Source Code Archiving to the Rescue of Reproducible Deployment

Guix + Software Heritage

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GuixHPC

Software Heritage
THE GREAT LIBRARY OF SOURCE CODE

Previously on “Open Research” dev room. . .

2021 (link)

Previously on “Open Research” dev room. . .

2021 (link)

Guix

2023 (link)

Previously on “Open Research” dev room. . .

2021 (link)

2023 (link)

+

2025

Software is dual

human-readable vs machine-readable

source + transformation ⟶ binary

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4004e6: 55
4004e7: 48 89 e5
4004ea: bf 84 05 40 00
4004ef: b8 00 00 00 00
4004f4: e8 c7 fe ff ff
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4004fa: 5d
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THE GREAT LIBRARY OF SOURCE CODE

long term transparency

Typical scenario

Alice publishes a result in 2022

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- ... But not `v0.9`.
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Why?

Does Blake fully **control over the sources of variations**?

Questions about a computational environment (deployment)

- What is the source code?
- What are the tools required for building?
- What are the tools required for running?
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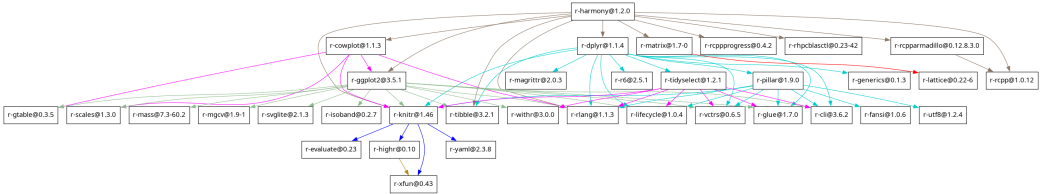
How to capture the answer to these questions?

Usually: package manager (Conda, APT, Brew, ...); Modulefiles; container; etc.

Deployment = Directed Acyclic Graph (*DAG*)



Each node specifies a recipe defining:

- code source — and potentially some *ad-hoc* modifications (`patch`)
- build-time tools — compilers, build automation, configuration flags etc.
- dependencies — other packages ($\rightarrow$recursive $\rightsquigarrow$ graph)

complete graph: more than 477 nodes

Guix comes in!

- Software development tool developed since 2012 by a large community
- Package manager or as a complete standalone system
- Functional software deployment model (pioneered by Nix)

transparent and verifiable

tool of choice when deploying software for reproducible research workflows

Revision = one specific graph

this tool "at version 0.9" = one unambiguous graph

```
$ guix describe
Generation 76 Apr 25 2022 12:44:37 (current)
  guix eb34ff1
    repository URL: https://git.savannah.gnu.org/git/guix.git
    branch: master
    commit: eb34ff16cc9038880e87e1a58a93331fca37ad92
```

one revision **pins** the complete collection of packages and Guix itself

this revision `eb34ff1` captures the **complete** graph

- Alice says "I used Guix at revision `eb34ff1`"
- Blake knows all for deploying the exact same environment

Reproducible deployment (ideally)

- Alice says the tool `r-harmony` from Guix revision `eb34ff1`.
- Blake runs on a different machine or at a different point in time:

```
guix time-machine --commit=eb34ff1 -- install r-harmony
```

and Blake deploys the *exact same software environment*, bit-for-bit.

Under the assumptions

- All the source code is still publicly available. (e.g., more than 477)
- All the intermediary builds are deterministic.

“Link rot” empirical evaluation = the problem

(completed mid-2024)

	Dec. 2022 v1.4.0
#sources	20 184
avail.	96.4%
missing	3.6%
hash mis.	52

“Link rot” empirical evaluation = the problem

(completed mid-2024)

	Dec. 2022 v1.4.0
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- `openjdk-9.181.tar.bz2` is unavailable
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- `openjdk@9.181` had 184 dependents
  loosing it $\Longrightarrow$ loosing 185 packages, not one.

“Link rot” empirical evaluation = the problem

(completed mid-2024)

	May 2021 v1.3.0	Dec. 2022 v1.4.0
#sources	15 520	20 184
avail.	95.7%	96.4%
missing	4.3%	3.6%
hash mis.	66	52

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	Nov. 2020 v1.2.0	May 2021 v1.3.0	Dec. 2022 v1.4.0
#sources	13 609	15 520	20 184
avail.	95.0%	95.7%	96.4%
missing	5.0%	4.3%	3.6%
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	Apr. 2020 v1.1.0	Nov. 2020 v1.2.0	May 2021 v1.3.0	Dec. 2022 v1.4.0
#sources	11 659	13 609	15 520	20 184
avail.	92.4%	95.0%	95.7%	96.4%
missing	7.6%	5.0%	4.3%	3.6%
hash mis.	63	69	66	52

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avail.	91.5%	92.4%	95.0%	95.7%	96.4%
missing	8.5%	7.6%	5.0%	4.3%	3.6%
hash mis.	87	63	69	66	52

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Software Heritage comes in!

