Reproducible builds ecosystem

Where some of us are
and some hints where this might be going...

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holger@layer-acht.org

LibrePlanet (Cambridge, MA)
2016-03-20

about me

- `B8BF 5413 7B09 D35C F026 FE9D 091A B856 069A AA1C`
- Debian user since 1995
- Debian contributor since 2001
- Debian developer since 2007
- DebConf organizer, founded the DebConf video team
  - `http://video.debian.net`
- Debian-Edu (Debian for education)
- Debian QA (quality assurance)
  - `https://piuparts.debian.org`
  - `https://jenkins.debian.net` (1100 jobs continously testing Debian)
- Debian LTS (Long Term Support)

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Detour: naming is a hard problem...

- https://jenkins.debian.net
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- all point to the same system, 78.137.96.196

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- https://jenkins.debian.net
- ~~https://reproducible.debian.net~~
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- https://reproducible-builds.org
- all point to the same system, 78.137.96.196
- and sometimes only https://tests.r-b.org fit on the slides

more about me

- `B8BF 5413 7B09 D35C F026 FE9D 091A B856 069A AA1C`
- `8F03 B243 8719 BA6B 1A35 0EB6 40C2 DEA2 F56C 7256`
- Debian Reproducible builds team member
  - until April 2016 together with Lunar funded by the Linux Foundation
  - within in the team I'm mostly working on `https://tests.reproducible-builds.org`

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- `sudo apt-get install torbrowser-launcher`

Debian reproducible builds team

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Asheesh Laroia
Chris Lamb
Chris West
Christoph Berg
Daniel Kahn Gillmor
David Suarez
Dhole
Drew Fisher
Esa Peuha
Guillem Jover
Hans-Christoph Steiner
Helmut Grohne
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HW42
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Johannes 'josch' Schauer
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Who are you?

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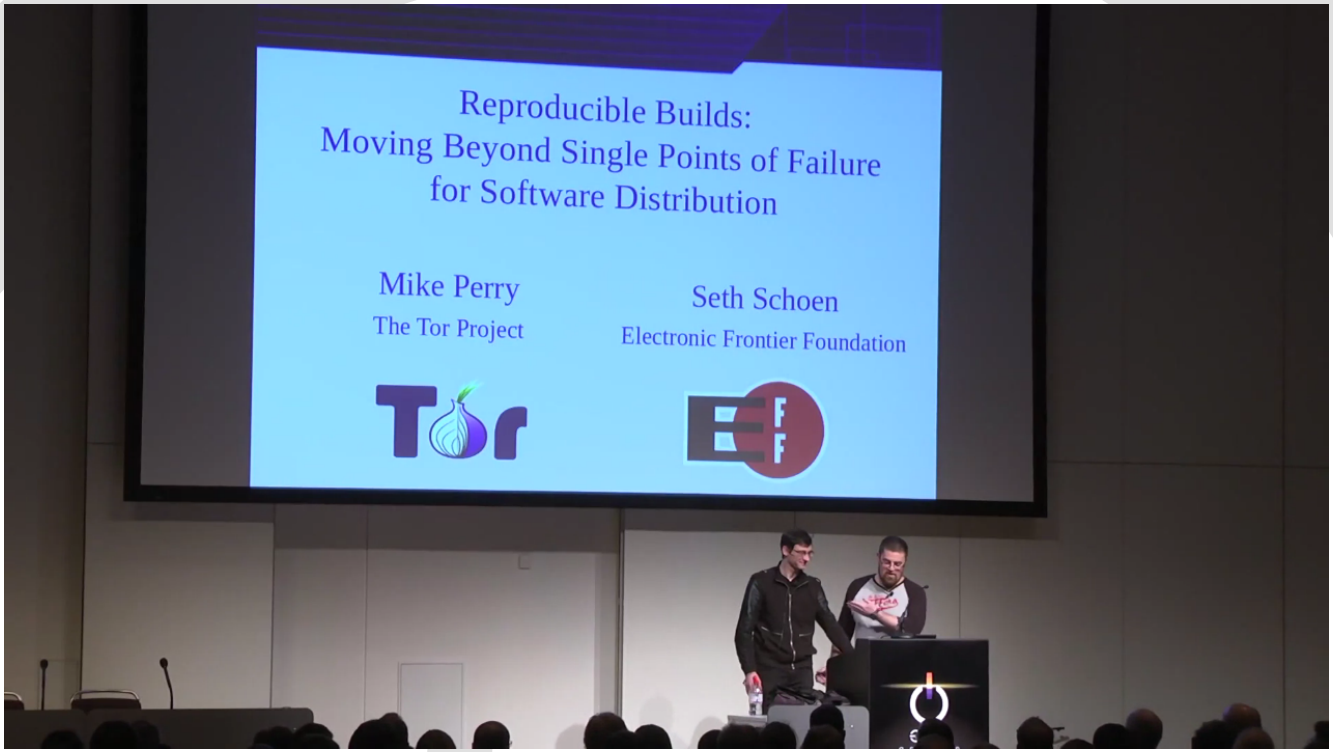
- Contributed to this effort?

The problem



Available on `media.ccc.de`, 31c3

A few examples from that 31c3 talk

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- CVE-2002-0083: remote root exploit in `sshd`, a single bit difference in the binary
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- financial incentives to crack developer machines...
- how can you be sure what's running on your machine or on a build daemon network? Do you ever leave your USB3 ports alone?

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- 31c3 talk had a live demo with a kernel module modifying source code in memory only
- financial incentives to crack developer machines...
- how can you be sure what's running on your machine or on a build daemon network? Do you ever leave your computers alone?

Another example from real life

At a CIA conference in 2012:

[edit] (S//NF) Strawhorse: Attacking the MacOS and iOS Software Development Kit

(S) Presenter: [redacted], Sandia National Laboratories

(S//NF) Ken Thompson's gcc attack (described in his 1984 Turing award acceptance speech) motivates the StrawMan work: what can be done of benefit to the US Intelligence Community (IC) if one can make an arbitrary modification to a system compiler or Software Development Kit (SDK)? A (whacked) SDK can provide a subtle injection vector onto standalone developer networks, or it can modify any binary compiled by that SDK. In the past, we have watermarked binaries for attribution, used binaries as an exfiltration mechanism, and inserted Trojans into compiled binaries.

(S//NF) In this talk, we discuss our explorations of the Xcode (4.1) SDK. Xcode is used to compile MacOS X applications and kernel extensions as well as iOS applications. We describe how we use (our whacked) Xcode to do the following things: -Entice all MacOS applications to create a remote backdoor on execution -Modify a dynamic dependency of securityd to load our own library - which rewrites securityd so that no prompt appears when exporting a developer's private key -Embed the developer's private key in all iOS applications -Force all iOS applications to send embedded data to a listening post -Convince all (new) kernel extensions to disable ASLR

(S//NF) We also describe how we modified both the MacOS X updater to install an extra kernel extension (a keylogger) and the Xcode installer to include our SDK whacks.

