Reproducible Builds

Valerie Young
(spectranaut)

Linux Conf Australia 2016

Reproducible Builds

What if you could always compile free software?

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Valerie Young

- F96E 6B8E FF5D 372F FDD1 DA43 E8F2 1DB3 3D9C 12A9
- 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.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 effect on software freedoms
3. Up-to-date history of reproducible builds efforts
4. What is left to do..?

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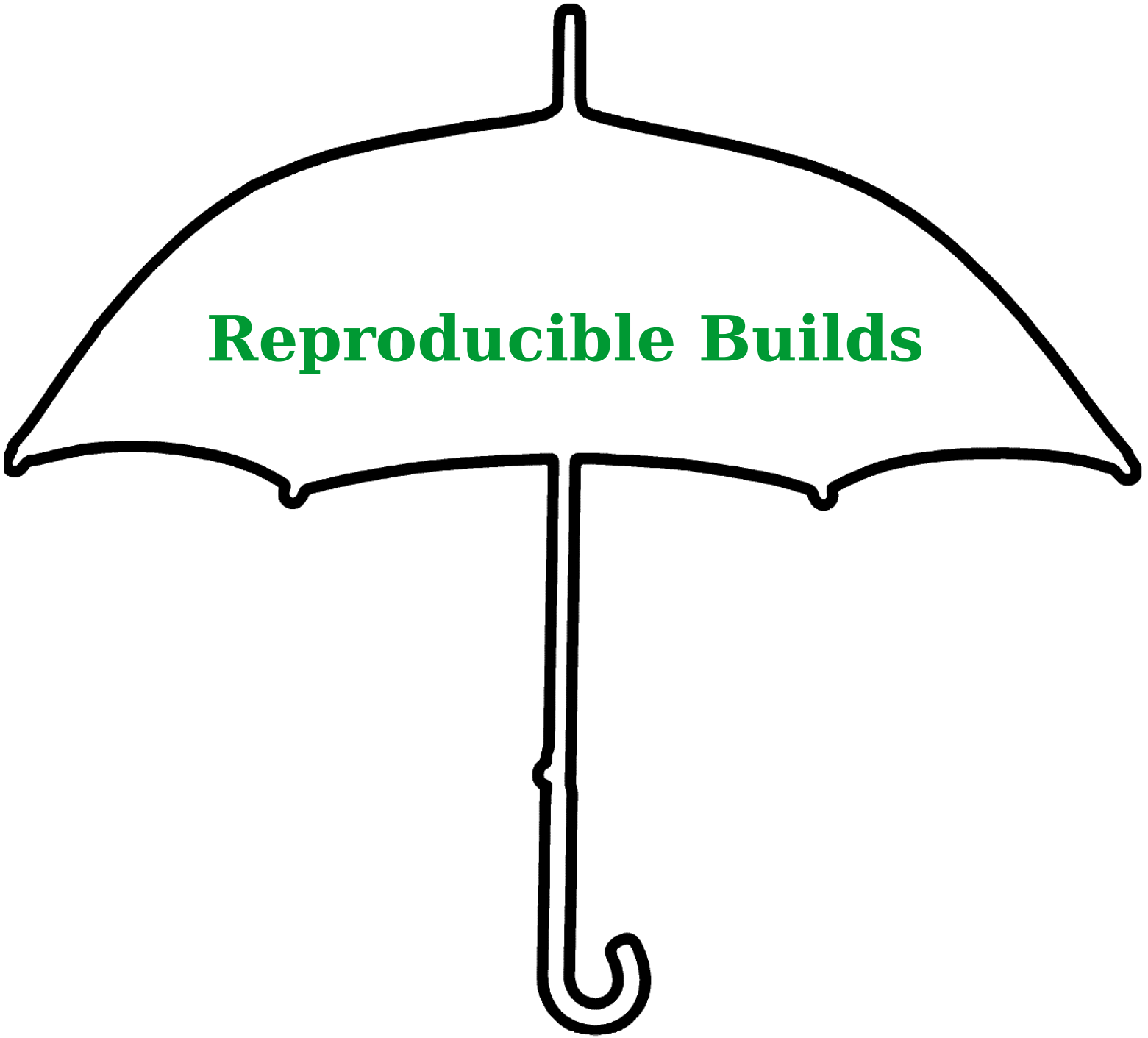
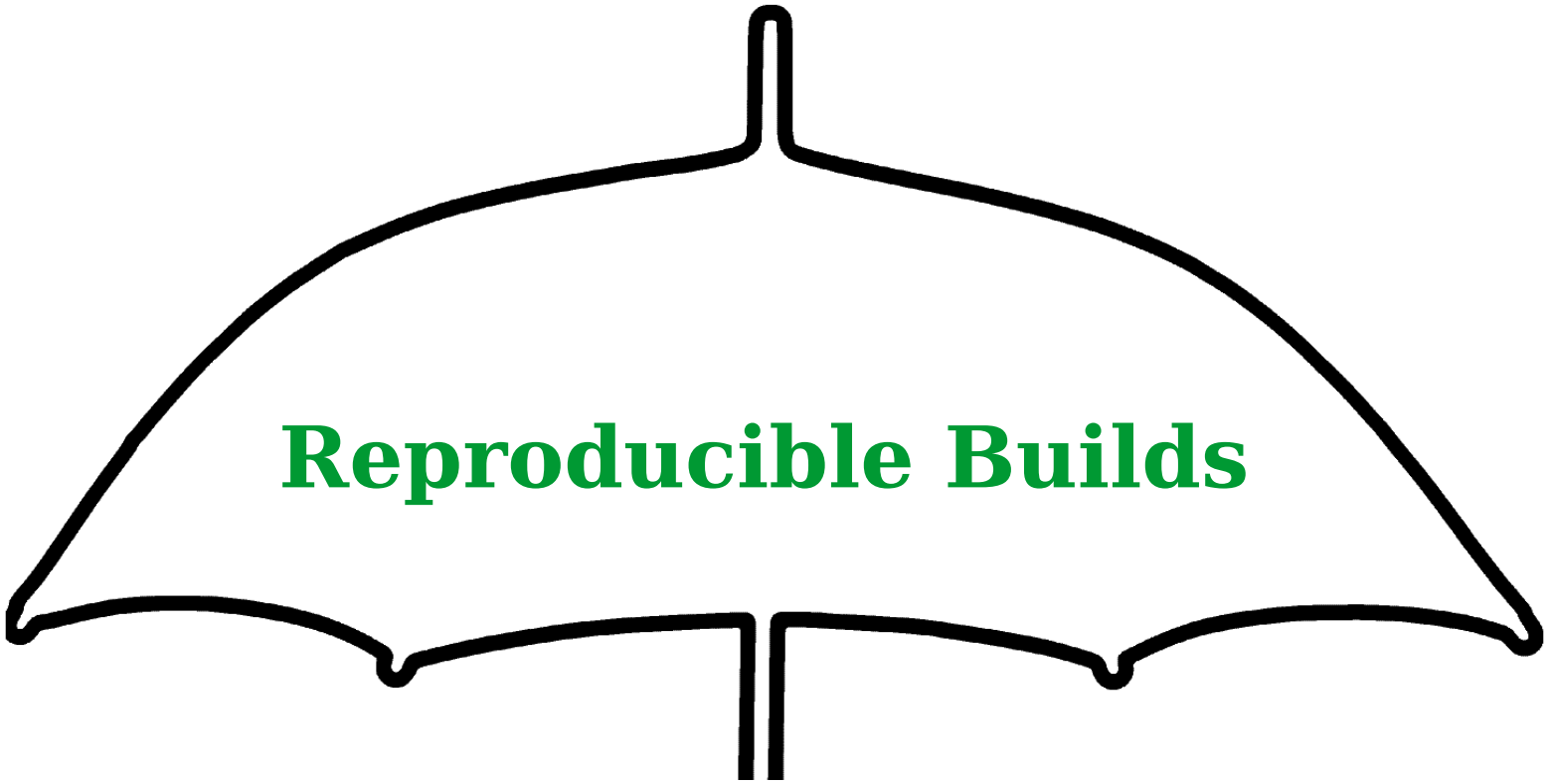
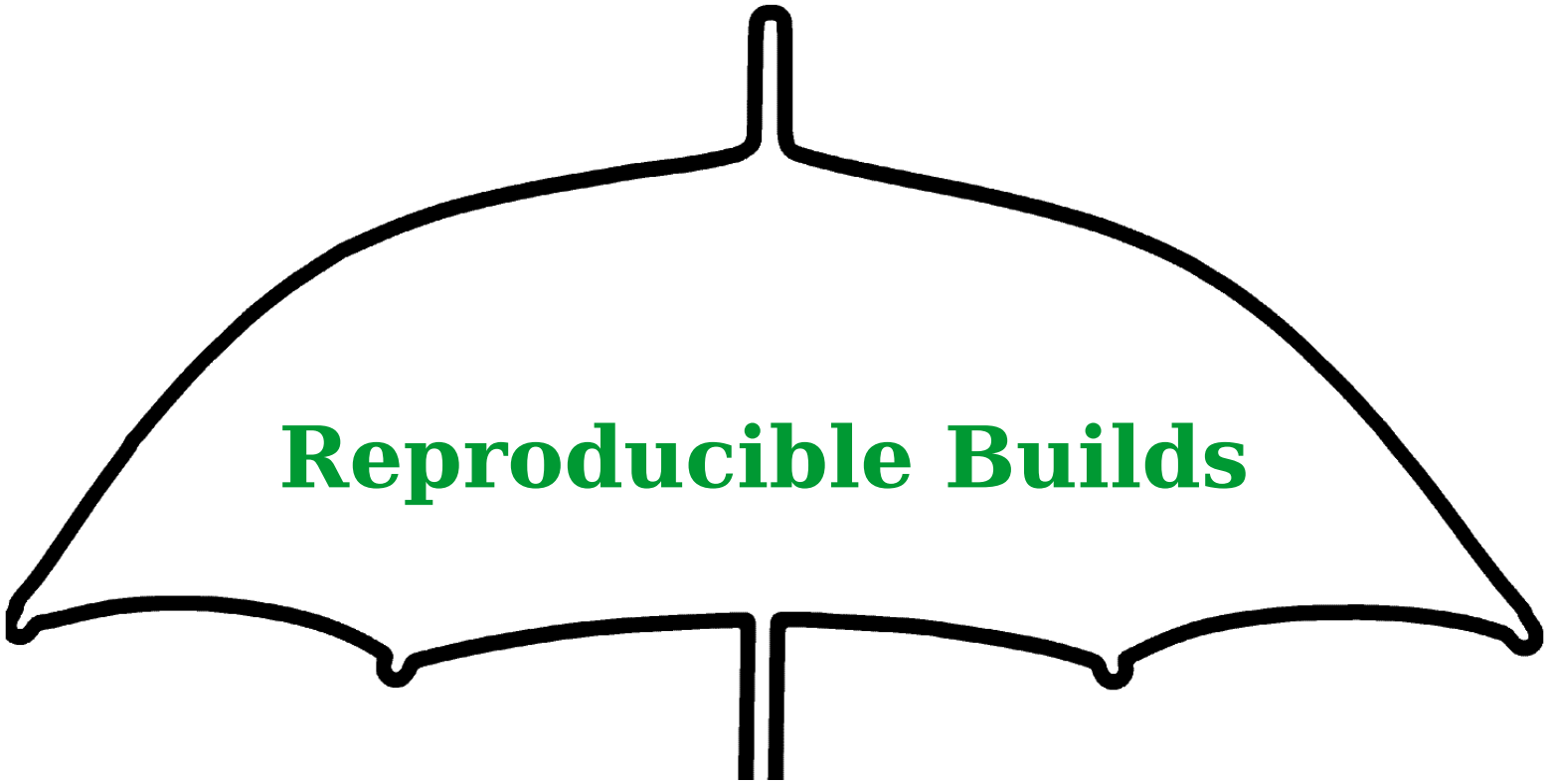

