Ten years analysing large code bases: a perspective

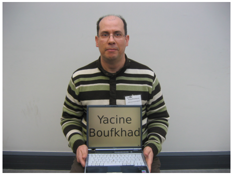
Roberto Di Cosmo
http://www.dicosmo.org

04/12/2015
EvoLille

Credits: joint work with...

Pietro Abate

Jaap Boender



Yacine Boufkhad

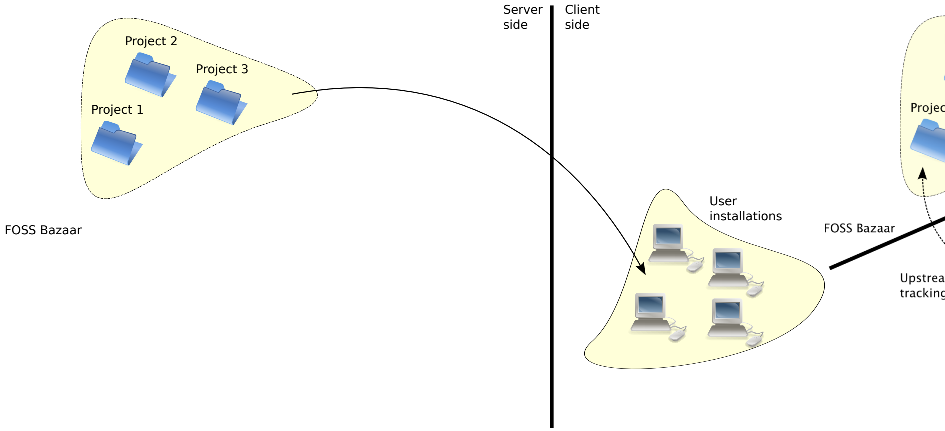
Stefano Zacchiroli

Ralf Treinen

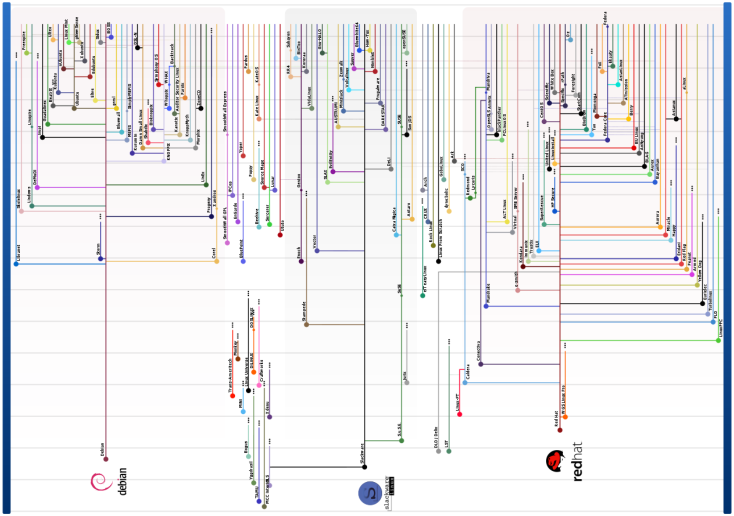
Jérôme Vouillon

Free Software, industrialised: distributions

Idea from FOSS in the 1990s: distributions are intermediate software vendors between FOSS developers and users, offering to share upstream tracking, integration, testing and QA among all of us



Distributions: a “somehow” successful idea …



Key notions: packages and package managers

Packages and their metadata

$$\text{Package} = \begin{cases} \text{some files} \\ \text{some scripts} \\ \text{metadata} \end{cases}$$

- Identification
- Inter-package rel.
  - Dependencies
  - Conflicts
- Feature declarations
- Other
  - Package maintainer
  - Textual descriptions
  - ...

