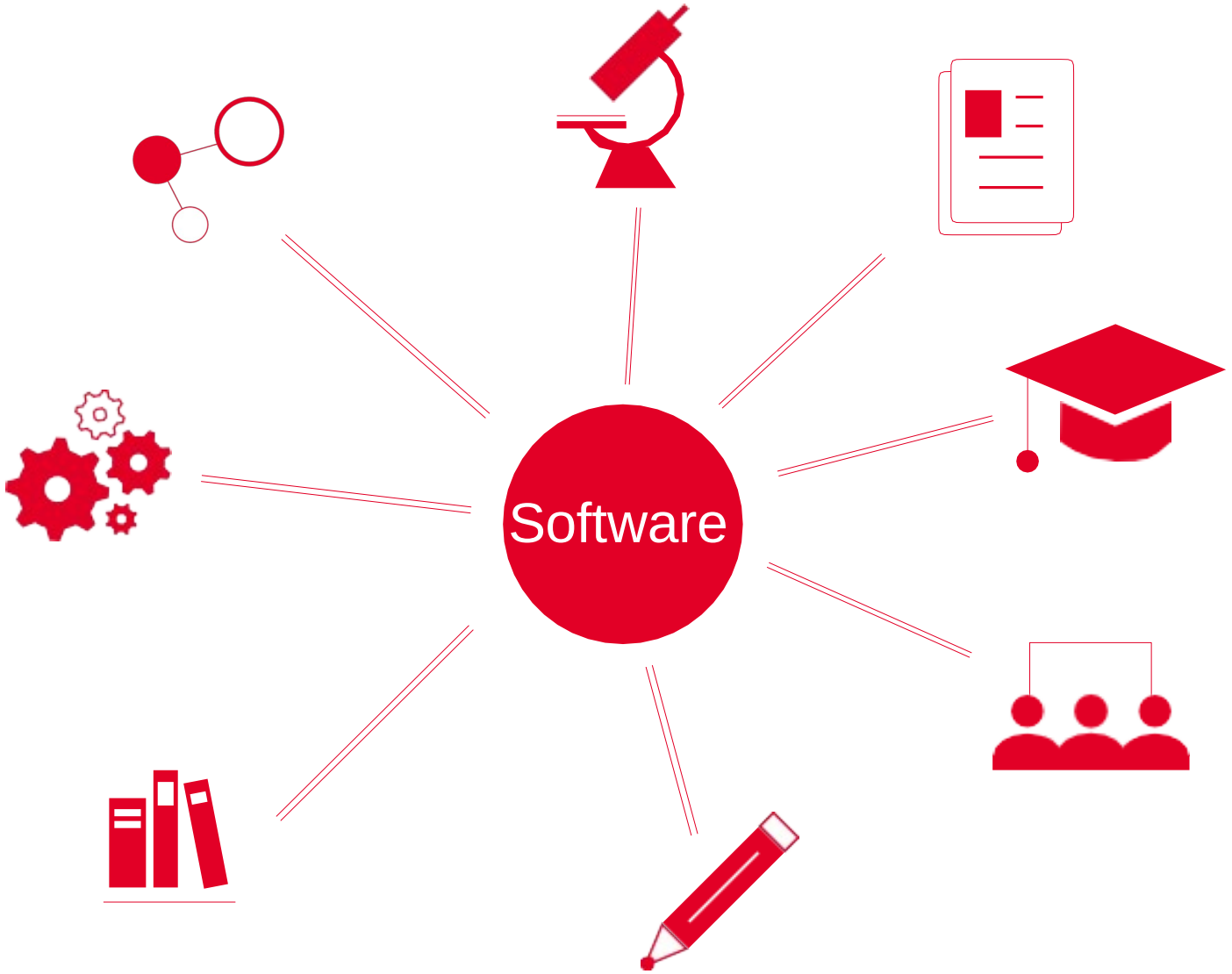
Software Heritage — Building the Software Pillar of Open Science

Stefano Zacchiroli

Télécom Paris
Institut Polytechnique de Paris

Software is everywhere



Software *Source Code*

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

Hello World

Program (excerpt of binary)	Program (source code)

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
	/* 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."

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."