Reproducible Builds



Goals:

1. Compilation of binary should be deterministic



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2. Build environment of binary should be reproducible

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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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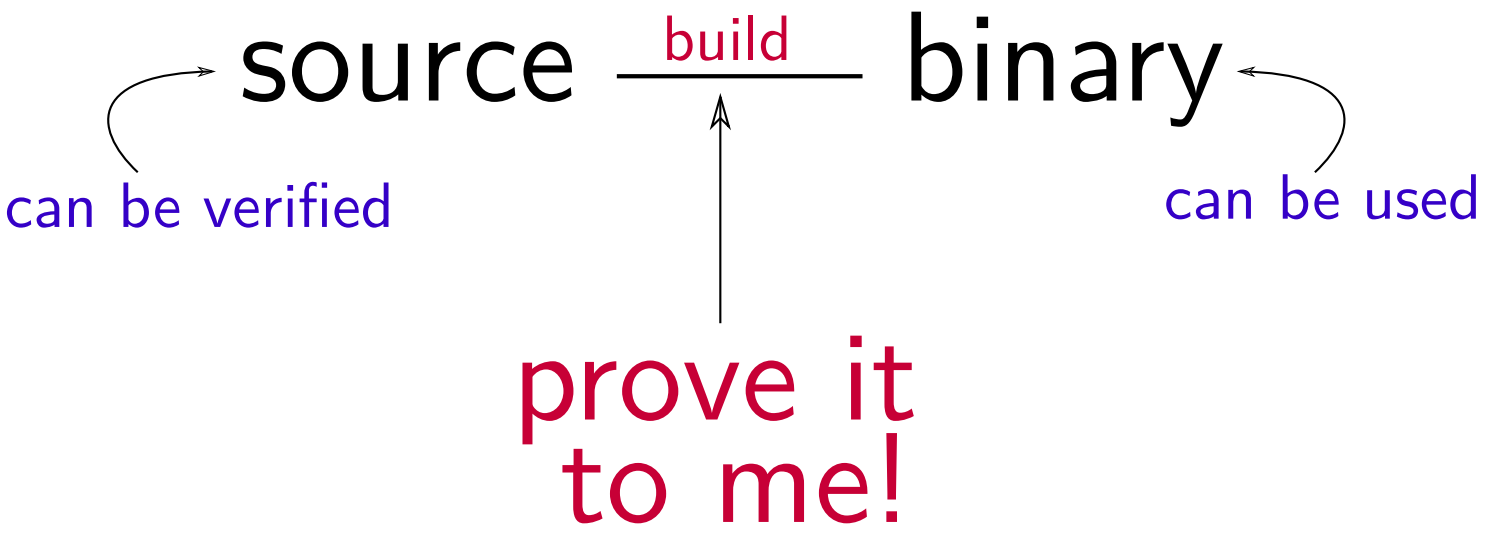

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  - OpenSSH (CVE-2002-0083)

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?

