The SWH-ID

A digital fingerprint identifying software source code

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Software Heritage

THE GREAT LIBRARY OF SOURCE CODE

Outline

Source Code: *executable* and *human readable* knowledge

"The source code for a work means the preferred form of the work for making modifications to it." *GPL Licence*

Hello World

Program (excerpt of binary)

```
4004e6: 55
4004e7: 48 89 e5
4004ea: bf 84 05 40 00
4004ef: b8 00 00 00 00
4004f4: e8 c7 fe ff ff
4004f9: 90
4004fa: 5d
4004fb: c3
```

Program (source code)

```
/* Hello World program */

#include<stdio.h>

void main()
{
    printf("Hello World");
}
```

Len Shustek, CHM *"Source code provides a view into the mind of the designer."*

The Paris call: Software Source Code is part of our Heritage

November, 2018 at the UNESCO headquarters experts signed *the engagement*


UNESCO

"Building peace in the minds of

United Nations Educational, Scientific and Cultural Organization

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Experts call for greater recognition of software source code as heritage for sustainable development

16 November 2018

- Recognise software source code as a precious asset of humankind
- Support the development of shared infrastructures
- Foster international collaboration to build a common framework

see full text

Outline

Software Heritage

THE GREAT LIBRARY OF SOURCE CODE

Collect, preserve and share the *source code* of *all the software*

Preserving our heritage, enabling better software and better science for all

Reference catalog

find and reference all the source code

Universal archive

preserve all the source code

Research infrastructure

enable analysis of all the source code

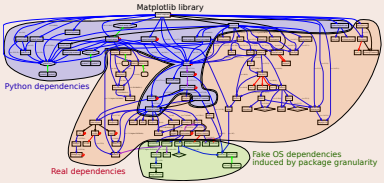
Source code is *special*

Software evolves over time

- projects may last decades
- the *development history* is key to its *understanding*

Layers of complexity

- *millions* of lines of code
- large *web of dependencies*
- sophisticated *developer communities*



Bottomline

- we must archive *all* the source code
- we must preserve *all* the history of its development
- we must identify *all* the archived software artifacts (more than 20 billions today!)

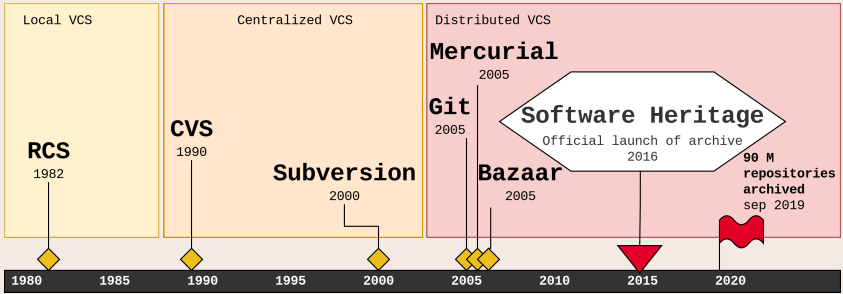
how can we do this?

Evolution of software development

Version control system (VCS)

- records changes made to a (set of) *source code file* (s)
- allows to operate on versions: diff/merge/fork/recover etc.
- essential tool for software development

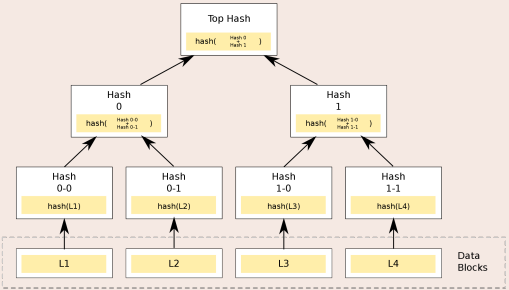
Three decades of evolution



Requirements for the D in DVCS

- intrinsic unique identifiers… (here: *cryptographic signature*, aka "hash")
- … that work for tree structures (software directories)

Merkle tree to the rescue (R. C. Merkle, Crypto 1979)