`firstlook.org/theintercept/2015/03/10/ispy-cia-campaign-steal-apples-secrets/`

The solution

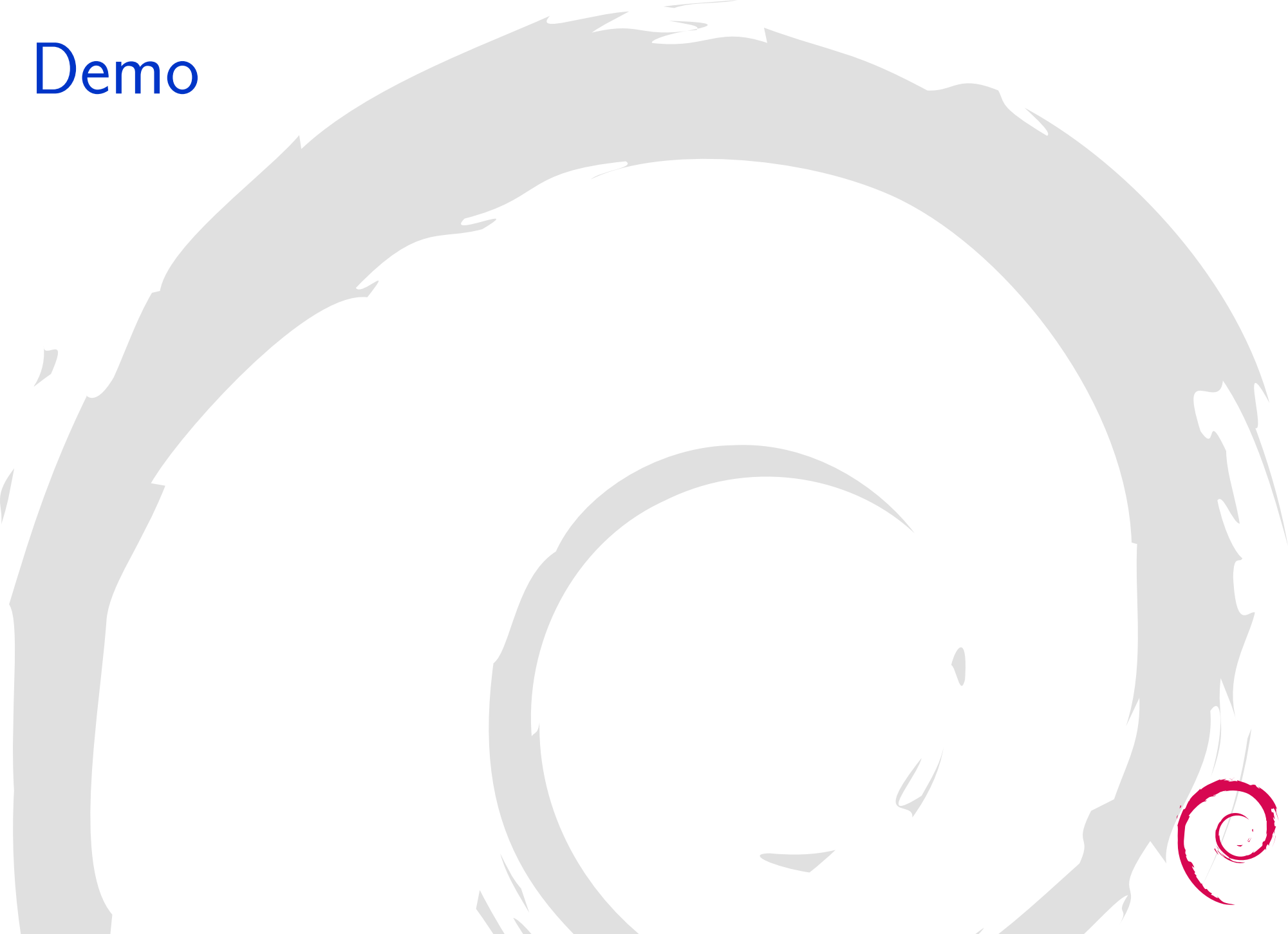
Promise that anyone can always generate identical binary packages from a given source

The solution

We call this:

“Reproducible builds”

Demo



This should become the **norm**.

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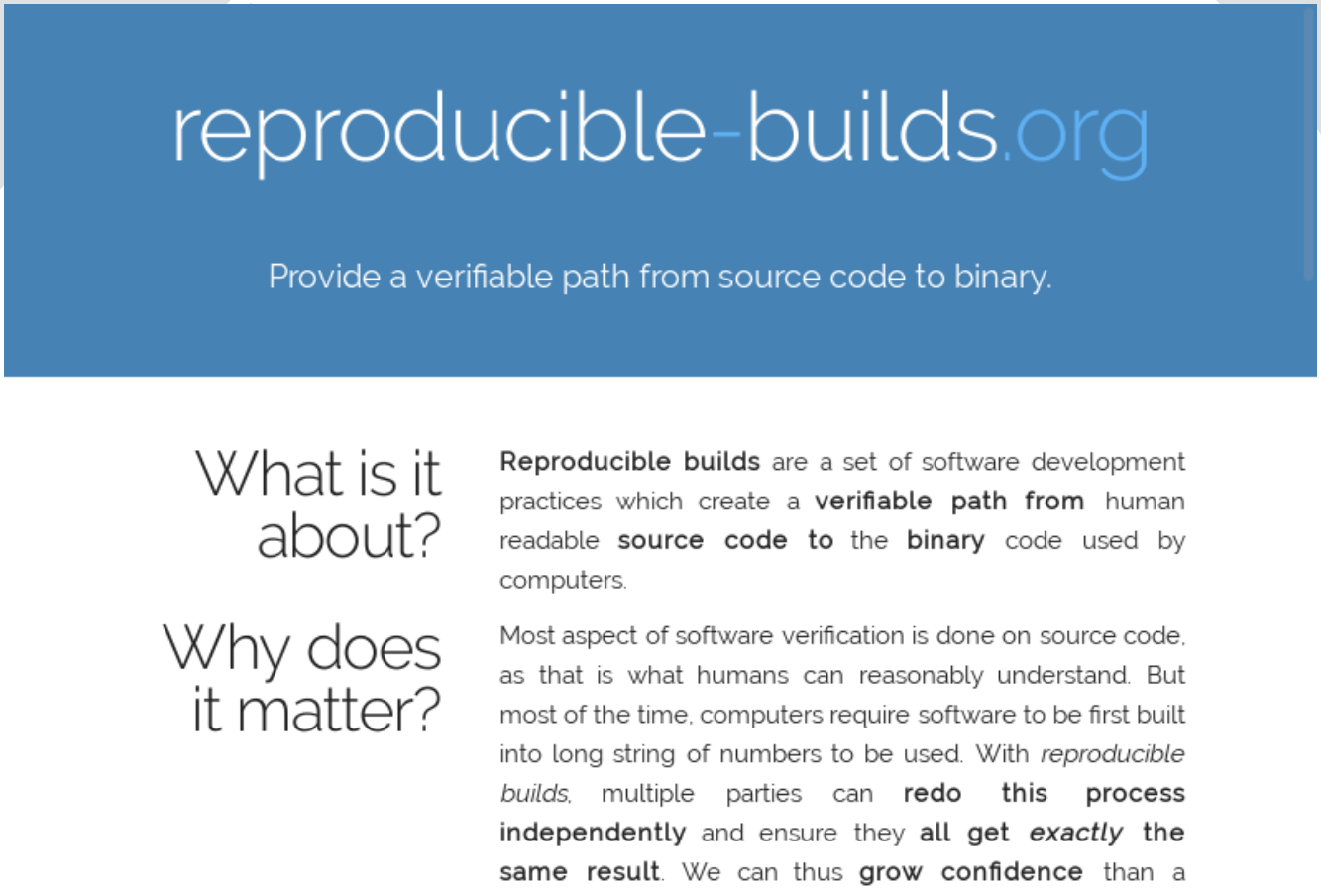
We want to change the meaning of ”free software”:

