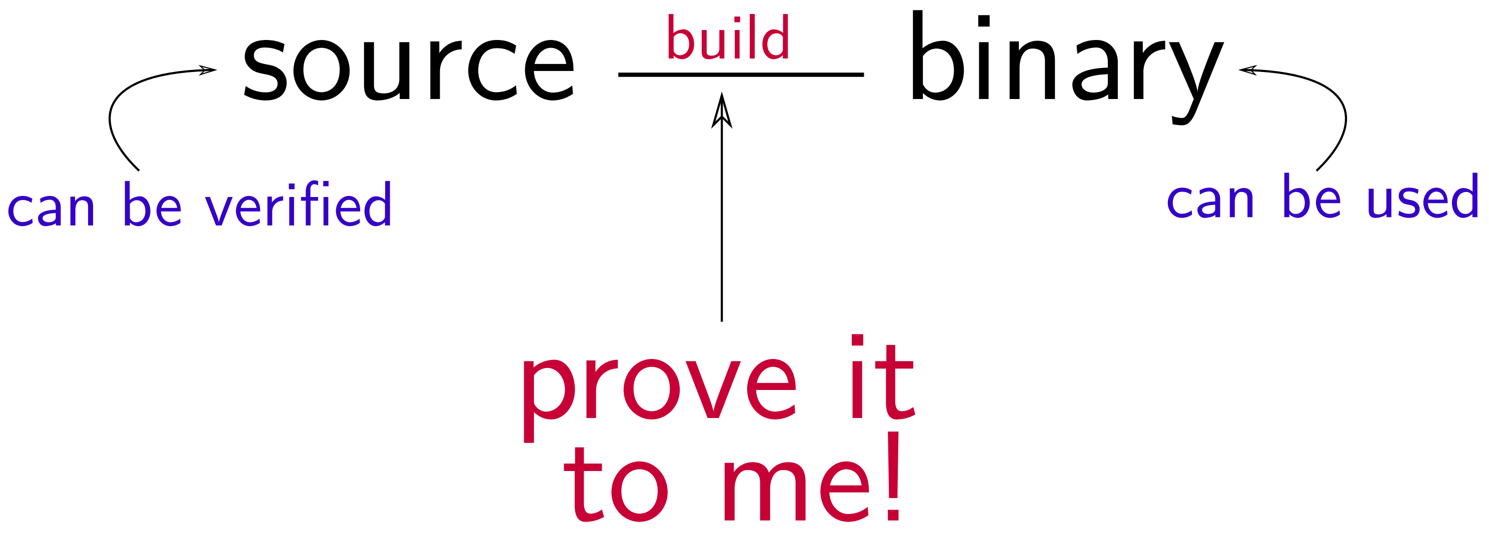

source build binary

can be verified

can be used

prove it
to me!

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- Not without faith.

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  - OpenSSH (CVE-2002-0083)

Freedom 1a: Can we **study** the program?

- Not without faith.. or bit-for-bit reproducibility!
- Even one bit can compromise a computer
  - OpenSSH
- Without reproducible builds, the developer is single point of failure
  - Compromised human or machines

For more security motivation, see:
https://events.ccc.de/congress/2014/Fahrplan/events/6240.html

Freedom 1b:
Can we **change** the program?

source $\overset{\text{build}}{\rule{2cm}{0.4pt}}$ binary

Freedom 1b:
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- Not without great difficulty.

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- Arguably, code is easier to edit than compile
  - Lower barrier to contribution for non-technical, competent people (designers? User researchers?)

in summary:

reproducible builds

=

freedoms to **study** and **change** programs.

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How to change 60 years of non-deterministic programming habits?

bitcoin

- Since 2012
- Why?
  - $$$

₿bitcoin

- Since 2012
- Why?
  - $$$
- Created Gitian
  - Build within virtual machine
  - Standardized inputs
- Removes indeterminacies:
  - Compiler and kernel versions
  - Build machine meta-data (hostname, time)

- Reproducibly built since 2012
- Why?
  - Human lives.

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  - Human lives.
- More complex
  - Firefox browser
  - And 50+ packages
- Used Gitian
  - And a few months of developing..

What else did Tor find?

- Python os.walk: Multi-threaded build processes results in random file ordering.
- GNU binutils: Consistently random bits... that result from uninitialized memory.

More fun Tor reproducibility facts:
https://blog.torproject.org/blog/deterministic-builds-part-two-technical-details

What else did Tor find?

- Python os.walk: Multi-threaded build processes results in random file ordering.
- GNU binutils: Consistently random bits… that result from uninitialized memory.