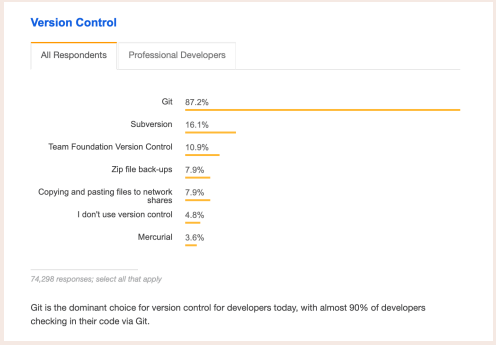


Combination of

- tree
- hash function

A massive adoption

Stack Overflow [Survey 2018]



In numbers

GitHub [Octoverse 2017] [Blog 2018]

- 100.000.000+ repositories
- 40.000.000+ developers worldwide

Bitbucket [Blog 2019]

- 28.000.000+ repositories
- 10.000.000+ developers worldwide

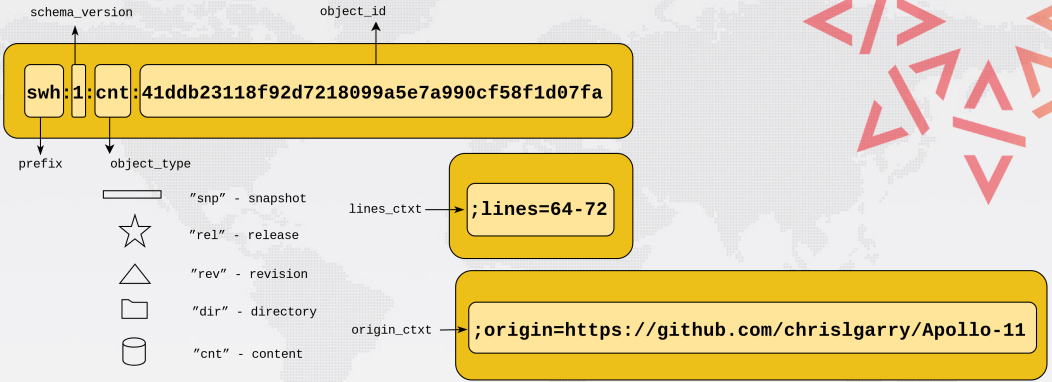
GitLab [Blog 2019]

- 1.000.000 MRs March 19'

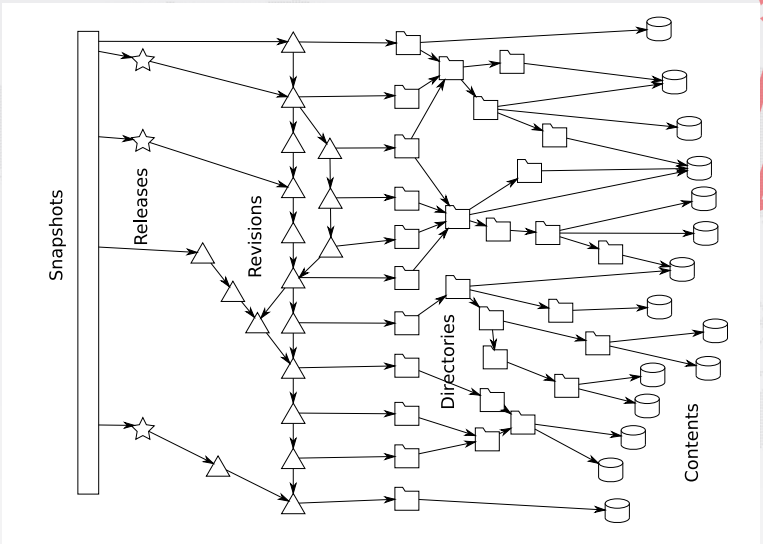
Let's use it!

