Towards a Software Pillar for Open Science

from policy to implementation

Roberto Di Cosmo

Dagstuhl 2^5 anniversary

Director, Software Heritage
Inria and Université de Paris Cité

June 24th 2022

Software Heritage

THE GREAT LIBRARY OF SOURCE CODE

Outline

1. Introduction
2. Open Science
3. An emerging policy framework
4. Towards implementation: assessing the needs for a software pillar
5. Focus on ARDC and infrastructures
6. Demo time!
7. Actions

Short Bio: Roberto Di Cosmo

Computer Science professor in Paris, now working at INRIA

- *30+ years* of research (Theor. CS, Programming, Software Engineering, Erdos #: 3)
- *20+ years* of Free and Open Source Software
- *10+ years* building and directing structures for the common good

1999 *DemoLinux* – first live GNU/Linux distro

2007 *Free Software Thematic Group*
150 members 40 projects 200Me

2008 *Mancoosi project* www.mancoosi.org

2010 *IRILL* www.irill.org

2015 *Software Heritage* at INRIA

2018 *National Committee for Open Science*, France

2021 *EOSC Task Force on Infrastructures for Software*, European Union

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Why Open Science?

Open Science (Second National Plan for Open Science, France, 2021)

Unhindered dissemination of results, methods and products from scientific research.
It draws on *the opportunity provided by recent digital progress* to develop *open access* to *publications* and – as much as possible – *data*, *source code* and *research methods*.

Jean-Eric Paquet (EU DGRI, on the objective of Open Science)

"Increase *scientific quality*, the *pace of discovery and technological development*, as well as *societal trust in science*."

Mariya Gabriel (EU Commissionneer for Research)

The COVID-19 crisis has also shown that cooperation at international level in research and innovation is more important than ever, including through *open access to data and results. No nation, no country can tackle any of these global challenges alone.*

Yuval Noah Harari (on COVID 19)

"The real antidote [to epidemic] is scientific knowledge *and* global cooperation."

Two well known pillars of Open Science

Open Access (a long, painful, unfinished story)

- 19XX's: compulsory exclusive copyright transfer to publishers (unlawful?) (notable exceptions: US federal agencies and UK Crown Copyright)
- 1990's: Internet, Web and ArXiv break the marriage of convenience of researchers with publishers
- 2000's: declarations (Budapest, 2001; Berlin 7, 2009) and actions (LIPIcs, 2009)
- 2010's: reactions (SciHub, 2011; Plan S, 2018) and transformations (not so easy)

TL;DR: see my viewpoint in 2005 and the SIGPLAN blog in 2020

Open Data (less painful, but still unfinished story)

- 1957-1958: International Geophysical Year shows the way
- 2006 (and 2021): OECD recommendation on publicly funded research data
- 2016 and later: FAIR terminology (*focus on metadata, sort of forgets open…*)

Some lessons learned

Risk factors, mistakes to avoid

- legal and economic framework
  - closed, for profit infrastructures with unaligned goals may lead to
    - proprietarization of public research results
    - creation of dysfunctional markets
  - operation of open non profit infrastructure funded with project money
- operational balkanisation
  - proliferation of infrastructure silos
  - duplicated contents with different identifiers
  - costly efforts to federate after-the-fact
  - uneven quality of information

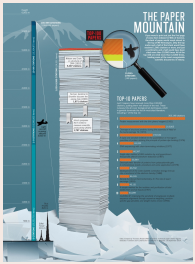
Taking notice

2021: exemplarity criteria for the french national open science fund

Thansk to Dagstuhl for its key role for the Computer Science community

Software is a pillar of Open Science

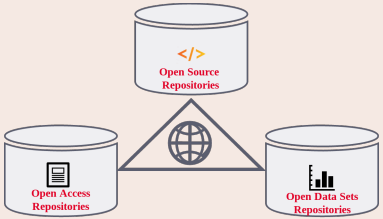
Software powers modern research



[…] software […] essential in their fields.
Top 100 papers (Nature, 2014)

Sometimes, if you dont have the software, you dont have the data
Christine Borgman, Paris, 2018

A key pillar: software (source code)



The links in the picture are important

Nota Bene

software may be a *tool*, a *research outcome* and a *research object*

access to the *source code* is essential!

Preserving (the history of) source code is necessary for *reproducibility*

Software *Source Code* is Precious Knowledge

Harold Abelson, Structure and Interpretation of Computer Programs (1st ed.) 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."