Problems they could not solve:

- Takes a long time
- Browser profile-guided optimizations

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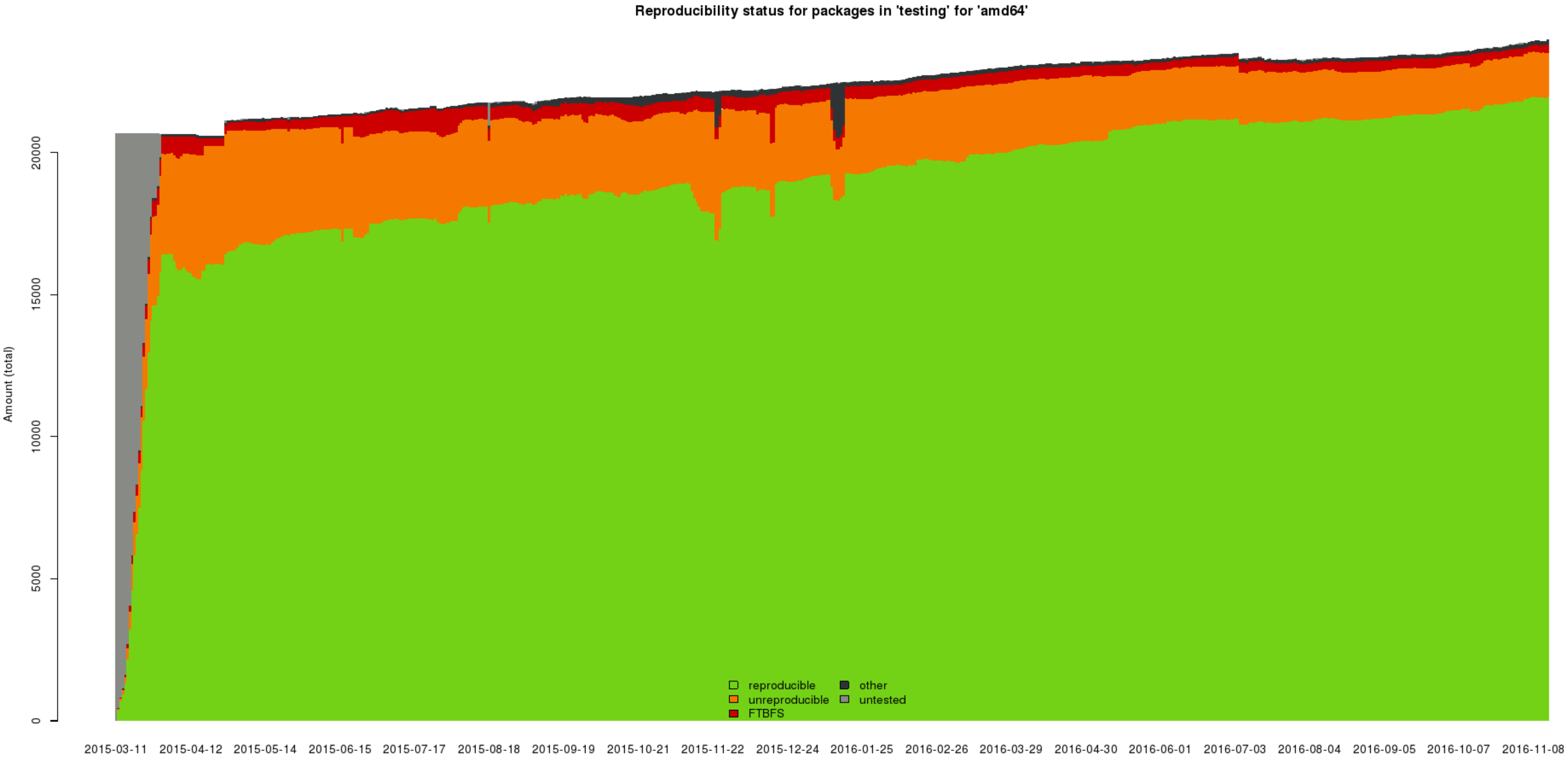
Think reproducing Tor sounds hard?

- >40,000 packages
- ~1000 developers
- All the languages..
- ..all the compilers.