Like all digital information, source code is fragile

link rot: projects are created, moved around, removed

"too big to fail": e.g., Gitorious, Google Code, Bitbucket

If a website disappears, you go to the Internet Archive...

Where do you do if (a repository on) GitHub or GitLab goes away?

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Answer: **Software Heritage**

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collect, preserve and share source code

If a website disappears, you go to the Internet Archive...

Where do you do if (a repository on) GitHub or GitLab goes away?

Answer: **Software Heritage**

The SWH archive is the largest publicly available archive of software source code.

Software Heritage: international + non-profit

built with long term in mind

Sharing the vision

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www.softwareheritage.org/support/testimonials

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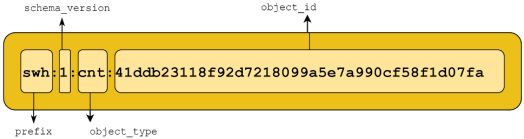
Software Heritage Identifiers (SWHID)

swhid.org



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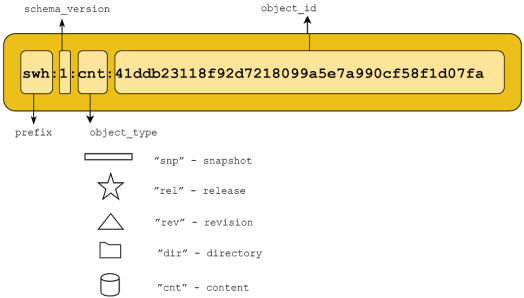

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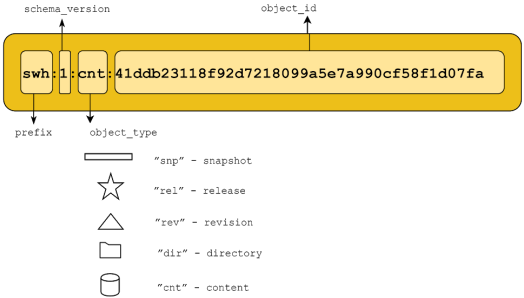

https://archive.softwareheritage.org/swh:1:cnt:41ddb23118f92d7218099a5e7a990cf58f1d07fa

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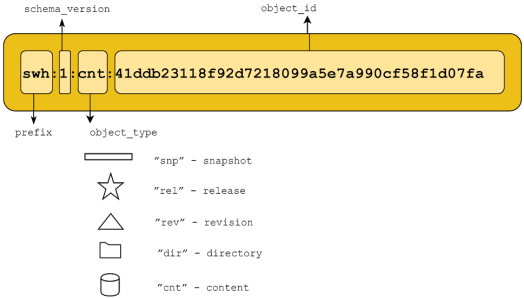

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an emerging standard

specification (link)

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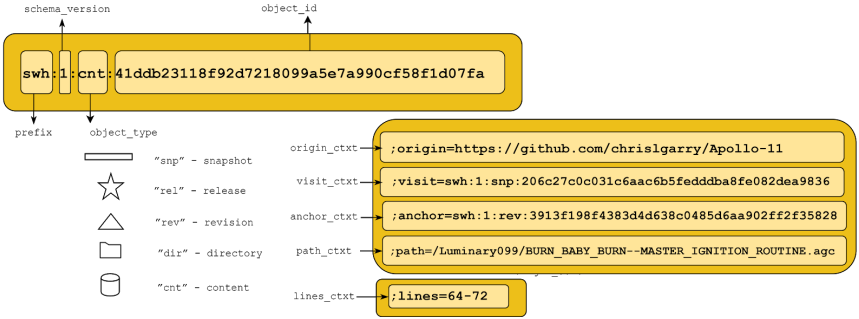

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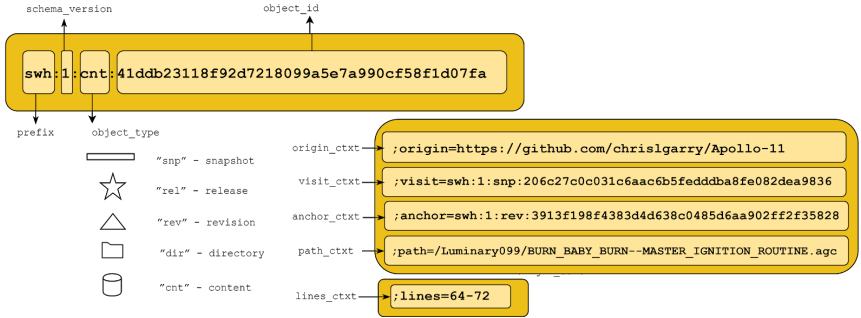