it’s only free software if it’s reproducible!

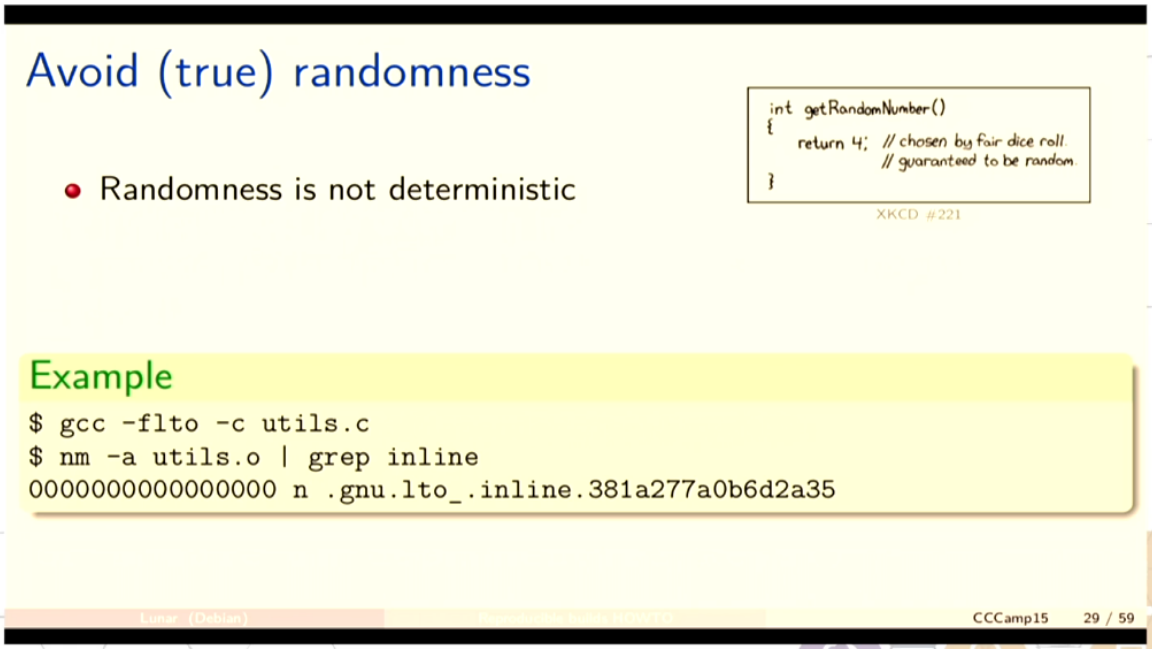
reproducible-builds.org

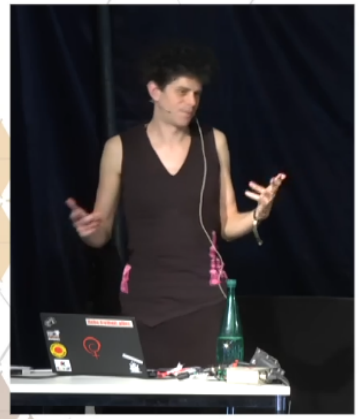
- `https://reproducible-builds.org`



Documentation about common problems

- `https://reproducible-builds.org/docs`
- Lunar's talk from CCCamp 2015 also on `https://media.ccc.de`





Common problems

- time stamps

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- time stamps
- timezones
- locales

Common problems

- time stamps
- timezones
- locales
- everything else (seperated into known issues and the blurry rest)

SOURCE_DATE_EPOCH

- Build date (timestamps) usually not useful for the user

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- SOURCE_DATE_EPOCH is defined as the last modification of the source, since the epoch (1970-01-01)
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- can also be used for random seeds etc.

SOURCE_DATE_EPOCH

- Build date (timestamps) usually not useful for the user
- `SOURCE_DATE_EPOCH` is defined as the last modification of the source, since the epoch (1970-01-01)
- `SOURCE_DATE_EPOCH` can be used instead of current date
- can also be used for random seeds etc.
- in Debian, set from the latest `debian/changelog` entry
- solution has been adopted by other projects & distributions (NetBSD, FreeBSD, Arch Linux, Guix, Fedora...)

SOURCE_DATE_EPOCH

- SOURCE_DATE_EPOCH spec availble
- https://reproducible-builds.org/specs/

SOURCE_DATE_EPOCH (closed bugs)

- dh-strip-nondeterminism
- ~~#791823~~: debhelper
- ~~#787444~~: help2man
- ~~#790899~~: epydoc
- ~~#794004~~: ghostscript
- ~~#796130~~: man2html
- ~~#783475~~: texi2html
- ~~#794586~~: ocamldoc
- ~~#795942~~: wheel
- ...

SOURCE_DATE_EPOCH (open/pending bugs)

- gcc (__DATE__ and __TIME__ macros)
  https://gcc.gnu.org/ml/gcc-patches/2015-06/msg02210.html
- #792687, #804141: gettext
- #792201: doxygen
- #800797: docbook-utils
- #801621: perl (Pod::Man)
- #790801: txt2man
- #791815: libxslt
- #794681: qt4-x11 (qthelpgenerator)
- #792202: texlive-bin
- ...

tests.reproducible-builds.org

- Continuously testing Debian `testing`, `unstable` and `experimental`
- Also testing: coreboot, OpenWrt, NetBSD, FreeBSD, Arch Linux, Fedora and soon F-Droid and Guix too

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- Really simple code.
- Untested patches are fine as long as they only break your stuff.