How to began:

- A discussion at DebConf13 and a wikipage
- Attempts to prove reproducibility of a few packages
- Quickly realized many problems exist in packaging toolchain
- End of 2014 saw the beginning of continuous testing of all packages

tests.reproducible-builds.org



tests.reproducible-builds.org/**<package>**

☀ Reproducible

🌧 Unreproducible

tests.reproducible-builds.org/**<package>**

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- Test = building twice and comparing

tests.reproducible-builds.org/**<package>**

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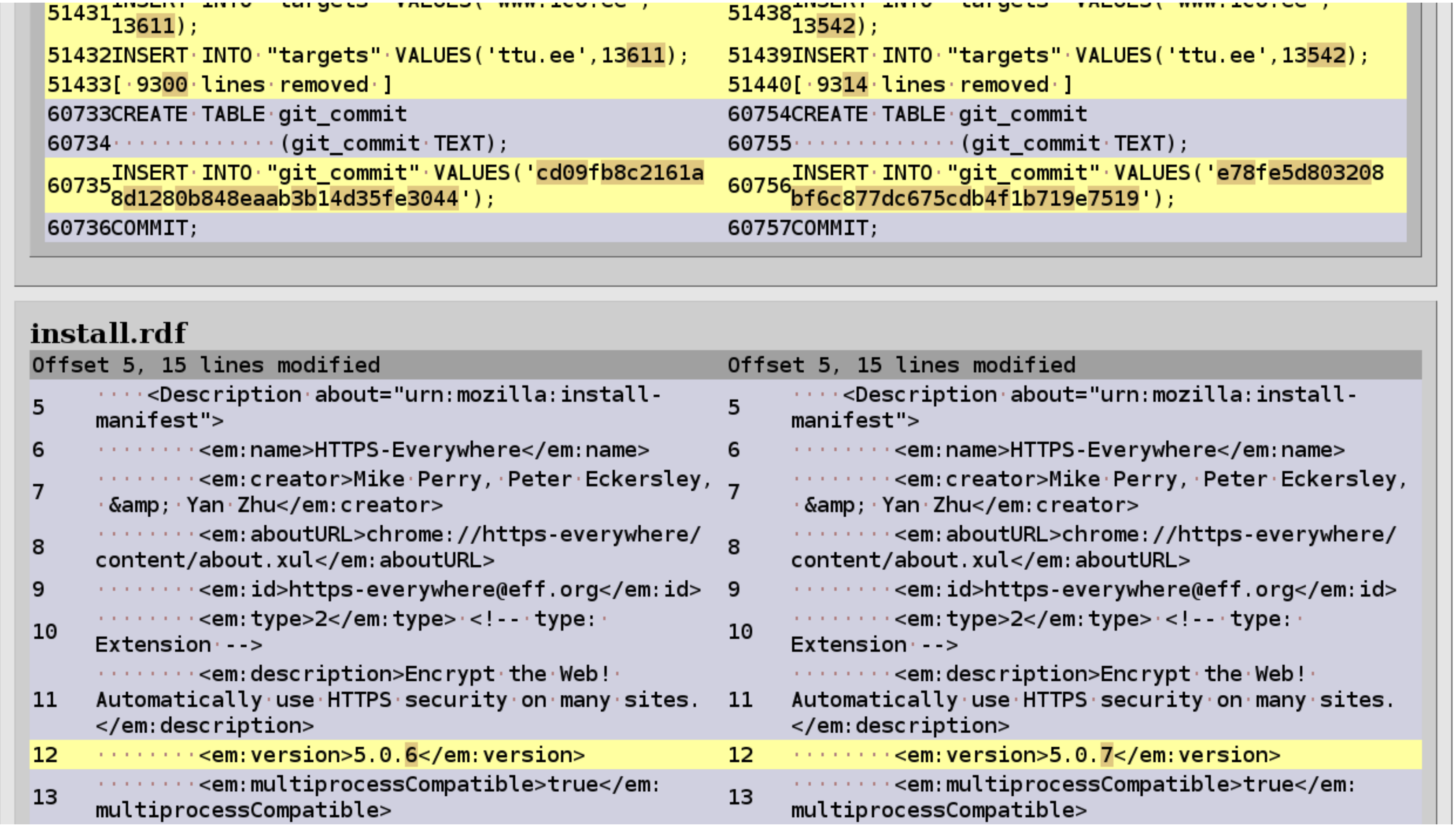
- Test = building twice and comparing
- Testing on amd64, arm and i386
- Variations between builds:
  - domain
  - hostname
  - timezone
  - language
  - locale
  - time
  - user
  - program id
  - shell
  - kernel
  - cpu type
  - file ordering