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content-addressed server

an emerging standard

specification (link)

Source code identification

`origin` specifies:

- `method`: *tarball*, VCS as Git, Mercurial, Subversion, etc.
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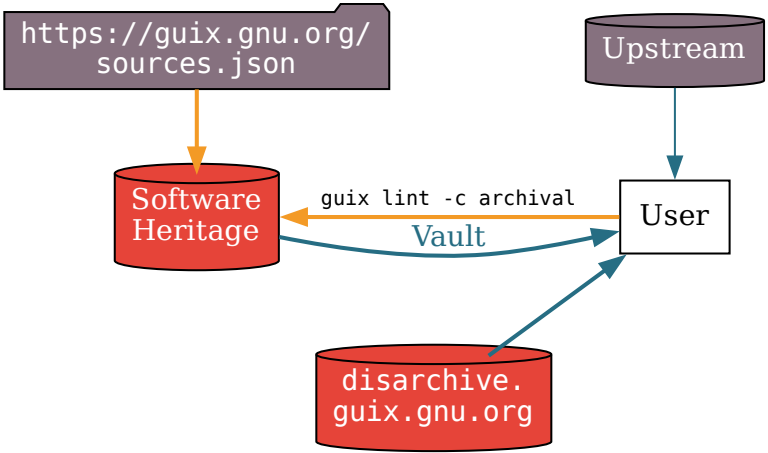
- a **content-addressed server**

  as served by the Guix project or the Nix project, or the Software Heritage initiative.

Architecture = connecting Guix and Software Heritage



Why Disarchive? = issue with compressed *tarballs*

```
(sha256
   (base32 "1df7b...")
```

```
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1df7b...

$ guix hash \                    # Fast compression
   <(gzip -dc harmony_1.2.0.tar.gz | gzip -1 -c)
03v29...

$ guix hash \                    # Best compression
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10j87...
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```
# Extract the compressed tarball
$ guix hash harmony-1.2.0 \
    --serializer=nar
b7900...

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```

xkcd #927 ^W^W

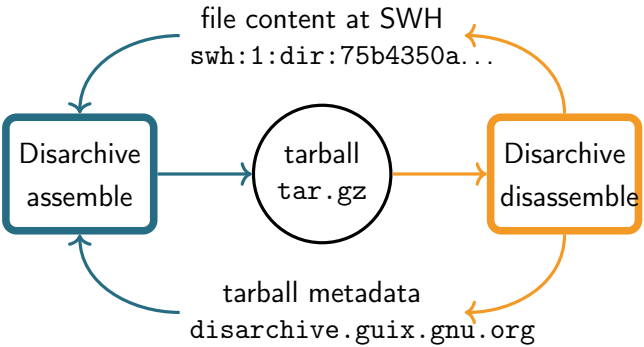
Cryptographic hash algorithm and data serializer are important for retrieving.

Disarchive dissemble output = description of metadata

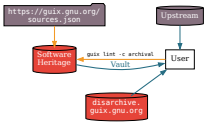
```
(disarchive
  (version 0)
  (gzip-member
    (name "harmony_1.2.0.tar.gz")
    (digest (sha256 "a63c7d7..."))
    (header (mtime 1701246604)
        (extra-flags 0) (os 3))
    (footer (crc 2567676087)
            (isize 6225920))
    (compressor gnu)
    (input
     (tarball
       (name "harmony_1.2.0.tar")
       (digest (sha256 "6c50a34..."))
       (default-header
         (uid 1010)
         (gid 100)
         (chksum (trailer " "))
         (magic "ustar ")
         ;; more omitted
```