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

- Not without great difficulty… or reproducible builds!
- “Build environment should be reproducible”
  - Lower barrier to contribution for lazy people
- Arguably, code is easier to edit than compile
  - Lower barrier to contribution for non-technical, competent people (designers? User researchers?)

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

- Since 2012
- Why?
  - $$$
- Created Gitian
  - Build in VM
- Removes indeterminacies:
  - Compiler versions
  - Kernel versions
  - Build machine meta-data (hostname, time)

- Reproducibly built since 2012
- Why?
  - 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?

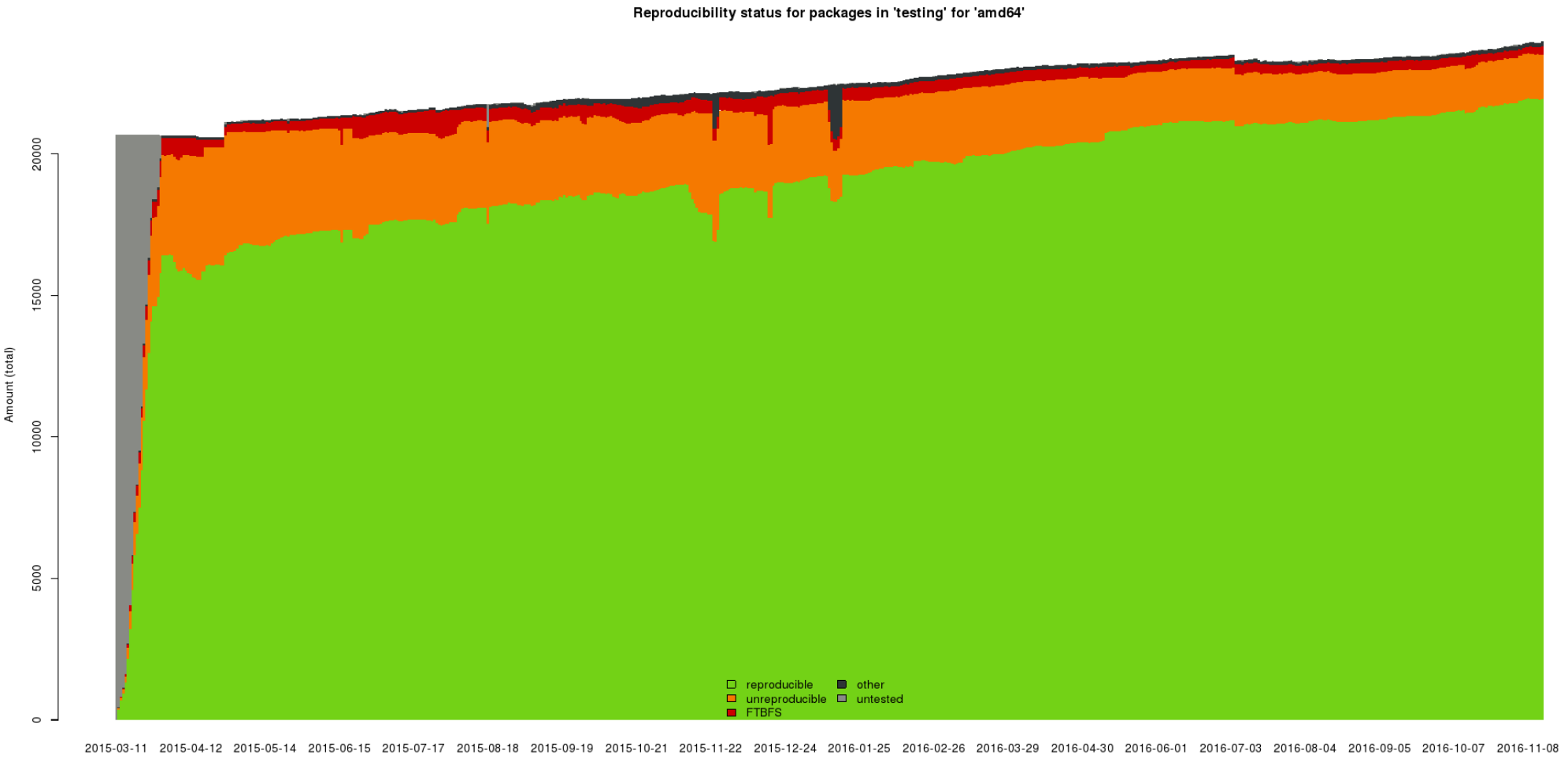
debian

- >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 maybe problems existed in packaging toolchain
- End of 2014 saw the beginning of continuous testing of all packages