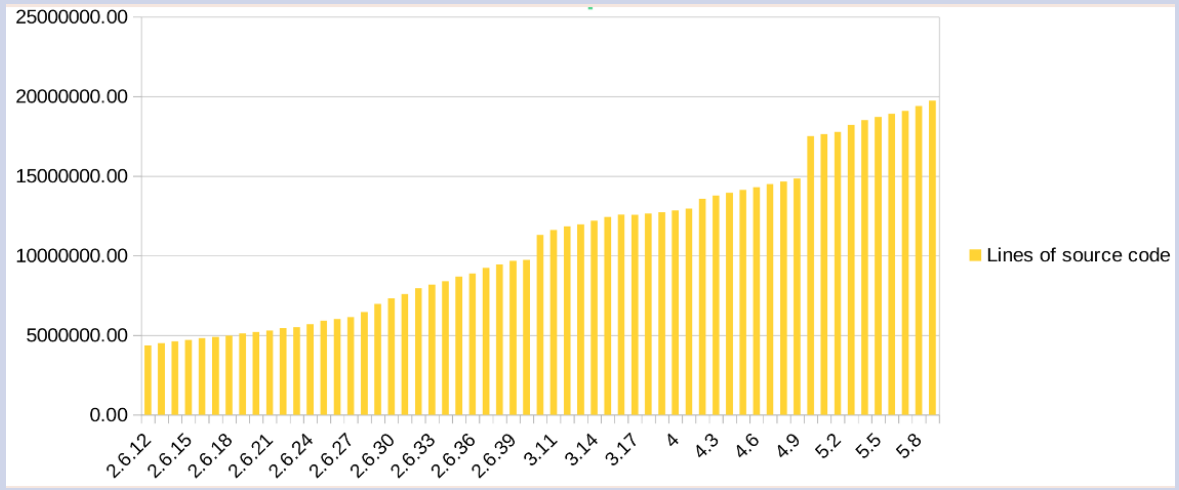
A lightning fast growth

Apollo 11 (~60.000 lines), 1969

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

Margaret Hamilton

Linux Kernel : 20 million lines. . .



. . . now in your pockets!

Open source software is eating the software world

tens of millions of developers collaborate on open source software worldwide today

Reuse is the new rule

80% to 90% of a new application is… just reuse! (Sonatype survey, 2017)

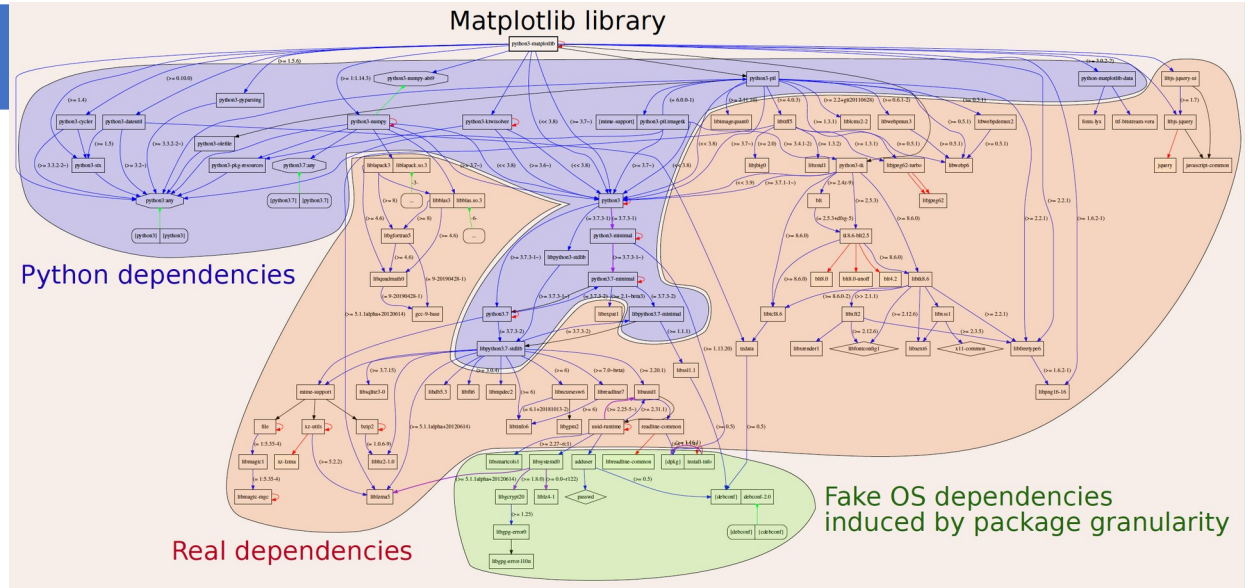
Source code is *special*: software is *not* data

