

Reproducible builds ecosystem

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

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FOSDEM16 (Brussels, Belgium)
2016-01-31

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 continuously testing Debian)
- Debian LTS (Long Term Support)



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Detour: naming is a hard problem...

- <https://jenkins.debian.net>
- <https://reproducible.debian.net>
- <https://tests.reproducible-builds.org>
- <https://reproducible-builds.org>



Detour: naming is a hard problem...

- <https://jenkins.debian.net>
- ~~<https://reproducible.debian.net>~~
- <https://tests.reproducible-builds.org>
- <https://reproducible-builds.org>
- all point to 78.137.96.196



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- ~~<https://reproducible.debian.net>~~
- <https://tests.reproducible-builds.org>
- <https://reproducible-builds.org>
- all point to 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

akira

Andrew Ayer

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

Holger Levsen

Jelmer Vernooij

josch

Juan Picca

Lunar

Mathieu Bridon

Mattia Rizzolo

Nicolas Boulenguez

Niels Thykier

Niko Tyni

Paul Wise

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HW42

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Joachim Breitner

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Who are you?

- Contributed to Free Software?



Who are you?

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- Seen a talk about reproducible builds last year?



Who are you?

- Contributed to Free Software?
- Seen a talk about reproducible builds last year?
- Contributed to this effort?





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Motivation

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Common ressources

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Status Debian

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Status Non-Debian World

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Future work

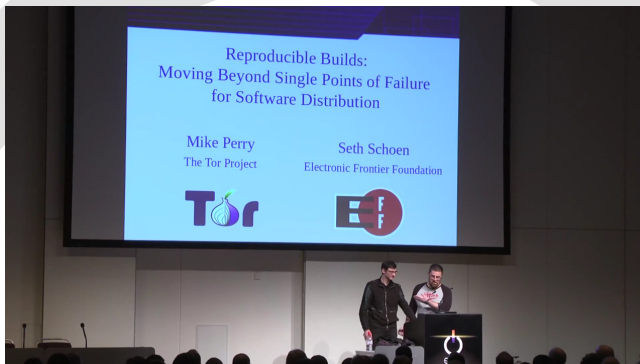
6

Getting involved

7

Questions, comments, ideas?

The problem



Available on media.ccc.de, 31c3



A few examples from that 31c3 talk

- CVE-2002-0083: remote root exploit in sshd, a single bit difference in the binary



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A few examples from that 31c3 talk

- 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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- 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/](http://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.



This should become the **norm.**

We want to change the meaning of "free software":
it's only free software if it's reproducible!



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reproducible-builds.org

- <https://reproducible-builds.org>

reproducible-builds.org

Provide a verifiable path from source code to binary.

What is it
about?

Reproducible builds are a set of software development practices which create a **verifiable path from** human readable **source code** to the **binary** code used by computers.

Why does
it matter?

Most aspect of software verification is done on source code, as that is what humans can reasonably understand. But most of the time, computers require software to be first built into long string of numbers to be used. With *reproducible builds*, multiple parties can **redo this process independently** and ensure they **all get exactly the same result**. We can thus **grow confidence** than a



Documentation about common problems

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

Avoid (true) randomness

- Randomness is not deterministic

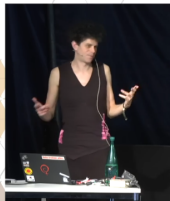
```
int getRandomNumber()
{
    return 4; // chosen by fair dice roll
            // guaranteed to be random
}
```

XXKD #221

Example

```
$ gcc -flto -c utils.c
$ nm -a utils.o | grep inline
0000000000000000 n .gnu.lto_.inline.381a277a0b6d2a35
```

CCCamp15 29 / 55



Common problems

- time stamps



Common problems

- 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)
- SOURCE_DATE_EPOCH can be used instead of current date
- can also be used for random seeds etc.



SOURCE_DATE_EPOCH

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- 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, ...)

