Software Heritage: key infrastructure for Open Science and Open Source

Roberto Di Cosmo

Director, Software Heritage
Inria and Université de Paris Cité

25 November 2023

Software Heritage

THE GREAT LIBRARY OF SOURCE CODE

Outline

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

Software and Source code: a reminder

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

GPL Licence

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```
Hello World
```

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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
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Program (source code)

```
/* Hello World program */

#include<stdio.h>

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

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."

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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
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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;
}
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Len Shustek, Computer History Museum 2006

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

~ 50 years, a lightning fast growth

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"When I first got into it, nobody knew what it was that we were doing. It was like the Wild West."

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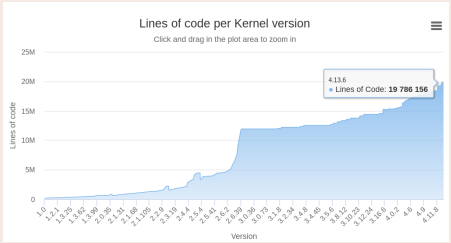
Linux Kernel



… now in your pockets!

Free Software: 40 years, 4 layers, in a nutshell

Free Software, AKA: *Open Source*, FOSS, FLOSS,...

Software that offers to *its users* the freedom to:

- use the software
- study and adapt the software
- distribute software copies
- distribute modified copies

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we faced many common issues *way before Open Science was on the radar*

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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*.

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Yuval Noah Harari (on COVID 19)

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

The scientific method…

The experimental method

- make an *observation*
- formulate an *hypothesis*
- set up an experiment
- elaborate a *theory*

And then we reproduce and verify.

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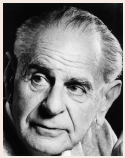
Reproducibility is the key

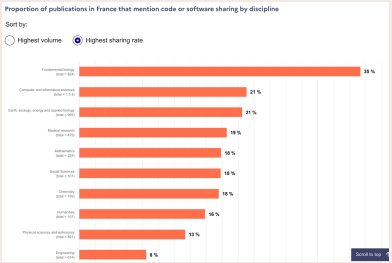


non-reproducible single occurrences are of no significance to science

Karl Popper, The Logic of Scientific Discovery, 1934

Software is a pillar of Open Science

Software powers modern research



Over 20% of articles across all disciplines share software

2023 French Open Science Monitor

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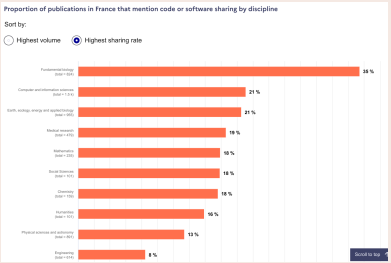

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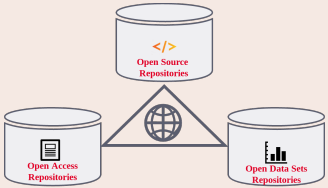

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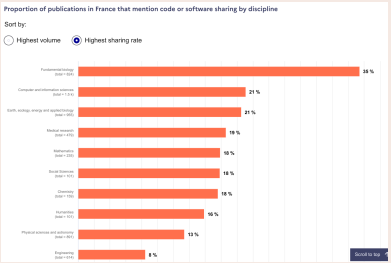

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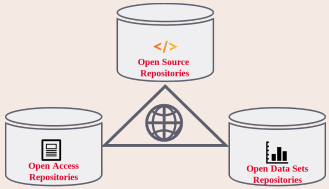

Links are important

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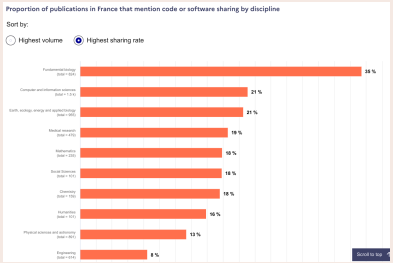

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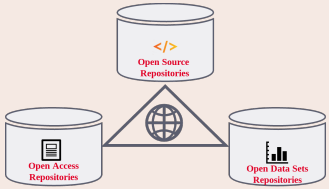