Outline

The SWH-ID schema

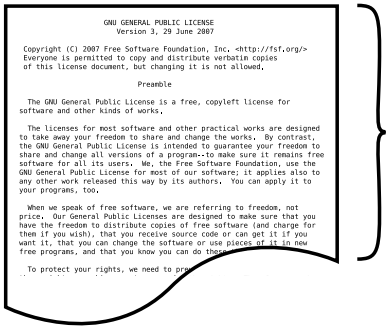


A worked example



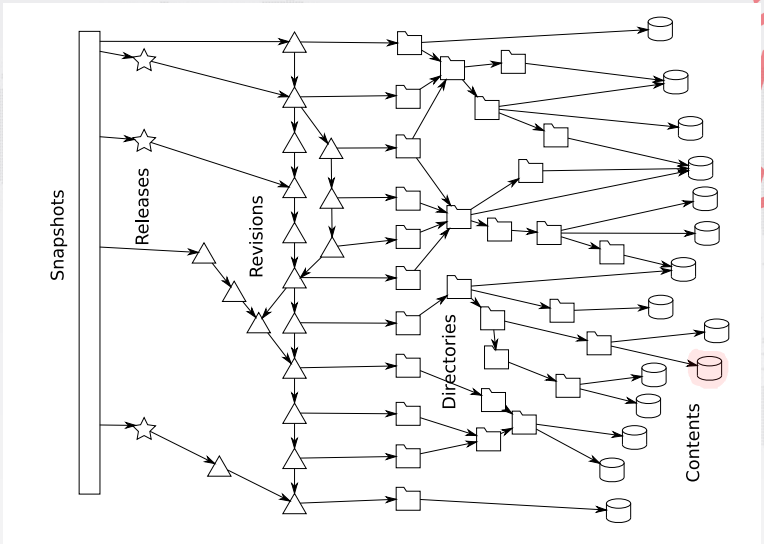
A worked example

Contents



sha1: 8624bcdae55baeef...
sha256: 8ceb4b9ee5aded...
sha1_git: 94a9ed024d385...
length: 35147

A worked example



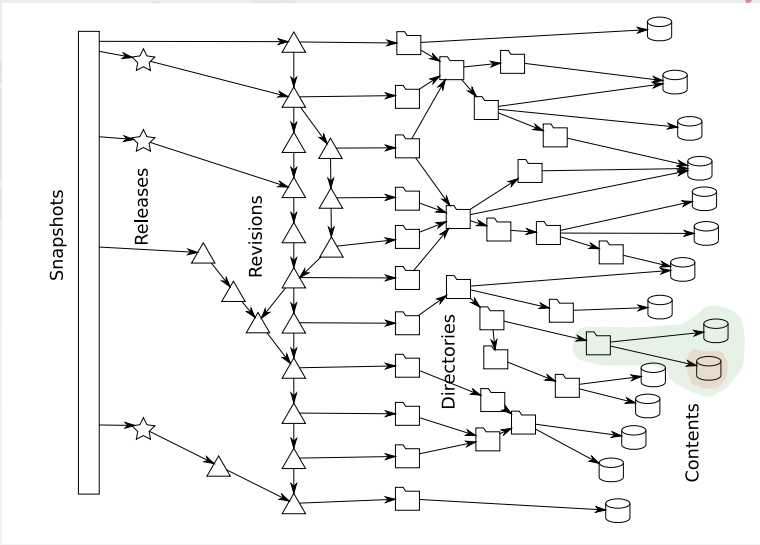
A worked example

Directories

```
100644 blob c5baade4c44766042186ef858c0fd63d587ebf09 .gitignore
100644 blob 2d0a34af6f52cf3cf6b0c2f7bd0648fbd255e77f AUTHORS
100644 blob 94a9ed024d3859793618152ea559a168bbcbb5e2 LICENSE
100644 blob d9b2665a435a43f8a79a84e0867751dfb095c7bb MANIFEST.in
100644 blob 524175c2bad0b35b975f79284c2f5a6d5eaf2eb4 Makefile
100644 blob 5c7e3a5bbddb038682ba7793f440492ed9678bb3 Makefile.local
100644 blob 8617980629cd24e6080404f09aa749b085b3e07b README.db_testing
100644 blob 76b29f94cf815e0869c414d38d78d7ce08ec514e README.dev
040000 tree e1e10ecef948af0b93adb0372afc89f12e92618a bin
040000 tree 83e56d0beaf7793c77a45a345c80fcb8af503013 debian
040000 tree a34c9c4ba213f0cedc67f9816348d27955577af5 docs
100644 blob f2a6d32c6135aa7287bbd76167b01df2ae4f1539 requirements.txt
100755 blob eee147c36caf1bbc2d820da8dc026cb5b68180bc setup.py
040000 tree 224bb4c1f4c67fca1d160bffd2d06094e7e1abf3 sql
040000 tree 8631c9cd77bbe993168107ab5baf51f40c6300be swh
040000 tree 8fb905b56ba8ed692f1209b2773b474c6c1d66c1 utils
```