tests.reproducible-builds.org



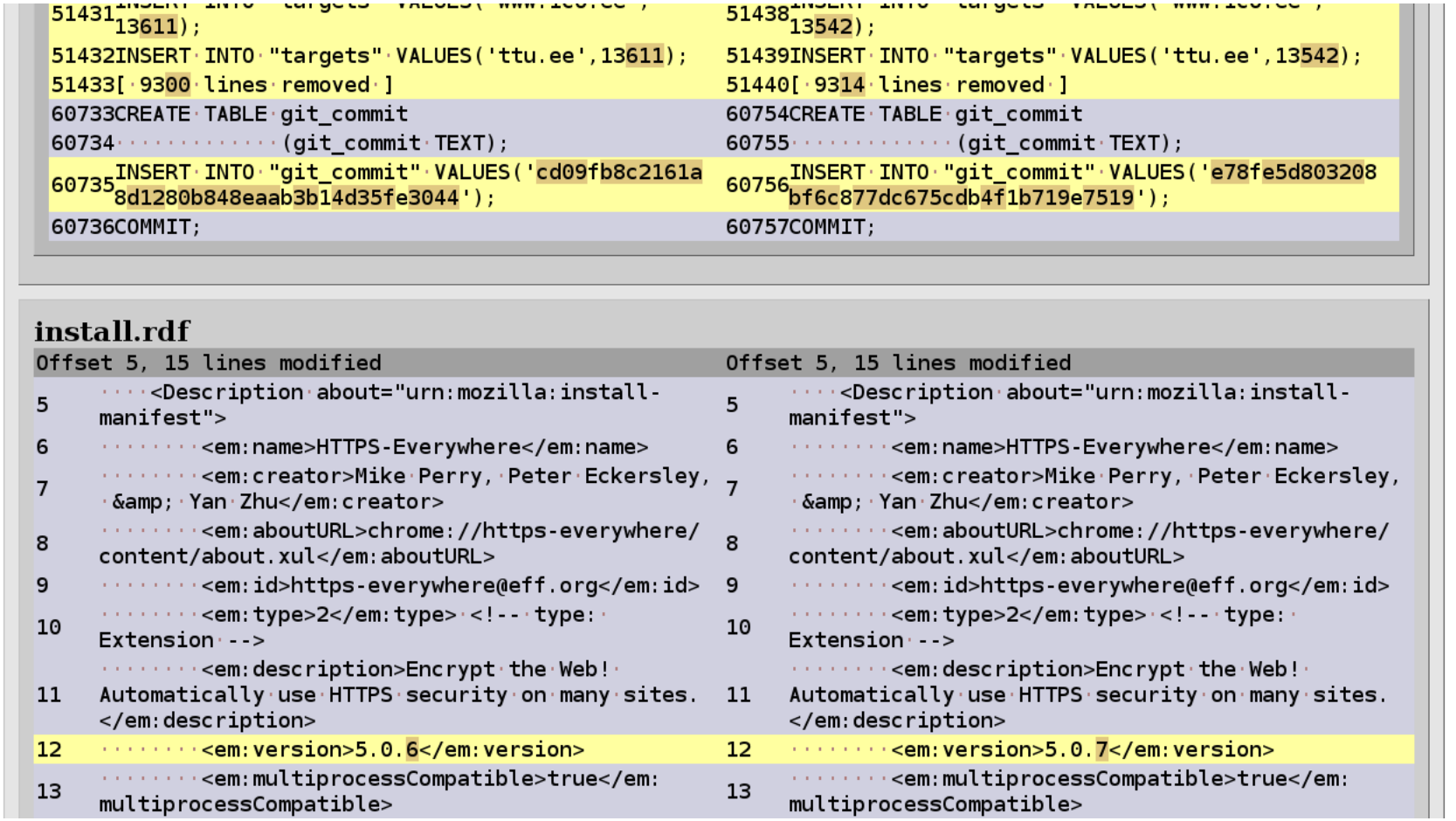
tests.reproducible-builds.org/<**package**>

