# Introduction to Reproducible Builds

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## Goals

The Reproducible Builds project aims to bring us closer to a world where binary software can be independently verified as the result of building the provided source code.

## Source Code

- Source code is readable and writeable by trained ~~monkeys~~ humans
- Computers run binary code
- How do you know the binary code the computer is running was produced from the source code?

## Scientific Methods

Reproducibility is the ability of an entire experiment or study to be duplicated, either by the same researcher or by someone else working independently.
`https://en.wikipedia.org/wiki/Reproducibility`

## Ooooh, Math(s)!

```
$ python -c 'x=1 ; y=1 ; print(x+y)'
2

$ python -c 'x=1 ; y=1 ; print(x+y)' | sha256sum
53c234e5e8472b6ac...8977b010655bfdd3c3  -

$ echo 2 | sha256sum
53c234e5e8472b6ac...8977b010655bfdd3c3  -
```

## But software building is more like...

x=source code
y=build arguments
z=toolchain (compiler, liker, libraries, etc.)
r=other stuff (time of build, running OS, username building software, environment variables, etc.)
$x + y + z + r = ?$

## Independent verification

source code + build environment + build instructions

=

bit-by-bit identical copies

anyone can verify the result

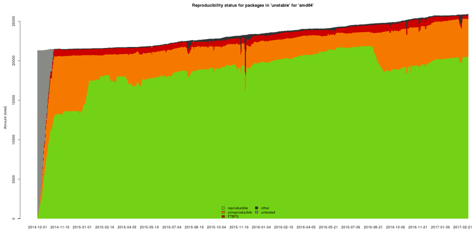
`https://reproducible-builds.org/docs/definition/`

## History in Debian

- Mentioned on lists as early as 2007
- Didn't gain traction until more recently
- Automated rebuilding of Debian's 25,000+ source packages began in late 2014
- Currently rebuilding roughly 1,600-2,200 packages a day on each of amd64, i386, arm64 and armhf

## A plague of unreproducibility

- About 4,800 (19%) of software in Debian unstable
- About 1,300 (5%) of software in Debian testing
- Patches in Debian toolchains and packages, but patches are swimming upstream



## Reproducibility matters

What kind of security implications are we facing?

- CVE-2002-0083: Remote root exploit in OpenSSH, caused by an off-by-one error
- 2015: XcodeGhost: malware variant of Apple's SDK Infected over 4,000 apps in Apple's App store

## Trusting Trust

Reflections on Trusting Trust by Ken Thompson 1984

- `https://www.ece.cmu.edu/~ganger/712.fall02/papers/p761-thompson.pdf`

## Diverse Double-Compilation

Diverse Double-Compilation by David A. Wheeler 2005/2009

- `https://www.dwheeler.com/trusting-trust/`

## Common problems

- timestamps
- timezone
- file sort order
- locales

## timestamps

- Embedded timestamps:

```
U-Boot SPL 2016.01+dfsg1-3 (Feb 21 2016 - 21:39:10)
```

## timestamps: Please No

- There's no timestamps like NO timestamps.

## timestamps: SOURCE_DATE_EPOCH

- If you really must, use the SOURCE_DATE_EPOCH specification, which specifies the timestamp to use in a standardized environment variable.

`https://reproducible-builds.org/specs/source-date-epoch/`

## timezone

- The timezone of the running build can impact output:
  $ LC_ALL=C date –date "@1478647393" –rfc-2822 Tue, 08 Nov 2016 15:23:13 -0800
- Set to UTC using TZ environment variable:
  $ TZ=UTC LC_ALL=C date –date "@1478647393" –rfc-2822 Tue, 08 Nov 2016 23:23:13 +0000

https://reproducible-builds.org/docs/timezones/

## file sort order

- Bad Makefile:

```
SRCS = $(wildcard *.c)
tool: $(SRCS:.c=.o)
  $(CC) -o $@ $^
```

- Good Makefile:

```
SRCS = $(sort $(wildcard *.c))
tool: $(SRCS:.c=.o)
  $(CC) -o $@ $^
```

https://reproducible-builds.org/docs/stable-inputs/

## locales

- Sort order for C, as spoken in UNIX:

```
$ printf 'a\nB\nb\nA\n' | LC_ALL=C sort
  A
  B
  a
  b
```

- Sort order for English, as spoken in USA:

```
$ printf 'a\nB\nb\nA\n' | LC_ALL=en_US.UTF-8 sort
  a
  A
  b
  B
```

https://reproducible-builds.org/docs/locales/

## build path

Build path

- Hard to fix correctly
- Ongoing work to GCC and other major toolchains by Ximin Luo and others:
  - Some patches to GCC accepted, more in progress
  - draft specification: BUILD_PATH_PREFIX_MAP in progress
- Can be worked around by normalized build environment

## Write your code with intention

- Remove unintended inputs
- Remove random inputs
- Verifyable built results
- Gain confidence in your builds

## Buildinfo files

- specification:

`https://manpages.debian.org/jump?q=deb-buildinfo`

- examples from the real world:

`https://buildinfo.debian.net`

## Example .buildinfo

```
Source: libtext-simpletable-perl
Version: 2.03-1
Checksums-Sha256:
 7a285...a8b 10788 libtext-simpletable-perl_2.03-1_all.deb
Build-Architecture: amd64
Build-Date: Fri, 03 Mar 2017 07:56:17 +1400
Build-Path: /build/libtext-simpletable-perl-2.03/2nd
Installed-Build-Depends:
 autoconf (= 2.69-10),
 automake (= 1:1.15-6),
 zlib1g (= 1:1.2.8.dfsg-5)
Environment:
 DEB_BUILD_OPTIONS="parallel=15"
 LANG="C"
 LC_ALL="C"
 SOURCE_DATE_EPOCH="1439466701"
```

## Building tools

- reprotest - source rebuilder

```
reprotest 'dpkg-buildpackage -b --no-sign' '../*.deb'
```

- debrepro - simple .deb rebuilder

```
debrepro
```

## diffoscope

- diffoscope - an exceptionally clever diff tool
  `https://diffoscope.org`

## try.diffoscope.org

- diff as a service: `https://try.diffoscope.org/`
- trydiffoscope client

## Other projects

It goes well beyond Debian:
https://reproducible-builds.org/who/

- NixOS
- GNU Guix
- Fedora
- OpenSUSE
- FreeBSD
- Arch Linux
- Tails
- Bitcoin
- Coreboot
- Tor Browser
- And more...

## Thanks

- Core Infrastructure Initiative
- Profitbricks
- Codethink

All the great folks doing reproducible builds work!

## Copyright