Example (package metadata)

```
Package: aterm
Version: 0.4.2-11
Section: x11
Installed-Size: 280
Maintainer: Göran Weinholt ...
Architecture: i386
Depends: libc6 (>= 2.3.2.ds1-4),
  libice6 | xlibs (> 4.1.0), ...
Conflicts: suidmanager (< 0.50)
Provides: x-terminal-emulator
...
```

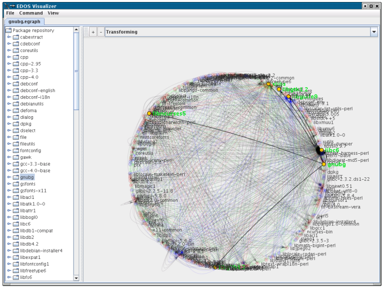
A package is the elemental component of modern distribution systems (not FOSS-specific). A working system is deployed by installing a package set (≈ 2'000+ for modern FOSS distros)

Inter-package relationships get complex…

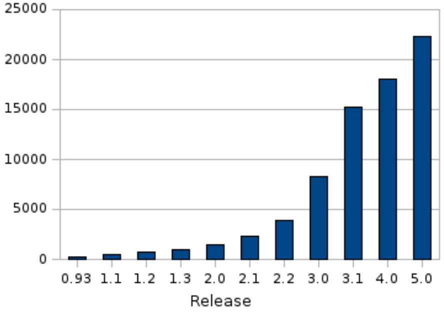
To play Backgammon…

```
Package: gnubg
Version: 0.14.3+20060923-4
Depends:  gnubg-data,  ttf-bitstream-
vera,  libartsc0  (>=  1.5.0-1),  . . . ,
libgl1-mesa-glx | libgl1, . . .
Conflicts: . . .
```

…pull a few strings



Distributions grow superlinearly



Using and maintaining such large software collections is becoming hard!

- ~~manual package review~~
- semi-automated tools

Using and maintaining free software distributions is hard

We need advanced tools:

1. end user side – package managers
   - install packages and their dependencies, ...
   - ...according to the user needs and policies
2. distribution editor side – QA infrastructure (our focus today)
   - find “broken” packages (now easy!)
   - find packages which impact large parts of the distribution
   - predict repository update woes
   - identify compatibility issues
   - ...

With a big boost from the Mancoosi project[1], we have made progress in both areas.

Let’s focus on the *distribution editor side*

[1] `http://www.mancoosi.org`

Ensuring Quality throughout evolution

The Quality Assurance team and the release manager need to track tens of thousands of packages, their bugs, their incompatibilities, etc. that change every day.

It is important to catch as many installation-related errors as possible before they hit the user and the BTS, and this requires automation.

Static analysis of package dependencies: the state of the art

- find packages that cannot be installed at all, and...
  - spot the ones that surely need to be fixed (know who to blame)
  - provide advance warning for future problems
- find the incompatibilities between packages
- show how these incompatibilities evolve
- automate package migration

QA 101: find *individually* broken packages

The installability problem

In a repository R, decide whether a package p can be installed in isolation

Theorem

The installability problem is NP complete (Di Cosmo et al. ASE 2006)

Solving tens of thousands of NP-complete problems?

In practice: recent SAT solvers handle current instances easily

- few explicit conflicts (without conflicts, just dual Horn clauses)

A practical tool

- `rpmcheck/debcheck` (*Vouillon, 2006*)
  - finds all broken packages and provides short explanations
  - fast: analyses $\approx 40'000$ (binary) packages in minutes
- In `dose3` library as `distcheck`, by Pietro Abate et al.
- Extensively used (*Abate, Di Cosmo et al. MSR 2015*)

QA 101, level 2: what can we say about the future?