 Reproducible  Unreproducible

- 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

Unreproducible Packages

Diffoscope

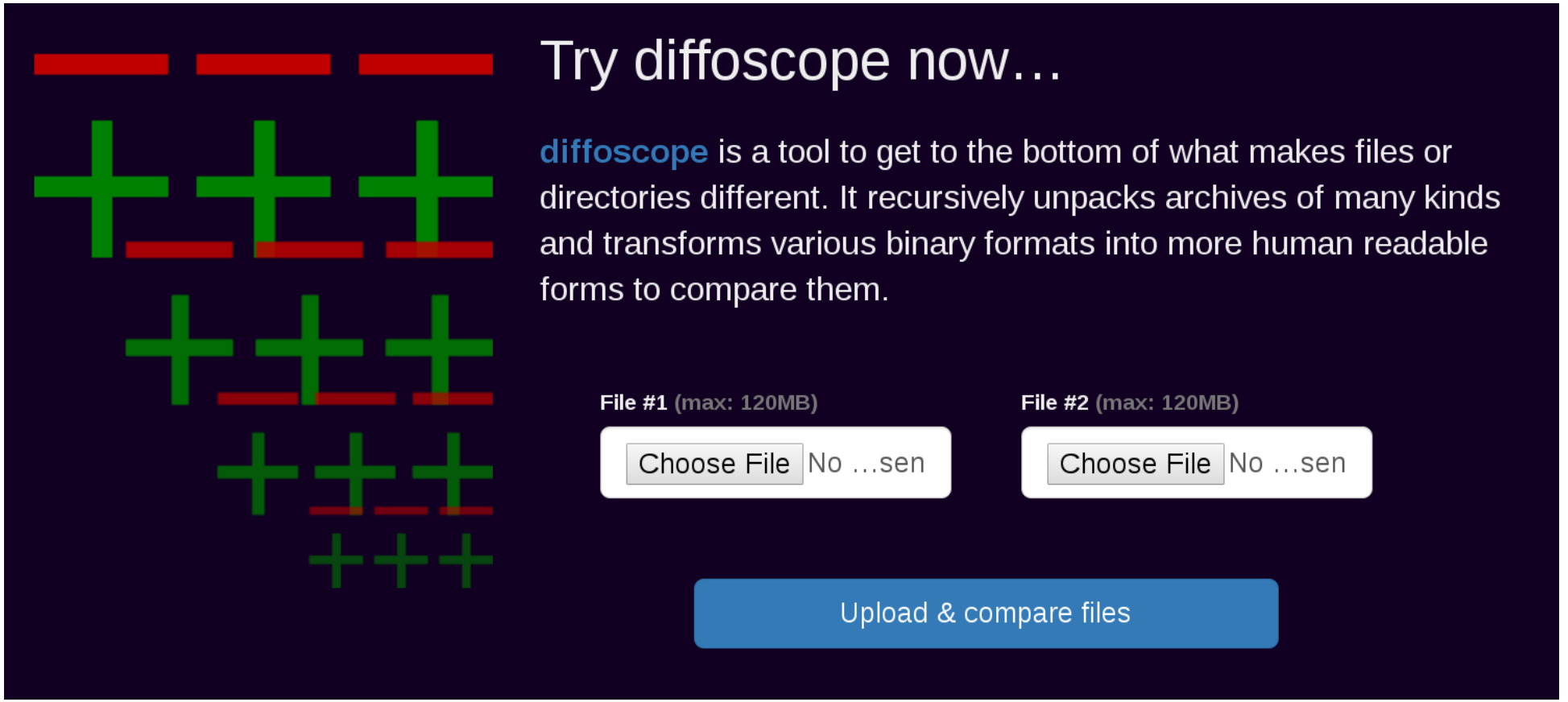


51431	13611);	51438	13542);
51432	INSERT INTO "targets" VALUES('ttu.ee',13611);	51439	INSERT INTO "targets" VALUES('ttu.ee',13542);
51433	[9300 lines removed]	51440	[9314 lines removed]
60733	CREATE TABLE git_commit	60754	CREATE TABLE git_commit
60734	(git_commit TEXT);	60755	(git_commit TEXT);
60735	INSERT INTO "git_commit" VALUES('cd09fb8c2161a8d1280b848eaab3b14d35fe3044');	60756	INSERT INTO "git_commit" VALUES('e78fe5d803208bf6c877dc675cdb4f1b719e7519');
60736	COMMIT;	60757	COMMIT;

install.rdf

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

https://try.diffoscope.org



Unreproducible Packages

Issue Tracking

- We have “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`
- Many incredible Debian developers and contributors up keep these notes.
  - Filed >2000 bugs with patches
  - Filed >3000 bugs that fail to build with new libs

TIMESTAMPS

- 112 issues are related to recording the time of the build in the binary.
  - Need build timestamps for documentation?
  - Need build timestamps for reconstructing build env?
  - Need builds timestamps for randomness seed?
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Nope, you don't!

TIMESTAMPS

- Debian recommends: **SOURCE_DATE_EPOCH**
  - 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

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2. Reproducible builds effect on 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 metadata: Debian's **.buildinfo** files

- .buildinfo files contain:
  - Checksum of the source
  - Checksum of generated binaries
  - Exact versions of all build dependencies
- Left to do: distribute .buildinfo files