tests.reproducible-builds.org/**<package>**

Diffoscope

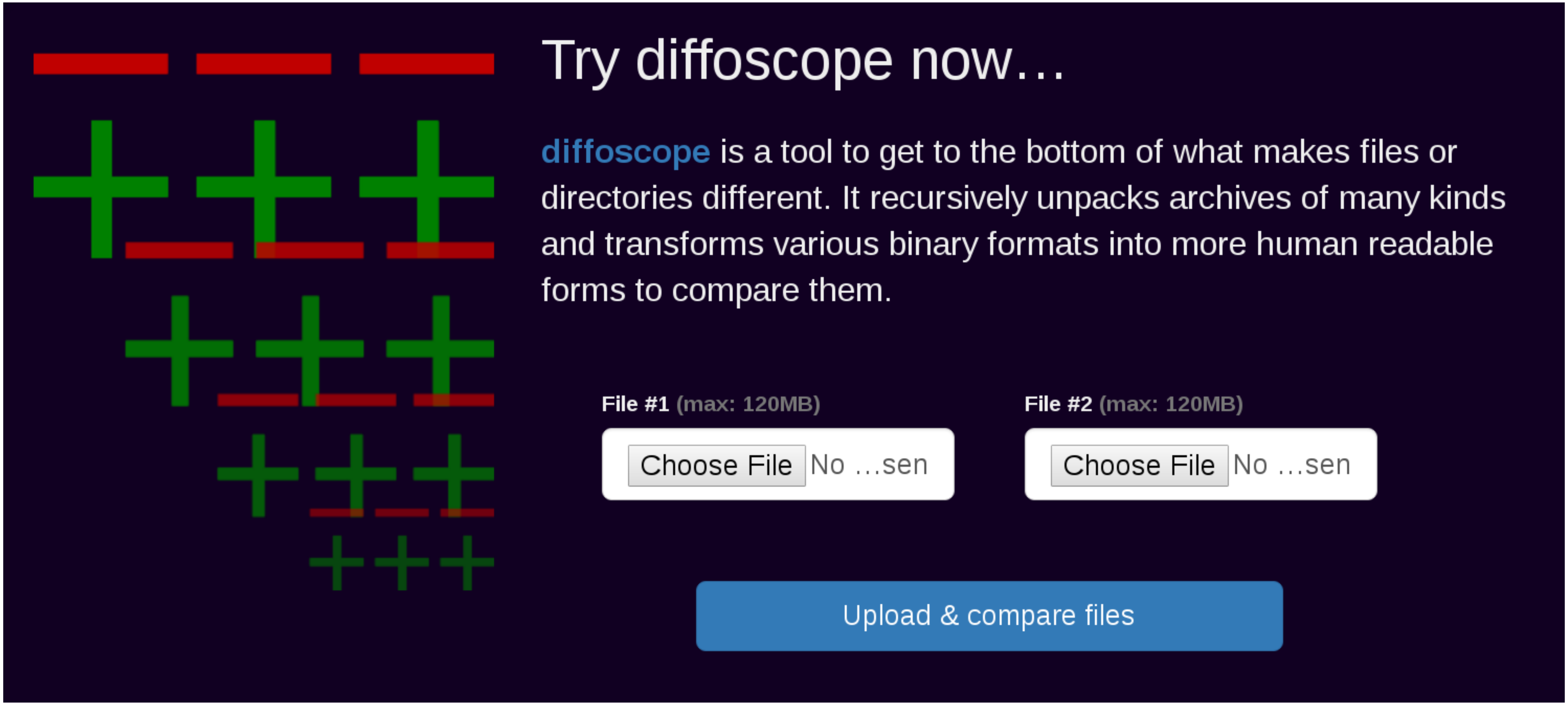


```
51431INSERT INTO "targets" VALUES('www.ttu.ee',      51438INSERT INTO "targets" VALUES('www.ttu.ee',
     13611);                                               13542);
51432INSERT INTO "targets" VALUES('ttu.ee',13611);   51439INSERT INTO "targets" VALUES('ttu.ee',13542);
51433[ 9300 lines removed ]                          51440[ 9314 lines removed ]
60733CREATE TABLE git_commit                         60754CREATE TABLE git_commit
60734            (git_commit TEXT);                  60755            (git_commit TEXT);
60735INSERT INTO "git_commit" VALUES('cd09fb8c2161a   60756INSERT INTO "git_commit" VALUES('e78fe5d803208
     8d1280b848eaab3b14d35fe3044');                        bf6c877dc675cdb4f1b719e7519');
60736COMMIT;                                         60757COMMIT;
```

install.rdf

```
Offset 5, 15 lines modified                          Offset 5, 15 lines modified
5     <Description about="urn:mozilla:install-       5     <Description about="urn:mozilla:install-
      manifest">                                           manifest">
6             <em:name>HTTPS-Everywhere</em:name>    6             <em:name>HTTPS-Everywhere</em:name>
7             <em:creator>Mike Perry, Peter Eckersley, 7           <em:creator>Mike Perry, Peter Eckersley,
       &amp; Yan Zhu</em:creator>                           &amp; Yan Zhu</em:creator>
8             <em:aboutURL>chrome://https-everywhere/ 8            <em:aboutURL>chrome://https-everywhere/
      content/about.xul</em:aboutURL>                      content/about.xul</em:aboutURL>
9             <em:id>https-everywhere@eff.org</em:id> 9            <em:id>https-everywhere@eff.org</em:id>
10            <em:type>2</em:type> <!-- type:        10            <em:type>2</em:type> <!-- type:
      Extension -->                                        Extension -->
              <em:description>Encrypt the Web!                     <em:description>Encrypt the Web!
11    Automatically use HTTPS security on many sites. 11   Automatically use HTTPS security on many sites.
      </em:description>                                    </em:description>
12            <em:version>5.0.6</em:version>         12            <em:version>5.0.7</em:version>
13            <em:multiprocessCompatible>true</em:   13            <em:multiprocessCompatible>true</em:
      multiprocessCompatible>                              multiprocessCompatible>
```