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Nota Bene

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

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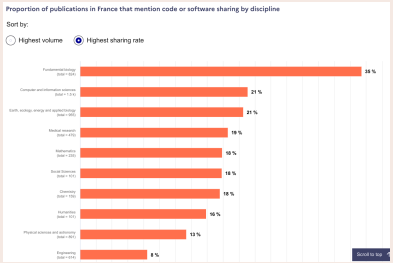

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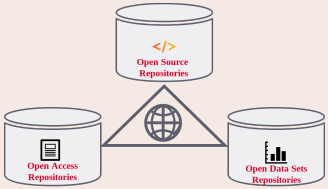

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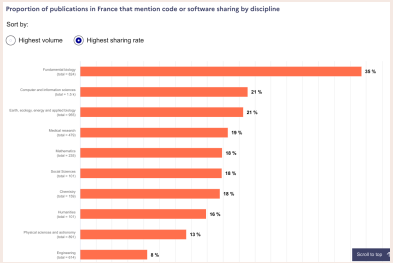

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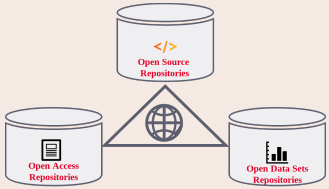

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Preserving (the history of) source code is necessary for *reproducibility*

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What is at stake

ARDC

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

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- Sustainability (legal, financial, etc.)
- Technology transfer
- Advanced technologies and tools (quality, traceability, etc.)

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Here we will focus on ARDC

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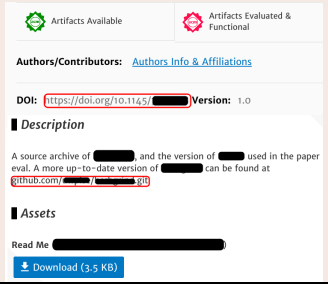

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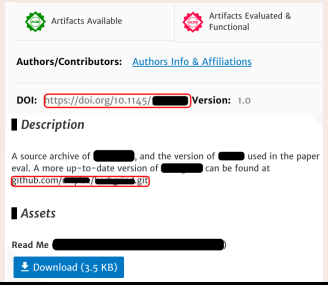

Can get no satisfaction…

A *Poor user experience*

B *No preservation guarantee*

C Can do *so much* better

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)

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

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Universal archive

preserve and share all software source code

Research infrastructure

enable analysis of all software source code

Sharing the vision

United Nations
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And many more ...
www.softwareheritage.org/support/testimonials

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Donors, members, sponsors

Inria

Diamond sponsor

Platinum sponsors

Gold sponsors

Silver sponsors

Bronze sponsors

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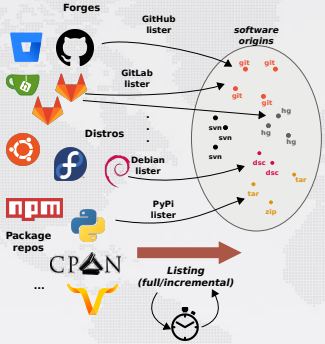
One infrastructure
open and shared

The largest archive ever built

Bitbucket	git	
2,012,133 origins	19,494 origins	21,486 origins
debian		GitHub
129,217 origins	6,424 origins	152,282,093 origins
GitLab	Guix	GNU
3,989,638 origins	12,451 origins	354 origins
heptapod	launchpad	Maven
1,096 origins	356,873 origins	93,710 origins
NixOS	npm	
12,451 origins	1,799,296 origins	4,083 origins
Phabricator	python	SOURCEFORGE
185 origins	427,135 origins	308,970 origins

Address common Open Science and Open Source needs: archival



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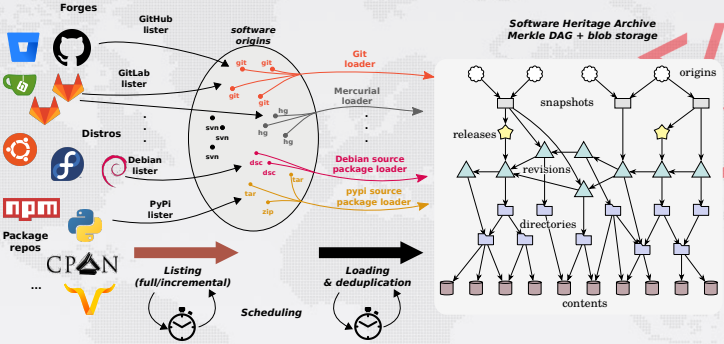