Definition (outdated packages)

p is outdated if *p* is not installable, and it remains uninstallable no matter how the *other* packages evolve *(i.e. p's maintainer has no excuses)*

Definition (challengers)

p challenges *q* if upgrading *p* "forces" to upgrade *q*

What they have in common:

- properties that hold in *all* installations of *any* future evolution of the repository
- seems unfeasible, but *we can efficiently decide* some properties of this kind

Abate, Di Cosmo, Treinen, Zacchiroli
Learning from the Future of Component Repositories
CBSE 2012. *Best paper award*

Tools in the *dose* library now used in `qa.debian.org/dose`

QA 201: Package Co-Installability

Next step: interaction between packages

> Example: is there any package which cannot be installed together with `iceweasel`? with `kde-full`?

Definition: a set of packages are *co-installable* if they can be installed together.

- all packages *should be* installable (individually!)
- *some* package incompatibilities *are expected*

Can we *summarise* all incompatibility issues, and avoid browsing through hundreds of hyperlinked pages?

Coinst

A simplification theory for repositories, based on the extraction of a co-installability kernel, i.e. a repository much smaller than the original but equivalent wrt co-installability.

Highlights:

- reflexive/transitive dependency closure
- equivalent classes and quotients
- machine-checked proofs (in Coq!)

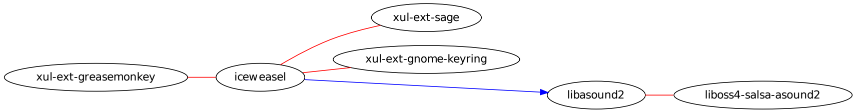
In a word: tough maths at work!

A tool: coinst (packaged in Debian)

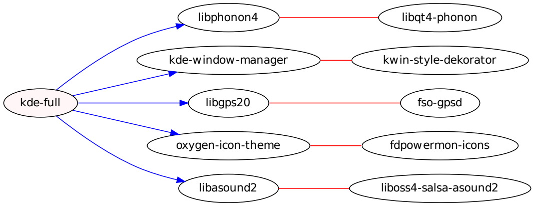
Vouillon, Di Cosmo
On Software Components Co-Installability
ESEC/FSE 2011: Foundations of Software Engineering.
Best Artifact Award.

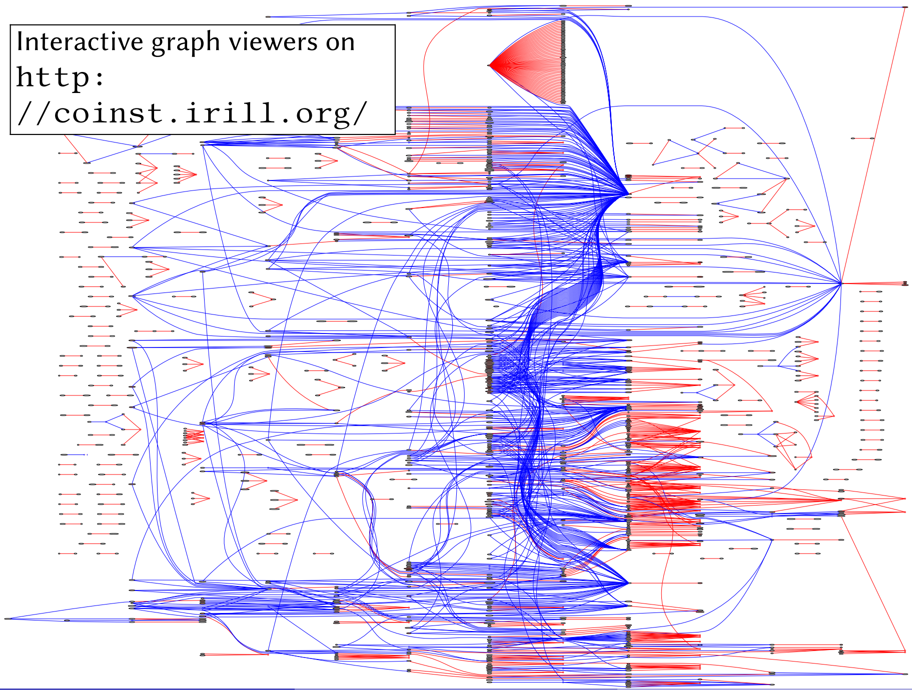
Co-Installability Graphs

```
coinst -root iceweasel -o graph.dot Packages_i386
```



