Preserving Software

Challenges and opportunities for reproductibility

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Journée Reproductibilité

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Reproducibility

Reproducibility (Wikipedia)

the ability of an entire experiment or study to be *reproduced*, either by the researcher or *by someone else working independently*. It is one of the main principles of the scientific method.

Reproducibility in the digital age

For an experiment involving software, we need

open access to the scientific article describing it

open data sets used in the experiment

source code of all the components

environment of execution

stable references between all this

The first two items are already widely discussed!

Why Open Source?

Some people claim that having (all) the source of the code used in an experiment is *not worth the effort* [1].
Sure, diversity *is* important, but consider that:

- source code is like the proof used in a theorem: can we really accept *Fermat statements* like "the details are omitted due to lack of space"?
- and even more so when the complexity of modern systems makes even the simplest experiment depend on a wealth of components and configuration options?

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- having access to all the source code is not just necessary to *reproduce*, it is also useful to *evolve and modify*, to *build new experiments* from the old ones

[1] "Replicability is not Reproducibility: Nor is it Good Science", Chris Drummond, ICML 2009

Digital preservation

Digital Preservation (Wikipedia)

In library and archival science, digital preservation is a *formal endeavor* to ensure that digital information of continuing value *remains accessible and usable*.

Digital Preservation for Reproducibility

(Digital) preservation is the *unstated assumption* underlying reproducibility efforts for all scientific experiments:

we cannot reproduce an experiment
whose description has been lost!

What is a *description*?

In our modern world, this comprises *articles*, *data* and, yes, *software*!

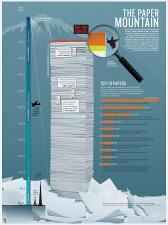
Software is Science's cornerstone

Software is *an essential component* of modern scientific research

Deep *knowledge* from mathematics, physics, chemistry, biology, medicine, finance and social sciences *is now inextricably embodied into complex software systems*, at a level of detail that goes way beyond that of the usual scientific publications.

Top 100 papers (Nature, October 2014)

> *[...] the vast majority describe experimental methods or software that have become essential in their fields.*
>
> *http://www.nature.com/news/the-top-100-papers-1.16224*



Bottomline: Software is *Knowledge* that needs to be preserved!

Like all digital information, software is *fragile*

Causes of information loss

Human accidental or malicious deletion, ...

Storage Media, Practices, Systems disaster events, corruption, damage, wear and tear, aging ...

Logical Format or Migration Inability to Access, Read, Interpret, Validate, or Use information
Loss of the necessary software tools
Loss or damage to references to associated information

Encryption Lost access keys, decryption devices

Authenticity Failure to identify the intended versions

External Service Providers Out of business, high exit cost, ...

An example is worth a thousand words...

Inconsiderate loss of code: Y2K

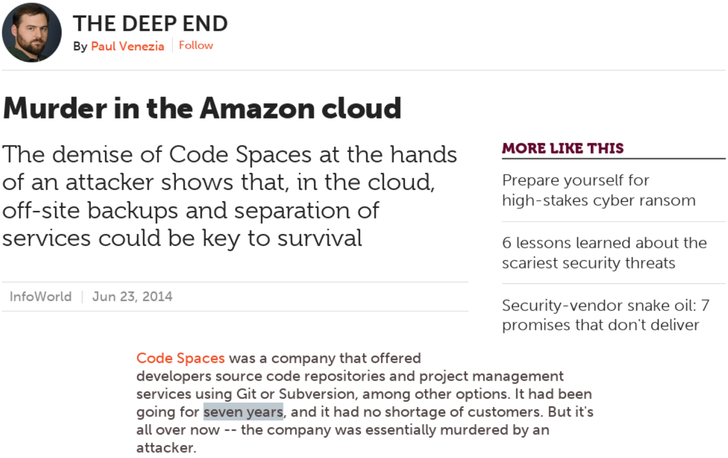
Y2K : The Year 2000 Bug Crisis

The announced disasters did not occurr, and we'll never know if it's because of the billions spent on fixing the bug, but ...

An Inconvenient Truth

... this bug uncovered the astonishing fact that, in 1999, an estimated 40% of companies had either *lost*, or thrown away the original source code for their systems!