SOURCE_DATE_EPOCH

- SOURCE_DATE_EPOCH spec available
- <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: ocaml-doc
- #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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- 230 jenkins jobs running on 22 hosts
- 42 scripts with a total of 4k lines of Python and 6k lines of Bash Shell
- 29 contributors for `jenkins.debian.net.git`



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- 230 jenkins jobs running on 22 hosts
- 42 scripts with a total of 4k lines of Python and 6k lines of Bash Shell
- 29 contributors for `jenkins.debian.net.git`
- Really simple code.
- Untested patches are fine as long as they only break your stuff.

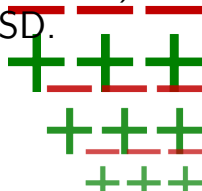
Variations (when testing Debian)

| 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 |
| UTS namespace | shared with the host | <i>modified using /usr/bin/unshare --uts</i> |
| 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 (<i>work in progress</i>) on armhf varied a bit | |
| filesystem | same for both builds on amd64: (tmpfs), on armhf ext3/4 (<i>and we have disorderfs, but the code is disabled</i>) | |
| 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 | <i>is likely the same...</i> | |



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), Arch Linux, Guix, Homebrew. Works on BSD.
- Maintainers in other distros wanted.
- <https://diffoscope.org/>



diffoscope example (HTML output)

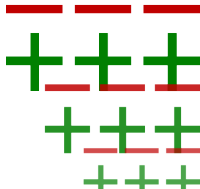
| | |
|--|--|
| 51431INSERT INTO "targets" VALUES ('ttu.ee', 13611); | 51438INSERT INTO "targets" VALUES ('ttu.ee', 13542); |
| 51432INSERT INTO "targets" VALUES ('ttu.ee', 13611); | 51439INSERT INTO "targets" VALUES ('ttu.ee', 13542); |
| 51433[9300 lines removed] | 51440[9314 lines removed] |
| 60733CREATE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

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 --> |
|<em:description>Encrypt the Web! |<em:description>Encrypt the Web! |
| 11Automatically use HTTPS security on many sites.</em:description> | 11Automatically 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> |

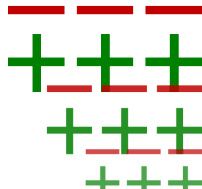
Try diffoscope

- <https://try.diffoscope.org>



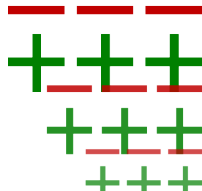
diffoscope is "just" for debugging

- 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`!