```
(headers
  ("harmony/"
   (mode 493)
   (mtime 1701246604)
   (chksum 5084)
   (typeflag 53))
   ;; many headers omitted
   ("harmony/inst/doc/Seurat.R"
    (size 4130)
    (mtime 1701214143)
    (chksum 6701)))
(padding 0)
(input
  (directory-ref
    (version 0)
    (name "harmony_1.2.0")
    (addresses
      (swhid
          "swh:1:dir:75b4350a..."))
    (digest (sha256
        "3a46bbf..."))))))))
```

Separate storage



Retrieving source code = SWH Vault + Disarchive



content-address

Guix: "*normalized archived*" (`nar`) + `sha256`

SWH: SWHID = Git compatible `sha1`

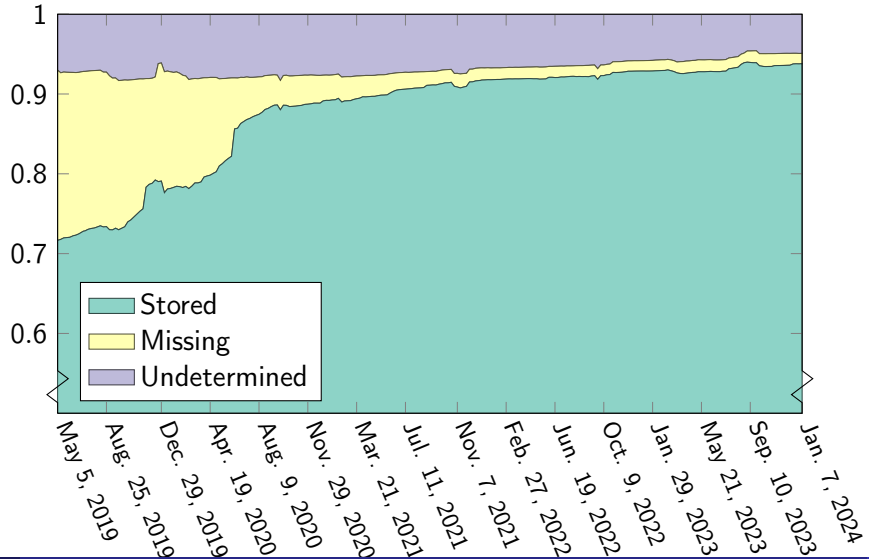
Case: VCS checkouts

- SWH addresses content as SWHID and associates the `nar-sh256` as *external identifier*.
- Guix queries using `nar-sh256` and gets back SWHID.
- Guix asks SWH Vault to "cook" the files and fetch them.

Case: *tarballs*

- Using Disarchive disassemble output, from `nar-sha256`, Guix gets SWHID.
- Guix asks SWH Vault to "cook" the files and fetch them.
- Using Disarchive disassemble output, Guix assembles bit-identical *compressed tarball*.

Coverage by sampled Guix revision



Work in progress

```
guix time-machine --commit=v1.0.0 -- install r-harmony
```

Installs (and potentially rebuilds) Harmony defined in Guix 1.0.0 from 2019.

- This command exploits SWH support as it was in 2019: in its infancy.
- Recovery mechanism is itself improving over time.
- Mitigations:
  - Delegate downloading to the Guix build daemon.
    (special and dedicated "builders" as `builtin:download` or `builtin:git-download`)
  - Recover source code referenced by past revisions using present-day techniques.

- Support more archive formats including lzip, Zip, unusual gzip compression.
- Deal with (long) *cooking* time by SWH Vault,
  from minutes to days depending on artifact size and service load.

Conclusion

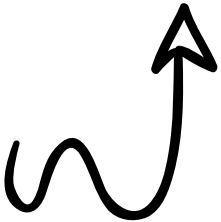
- Cite and reference source code using SWHID
- Use Guix!

The source of these slides is archived.
(Software Heritage id swh:1:dir:f5ed6543eabd6c5fb989c76412760088601b064b (link))

Toward better “Open Research”

Software Heritage

The ReScience Journal



Questions?

guix-science@gnu.org

swh-devel@inria.fr

https://hpc.guix.info

https://www.softwareheritage.org

These slides are archived.
(Software Heritage id swh:1:cnt:5926f6bb438a9b5c9e4914c137ad15101522179d (link))

Appendix

Example of VCS retrieval

```
building /gnu/store/agsi5ynwvmyfscc2avxkf7i3089m1p0i-scons-3.0.4-checkout.drv...
Initialized empty Git repository in /gnu/store/2p3cb96q8zk2pnarcnkwaifqw3l8gc70-scons-3.0.4-checkout/.git
fatal: unable to access 'https://github.com/SCons/scons.git/': Could not resolve host: github.com
Failed to do a shallow fetch; retrying a full fetch...
fatal: unable to access 'https://github.com/SCons/scons.git/': Could not resolve host: github.com
git-fetch: '/gnu/store/lcygm0p2d59acvwi12lwldg5c0d4czpr-git-minimal-2.41.0/bin/git fetch origin'
failed with exit code 128
Trying content-addressed mirror at bordeaux.guix.gnu.org...
Unable to fetch from bordeaux.guix.gnu.org, getaddrinfo-error: (-2)
Trying content-addressed mirror at ci.guix.gnu.org...
Unable to fetch from ci.guix.gnu.org, getaddrinfo-error: (-2)
Trying content-addressed mirror at bordeaux.guix.gnu.org...
Unable to fetch from bordeaux.guix.gnu.org, getaddrinfo-error: (-2)
Trying to download from Software Heritage...
SWH: found directory
with nar-sha256 hash 16a209173f87735020b29d84f497d44204cbcf86a451066342c51ff47996c8f7
at 'swh:1:dir:d3d1330dfc409be4624a01d384868fea0427c4c3'
swh:1:dir:d3d1330dfc409be4624a01d384868fea0427c4c3/
swh:1:dir:d3d1330dfc409be4624a01d384868fea0427c4c3/.appveyor.yml
...
successfully built /gnu/store/agsi5ynwvmyfscc2avxkf7i3089m1p0i-scons-3.0.4-checkout.drv
```

Example of *tarball* retrieval