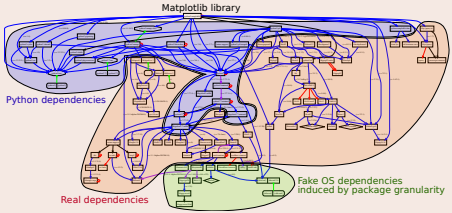
Source code is *special* (software is *not* data)

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
  - *research software* a thin top layer
- sophisticated *developer communities*



The human side

design, algorithm, code, test, documentation, community, funding

and so many more facets …

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International highlights

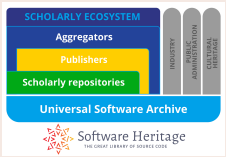
Paris Call on Software Source code (2019, UNESCO)

40 international experts call to *"promote software development as a valuable research activity, and research software as a key enabler for Open Science/Open Research, [...] recognising in the careers of academics their contributions to high quality software development, in all their forms"*

UNESCO recommendations for Open Science, 2018-2021

"The source code must be included in the software release and [...] the license must allow modifications, derivative works and sharing [...]"
"Open science infrastructures should be [...] essentially not-for-profit and long-term"

EOSC SIRS report: Software Source Code and Open Science, 2020



- connect scholarly ecosystem via Software Heritage
- use open non profit infrastructures
- open source first: *"all research software should be made available under an Open Source license by default"*

French National plan for Open Science, 2021-2024

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SECOND FRENCH PLAN FOR OPEN SCIENCE

Generalising open science in France 2021-2024

1

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ET DE L'INNOVATION

Launch on 6 July 2021 by Frédérique Vidal, Minister for Higher Education, Research and Innovation

- Multiplying the **levers for change** in order to **generalise open science practices**
- Structuring the **policy for opening up or sharing research data**
- New commitments to the **opening of source code** produced by research
- **European and international inclusion** in the context of the French Presidency of the European Union
- **Disciplinary and thematic variations**: open science policies must be adapted to disciplinary specificities

2

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Path Three :

Opening up and promoting source code produced by research

7 **Recognize and support the dissemination under an open source license of software** produced by publicly funded research programmes

8 **Highlight the production of source code** from higher education, research and innovation

9 Define and promote an **open source software policy**

« The opening of software source code is a major challenge for the **reproducibility** of scientific results. »

« Distribution of software products under **open source licence** will be preferred. »

3

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Define and promote an open source software policy

- Produce a **National Charter for Open Source Software** coming from higher education, research and innovation
- Develop the **link between data and software** through a network of **Chief Data Officers** in the various universities and research performing organisations.
- Develop the **economic models of open source software** and make them known within commercialization services
- **Support Software Heritage** and recommend it for the archiving and referencing of source code

Recognise source code as a contribution to research

- Create an **open source research software prize**
- **Provide greater recognition** for software production in the career of researchers, research support staff

Build an ecosystem that connects code, data and publications

- Develop **proper coordination** between software forges, open publication archives, data repositories and the scientific publishing sector.

4

Research Software is getting recognized

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Accueil > Recherche > Science ouverte

Publié le 05.02.2022

Sommaire

- The Coq proof assistant : lauréat de la catégorie Scientifique et technique
- Scikit-learn : lauréat de la catégorie Communauté
- Faust : lauréat de la catégorie Documentation
- Gammapy : prix du jury
- Jury

Remise des prix science ouverte du logiciel libre de la recherche

Le ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation remet pour la première année les Prix science ouverte du logiciel libre de la recherche. Dix logiciels mis au point par des équipes françaises sont récompensés pour leur contribution à l'avancée de la connaissance scientifique.

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A plurality of needs

Researchers

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

Laboratories/teams

- track software contributions
- produce reports
- maintain web page

Research Organization

know its software assets

- technology transfer
- impact metrics
- funding strategy
- career evaluation

What is at stake

ARDC

- Archive for retrieval (*reproducibility*)
- Reference for identification (*reproducibility*)
- Describe for discovery and reuse
- Cite/Credit for credit and evaluation

Before ARDC

- Development practices and tools (VCS, build system, test suites, CI, ...)
- Opening up towards a community (documentation, organization, communication)

Need training, best practices

Beyond ARDC

- Policies (dissemination, reuse, careers!)
- Sustainability (legal, economic etc.)
- Technology transfer
- Advanced technologies and tools (quality, traceability, etc.)

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Forges are *not* archives!

2015: the first big bad news

Google Code and Gitorious.org shutdown: ~1M endangered repositories

- broken links in the web of knowledge (my papers too)

2019: big bad news keep coming in

- summer 2019: BitBucket announces Mercurial VCS sunset
- july 2020: BitBucket erases *250.000* repositories (including research software)

2021: … in Academia too

- october 2021: Inria's old gforge is unplugged
  - breaks the build chain of the OCaml package manager (Opam)

Bottomline

we need a universal archive of software source code: now we have one!