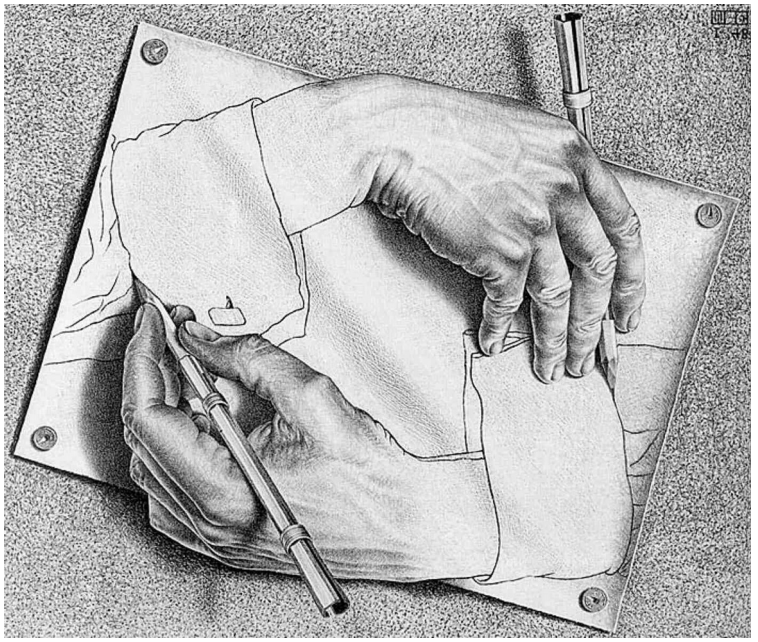
.buildinfo file

```
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 metadata: Can you verify the builds?

- We need tools to re-create build environment
  - Debian: can use .buildinfo files and archive.debian.net
  - other distros: ...?

Delivering build environment metadata with software..



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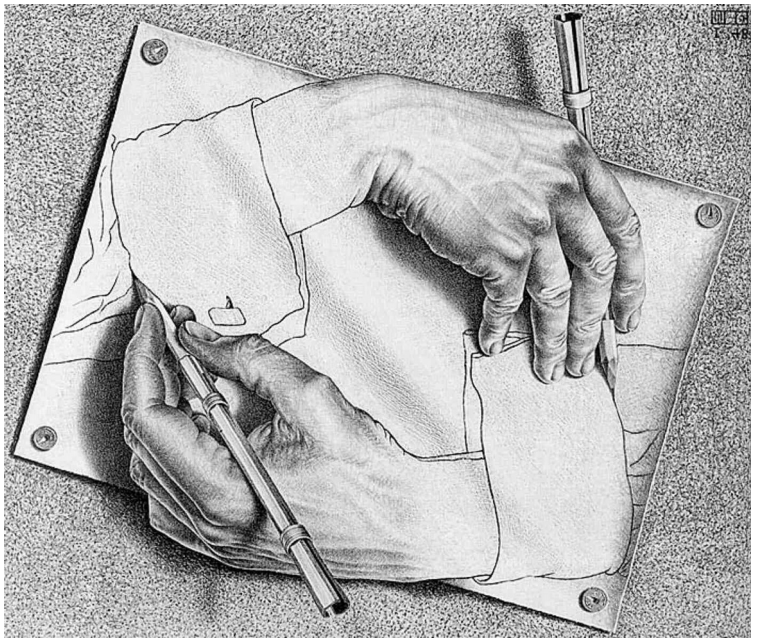

Delivers the **freedom** to **modify** software.

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  - Allows audits of binaries
  - Presently unaudited binaries include: voting software, VW emission scandal...
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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

- Who will rebuild software?
  - Dedicated rebuilders
  - Other developers
- 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
