Software Source Code in Research and Open Science

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Software Heritage

THE GREAT LIBRARY OF SOURCE CODE

Outline

Software source code: *human readable* and *executable knowledge*

Harold Abelson, Structure and Interpretation of Computer Programs (1985)

"Programs must be written for people to read, and only incidentally for machines to execute."

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;
}
```

Len Shustek, Computer History Museum (2006)

"Source code provides a view into the mind of the designer."

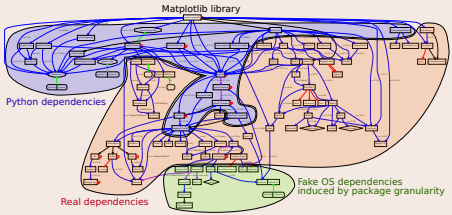
Source code is *special* (software is *not* data)

Software *evolves* over time

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

Complexity

- *millions* of lines of code
- large *web of dependencies*
  - easy to break, difficult to maintain
- sophisticated *developer communities*



A vast part is not research software

- industry and communities drive standards, build the necessary support layers

Source code is *special*, cont'd

Versioning, granularity

Project "Inria created OCaml and Scikit-learn"

Release "2D Voronoi Diagrams were introduced in CGAL 3.1.0"

Precise state of a project "This result was produced using commit 0064fbd…"

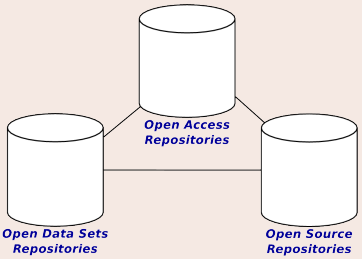
Code fragment "The core algorithm is in lines 101 to 143 of the file parmap.ml contained in the precise state of the project corresponding to commit 0064fbd…."

Authors can have multiple roles:

- Architecture, Management, Development, Documentation, Testing, …

Software Source code: pillar of Open Science

Three pillars of Open Science



A plurality of needs

Researcher

- archive and reference software used in articles
- find useful software
- get credit for developed software
- verify/reproduce/improve results

Laboratory/team track software contributions

- produce reports / web page

Research Organization know its software assets

- technology transfer
- impact metrics

What is at stake — in increasing order of difficulty

Archival

Research software artifacts must be properly archived

make sure we can *retrieve* them (*reproducibility*)

Identification

Research software artifacts must be properly referenced

make sure we can *identify* them (*reproducibility*)

Metadata

Research software artifacts must be properly described

make it easy to *discover* them (*visibility*)

Citation

Research software artifacts must be properly cited *(not the same as referenced!)*

to give *credit* to authors (*evaluation*!)

We need infrastructures *designed for* software source code: now we have one!

Outline

Software Heritage, in a nutshell

Software Heritage

THE GREAT LIBRARY OF SOURCE CODE

Collect, preserve and share *all* software source code

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

Reference catalog

find and reference all software source code

Universal archive

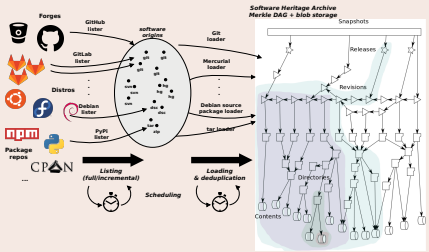
preserve all software source code

Research infrastructure

enable analysis of all software source code

Addressing the four needs

Archive (8B+ files, 130M+ projects!)



- save.softwareheritage.org
- deposit.softwareheritage.org

Reference (20 billion SWHIDs)

Intrinsic, decentralised, cryptographically strong identifiers, SWHIDs

Now supported in SPDX 2.2, Wikidata etc.

Describe

- Intrinsic metadata from source code
- Contributed the Codemeta generator

Cite

- Contributed software citation style biblatex-software, v 1.2-2 now on CTAN

Outline

A walkthrough

- Browse the archive
- Get and use SWHIDs (full specification available online)
- cite software with the biblatex-software style from CTAN
- Example use in a research article: compare Fig. 1 and conclusions
  - in the 2012 version
  - in the updated version using SWHIDs and Software Heritage
- Example use in a research article: extensive use of SWHIDs in a replication experiment
- Trigger archival of your preferred software in a breeze
- curated deposit in SWH via HAL, see for example: LinBox, SLALOM, Givaro, NS2DDV, SumGra, Coq proof, ...
- rescue landmark legacy software, see the SWHAP process with UNESCO

Outline

Sharing the vision

United Nations Educational, Scientific and Cultural Organization

And many more ...

www.softwareheritage.org/support/testimonials

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Come in, we're open!

Software Heritage

- *universal* source code archive
- *intrinsic* identifiers (SWHIDS)
- *open*, *non profit*, long term
- *infrastructure* for Open Science

You can help improve science!

- *use* SWH and *save* relevant source code
- *build on* SWH (see swmath.org and ipol.im)
- *contribute* to SWH: *it is open source*
- spread the word

Jean-François Abramatic, Roberto Di Cosmo, Stefano Zacchiroli
Building the Universal Archive of Source Code, CACM, October 2018 (10.1145/3183558)

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Referencing Source Code Artifacts: a Separate Concern in Software Citation,
CiSE 2020 (10.1109/MCSE.2019.2963148) (hal-02446202)

Pierre Alliez, Roberto Di Cosmo, Benjamin Guedj, Alain Girault, Mohand-Said Hacid, Arnaud Legrand and Nicolas Rougier
Attributing and referencing (research) software: Best practices and outlook from Inria,
CiSE 2020 (10.1109/MCSE.2019.2949413) (hal-02135891)