Variations (when testing Debian)

variation	first build	second build
hostname	`jenkins`	`i-capture-the-hostname`
domainname	`debian.net`	`i-capture-the-domainname`
`env TZ`	`GMT+12`	`GMT-14`
`env LANG`	`C`	`fr_CH.UTF-8`
`env LC_ALL`	not set	`fr_CH.UTF-8`
`env USER`	`pbuilder1`	`pbuilder2`
uid	`1111`	`2222`
gid	`1111`	`2222`
shell	`dash`	`bash`
UTS namespace	shared with the host	*modified using `/usr/bin/unshare --uts`*
kernel version	Linux 3.16 or 4.X	on amd64 always varied, on armhf sometimes
umask	0022	0002
CPU type	same for both builds on amd64 *(work in progress)*	
	on armhf varied a bit	
filesystem	same for both builds on amd64: (`tmpfs`), on armhf `ext3/4`	
		(and we have `disorderfs`, but the code is disabled)
year, month, date	on amd64: 398 days variation, on armhf not yet	
hour, minute	hour is usually the same... usually, the minute differs...	
everything else	*is likely the same...*	

Debugging problems: `diffoscope`

- Examines differences **in depth**.
- Outputs HTML or plain text with human readable differences.
- Recursively unpacks archives, uncompresses PDFs, disassembles binaries, unpacks Gettext files, ...
- Easy to extend to new file formats.
- Falls back to binary comparison.
- Available from `git`, PyPI, Debian (sid and stretch), Fedora, Arch Linux, FreeBSD, NetBSD, Guix, Homebrew..
- Maintainers (upstream and in other distros) wanted.
- `https://diffoscope.org/`

diffoscope example (HTML output)

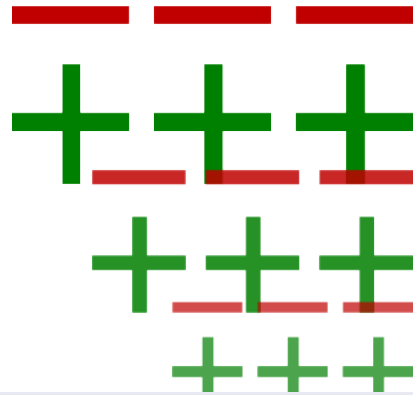
51431	13611);	51438	13542);
51432	INSERT INTO "targets" VALUES('ttu.ee',13611);	51439	INSERT INTO "targets" VALUES('ttu.ee',13542);
51433	[9300 lines removed]	51440	[9314 lines removed]
60733	CREATE TABLE git_commit	60754	CREATE TABLE git_commit
60734	(git_commit TEXT);	60755	(git_commit TEXT);
60735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

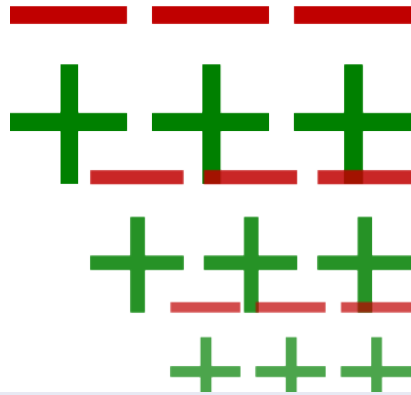
Try diffoscope

- https://try.diffoscope.org



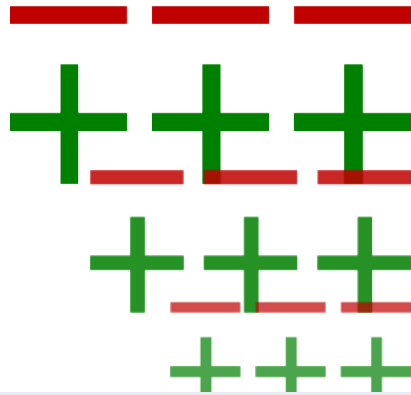
`diffoscope` is "just" for debugging

- Reminder: `diffoscope` is for **debugging**



`diffoscope` is "just" for debugging

- Reminder: `diffoscope` is for **debugging**
- "reproducible" according to our definition means: **bit by bit identical**. So the tools for testing whether something is reproducible are either `diff` or `sha256sum`!



amd64 architecture on tests.r-b.org

- amd64: 106 cores and 282 GB RAM split on 9 VMs
  - 4 VMs with 17/18 cores and 32 GB for Debian
  - 1 VM (soon 2) with 8 cores and 16 GB for most of the rest
  - 1 jenkins VM and 1 jenkins-test VM
  - 1 extra VM for building FreeBSD
- sponsored by https://profitbricks.co.uk

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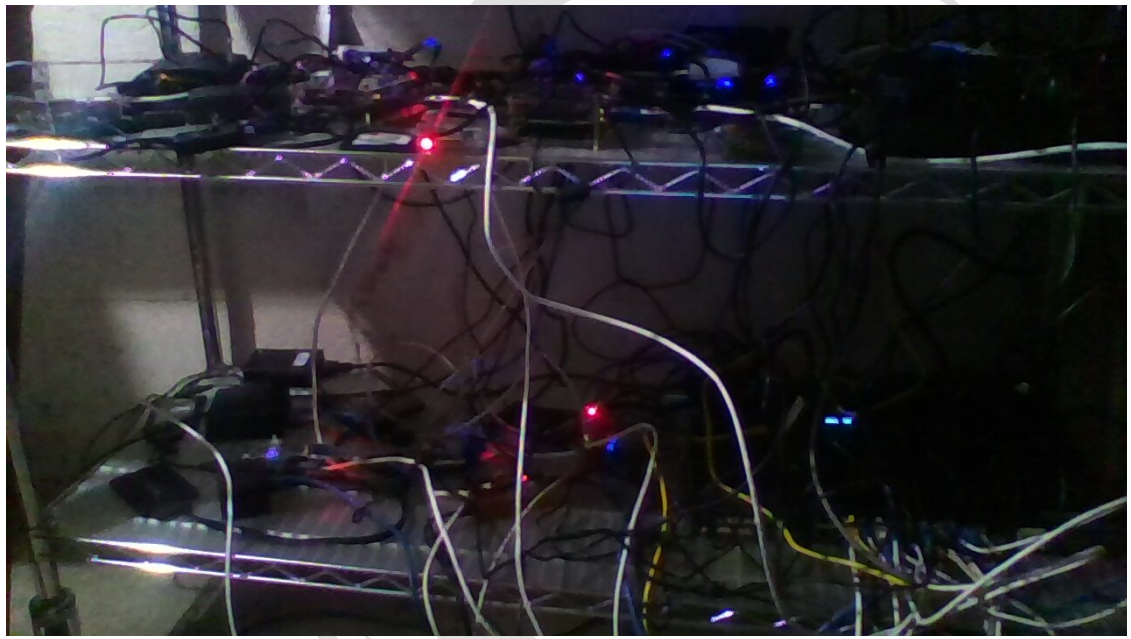
- sponsored by https://profitbricks.co.uk
- next week: downscale to 2 VMs and dedicate those 2 others to i386
  - then rebuilding all of unstable and testing on both archs will roughly take two weeks...

armhf architecture on tests.r-b.org

- `armhf`: 14 nodes with 50 cores and 23 GB RAM
  - a few more nodes planned
  - combined they only draw 100 watts of power

- hosted by `vagrant@debian.org`, several hardware sponsors (Debian, TechNexion, LeMaker, SolidRun, Beagleboard.org and Aikidev) plus 4.5k USD by Debian