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*



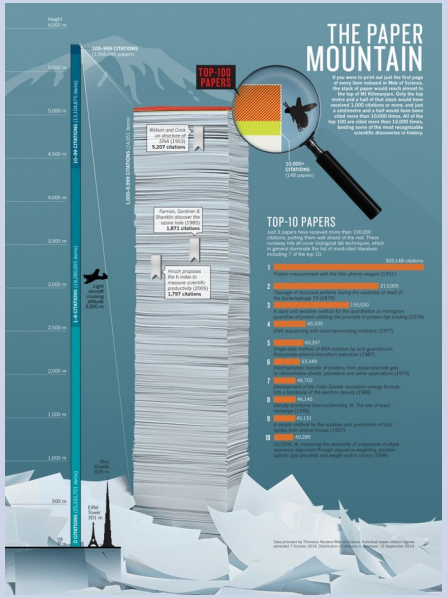
The human side

copyright law applies!

fruit of human ingenuity: design, algorithm, code, test, documentation, community, funding, and so many more facets…

A long overlooked pillar of Open Science

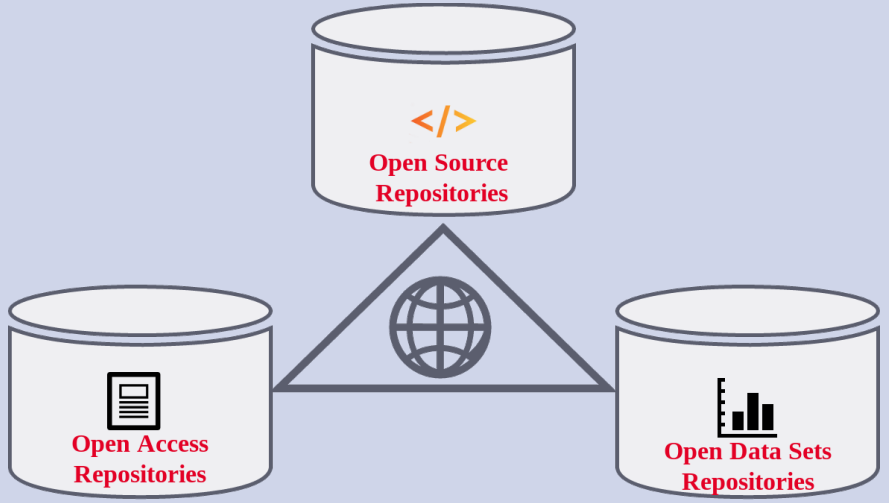
Software powers modern research



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

Sometimes, if you don't have the software, you don't have the data
Christine Borgman, Paris, 2018

Missing pillar: software (source code)



The links in the picture are *essential*

Software may be a **tool**, an **outcome** and a **research object**

Open source (open access to the source code) is necessary

- avoid reinventing the wheel, accelerate scientific discoveries
- **preserving source code** and its history is necessary for *reproducibility*