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unconfirmed checksums before installing? (Y/n)
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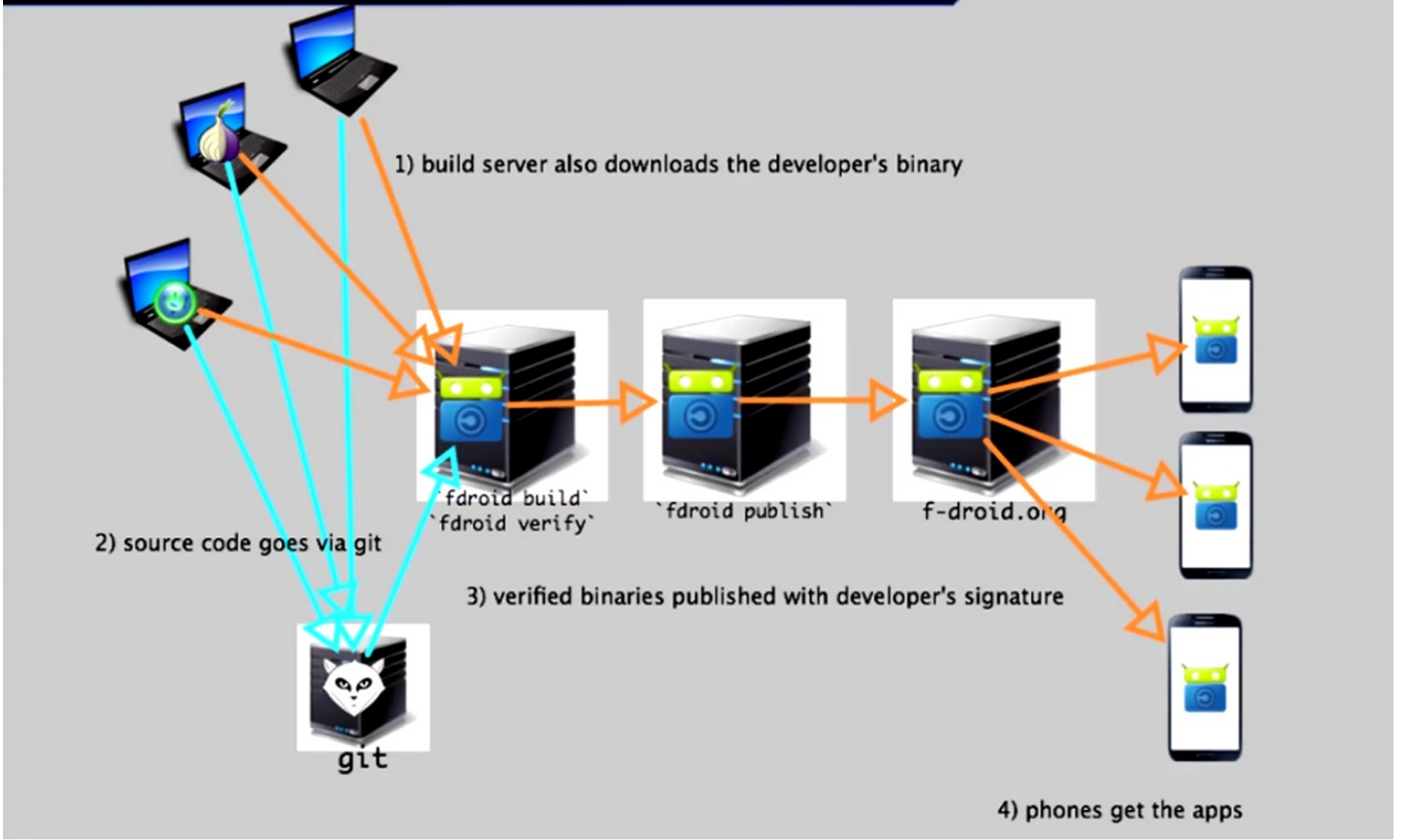
```
How many signed checksums do you require to call
a package “reproducible”?
```

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

FDroid reproducible process



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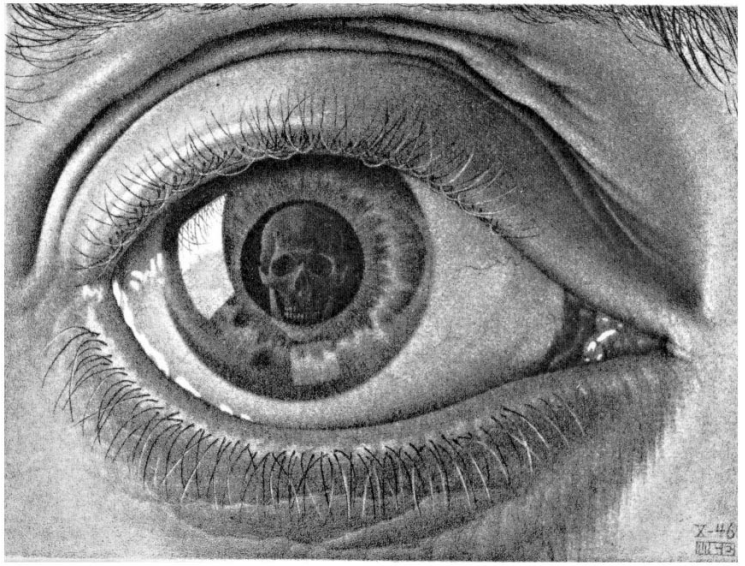
Delivering the verification of reproducibility with binaries..



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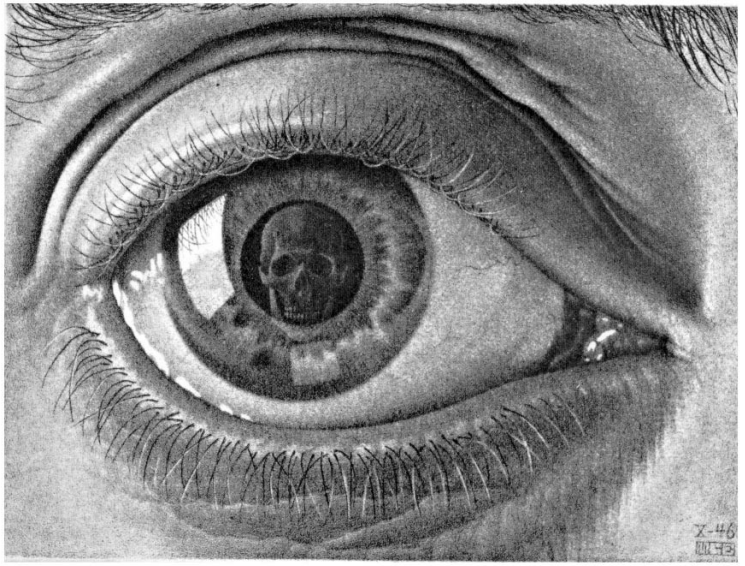

Delivers the **trust** we have in free software because we can **study** the source.

With this software freedom, what do we get?

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

Thanks!

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