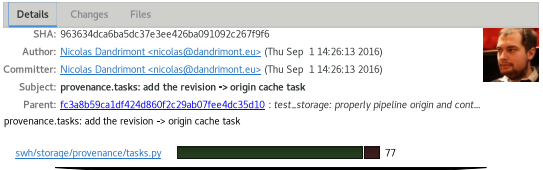
id: 515f00d44e92c65322aaa9bf3fa097c00ddb9c7d

A worked example



A worked example

Revisions

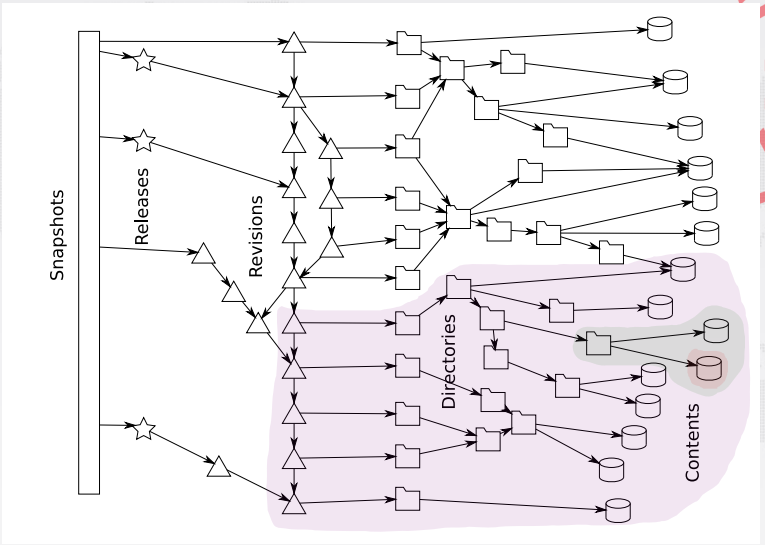


tree 515f00d44e92c65322aaa9bf3fa097c00ddb9c7d
parent fc3a8b59ca1df424d860f2c29ab07fee4dc35d10
author Nicolas Dandrimont <nicolas@dandrimont.eu> 1472732773 +0200
committer Nicolas Dandrimont <nicolas@dandrimont.eu> 1472732773 +0200