https://try.diffoscope.org



Try diffoscope now…

diffoscope is a tool to get to the bottom of what makes files or directories different. It recursively unpacks archives of many kinds and transforms various binary formats into more human readable forms to compare them.

tests.reproducible-builds.org/**<package>**

Issue Tracking

- “notes” for most unreproducible packages

tests.reproducible-builds.org/**<package>** Issue Tracking

- “notes” for most unreproducible packages
- 261 distinct issues tagged in notes.git
  - Described in issues.git
  - Examples: `timestamps_in_zip`, `captures_build_path`, `different_encoding`, `different_due_to_umask`, `plist_weirdness`, `leaks_path_environment_variable`,`timestamps\_in\_cpio\_archive`

tests.reproducible-builds.org/**<package>**

Issue Tracking

- Many incredible Debian developers and contributors up keep these notes.
  - Filed >2000 bugs with patches
  - Filed >3000 bugs that fail to build from source

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Nope, you don't!

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  - Environment variable
  - Set to the last time the source was changed
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  - Set to the last time the source was changed
  - Specification has been written for upstream developers
  - Many have followed:
    - Debhelper, epydoc, ghostscript, ocamldoc...
    - In discussion: GCC for `__DATE__` and `__TIME__` macros

Additional projects

- Testing: OpenWRT, coreboot, NetBSD, FreeBSD
- Almost testing: ArchLinux, Fedora and F-Driod

More information

- reproducible-builds.org
- Lunar talk on “How to make your software reproducible” at Chaos Communication Camp 2015

Overview

1. What is “Reproducible Builds”?
2. Reproducible builds and software freedoms
3. Recent history of reproducible builds
4. **What is left to do..?**

“Reproduced Builds” are not enough

Part I

- Debian is 0% reproducible until *any user* can reproduce any given binary Debian package.
- “Build environment should be reproducible”

Build environment reproducibility: Sandboxing

- Bundle the build environment
  - Gitian virtual machine with “descriptors”
  - Docker container
  - OpenWRT “SDK” contains all dependencies

Build environment reproducibility: Sandboxing

- Bundle the build environment
  - Gitian virtual machine with “descriptors”
  - Docker container
  - OpenWRT “SDK” contains all dependencies
- Problems:
  - Can you trust the bundled OS?
  - Big and/or slow?

Build environment reproducibility: Debian's **.buildinfo** files

- Standard file to tie together source, binary and build environment
- .buildinfo files contain:
  - Checksum of the source
  - Checksum of generated binaries
  - Exact versions of all build dependencies

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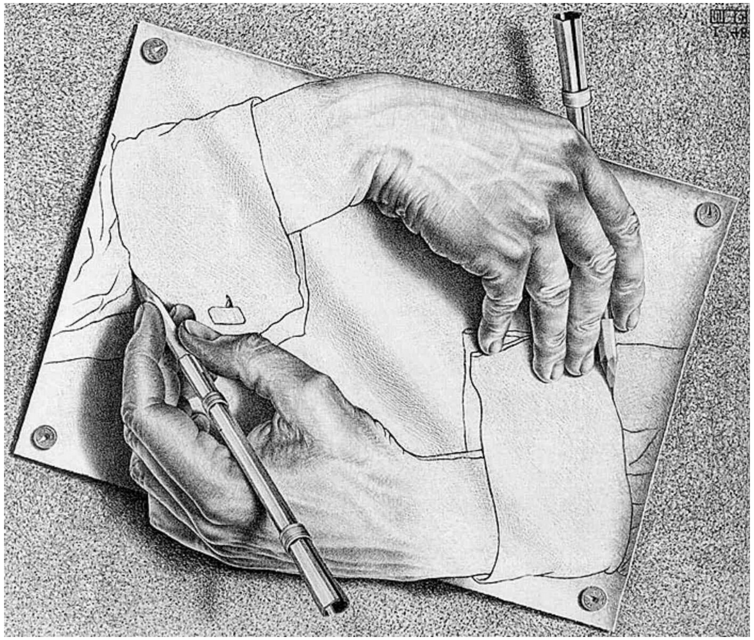
  - Exact versions of all build dependencies
- ***Ongoing work:*** distribute .buildinfo files with binary