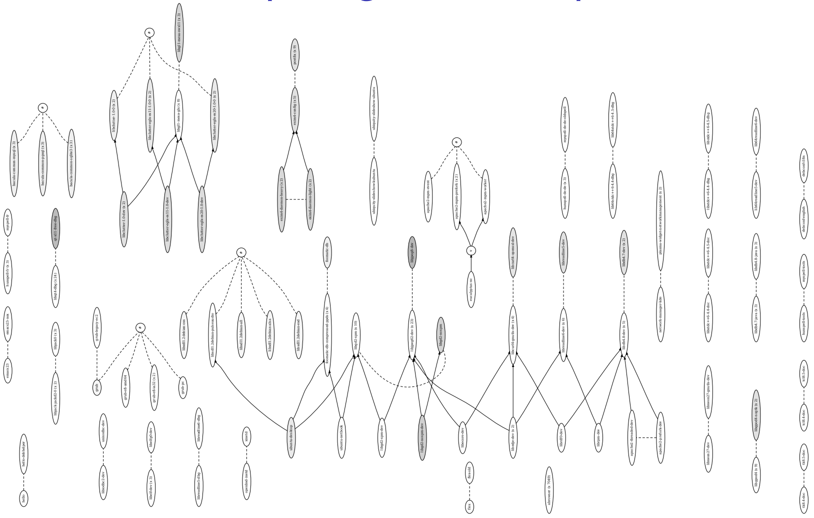
```
coinst -root kde-full -o graph.dot Packages_i386
```





Interactive graph viewers on `http://coinst.irill.org/`

Ubuntu main: 7'000 packages, 31'000 dependencies



http://coinst.irill.org

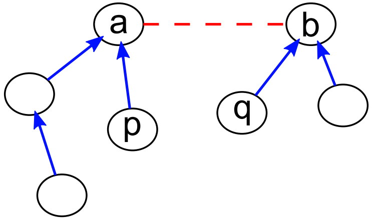
Running time: less than 10 seconds!

QA 301: New Co-Installability Issues

Compare two versions of a repository

- New issues are more likely to be bugs
- Can report *precisely* what changes caused an issue

Example



Many new issues between packages p and q due to a *single* new conflict between packages a and b.

Vouillon, Di Cosmo
Broken Sets in Software Repository Evolution
ICSE 2013

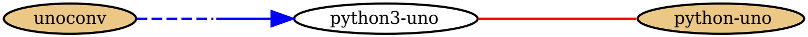
Finding New Co-Installability Issues

Tool `coinst-upgrades`

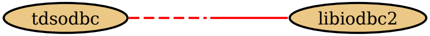
`http://coinst.irill.org/upgrades`

- graphs illustrating each new issue
- context: other packages involved, package popularities (popcon)

The *new* version of `unoconv` depends on *any* version of `python3-uno`

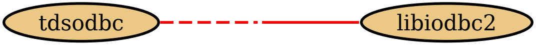


The *new* version of `tdsodbc` conflicts with *any* version of `libiodbc2`



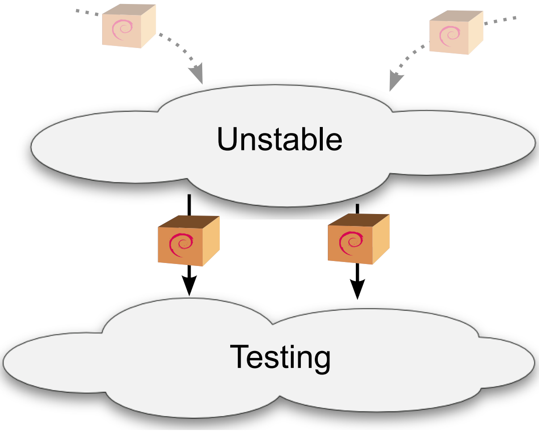
Package `libiodbc2` had been unmaintained for years
Should not be a big issue if it gets removed, right?