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- `armhf`: 14 nodes with 50 cores and 23 GB RAM
  - a few more nodes planned
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  - roughly takes 4 weeks to build one Debian suite
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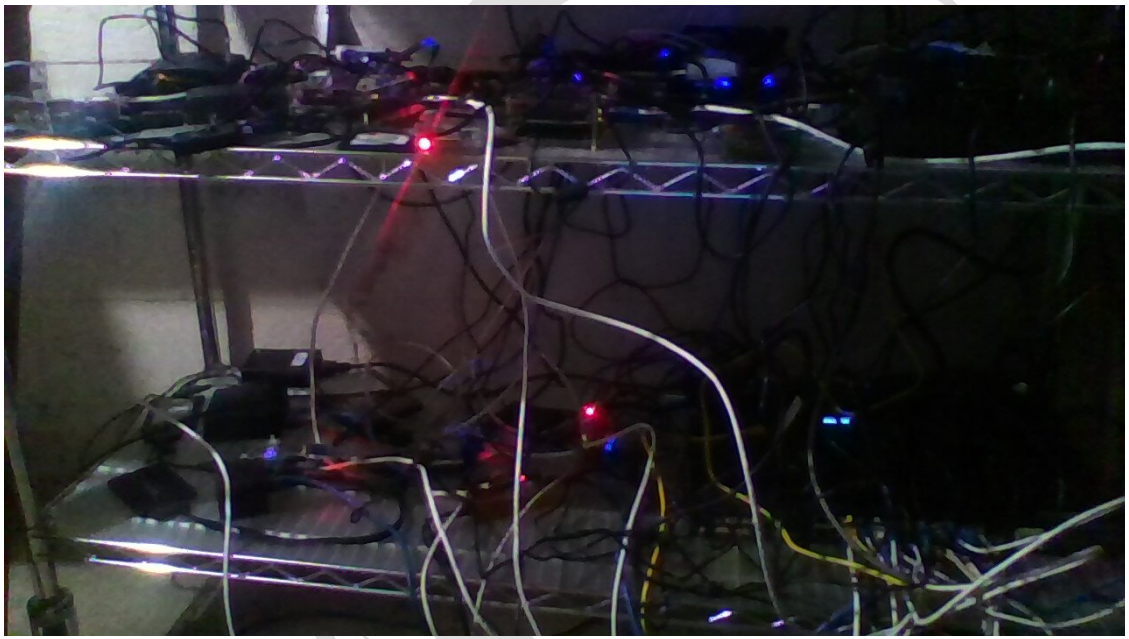
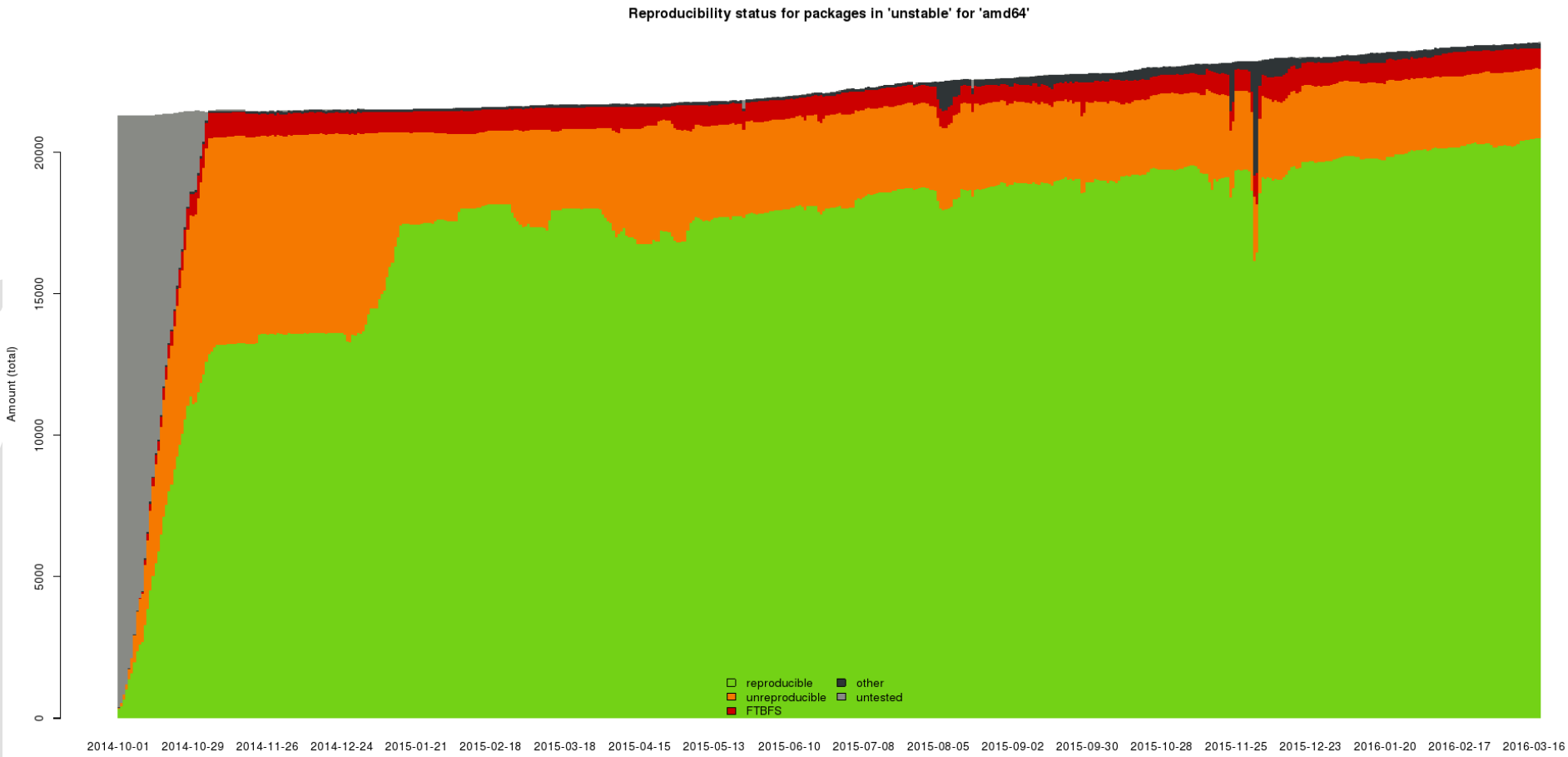


Progress in Debian unstable



20,514 (85.8%) out of 23,902 source packages are reproducible in our test framework