```
Trying to use Disarchive to assemble /gnu/store/zwmrwlb2l53xbllxcw3axad54kyqcplp-Python-3.12.2.tar.xz...
Retrieving Disarchive spec
from https://disarchive.guix.gnu.org/sha256/be28112dac813d2053545c14bf13a16401a21877f1a69eb6ea5d84c4a0f3d
Assembling the directory Python-3.12.2
Downloading /gnu/store/zwmrwlb2l53xbllxcw3axad54kyqcplp-Python-3.12.2.tar.xz from Software Heritage...
SWH vault: requested bundle cooking, waiting for completion...
SWH vault: Processing...
swh:1:dir:72d77318a8c52ddfc004251fb7297799135704e6/
swh:1:dir:72d77318a8c52ddfc004251fb7297799135704e6/Python-3.12.2/pyconfig.h.in
...
Checking Python-3.12.2 digest... ok
Assembling the tarball Python-3.12.2.tar
Checking Python-3.12.2.tar digest... ok
Assembling the XZ file Python-3.12.2.tar.xz
Checking Python-3.12.2.tar.xz digest... ok
Copying result to /gnu/store/zwmrwlb2l53xbllxcw3axad54kyqcplp-Python-3.12.2.tar.xz
successfully built /gnu/store/nx97h7yr21l04nn60mqlf1yzfyxj06jh-Python-3.12.2.tar.xz.drv
source is at 'Python-3.12.2'
applying '/gnu/store/cdla0h7pcnckxlk3aflik3zsmbsfxzfp-python-3-deterministic-build-info.patch'...
applying '/gnu/store/ns40bs4bs19syckgh7v37rbxax0wfq01-python-3.12-fix-tests.patch'...
applying '/gnu/store/d7xlln76p372rssay94xkwbzf9p9p1rn-python-3-hurd-configure.patch'...
successfully built /gnu/store/y6s4xxsk5fc5909wafcvp2mxh5lc6c65-Python-3.12.2.tar.xz.drv
```

Example of *bugs* (read Missing in Coverage)

```
Trying to download from Software Heritage...
SWH: found directory
with nar-sha256 hash c98bd6991721d60b9a79600428bfbe8db0aaac3d383cd2df803ed7867c7cb63b
at 'swh:1:dir:218d95849f10fc0691d7dfa80999ce5061e654ef'
swh:1:dir:218d95849f10fc0691d7dfa80999ce5061e654ef/
...
swh:1:dir:218d95849f10fc0691d7dfa80999ce5061e654ef/wisp.py
r:sha256 hash mismatch for /gnu/store/7pcac04x82wyhknyfkdwhk3j958n2r75-guile-wisp-1.0.7-checkout:
  expected hash: 0fxngiy8dmryh3gx4g1q7nnamc4dpszjh130g6d0pmi12ycxd2y9
  actual hash:   0z7y487nnmw22xry82bb75shwp50gacm4kbwn01vhhli2bchpx37
hash mismatch for store item '/gnu/store/7pcac04x82wyhknyfkdwhk3j958n2r75-guile-wisp-1.0.7-checkout'
build of /gnu/store/8lcrd6n6m18hzh9dszm8c1xhjyfd54d9-guile-wisp-1.0.7-checkout.drv failed
View build log at '/var/log/guix/drvs/8l/crd6n6m18hzh9dszm8c1xhjyfd54d9-guile-wisp-1.0.7-checkout.drv.gz'
guix build: error: build of `/gnu/store/8lcrd6n6m18hzh9dszm8c1xhjyfd54d9-guile-wisp-1.0.7-checkout.drv' f
```

Discussion (SWH) #5093 (link)
(Guix) #71631 (link)

Fixed by `bd908af0c619cb1b74afeeb07839d7af08de9d91`