Context is Crucial



Depend on `libiodbc2` (about 380 packages): kcolorchooser, kdesdk-misc, kdevelop-php-docs, blinken, kdevelop, kmousetool, ktorrent, kalgebra, konqueror, klipper, kchmviewer, mplayerthumbs, libsmokekutils3, kjots, ksshaskpass, cantor, network-manager-kde, kbattleship, choqok, kdesdk-dbg, krusader-dbg, libkdegames-dev, kmidimon, klettres, quassel-kde4, libakonadi-ruby, konq-plugins, ktorrent-dbg, kiriki, plasma-widgets-workspace, kvirc-dbg, konversation-dbg, libkiten-dev, kdm-gdmcompat, plasma-netbook, libokular-ruby1.8, eqonomize, kdenetwork-dbg, libsmokeplasma3, kspread, lokalize, korganizer, parley, kfourinline, libsmokekde-dev, kfind, kdepim-groupware, ksnapshot, libiodbc2-dev, plasma-runners-addons, libsmokekdeui4-3, printer-applet, ark, kdeutils, kover, rocs, kdesvn-dbg, kdevplatform-dev, libkdepim4, ktron, cantor-backend-sage, kinfocenter, …

QA 501: package migration



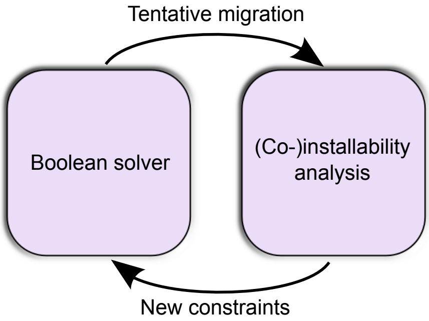
Conflicting goals

- package should reach *testing* rapidly
- keep *testing* as stable as possible

The *comigrate* tool

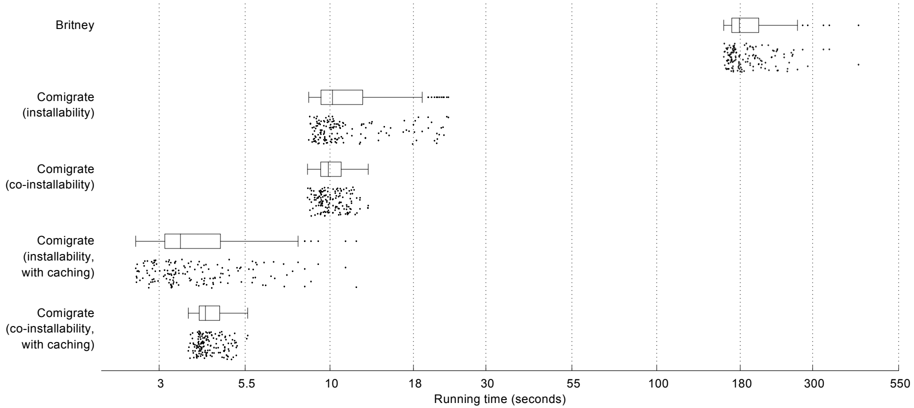
- Supplement/Replace Britney
  Generate hints that can be fed to Britney
- Interactively investigate migration issues
  Run it repeatedly, studying different scenarios
- Report of issues preventing package migration
  `http://coinst.irill.org/report/`

Tool Core: Computing Package Migrations



- Start with simple constraints
- The Boolean solver generates a tentative migration
- Check for (co-)installability issues; analyse these issues to generate new constraints (“package A cannot migrate”, or “package A cannot migrate without package B”)
- Repeat until no more issue is found

Performance



Data collected twice a day from 2013-06-24 to 2013-09-09

Missing datapoints: Britney can take more than 24 hours (Perl transition)....