A plurality of needs

Researchers

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

Laboratories/teams

- **track** software contributions
- produce reports
- maintain webpage

Research Organization

know **its software assets**

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

What is at stake: ARDC in increasing order of difficulty

Archive

Research software artifacts must be properly **archived**

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

Reference

Research software artifacts must be properly **referenced**

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

Describe

Research software artifacts must be properly **described**

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

Cite/Credit

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

to give credit to authors *(evaluation!)*

Software Heritage in a nutshell

www.softwareheritage.org

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

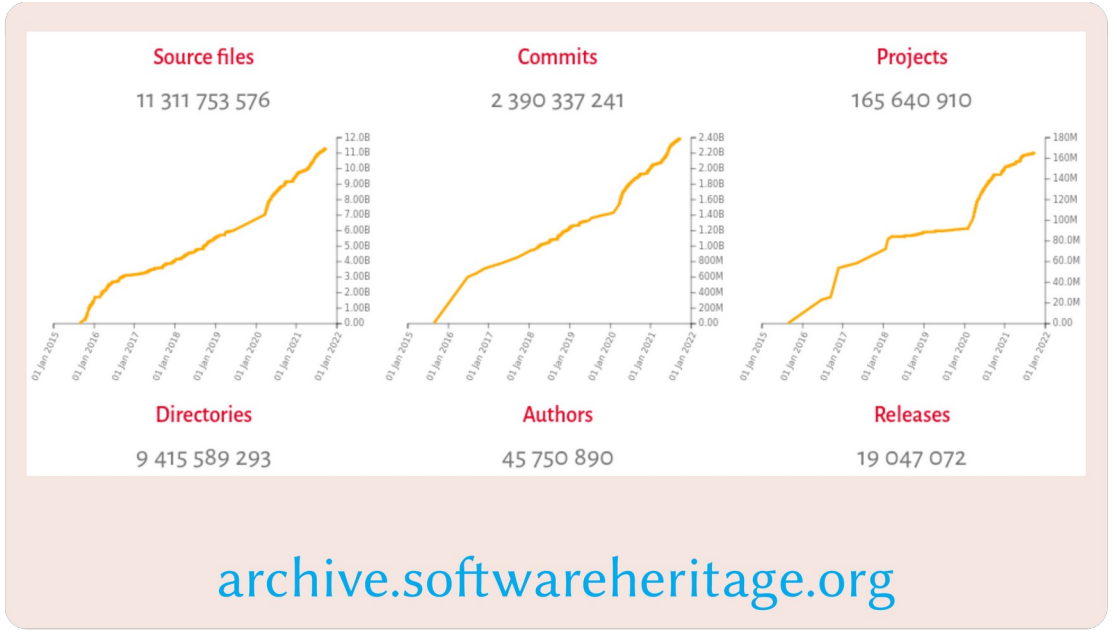
Universal archive

preserve all software source code

Research infrastructure

enable analysis of all software source code

The largest public source code archive, principled



archive.softwareheritage.org

Technology

- transparency and FOSS
- replicas all the way down

Content (billions!)

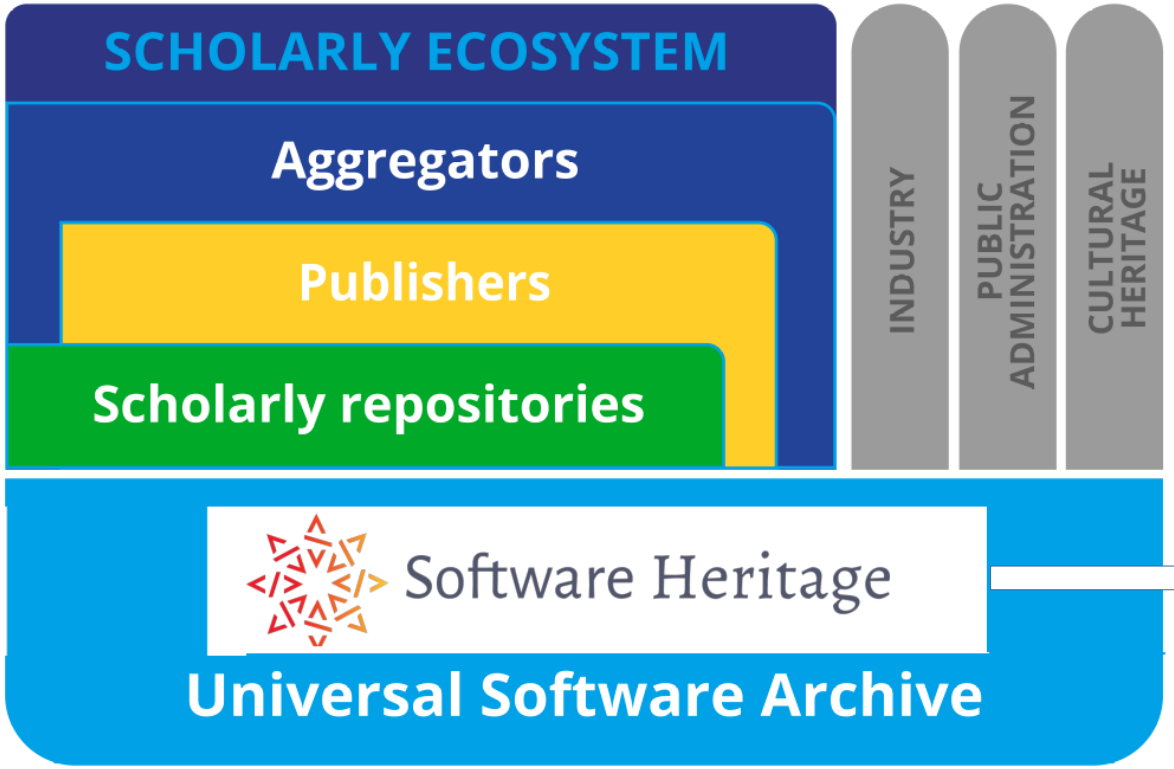
- intrinsic identifiers
- facts and provenance