.buildinfo file

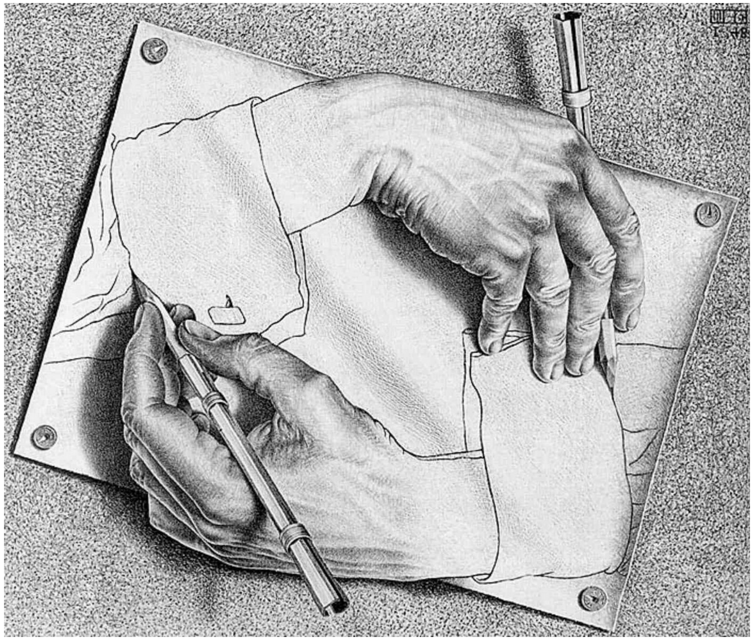
```
Format: 1.9
Build-Architecture: amd64
Source: txtorcon
Binary: python-txtorcon
Architecture: all
Version: 0.11.0-1
Build-Path: /build/txtorcon-0.11.0-1
Checksums-Sha256:
 a26549d9…7b 125910 python-txtorcon_0.11.0-1_all.deb
 28f6bcbe…69 2039 txtorcon_0.11.0-1.dsc
Build-Environment:
 base-files (= 8),
 base-passwd (= 3.5.37),
 bash (= 4.3-11+b1),
 …
```

Build environment reproducibility: Debian's **.buildinfo** files

- ***Next step:*** build tools to re-create build environment
  - Debian: can use .buildinfo files with archive.debian.net
  - other distros: ...?



Delivering build environment metadata
with binary software..



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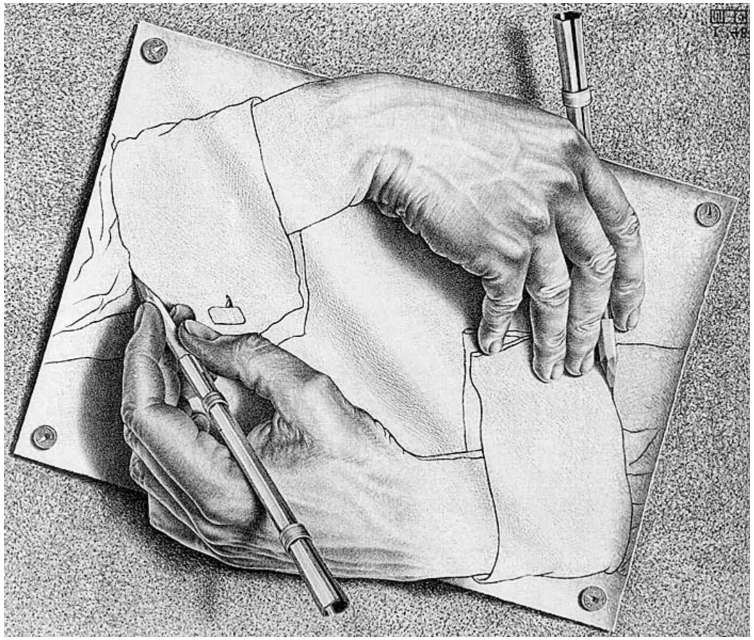

Delivers the **freedom** to **change** software.

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- Easier regulation..
  - Allows audits of binaries
  - Presently unaudited binaries include: voting software, VW emission scandal…
- Easier GPL enforcement
- Perhaps a more long term preference for free software?

“Reproduced Builds” are not enough

Part II

- How can we surface verified reproducibility to a non-developer?