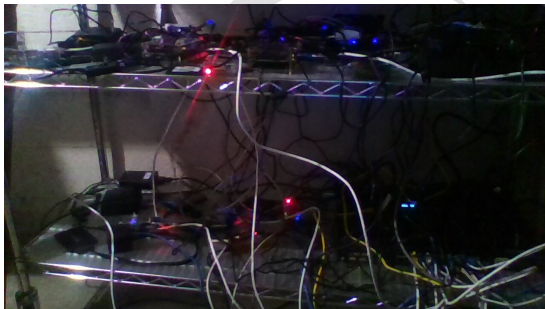
amd64 architecture on tests.r-b.org

- 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>



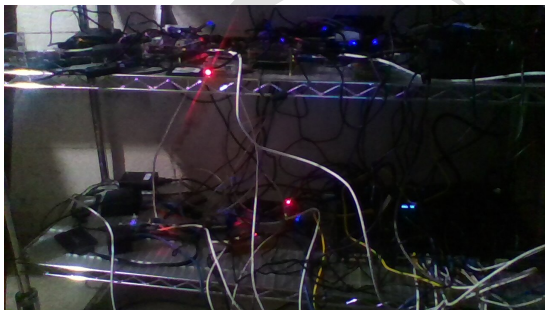
armhf architecture on tests.r-b.org

- 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



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
 - ▶ roughly takes 4 weeks to build one Debian suite
- 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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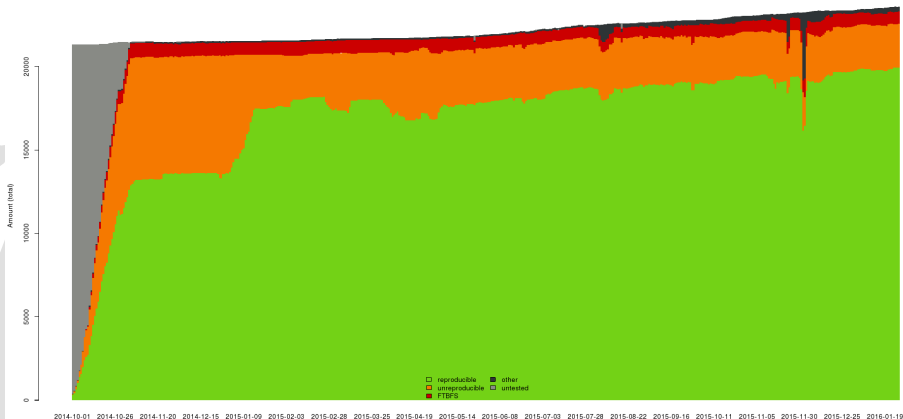
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Questions, comments, ideas?

Progress in Debian unstable

Reproducibility status for packages in 'unstable' for 'amd64'



20,079 (85%) out of 23,595 source packages are reproducible
in our test framework



Notes and issues on tests.reproducible-builds.org

- 179 categorised distinct issues
- 3,792 notes



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- 2549 unreproducible packages in sid, but only 139 without a note
- 728 packages failing to build, but only 74 without a note



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

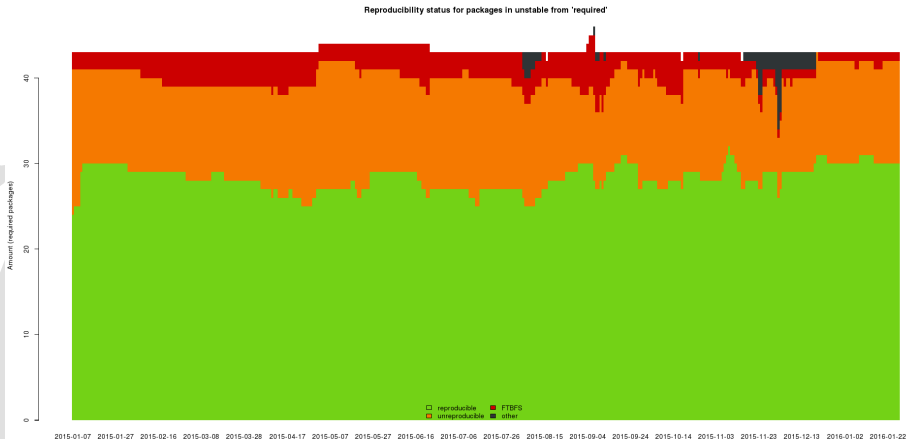


Debian packages on tests.reproducible-builds.org

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



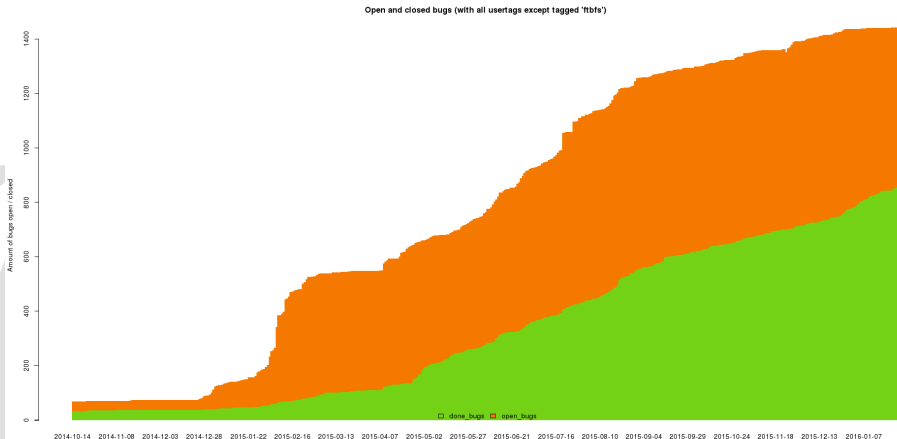
Debian package sets on tests.r-b.org



29 different "package sets", eg. required is only 68% reproducible



Progress in the Debian bug tracker



As a rule, we file bugs with patches.
There are 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`, ...
- ...