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

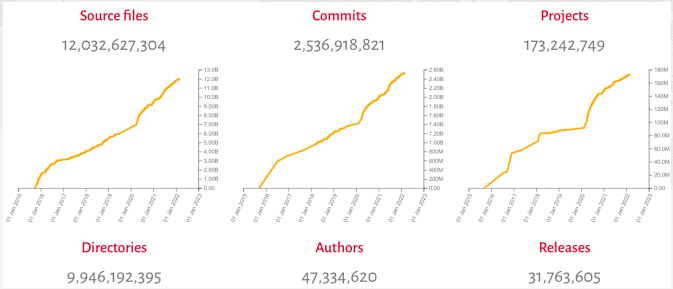
Research infrastructure

enable analysis of all software source code

The largest software archive, a shared infrastructure

Cultural Heritage | Industry | Research | Public Administration

Software Heritage



Sharing the vision

United Nations Educational, Scientific and Cultural Organization

And many more ...

www.softwareheritage.org/support/testimonials

Donors, members, sponsors

Diamond sponsor

Platinum sponsors

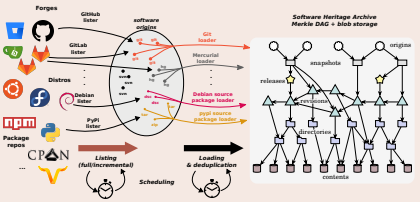
Gold sponsors

Silver sponsors

Bronze sponsors

Addressing the four needs (see ICMS 2020 for details)

Archive (12B+ files, 170M+ 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/Credit

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

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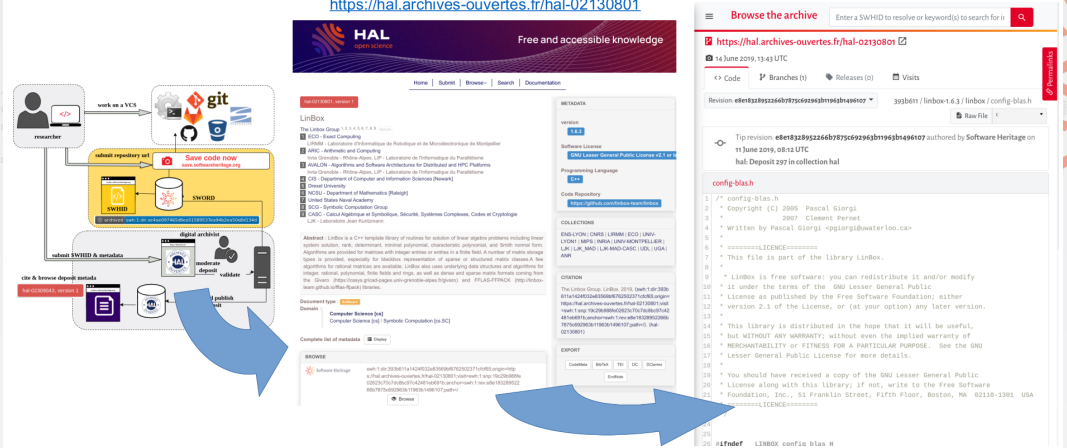
A walkthrough

- Browse the archive (your work may be already there !)
- Trigger archival of your preferred software in a breeze
- Get and use SWHIDs (full specification available online)
- Cite software using the biblatex-software package from CTAN
- Example in a journal: an article from IPOL
- Example with Parmap: devel on Github, archive in SWH, curated deposit in HAL
- Extracting all the software products for Inria, for CNRS, for LIRMM or for Rémi Gribonval using HalTools
- Curated deposit in SWH via HAL, see for example: LinBox, SLALOM, Givaro, NS2DDV, SumGra, Coq proof, ...
- 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

Overview of the Software Heritage / HAL synergy



swh:1:dir:393b611a1424f032e83569bf6762502371cfcf65

FAIRCORE4EOSC: Dagstuhl - SWH to implement same as the HAL example above

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Call to action: best practices for ARDC are available… today!

Archiving and referencing

For all source code used in research (*yes, even small scripts!*)

- ensure it is archived in Software Heritage (see save code now)
- get the proper SWHID for your software (see detailed HOWTO)
- add it to research articles for reproducibility (see detailed HOWTO)

Describing and Citing/Crediting

For software you want to put forward (*mention in your CV, reports, etc., get citations and credit for it*), do the following extra steps:

- add codemeta.json with description (see the codemeta generator)
- reference in the HAL portal (french partners, see online HAL documentation)
- cite software using the biblatex-software package (in CTAN and TeXLive)

- train students and colleagues
- engage journals, conferences, learned societies

Call to action: policy making

A working agenda

- avoid proprietarisation: set the default to open
  - *publicly funded research software should be open source*, exceptions must be justified
- avoid balkanisation
  - build on common, shared, open, non profit infrastructures, like Software Heritage
- support mutualised common infrastructures
  - acknowledge the predominant human component of digital infrastructures
    - recurrent funding of their cost
    - proper evaluation of their service
- establish intelligent incentives
  - count quality software contributions in careers, avoid purely numerical indicators, keep the human in the loop

it's a long road, but together we can make it

Questions?

References


UNESCO, *Draft recommendations on Open Science*
2021, (online)


French Ministry of Research, *Second National Plan for Open Science*
2021, (online)


EOSC SIRS Task Force, *Scholarly Infrastructures for Research Software*
2020, Publications office of the European Commission, (10.2777/28598)


R. Di Cosmo, *Archiving and Referencing Source Code with Software Heritage*
International Conference on Mathematical Software 2020 (10.1007/978-3-030-52200-1_36)


J.F. Abramatic, R. Di Cosmo, S. Zacchiroli, *Building the Universal Archive of Source Code*
CACM, October 2018 (10.1145/3183558)