provenance.tasks: add the revision -> origin cache task

id: 963634dca6ba5dc37e3ee426ba091092c267f9f6

A worked example



A worked example

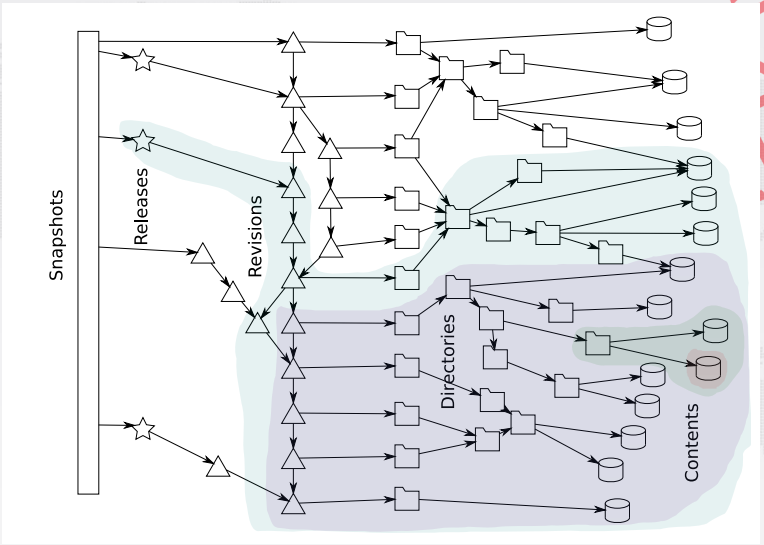
Releases

```
tag v0.0.51
Tagger: Nicolas Dandrimont <nicolas@dandrimont.eu>
Date:   Wed Aug 24 14:36:03 2016 +0200

Release swh.storage v0.0.51

 - Add new metadata column to origin_visit
 - Update swh-add-directory script for updated API
[...]

commit c0c9f16b1e134f593e7567570a1761b156e6eb1d
```

```
object c0c9f16b1e134f593e7567570a1761b156e6eb1d
type commit
tag v0.0.51
tagger Nicolas Dandrimont <nicolas@dandrimont.eu> 1472042163 +0200

Release swh.storage v0.0.51

 - Add new metadata column to origin_visit
 - Update swh-add-directory script for updated API
-----BEGIN PGP SIGNATURE-----

iQIzBAABCAAdBQJXvZTNFhxuaWNvbGFzQGRhbmRyaW1vbnQuZXUACgkQ7AWLMo2+
neqorw//aq6SOb5DijzEa+kWN3rXgVS+1K1vEVh1wNKAwx8eKJ7aX2kEiLDtt7uf
ahpZ6pz3q8nqs6aC1+YrxBfcih3L2YtrdZeWXWqr8xWNMaEoYDb8qaphwh8AD5t2
ICBIt2ujtXuCrDt93eKKPwvzZXq+hB0sMWy35Dr6jW7Z7K4Mu/PGglyIHPY55yo
IGEndWno7Vfh1Vm6t1n5qB7l5mXRaqA+becqddubTZ2xjj+jpIUqC8cyqN3hm/fL
qsj2mu8kyz3t8tG/H1/pV+I5OwBlnPoS5TH0tujoJEVgPK/dHSP79QuHDHZFkCao
klj6kAWyU80Mxb+nKVJeLbrR3+yWBFj3Qp5a1/V8oOTh6E1dALcNMpEaKCoKtMt
d/gMRax1ILg0EDfnsW67G6sDwKPKPHhgfVLQ3nV3GaQQTnu1RpMz006N9/hAwzC
Gg/K1PdHT4hzOll46wYPZyje0U2VXGFu6vVU9vFQ4ZR/WJn+0zMzdcRdRJlSUOMn
RpTTfUsbXUeXHGOpkgXhSYTnvp1gdPc76USTsK0aGe84AZm1Ik0mGrwXCVfPqlYo
nhhibBSHBNMoqyF6yTSOpUbYK70tpYRRUGKWDeRK0wKSxkWKUZGtKzy6JYqJjo29
gulwgZQif5qWQCB0OontAL2+HvPFaVyckMejUhg62cP/+EHIvUk=
=kOxP
-----END PGP SIGNATURE-----
```