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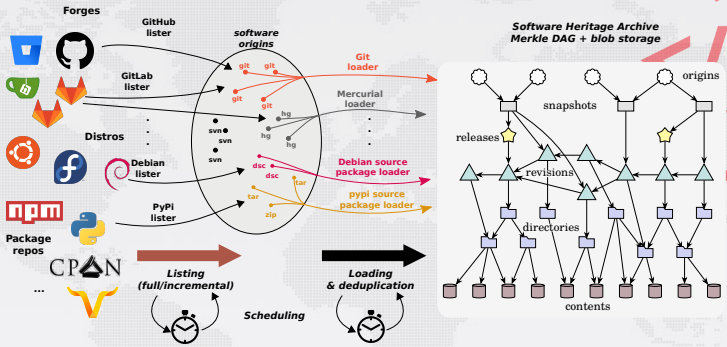


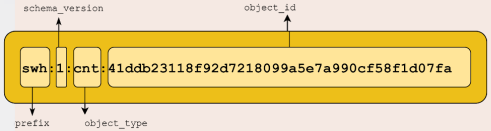
Global development history permanently archived in a uniform data model

- over 16 billion unique source files from over 260 million software projects
- ~1.5PB (compressed) blobs, ~35 B nodes, ~500 B edges

Address common Open Science and Open Source needs: reference

Software Heritage Identifiers (SWHID)

link to full docs



35+B
intrinsic,
decentralised,
cryptographic

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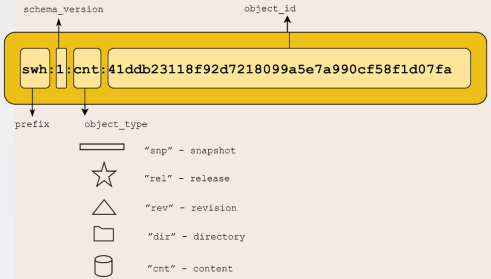

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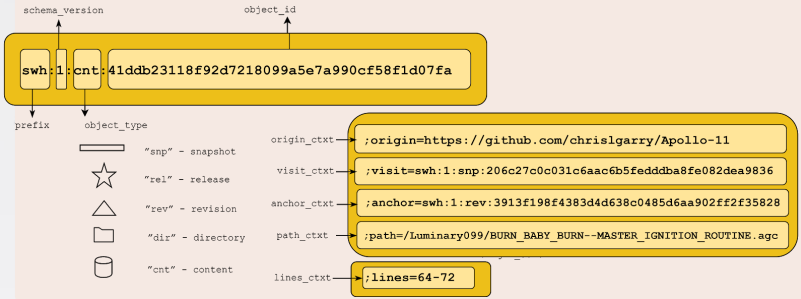

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Full fledged *source code references* for traceability, integrity and reproducibility

- Linux Foundation SPDX 2.2
- IANA-registered "swh:"
- WikiData property P6138

Examples: Apollo 11 AGC excerpt, Quake III rsqrt
Guidelines available, see the HOWTO

Breaking news: standardisation, see swhid.org

Outline

A walkthrough

- Browse and Reference (e.g. Apollo 11 [excerpt], your work may be already there !)
- Trigger archival, use the updateswh browser extension, configure the webhooks
- Cite with biblatex-software (CTAN, Overleaf ACMART template)
- Describe with Codemeta (use codemeta generator)
- Curated deposit in SWH via HAL, see for example: LinBox, SLALOM, Givaro, NS2DDV, SumGra, Coq proof, ...
- Extracting all the software products for Inria, for CNRS, for CNES, for LIRMM or for Rémi Gribonval using HalTools
- Example with Parmap: devel on Github, archive in SWH, curated deposit in HAL
- Example research articles:
  - compare Fig. 1 and conclusions in the 2012 version and the updated version
  - SWHID in a replication experiment

Outline

Calling for preservation: UNESCO

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

.6 November 2018

UNESCO, Inria, Software Heritage invite

40 international experts meet in Paris …

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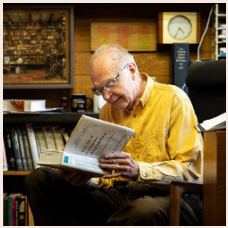
"[We call to] support efforts to gather and preserve the artifacts and narratives of the history of computing, while the earlier creators are still alive"

https://en.unesco.org/foss/paris-call-software-source-code

Calling for preservation: Donald Knuth and Len Shustek

Communications of the ACM, February 2021



"Telling historical stories is the best way to teach. It's much easier to understand something if you know the threads it is connected to."