Debian:
Uploading and Verifying

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- Who will rebuild and verify software?
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  - Other developers

Debian: Uploading and Verifying

- Who will rebuild and verify software?
  - Dedicated rebuilders
  - Other developers
- How will we sign and share the signatures on binaries?
  - “web of trust” solution probably won't scale

Debian:
Downloading and Verifying

```
Do you really want to install this
unreproducible software? (y/N)
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Debian: Downloading and Verifying

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Do you really want to install this
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unconfirmed checksums before installing? (Y/n)
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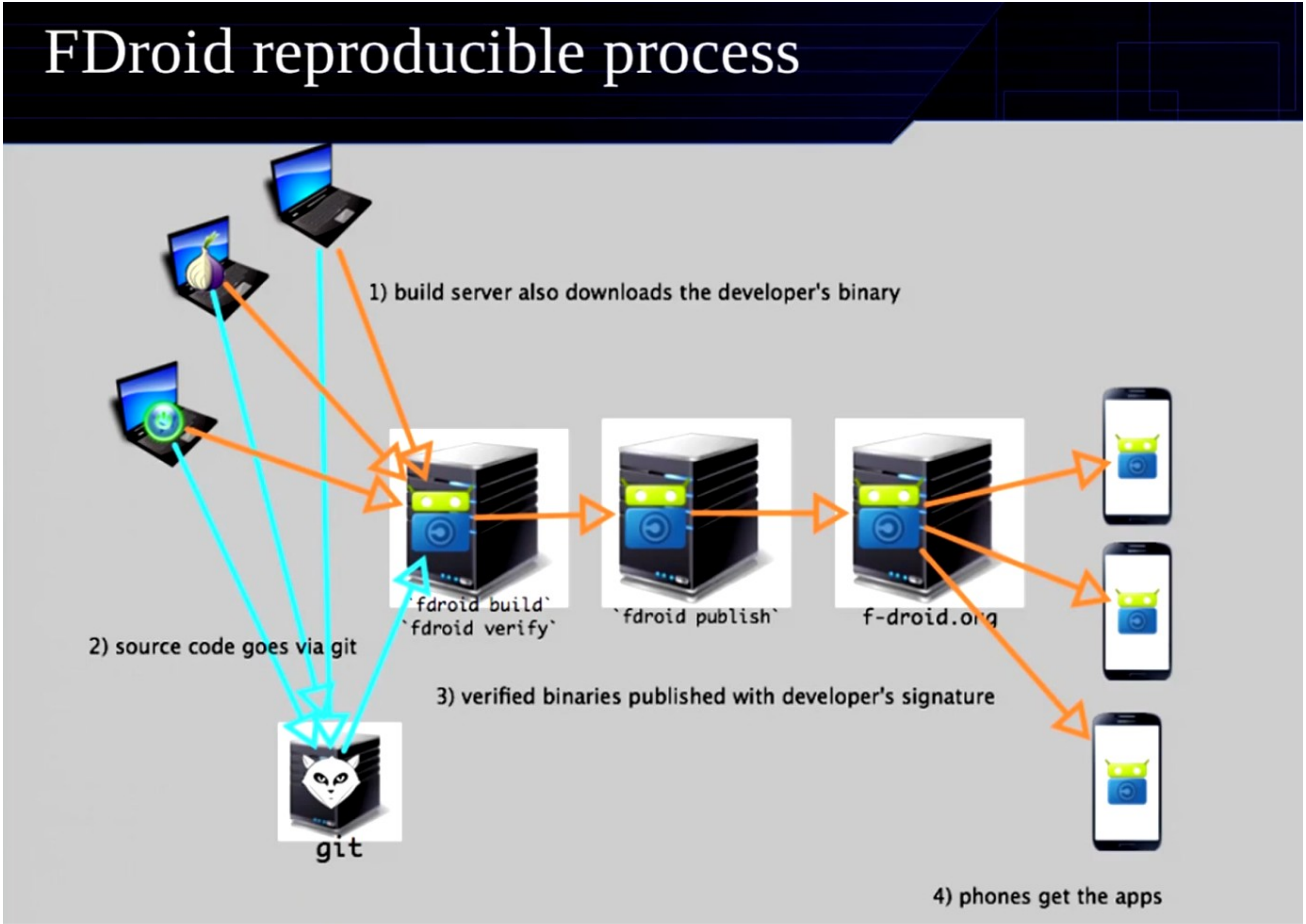
```
How many signed checksums do you require to call
a package “reproducible”?
```