Bibliography and tools excerpts

Di Cosmo, Leroy, Treinen, Vouillon et al
Managing the complexity of large free and open source package-based software distributions.
ASE 2006: Automated Software Engineering.

Di Cosmo and J. Vouillon.
On software component co-installability.
In *ESEC/FSE 2011.*

Abate, Di Cosmo, Treinen, Zacchiroli
Learning from the Future of Component Repositories
CBSE 2012: Component Based Software Engineering.

Vouillon, Dogguy, Di Cosmo.
Easing software component repository evolution.
ICSE 2014.

Abate, Di Cosmo, Gesbert, Le Fessant, Treinen, and Zacchiroli.
Mining component repositories for installability issues.
MSR 2015

Claes, Mens, Di Cosmo, and Vouillon.
A historical analysis of debian package incompatibilities.
MSR 2015

Tools

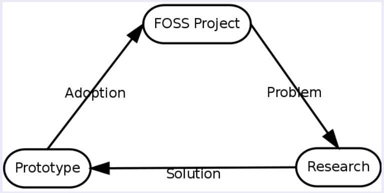
- Cudf library: `http://gforge.inria.fr/projects/cudf/`
- Dose library: `http://gforge.inria.fr/projects/dose/`
- Coinst suite: `http://coinst.irill.org`
- Debian QA: `http://qa.debian.org/dose`

A recurring pattern

In all examples above

- identify a real world problem whose solution requires a research effort
- work hard to find a solution
- implement a tool, validate it on real world cases
- publish a research article
- foster adoption (the hardest part!)

In a picture



Under the hood

Question:

What were the *technical* prerequisites that made this work possible?

Technical prerequisites

Availability

- all the (history of) Debian packages (after 2005)
- no *technical* restrictions
- no *legal* restrictions on content or metadata

Traceability

Debian packages have

- *unique identifier*
- *reference central repository*

Uniformity

Debian packages: a central catalog with

- *uniform metadata structure*
- *uniform naming and versioning schema*

These are all essential features for *reproducibility* and for *preservation*...

... we need them for *all* software!

Availability: software is *fragile*

damage
disaster
malicious
obsolete
deletion
reference
storage
media
aging
attack
tear
dependencies
dangling
wear
corruption
encryption
format

An example is worth a thousand words…

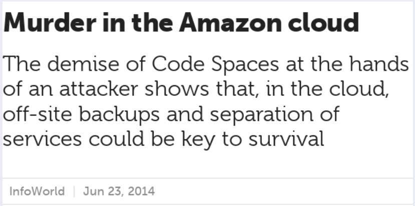
let's see a few

Inconsiderate or malicious loss of code

The Year 2000 Bug … uncovered an inconvenient truth

in 1999, an estimated 40% of companies had either *lost*, or thrown away the original source code for their systems!