Tell the world & collaborate

- Weekly reports since May 2015



Tell the world & collaborate

- Weekly reports since May 2015
- First Reproducible World Summit in December 2015 (Athens, Greece)
 - ▶ 40 people from 16 projects
 - ▶ `reproducible.debian.net` has become `tests.reproducible-builds.org`



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 - ▶ another Summit in April/May 2016?!
- 2 GSoC students in 2015, totally new contributors, totally rocking
 - ▶ more GSoC/Outreachy contributors this year??!



Detour: Reproducible builds demand a defined build environment

- ...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.



Detour: Reproducible builds demand a defined build environment

- ...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 seen this 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

- Section 4.15: “Sources **must** build reproducible binaries.”



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- We hope this will happen after stretch (Debian 9) release
- In 2016: “Sources **shall** build reproducible binaries.”



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- what's beyond (rebuilding, `.buildinfo` file handling, user tools) mostly still needs *design and code*



- 
- 1 Motivation
 - 2 Common ressources
 - 3 Status Debian
 - 4 Status Non-Debian World**

- 5 Future work

- 6 Getting involved

- 7 Questions, comments, ideas?

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 more active 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 be 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
- talk today, in K.4.601 at 15:40 CET
- next: watch talks, discuss with developers



Status ElectroBSD

- I have no idea... but am curious to find out!
- talk today, in K.4.601 at 14:35 CET



Status Fedora

- <https://tests.r-b.org/fedora> (23)
- maintained by Dhiru Kholia and h01ger
- rpm repo available by Dhiru, but still **0% reproducible**
- rpm format includes build time and build host and...
- recreating the build env: koji
- next: 24+rawhide, first reproducible rpm
- 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, sadly missed the talk yesterday
- recreating the build env: by design
- user verification tool: yes! (Guix challenge)



Status Guix

- I still have little idea, sadly missed the talk yesterday
- recreating the build env: by design
- user verification tool: yes! (Guix challenge)
- next: check your inbox, h01ger!



Unmentioned, with known activities

- Bitcoin
- Tor
- NixOS
- Qubes
- commercial, proprietary Software
- ?

Detour: what, reproducible commercial Software???

- Guess which

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- Guess which
- windows? (the source is available)
- medical devices in your body?
- arms?
- critical infrastructure like in nuclear powerplants?
- cars?

Detour: what, reproducible commercial Software???

- Guess which
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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)
- ?



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Release process issues

- In our current design and practices, rebuilding Debian stretch will require package versions which are not part of stretch.
- Rebuilding all of Debian a month prio the release?



Release process issues

- In our current design and practices, rebuilding Debian stretch will require package versions which are not part of stretch.
- Rebuilding all of Debian a month prio the release?
- This problem is per se not Debian specific at all...



Distributing .buildinfo files

- Probably 100,000 new files per Debian suite; 50% increase per suite
- Mirrors would not be happy, so should not go there



Distributing .buildinfo files

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- Mirrors would not be happy, so should not go there
- We'll need more files with detached signatures...
- Revoking signatures?
- ...



Rebuilders and sharing signed checksums

- Almost no work has been done here yet.



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- Systematic, automatic rebuilds?



Rebuilders and sharing signed checksums

- Almost no work has been done here yet.
- Systematic, automatic rebuilds?
- Different projects, different solutions?



Rebuilders and sharing signed checksums, cont.

- Individually 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.

- Individually signed checksums (think web of trust) could work in the Debian case (we have a gpg web of trust), but IMO won't scale.
- Another idea: rebuilders, run by large organisations (ACLU, CCC, CERN, Deutsche Bank, EDF, EON, Greenpeace, NASA, NSA, XYZ).



Rebuilders and sharing signed checksums, cont.

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

- "Do you really want to install this unreproducible software (y/N)"
- "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 still want more (arm(64)) cores!
- We want to test other architectures!
- 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...



Summary

- We've come a long way.
- We've made impressive progress.
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- We've made impressive progress.
- We're still not nearly where we want to be.
- 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!





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As a software developer

- 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](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



Listen to more talks in K.4.601 today!

- 14:35 ElectroBSD - Getting a reproducible BSD out of the door
- 15:40 Reproducible builds in FreeBSD packages





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Questions, comments, ideas?

- <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*



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- <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



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