```
Which rebuilders do you trust?
```



FDroid reproducible process

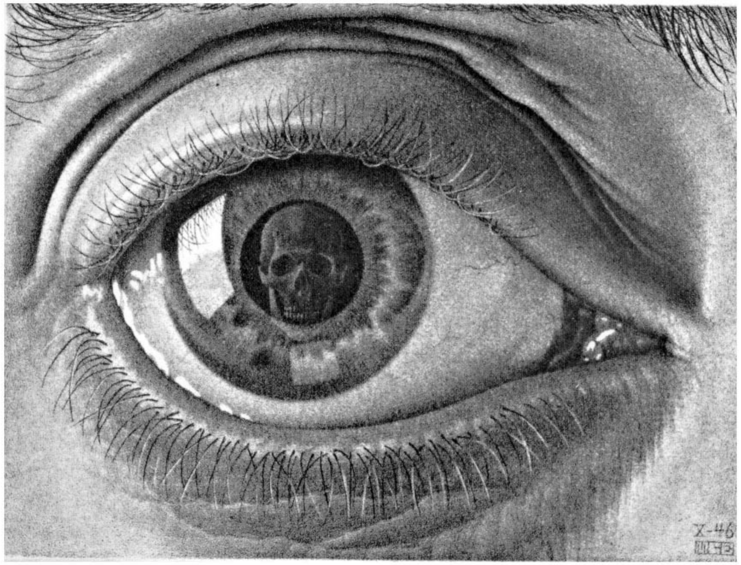
1) build server also downloads the developer's binary

2) source code goes via git

3) verified binaries published with developer's signature

4) phones get the apps

https://events.ccc.de/congress/2014/Fahrplan/events/6240.html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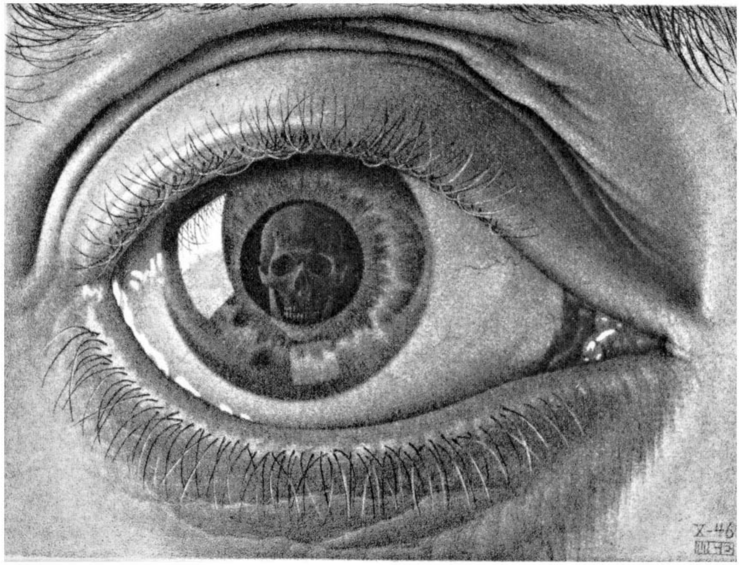
Delivering the verification of reproducibility with binaries..



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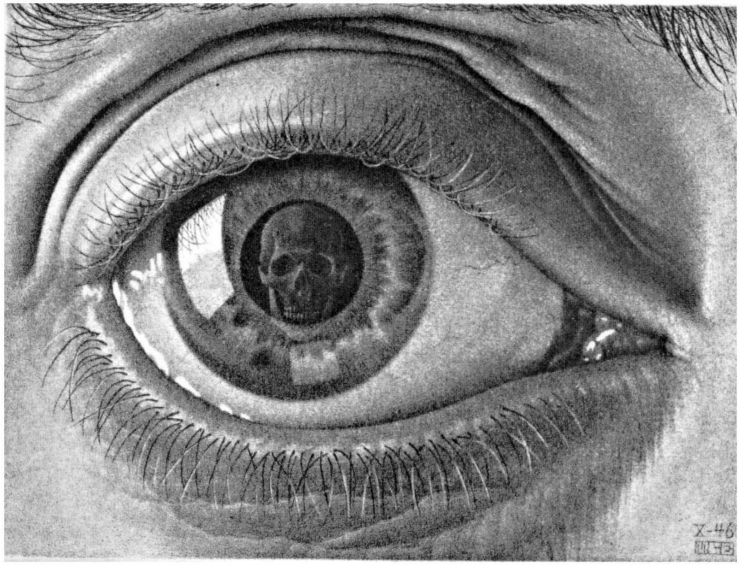

Delivers the **trust** we have in free software because we can **study** the source.

With this software freedom, what do we get?

- Assurance against compromised developers
- Assurance against compromised compilers
  - Unless you compromise them all!

With this software freedom, what do we get?

- Assurance against compromised developers
- Assurance against compromised compilers
  - Unless you compromise them all!
- Free software = provably safer and more transparent than proprietary.

Thanks!

More information:
reproducible-builds.org
#reproducible-builds on OFTC