Malicious loss of code: R.I.P. CodeSpaces



THE DEEP END
By Paul Venezia | Follow

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

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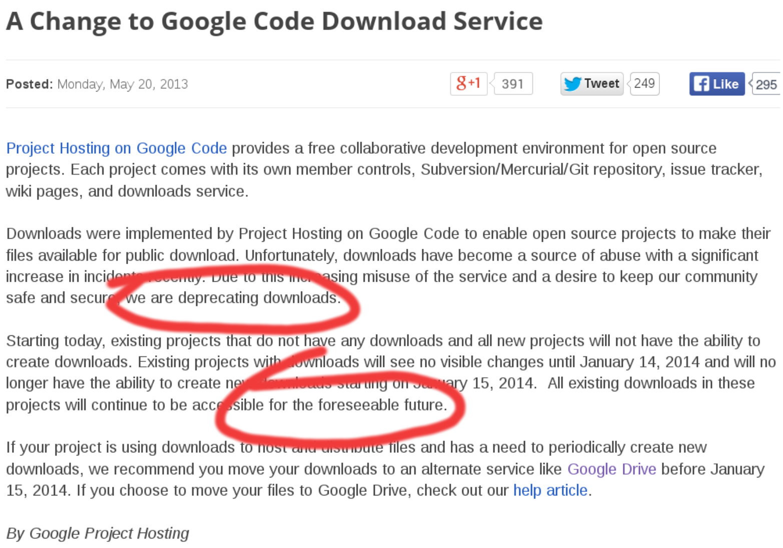
Security-vendor snake oil: 7 promises that don't deliver

Code Spaces was a company that offered developers source code repositories and project management services using Git or Subversion, among other options. It had been going for seven years, and it had no shortage of customers. But it's all over now -- the company was essentially murdered by an attacker.

Yes, for *seven years* all seemed good and well!

No, they did not recover the data.

Business-driven loss of code support: Google



A Change to Google Code Download Service

Posted: Monday, May 20, 2013

Project Hosting on Google Code provides a free collaborative development environment for open source projects. Each project comes with its own member controls, Subversion/Mercurial/Git repository, issue tracker, wiki pages, and downloads service.

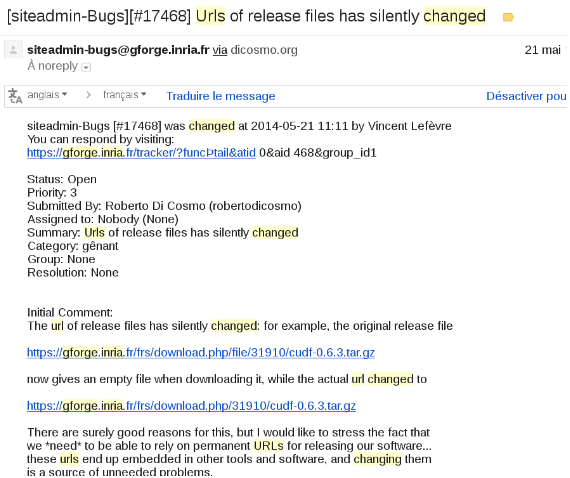
Downloads were implemented by Project Hosting on Google Code to enable open source projects to make their files available for public download. Unfortunately, downloads have become a source of abuse with a significant increase in incidents recently. Due to this increasing misuse of the service and a desire to keep our community safe and secure we are deprecating downloads.

Starting today, existing projects that do not have any downloads and all new projects will not have the ability to create downloads. Existing projects with downloads will see no visible changes until January 14, 2014 and will no longer have the ability to create new downloads starting on January 15, 2014. All existing downloads in these projects will continue to be accessible for the foreseeable future.

If your project is using downloads to host and distribute files and has a need to periodically create new downloads, we recommend you move your downloads to an alternate service like Google Drive before January 15, 2014. If you choose to move your files to Google Drive, check out our help article.

By Google Project Hosting

Disruption of the web of reference: our Gforge



[siteadmin-Bugs][#17468] Urls of release files has silently changed

siteadmin-bugs@gforge.inria.fr via dicosmo.org 21 mai

À noreply

siteadmin-Bugs [#17468] was changed at 2014-05-21 11:11 by Vincent Lefèvre
You can respond by visiting:
https://gforge.inria.fr/tracker/?funcÞtail&atid 0&aid 468&group_id1

Status: Open
Priority: 3
Submitted By: Roberto Di Cosmo (robertodicosmo)
Assigned to: Nobody (None)
Summary: Urls of release files has silently changed
Category: gênant
Group: None
Resolution: None

Initial Comment:
The url of release files has silently changed: for example, the original release file

https://gforge.inria.fr/frs/download.php/file/31910/cudf-0.6.3.tar.gz

now gives an empty file when downloading it, while the actual url changed to

https://gforge.inria.fr/frs/download.php/31910/cudf-0.6.3.tar.gz

There are surely good reasons for this, but I would like to stress the fact that
we *need* to be able to rely on permanent URLs for releasing our software...
these urls end up embedded in other tools and software, and changing them
is a source of unneeded problems.

Fixed, adding a redirection, by the Gforge team in **1** *day!*

Not always that lucky, though ...

Disruption of the web of reference: an old problem

URLs used in articles *do 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*
- *deep path hierarchies are linked to increased URL failures*

D. Spinellis. The Decay and Failures of URL References. Communications of the ACM, 46(1):71-77, January 2003.

Similar findings in
Lawrence, S. et al. Persistence of Web References in Scientific Research, IEEE Computer, 34(2), pp. 26–31, 2001.