Organization

- non-profit
- multi-stakeholder

The big picture (EOSC SIRS 2020 report)

Research Software Infrastructures: Overall Architecture

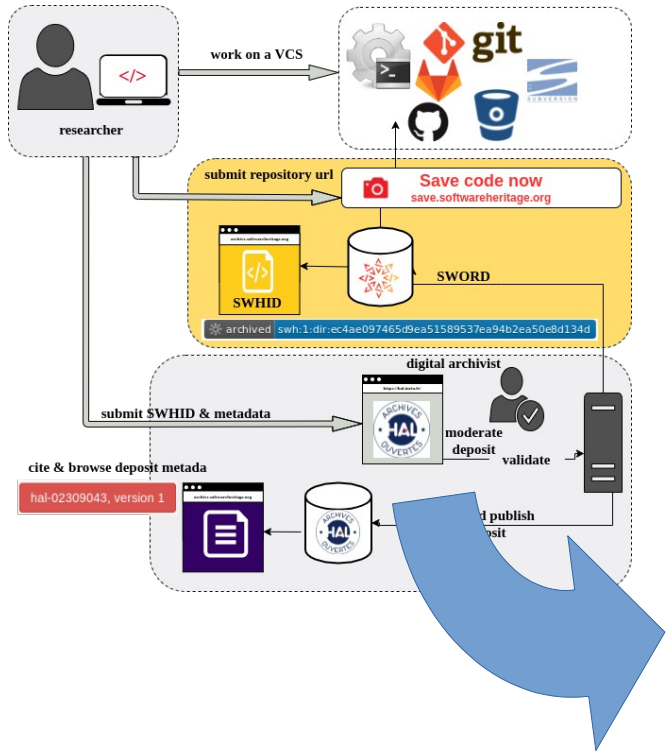


- **Scholarly ecosystem**
  - Aggregators collecting data from…
  - Academic publishers
  - Scholarly repositories