id: 85083a5cc14a441c89dea73f5bdf67c3f9c6afdb

A worked example



A worked example

git show-refs

Snapshots

```
commit 08ffeb25770109525eb3ce21691466c53a1d9158 refs/heads/atime
commit ba5443a24e3f9fe323a46c292cec4fcbe61c67eb refs/heads/directory-listing-arrays
commit d69e0dbf892383ff6589b27fbe1c05d27238d9c5 refs/heads/foo
commit cf7ff9eea0eb22f8946908f5a8019f67de468e08 refs/heads/master
commit 7eca197fc66d2024047e54b1ed9e8b44361a0fc2 refs/heads/tmp-directory-add
commit 642a205f37de85005a85d427b53ee4fb2252e82e refs/heads/tmp/generic-releases
tag 20f043b1379cf768d966597799fd4907c757f755 refs/tags/v0.0.1
tag 72a21991a384e539996dbb867bfb0bee72aee2cd refs/tags/v0.0.10
tag 3590e0ca0ebb070e5b376705fa230bbfa4ffa5cc refs/tags/v0.0.11
tag 33378427a403ba569a67777b8d58f6674fbc6556 refs/tags/v0.0.12
tag 06f74652755b327cf590311c2bfa036cf3b4b35d refs/tags/v0.0.13
tag 5a6325fe86ab854b581d7442667d92a11e32f3bd refs/tags/v0.0.14
tag 586fba4e580b4f5fab05f599367643cbcb1a9c7f refs/tags/v0.0.15
tag 8cd8b885f4098bf363177742bd289f660e5be51c refs/tags/v0.0.16
tag a542444ee3f0fbed35efb202fee035c809abc7d6 refs/tags/v0.0.17
tag 228a2f1650dd12222e556559462e1e06fc4993d9 refs/tags/v0.0.18
tag 606979a4ca05d497fc0d24aad00dce82636ef47c refs/tags/v0.0.19
tag 32bf5a59fc2a323baa6d5f15a6ad5382ec275a67 refs/tags/v0.0.2
tag 3147c3d31ec46cf6492f881e908b1237ebdff2c7 refs/tags/v0.0.20
tag 215ea50daba111e082e0b72e76eb4b6073a87908 refs/tags/v0.0.21
tag 3fb168c2072a5d6252124257a1e5dfc0f5fa1df refs/tags/v0.0.22
tag 8cdbee8da4d73fc5d262789e460a16ac3c72aba4 refs/tags/v0.0.23
...
```

id: b464cad1b66fff266a37b46ea6e7a04b545e904b

Demo time

Let's look at some famous exceprts of source code

Apollo 11 source code (excerpt)

```
P63SPOT3        CA      BIT6            # IS THE LR ANTENNA IN POSITION 1 YET
                EXTEND
                RAND    CHAN33
                EXTEND
                BZF     P63SPOT4        # BRANCH IF ANTENNA ALREADY IN POSITION 1

                CAF     CODE500         # ASTRONAUT:    PLEASE CRANK THE
                TC      BANKCALL        #               SILLY THING AROUND
                CADR    GOPERF1
                TCF     GOTOPOOH        # TERMINATE
                TCF     P63SPOT3        # PROCEED       SEE IF HE'S LYING

P63SPOT4        TC      BANKCALL        # ENTER         INITIALIZE LANDING RADAR
                CADR    SETPOS1

                TC      POSTJUMP        # OFF TO SEE THE WIZARD ...
                CADR    BURNBABY
```

Quake III source code (excerpt)

```
float Q_rsqrt( float number )
{
    long i;
    float x2, y;
    const float threehalfs = 1.5F;

    x2 = number * 0.5F;
    y = number;
    i = * ( long * ) &y; // evil floating point bit level hacking
    i = 0x5f3759df - ( i >> 1 ); // what the fuck?
    y = * ( float * ) &i;
    y = y * ( threehalfs - ( x2 * y * y ) ); // 1st iteration
// y = y * ( threehalfs - ( x2 * y * y ) ); // 2nd iteration, this
can be removed

    return y;
}
```

It works!

we have *intrinsic* identifiers for all 20+ billion objects in the archive

Outline

Food for thought

Intrinsic identifiers...

- can be extracted from the object itself, hence:
  - no need for a *central authority*, nor maintenance
  - any modification to the object changes the identifier
- identifies the *object*, not the *metadata* !

... *for source code*

- Distributed Version Control Systems made them popular
- massively used every day by millions of software developers
- Software Heritage provides SWH-IDs for billions of software artifacts

Come in, we're open!

www.softwareheritage.org — learn more
save.softwareheritage.org — save code now
www.softwareheritage.org/swhap — legacy software acquisition process
forge.softwareheritage.org — our own code

Questions?

References

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Computing in Science and Engineering, IEEE, pp.1-9. (10.1109/MCSE.2019.2963148) (hal-02446202)