Notes and issues on tests.reproducible-builds.org

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- 3,591 notes

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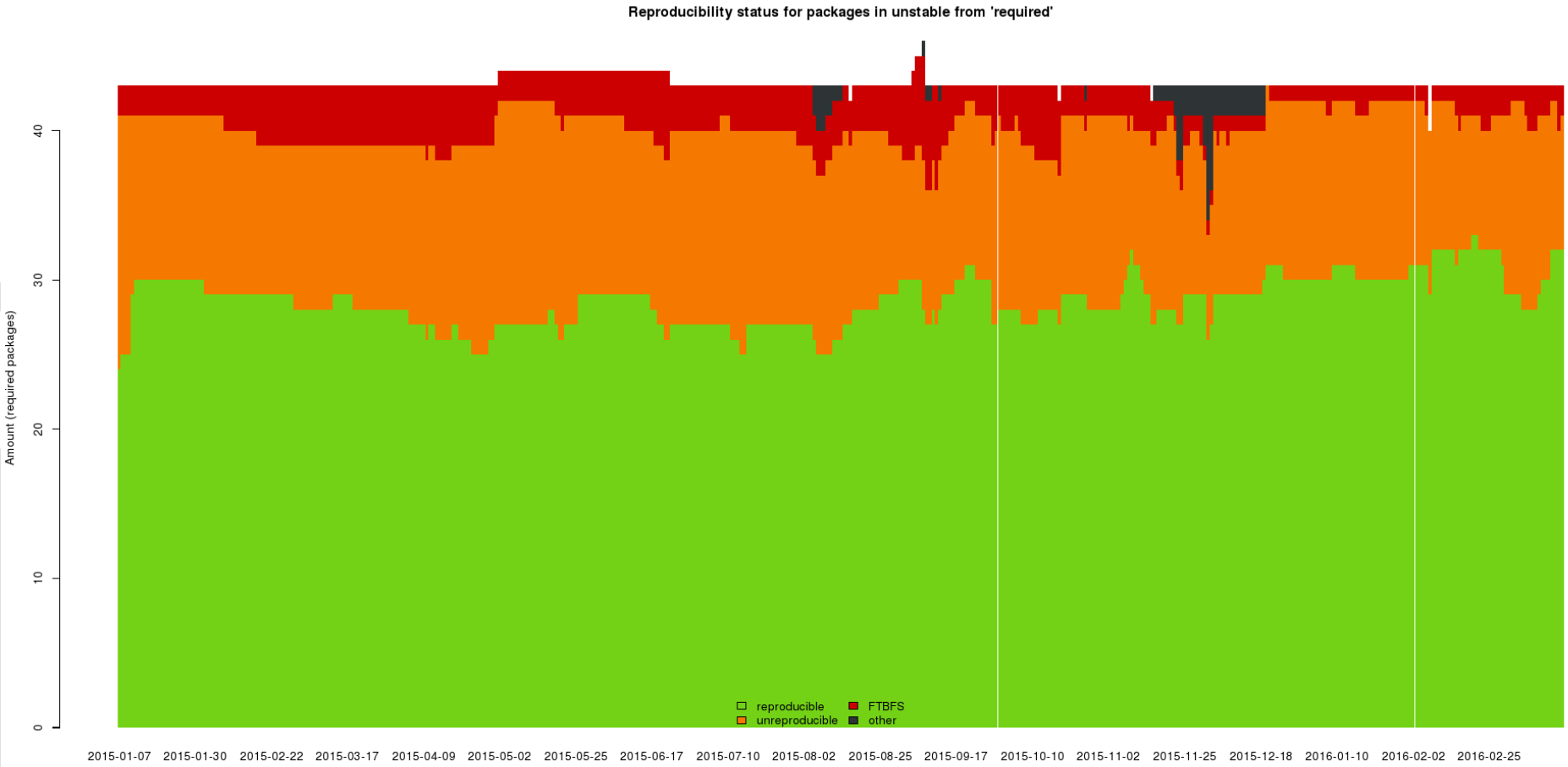
- maintained in `notes.git`
- currently Debian only, but cross distro notes are planned

Debian packages on tests.reproducible-builds.org

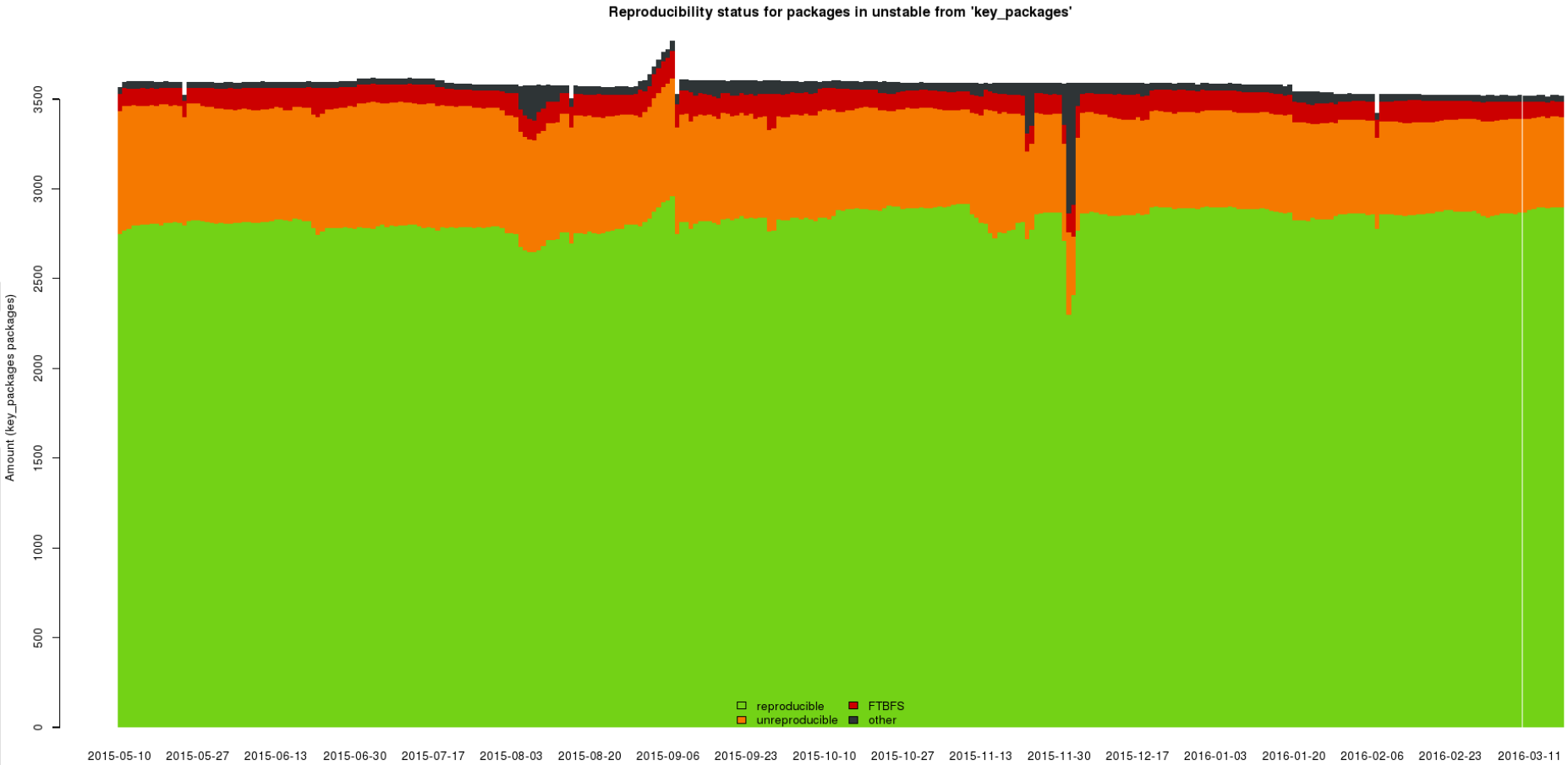
- `https://reproducible.debian.net/$src`