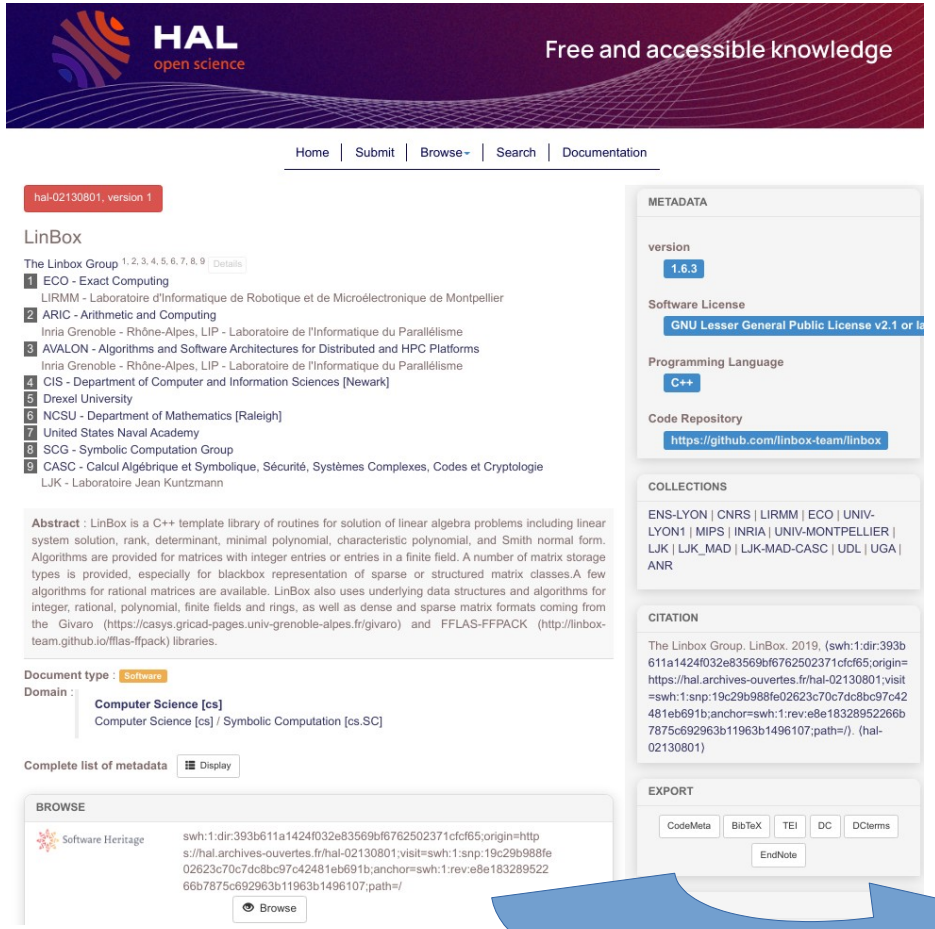
Key observations

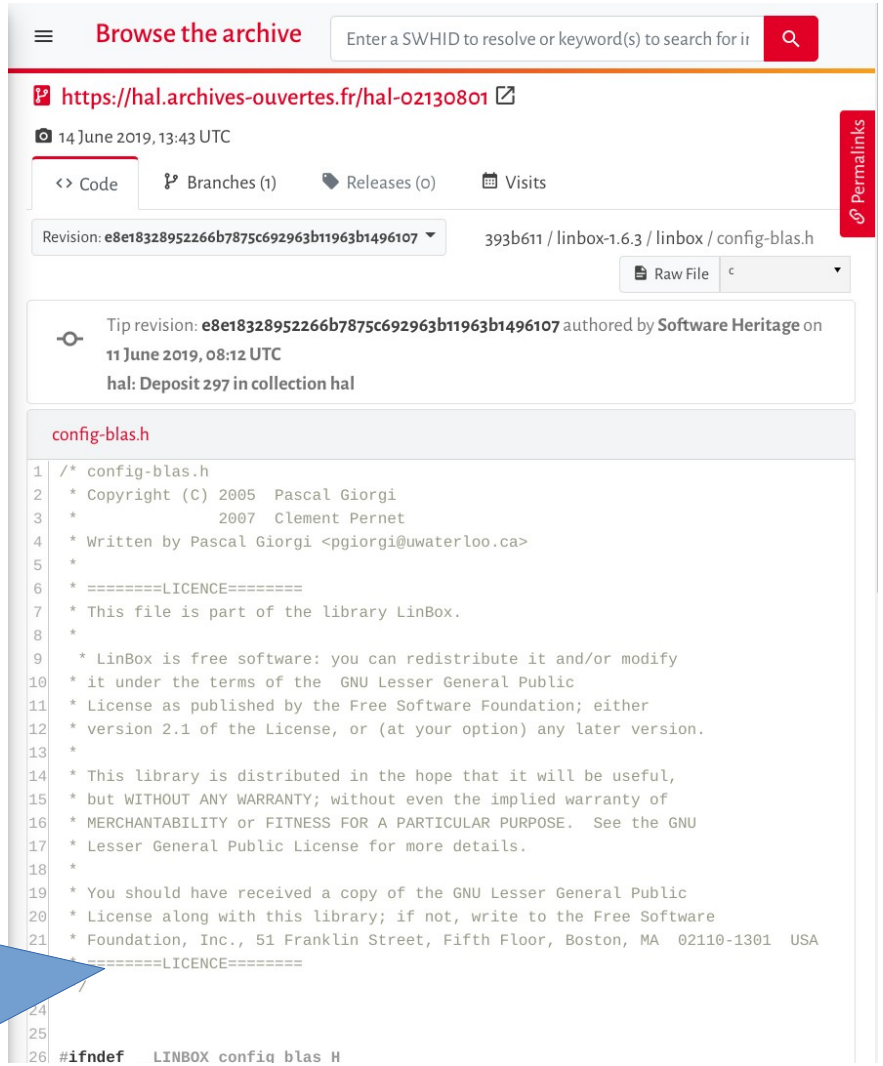
- One common layer for **archive and reference** shared with **all the software world**
- Added value in the scholarly ecosystem: **curation, citation and credit**

The HAL – Software Heritage success story



https://hal.archives-ouvertes.fr/hal-02130801





swh:1:dir:393b611a1424f032e83569bf6762502371cfcf65

What is needed

Policy for dissemination and reuse

- **Set the default to open source** for research software
- Open source **creates value** : adapt technology transfer and industry collaboration to it