CodeSpaces: source code hosting, 2007-2014



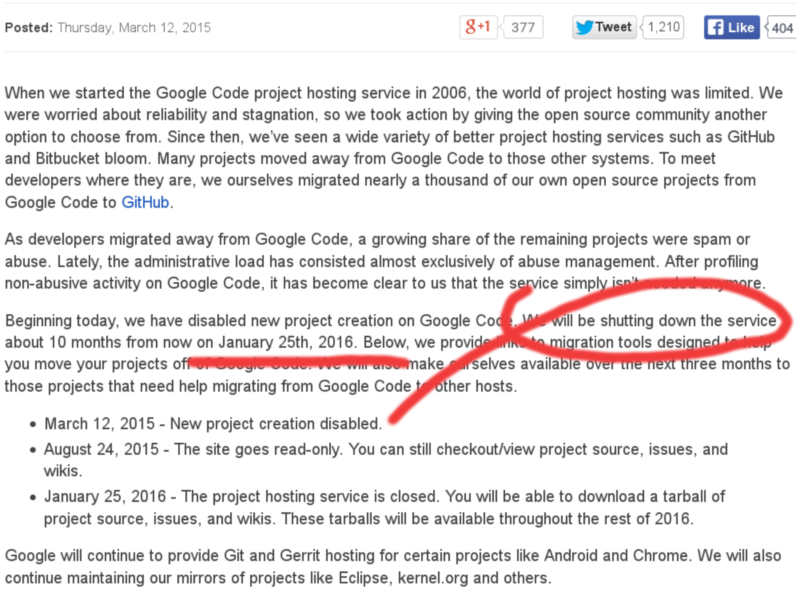
Murder in the Amazon cloud

The demise of Code Spaces at the hands of an attacker shows that, in the cloud, off-site backups and separation of services could be key to survival

InfoWorld | Jun 23, 2014

Yes, for *seven years* all seemed ok.
No, they did not recover the data.

Business-driven loss of code support: Google



Posted: Thursday, March 12, 2015

When we started the Google Code project hosting service in 2006, the world of project hosting was limited. We were worried about reliability and stagnation, so we took action by giving the open source community another option to choose from. Since then, we've seen a wide variety of better project hosting services such as GitHub and Bitbucket bloom. Many projects moved away from Google Code to those other systems. To meet developers where they are, we ourselves migrated nearly a thousand of our own open source projects from Google Code to GitHub.

As developers migrated away from Google Code, a growing share of the remaining projects were spam or abuse. Lately, the administrative load has consisted almost exclusively of abuse management. After profiling non-abusive activity on Google Code, it has become clear to us that the service simply isn't needed anymore.

Beginning today, we have disabled new project creation on Google Code. We will be shutting down the service about 10 months from now on January 25th, 2016. Below, we provide links to migration tools designed to help you move your projects off of Google Code. We will also make ourselves available over the next three months to those projects that need help migrating from Google Code to other hosts.

- March 12, 2015 - New project creation disabled.
- August 24, 2015 - The site goes read-only. You can still checkout/view project source, issues, and wikis.
- January 25, 2016 - The project hosting service is closed. You will be able to download a tarball of project source, issues, and wikis. These tarballs will be available throughout the rest of 2016.

Google will continue to provide Git and Gerrit hosting for certain projects like Android and Chrome. We will also continue maintaining our mirrors of projects like Eclipse, kernel.org and others.

Business-driven loss of code support: Gitorious

```
From: Rolf Bjaanes <rolf@gitorious.org>
To: zack@upsilon.cc
Subject: Gitorious.org is dead, long live Gitorious.
Message-Id: <30589491.20150416155909.552fdc4d164758
```

Hi zacchiro,

I'm Rolf Bjaanes, CEO of Gitorious, and you are receiving this email because you have a user on gitorious.org. As you may know, Gitorious was acquired by GitLab [1] about a month ago *(NDLR: 3/3/2015)*, and we announced that Gitorious.org would be shutting down at the end of May, 2015.
... Rolf

Traceability: disruption of the *web of reference*

Web links *are not* permanent (even *permalinks*)}

there is no general guarantee that a URL… which at one time points to a given object continues to do so
T. Berners-Lee et al. Uniform Resource Locators. RFC 1738.

404

URLs used in articles *decay*!

Analysis of *IEEE Computer* (Computer), and the *Communications of the ACM* (CACM): 1995-1999

- the *half-life* of a referenced URL *is approximately 4 years* from its publication date D. Spinellis. The Decay and Failures of URL References.
  Communications of the ACM, 46(1):71-77, January 2003.

Uniformity: nowhere to be seen

Reference repositor(ies)

- Bitbucket
- GitHub
- Gitorious (no, scratch this)
- Google Code (no, scratch this)
- Maven
- Sourceforge
- your institution's forge
- your home page
- ...