Debian package sets on tests.r-b.org



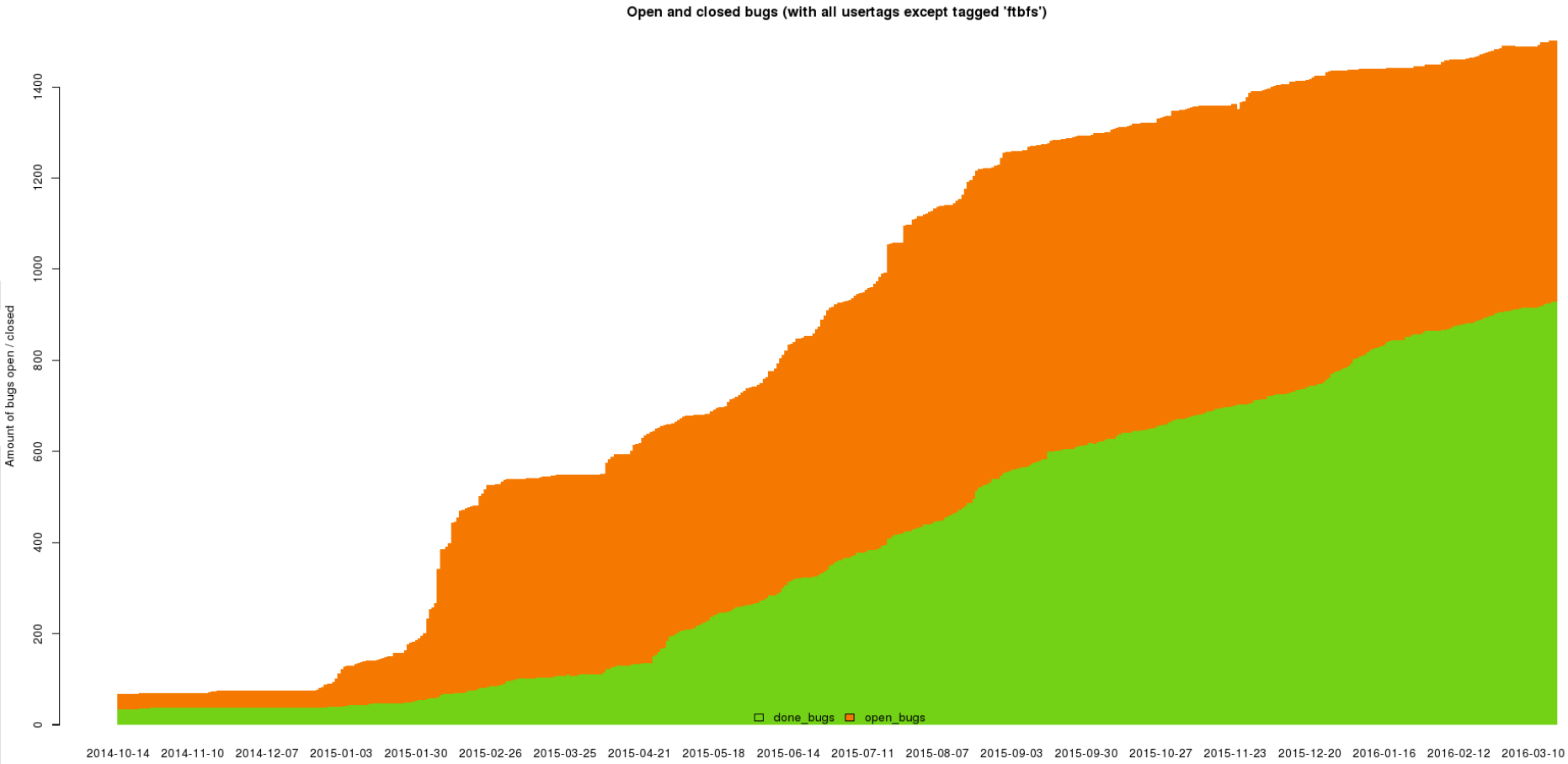
34 different "package sets", eg. `required` is only 70.2% reproducible

Debian package sets on tests.r-b.org



Debian's `key_packages` are 81.2% reproducible, but 489 packages (14.7%) will still need to be fixed

Progress in the Debian bug tracker



As a rule, we file bugs with patches.
There were very few exceptions.

What we did in Debian

- Agreed on using a fixed build path: `/build/`
- Recording the build environment: `.buildinfo`
- `strip-nondeterminism`
- `diffoscope` (formerly `debbindiff`)
- `SOURCE_DATE_EPOCH`
- `disorderfs`
- 1000+ patches: `dpkg`, `debhelper`, `sbuild`, ...
- 7 packages modified to achive those 85.8%
- ...

Tell the world & collaborate

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  - need a new editor

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- First Reproducible World Summit in December 2015 (Athens, Greece)
  - 40 people from 16 projects
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  - `reproducible.debian.net` has become `tests.reproducible-builds.org`
  - another summit in Summer 2016, somewhere in Europe

Tell the world & collaborate

- Weekly reports since May 2015
  - need a new editor
- First Reproducible World Summit in December 2015 (Athens, Greece)
  - 40 people from 16 projects
  - `reproducible.debian.net` has become `tests.reproducible-builds.org`
  - another summit in Summer 2016, somewhere in Europe
- 2 GSoC students in 2015, totally new contributors, totally rocking
  - more GSoC/Outreachy contributors this year - maybe **you**? Deadline is March 25th

Detour: Reproducible builds demand a defined build environment

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- ...and being able to re-create this build environment is mandatory too.
- Without an *sufficiently identical* build environment, reproducible builds will only happen by sheer luck.
- I've only verified for Debian so far... `koji` is designed for that too, Guix as well...
- I'd very much like to be corrected here, with tests.