Preservation of digital information is on the rise

A wealth of initiatives around us

- generalist: the Web archive at `archive.org`; Digital Preservation Coalition (UK); National Digital Information Infrastructure and Preservation Program (NDIIPP, USA); ...
- culture: books, music, video: `http://www.nationalarchives.gov.uk` (UK); INA (FR); ...
- social networks: Twitter is archived by the Library of Congress!
- libraries and scholarly work: ArXiv; Digital Preservation Network `http://www.dpn.org/`; ...
- scientific data: CINES (FR); Zenodo/OpenAire (CERN); ...

What about the software?

Software preservation challenges: awareness

Software is the mediator for our digital culture

> *Absent an ability to correctly interpret digital information, we are left with files full of "rotting bits" that are of no value.*

Vinton G. Cerf

Avoiding "bit rot": Long-term preservation of digital information.

Proceedings of the IEEE, 99(6):915–916, 2011.

If we do not preserve software, digital preservation is futile!

And yet, up to now...

software is *largely ignored* as an object of preservation...

computer scientists are mostly absent in the preservation landscape!

Software Preservation Challenges: it's *different*!

Unlike for books or movies, there is a big difference between *using* and *understanding* a piece of software.

Using software

Requires an executable, and access to the *execution environment*

Understanding software

Requires access to the *source code*:

> *The source code for a work means the preferred form of the work for making modifications to it.*
>
> *— GNU General Public Licence, version 2*

For reproducibility, we need *both*!

Software Preservation Challenges: it's *different*!

Preserving *software* is more complex than archiving books or scientific articles.

interdependencies a program relies on other software (libraries, compilers, development tools, runtime systems, etc.) as well as specific hardware components (or equivalent virtual machines) to be executed; so does our understanding of its functioning.

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evolution software is a *live object*: its detailed history contains key knowledge that cannot be reconstructed by only looking at an individual snapshot of the software source code.

To preserve *software* it is *not enough* to mimic processes that were intended to archive books, scientific articles or data.

Software Preservation: a Unique Opportunity

The *half empty glass* point of view

Nobody cares about software...
Computer scientists are absent from the preservation landscape...

Nobody loves us...

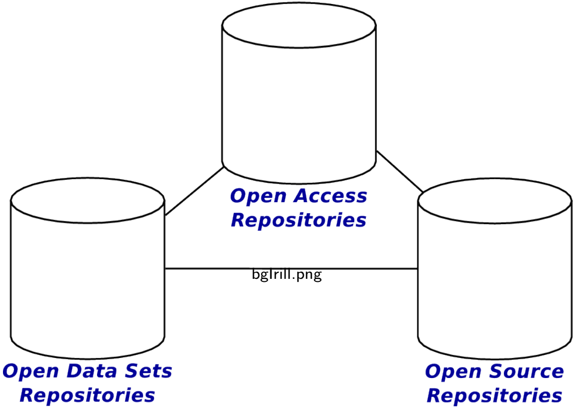
The *half full glass* point of view

Preserving software is a highly challenging task...
... it requires Computer Scientists in the loop

Luckily nobody cared!

Let's do it *right*, ... let's do it *now*!

The Knowledge Conservancy Magic Triangle



articles	ArXiv, HAL?, ...
data	Zenodo? (OpenAire)
software	coming soon from Inria!

Bits from the drawing board

Replication is the key

...let us save what remains: not by vaults and locks which fence them from the public eye and use in consigning them to the waste of time, but by such a multiplication of copies, as shall place them beyond the reach of accident.

Thomas Jefferson, February 18, 1791

recommendation

our preferred platform(s) should:

- provide easy means for making copies
- encourage the growth of a mirror network (like ArXiv did)

Bits from the drawing board

Free an Open Source Software is crucial

you have to do [digital preservation] with open-source software; closed-source preservation has the same fatal "just trust me" aspect that closed-source encryption (and cloud storage) suffer from.

D. Rosenthal, EUDAT, 9/2014

recommendation

our preferred platform(s) should:

- provide full details on their architecture
- make available all the source code used
- use open standards
- encourage a collaborative development process

Unfortunately, this is not (yet?) the case for HAL or Zenodo

Bits from the drawing board

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

Users should beware that there is no general guarantee that a URL which at one time points to a given object continues to do so, and does not even at some later time point to a different object due to the movement of objects on servers.

T. Berners-Lee et al. Uniform Resource Locators. RFC 1738.

recommendation

our preferred platform(s) should:

- provide *intrinsic* resource identifiers
- *avoid* intermediate index approaches like DOI

Conclusions

- Long term preservation is the *unspoken assumption* of all scientific reproductibility efforts
- We need to preserve scientific articles, scientific data *and* software (magic triangle)
- Digital preservation is on the rise, mostly thanks to librarians, with almost no computer scientists involved

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- Software preservation is not yet there and is in dire need of attention
- We have a great opportunity to seize... let's do it!