Let's Not Dumb Down the History of Computer Science
Donald E. Knuth, Len Shustek
https://doi.org/10.1145/3442377

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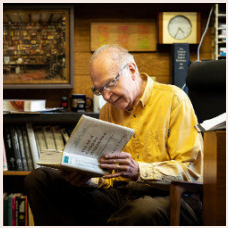

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A unique opportunity

most of the creators are still here: we can talk to them!

but the clock is ticking…

Paris Call on Software Source Code

"[We call to] support efforts to gather and preserve the artifacts and narratives of the history of computing, while the earlier creators are still alive"

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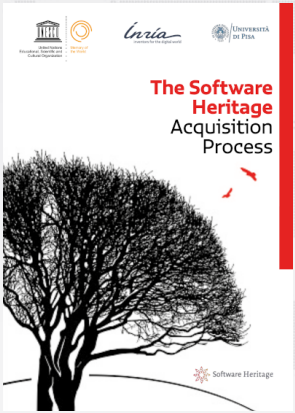

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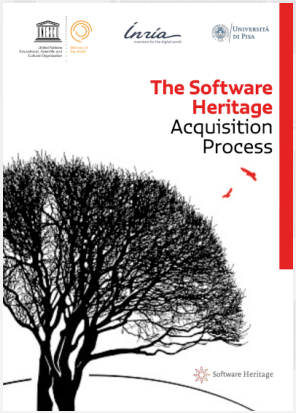

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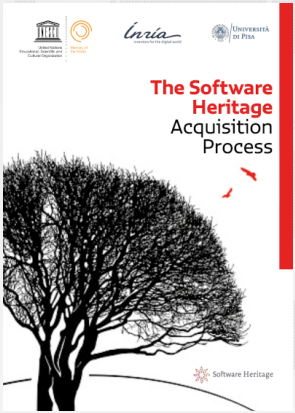

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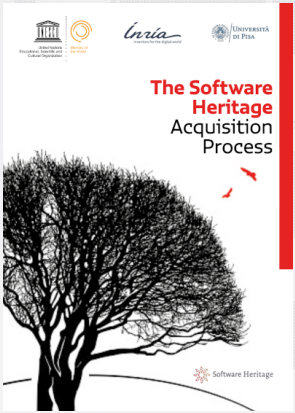

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- And illustrate with dedicated presentations

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see this live on the Software Stories website, and get *the guide*

Outline

Hold your breath!

- large scale *compression* of the archive
- large scale, efficient, *search* in the archive
- … and much more

Outline

Software Heritage: a shared open infrastructure

Software Heritage offers

- archival of all public source code
- reference of all public source code
- sharing cost with other partners
- standards based approach

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- born and based in the EU

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A growing and active community

Team

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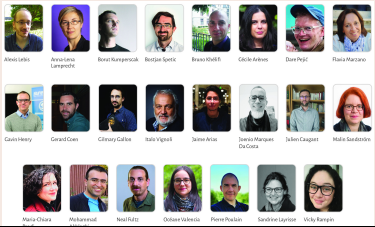
Ambassadors