Debian `.buildinfo` files

- Aggregates in the same file:
  - Sources (checksums)
  - Generated binaries (checksums)
  - Packages used to build (with specific version, checksums coming soon)
- Can be later used to exactly recreate environment
- For Debian, all versions are available from `snapshot.debian.org`

Example .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),
 …
```

Blockers for Debian: dpkg and dak

- dpkg
  - #138409: dpkg-dev: please add support for .buildinfo files
  - ~~#719844: make compression of {data,control}.tar.gz deterministic~~
  - #759999: set reproducible timestamps in .deb ar file headers
  - #787980: normalize file permissions when creating control.tar
  - #719845: make file order within data,control.tar.gz deterministic
- dak (ftp.debian.org)
  - #763822: please include .buildinfo files in the archive

debian-policy

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- In 2016: “Sources **shall** build reproducible binaries.” ?

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- Debian `unstable` still needs changes to `dpkg` and `ftp.debian.org` (for keeping `.buildinfo` files)
- what's beyond (rebuilding, `.buildinfo` file signing and distribution, user tools) mostly still needs *design and code*

Summary, next step for Debian

`tar --clamp-mtime`

- `https://savannah.gnu.org/patch/?8925`
- patch included in Debian since 2015-11-15
- doesn't help us, we need it upstream
- if you know `GNU tar` upstream developers...

Status coreboot

- `https://tests.r-b.org/coreboot`
- 99.2% reproducible with `seabios` payload
- tests maintained by Alexander 'lynxis' Couzens
- unclear what the next steps are...
- needs involvement from coreboot developers

Status OpenWrt

- `https://tests.r-b.org/coreboot`
- selected images are 100% reproducible and selected packages 99.7%
- using 13 patches send upstream on January 25th
- tests maintained by Alexander 'lynxis' Couzens and Bryan Newbold
- recreating the build env: needs to checked in practice
- user verification tools: not yet
- next, once patches are merged: rebuilding released binaries?!

Status NetBSD

- `https://tests.r-b.org/netbsd`
- 21 (38.8%) out of 54 built NetBSD files are reproducible
- tests maintained by Thomas 'wiz' Klausner and h01ger
- `MKREPRO=yes`
- `MK_TIMESTAMP=$SOURCE_DATE_EPOCH`
- recreating the build env: ?
- user verification tools: not yet
- next: ask Thomas :)

Status FreeBSD

- `https://tests.r-b.org/freebsd`
- base system not yet reproducible, but almost there
- 63% of 15k ports were reproducible in 2013 already, their wiki says
- tests maintained by h01ger
- recreating the build env: ?
- user verification tools: not yet
- next: test ports?

Status ElectroBSD

- FreeBSD fork, binary blobs removed, small subset of software
- reproducibility as a design goal and tested during development

Status Fedora

- `https://tests.r-b.org/fedora` (23)
- maintained by Dhiru Kholia and h01ger
- rpm repo available by Dhiru, but still **0% reproducible**
- first patch for `rpm` merged
- rpm format includes build time and build host and signatures...
- recreating the build env: koji
- next: test 24+rawhide
- next: first reproducible rpm, use koji
- next: get more people involved

Status Arch Linux

- `https://tests.r-b.org/archlinux`
- maintained by Levente 'anthraxx' Polyak and h01ger
- reproducible patches available for `pacman` by anthraxx
- recreating the build env: unaddressed
- next: use those patches, upstream them

Status F-Droid

- not yet: `https://tests.r-b.org/f-droid`
- maintained by Hans-Christoph Steiner and h01ger
- work has just begun...

Status Guix

- I still have little idea and time
- recreating the build env: by design
- user verification tool: yes! (Guix challenge)
- next: test it

Unmentioned, with known activities

- Bitcoin
- Tor
- NixOS
- Qubes
- (Subgraph)
- commercial, propietary Software
- ?

Detour: what, reproducible commercial Software???

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- critical infrastructure like in nuclear powerplants?
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- Gambling machines!

Unmentioned, unknown activities?

- OpenSUSE (could be tested easily...)
- Ubuntu
- OpenBSD
- Gentoo (stage1)
- ?

Release process issues

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- Rebuilding all of Debian a month prio the release?

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- This problem is per se not Debian specific at all...

Distributing `.buildinfo` files

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- We'll need more files with detached signatures...
- Revoking signatures?
- ...

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- Systematic, automatic rebuilds?
- Different projects, different solutions?

Rebuilders and sharing signed checksums, cont.

- Individuelly signed checksums (think web of trust) could work in the Debian case (we have a gpg web of trust), but IMO won't scale.

Rebuilders and sharing signed checksums, cont.

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- Another idea: rebuilders, run by large organisations (ACLU, CCC, CERN, Deutsche Bank, EDF, EON, Greenpeace, NASA, NSA, XYZ).
- Fedora rebuilds Debian, Debian rebuilds OpenSUSE, OpenSUSE rebuilds NetBSD, etc...

Integration in user tools

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Integration in user tools

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- "Do you want to build those packages which unconfirmed checksums, before installing? (Y/n)"
- "How many signed checksums do you require to call a package 'reproducible'?"
- "Which rebuilders do you want to trust?"

Future of tests.reproducible-builds.org

- We want to test other architectures!
  - `arm64` finally on the horizon
- We want to test other projects!
- We want more people contributing code for their projects!
- We want more people looking at the results!
- We don't want to build twice and test against what we built, but rather the binaries distributed by these projects (if any)

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- This is "just" a testing framework...

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- We've come a long way.
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- In fact, it's still fully not clear where we need to be going.
- Keep up the great work!
- Join the fun! There are many big and small things to do!

As a software developer

- Merge our patches

As a software developer

- Merge our patches
- Stop using build dates
- Use `SOURCE_DATE_EPOCH` instead
- See `https://reproducible-builds.org/specs/`

Getting involved - learning by doing

- Test for yourself:
  - Build something twice, run diffoscope on the results
    - For better results use our "reproducible" repository, `pbuilder` and a custom config
- Docs on the web:
  `https://reproducible-builds.org/docs/`
  `https://wiki.debian.org/ReproducibleBuilds/ExperimentalToolchain`
- Ask for help on `#debian-reproducible` or on mailing list

Join the Reproducible builds team(s)!

- Why?
  - ♡♡♡ Lovely group of people ♡♡♡
  - Learn something new everyday
  - Change the (software) world!
- What do we do?
  - Review packages
  - Identify issues and document solutions
  - `reproducible.d.n`, diffoscope, strip-nondeterminism
  - Propose changes for toolchain
  - Submit patches for individual packages
  - Write more general documentation and talk to the world

Form another team!

- Why?
  - Every distribution should be reproducible!
  - Learn something new everyday
  - Change the (software) world!
  - `https://tests.reproducible-builds.org/$project` needs **your** help
- How to get started?
  - Talk to me here or talk to us on IRC or via mail.
  - RTFM, there is lots of documentation
  - Experiment - learning by doing

Questions, comments, ideas?

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- `https://reproducible-builds.org/docs`
- `https://tests.reproducible-builds.org`
- `#reproducible-builds` on `irc.OFTC.net`
- and/or `#debian-reproducible` too!
- *with IRC notification by KGB-0*

Questions, comments, ideas?

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- *with IRC notification by KGB-0*
- https://lists.reproducible-builds.org
- https://twitter.com/ReproBuild

Thanks to...! ...and thank **you**, too!

- Debian "Reproducible Builds" team
  (you are just **so** awesome!)
- Linux Foundation and the Core Infrastructure Initiative

holger@debian.org

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