And they are all diffent / incompatible

The Software Heritage Project

Software Heritage
PRESERVING TECHNICAL KNOWLEDGE

Our mission

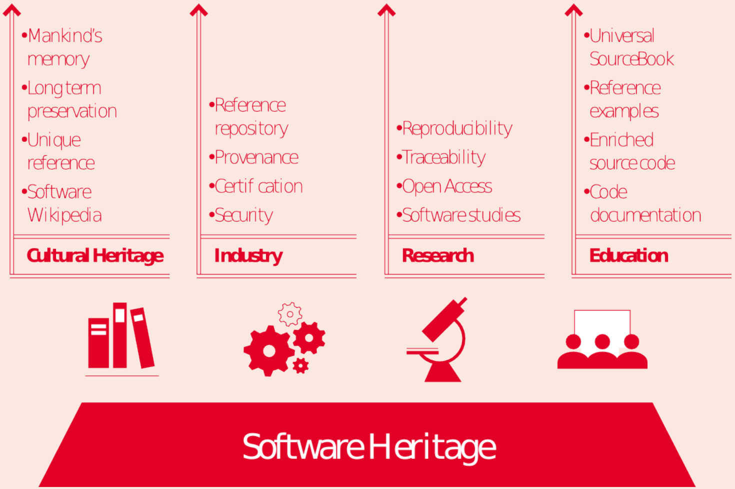
Collect, *organise*, *preserve* and *share all the software* that lies at the heart of our culture and our society.

Provides exactly

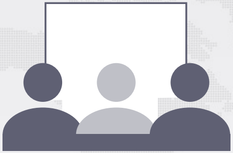
- availability
- traceability
- uniformity

We are working on the foundations

one infrastructure to build them all



Fostering wider education to computing



A global source referencing all software

- a *SourceBook* for technological *education*
- intrinsic persistent identifiers for stable course materials
- extensive access to real-world documentation

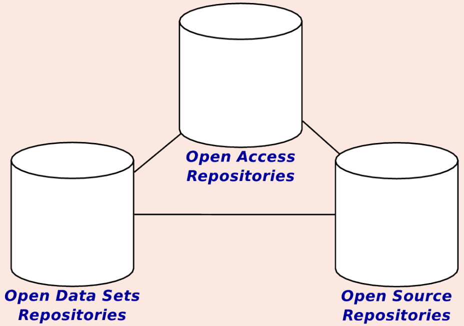
Supporting more accessible and reproducible Science

A global library referencing all software used in all research fields

- completes the infrastructure for Open Access in Science
- provides intrinsic persistent identifiers needed for scientific reproducibility
- enables large scale, verifiable Software Studies

The Knowledge Conservancy Magic Triangle

The Knowledge Conservancy Magic Triangle



Legenda (links are important!)

- articles: ArXiv, HAL, ...
- data: Zenodo, ...
- software: *Software Heritage* tackles this

Need your help

make it easy to integrate your work

- development workflow
- publication workflow
- contribute importers

make it ok to integrate, from the legal point of view

- make licences explicit
- make licences of dependencies explicit

make it useful for research

- contribute to the API

help us make Software Heritage sustainable

- support/sponsorship
- open process and collaboration

Focus on the legal issues

a plurality of concerns

Who owns the rights to your research?

- articles, data, software
- too often forgotten: metadata
    - Software Track in Science of Computer Programming, 2015
    - You own the software, but who owns the metadata?

we need to recover our rigths

- it is possible!
    - compulsory exclusive copyright transfer for free
        - is *illegal* in France (art L. 131-4 of CPI)
        - is debatable in all jurisdictions
- see Free Scientific Publication
- paying the editors (OpenAire) is *not a solution*

Questions

Questions?

Subscribe to

mailing list: swh-science@inria.fr
`https://sympa.inria.fr/sympa/info/swh-science`