A growing and active community

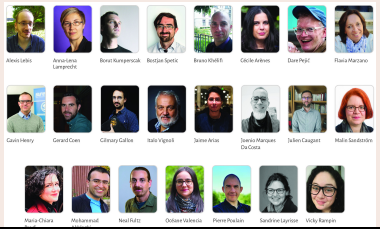
Team

Contributors to the platform

```
13:21:32    <seirl> from last time i ran it? it very likely is
13:21:47    <seirl> we had a x2 on the edges in a single year
13:23:14  <vlorentz> ah
13:53:44      <zack> seirl: I think i was remembering the LLP time on granet rather than the one (on the previous
                     graph) on the big mem telecom machine
13:54:01      <zack> wasn't it something like 10-14 days (on granet)?
13:55:11      <seirl> zack: it depends on the number of weights you use
13:55:23      <seirl> i had something like that to do the parameter sweep
13:55:31      <seirl> but then i settled on a few good gamma values
13:55:44      <seirl> and afterwards it was only ever ~3-4 days
14:02:57      <zack> ok
15:19:35    <jelmer> vlorentz: when is jenkins meant to kick in ? I didn't think the CI would mean you pasting test
                     results in comments :P
15:19:59    <jelmer> alternatively, I could try to get it working locally - for some reason tox doesn't run here,
                     complainining it can't find swh.scheduler
15:20:48  <vlorentz> jenkins is down until tomorrow evening (paris time)
15:20:59  <vlorentz> bad day for submitting your code :D
15:21:18  <vlorentz> er yeah I just fixed that issue
15:21:31  <vlorentz> but the fixed swh.scheduler is not pushed to pypi because jenkins
15:23:25    <jelmer> ah
15:23:40  <vlorentz> in the meantime, you can change apply this patch: https://gitlab.softwareheritage.org/-/
                     snippets/1546
15:23:44  <vlorentz> as an ugly workaround
15:24:13  <vlorentz> actually, just adding "pytest-postgresql < 4.0.0" should do it
15:25:00  <vlorentz> when jenkins is back online I'll push a new release of swh-scheduler without the missing
                     dependency on pytest-postgresql
```

Nicks: Alphare, ames, amj, amoeba, ar-jan, bchauvet[m], cmatrix[m], dan-, deesix, ericson2314, franckbret1, guerby, Guest92, haltode2, hplar, jayeshv, jelmer, KShivendu, landre[m], marmoute

Ambassadors



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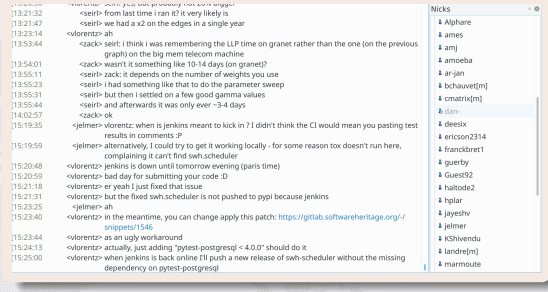

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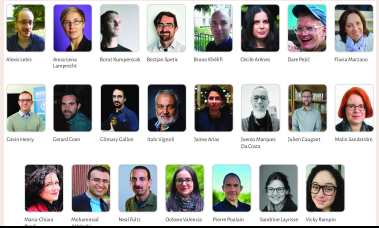


Awards

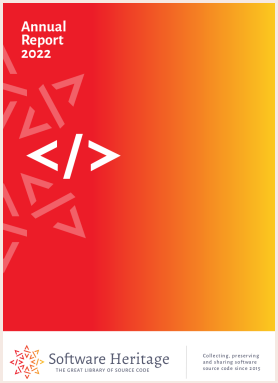
Antoine Pietri, best French PhD in Software Engineering **"Enabling Big Code analysis on a very large source code corpus"**. Awarded by the CNRS research working group GPL
https://theses.hal.science/tel-03515795v1

Stefano Zacchiroli with **Davide Rossi**. Google Award for Inclusion Research 2022, for the research project **"What Causes the Lack of Diversity in Open Source?"**.
https://research.google/outreach/aii-program/recipients/

Antoine Pietri with **Stefano Zacchiroli**. Award Best Dataset Paper: **"A Large-scale Dataset of (Open Source) License Text Variants"**.
https://arxiv.org/abs/2204.00256

Report and videos

Annual report



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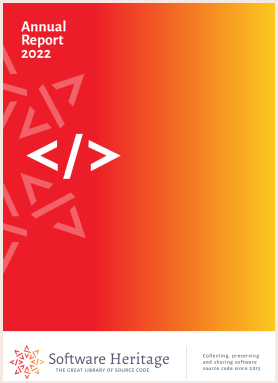

5 years in 5 minutes

Link

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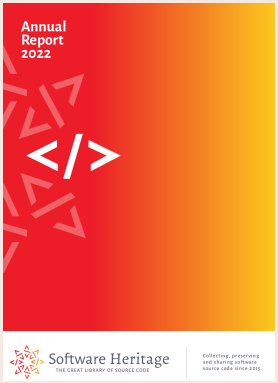

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Link

Evolution of our codebase

Link