Framework for evaluation and recognition

- Make software development count in a career (not the case in many countries)
- Avoid purely quantitative indicators

Sustainability

Technical improve quality of key research software

Organisational professional practices for governance and maintenance

Financial make open source research software as easy to fund as buying a license

Good news: awareness is raising

Paris Call on Software Source code (2019)

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

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

EOSC SIRS report (2020) and EOSC TF on infrastructures for research software

"all research software should be made available under an Open Source license by default, and all deviations from this default practice should be properly motivated »

See https://doi.org/10.2777/28598

UNESCO Open Science Recommendations (2021)

"Open science infrastructures should be organized and financed upon an essentially not-for-profit and long-term vision, which enhance open science practices and guarantee permanent and unrestricted access to all."

Focus on the French National plan for Open Science, 2021-2024

2nd National Plan for Open Science (6/7/2021)

Open and promote research software source code

- actions (selection)
  - charter for research software policy
  - recognize software development (see the 2021 prize)
  - coordinate communities of practice
  - build a connected ecosystem of research outputs
- recommendations (selection)
  - **Archive source code in Software Heritage**
  - **Standardize and use SWHID**
  - **Build a national catalog of research software**

See official announcement

Let’s build together the software pillar of open science

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

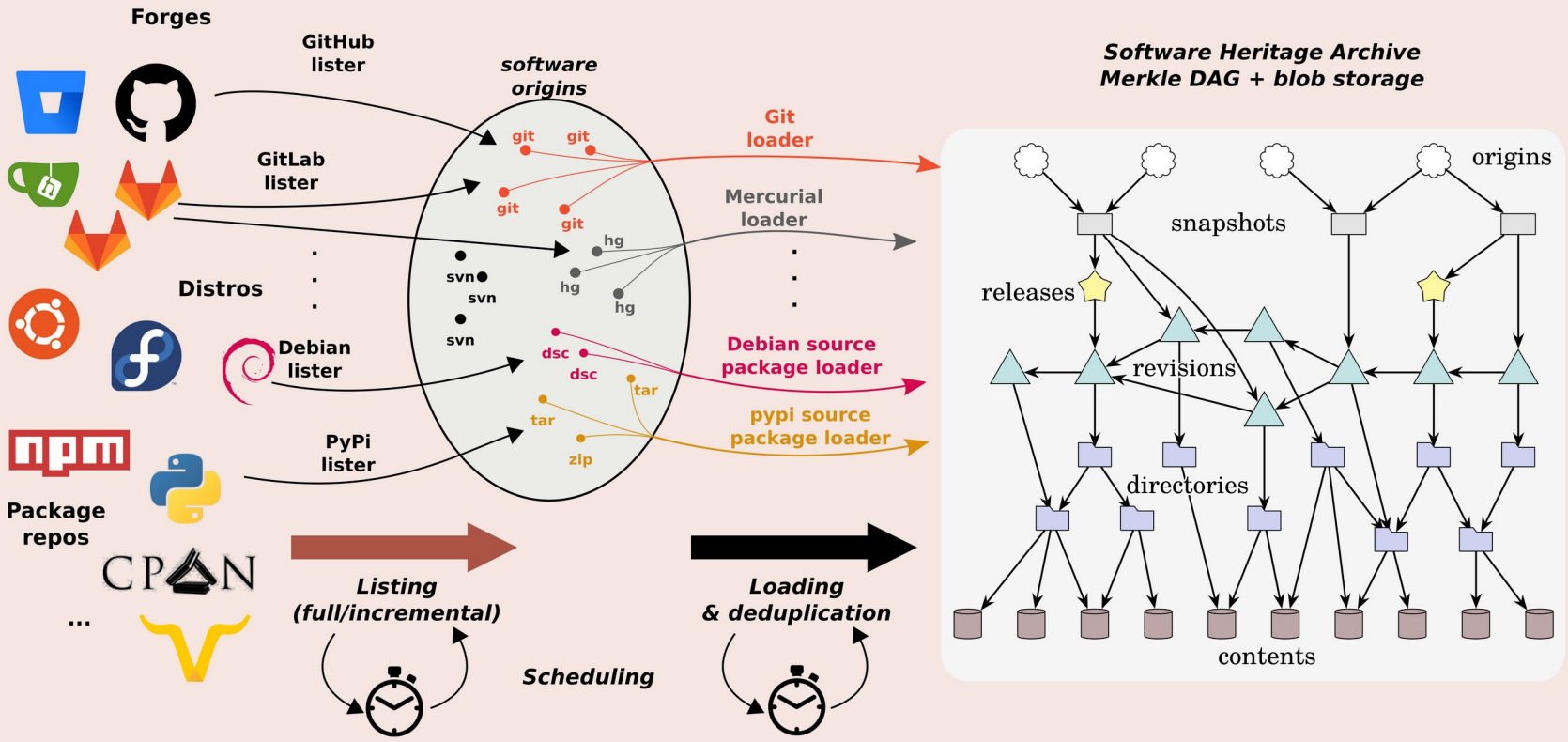
Questions

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)

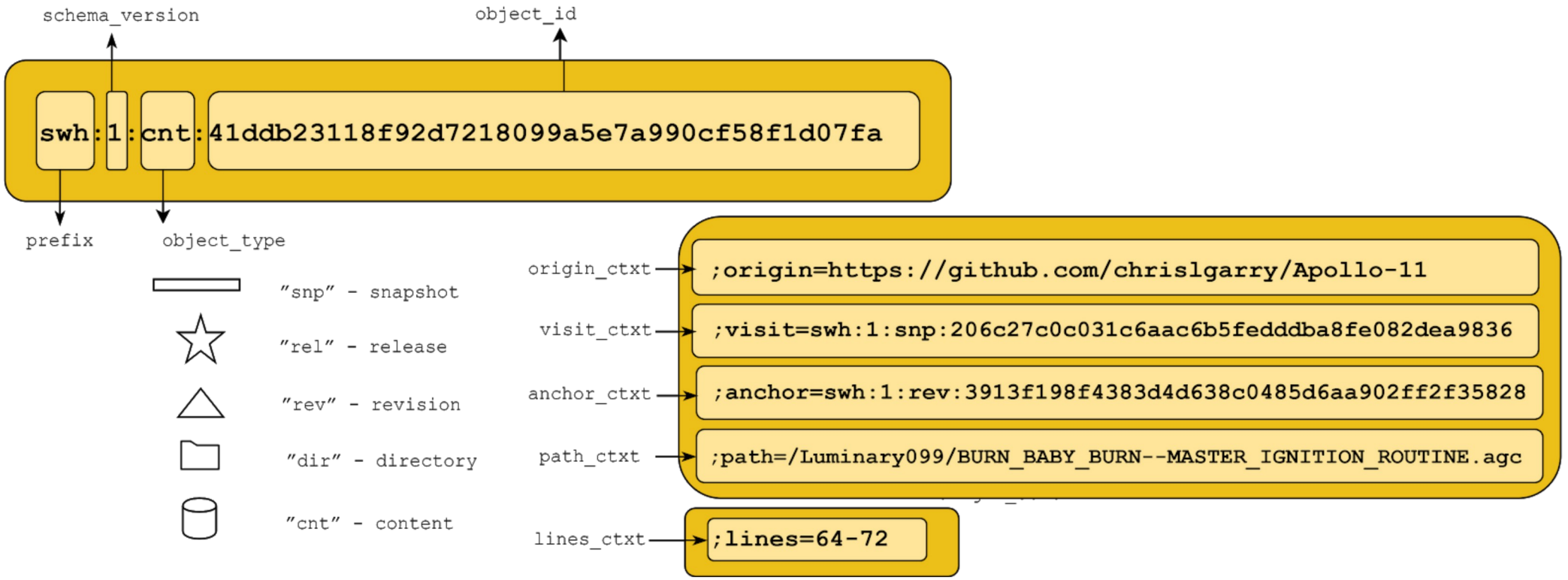
Appendix

A peek under the hood



A global graph linking together fully deduplicated source code artifact (files, commits, directories, releases, etc.) to the places that distribute them (e.g., Git repositories), providing a unified view on the entire *Software Commons*.
(Size: ~20 B nodes, ~200 B edges, ~900 TB blobs)

Software Heritage Identifiers (SWHIDs)



An emerging standard

- in Linux Foundation's SPDX 2.2
- IANA registered, WikiData property P6138

Examples:

- Apollo 11 AGC excerpt
- Quake III rsqrt

An international non-profit initiative

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