Reproducible Research, Open Science
Logging and backing up your work
Git Tips and Tricks, a Scientist Perspective

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June 7, 2016 – Reproducible Research Webinar (Episode IV)

Foreword about the organization (1/2)

There is currently a screencast of this seminar:

https://mi2s.imag.fr/pm/direct

The resulting video will be edited and available from GitHub that gathers all the information, slides, and resources:

https://github.com/alegrand/RR_webinars/blob/master/README.org

There is a few seconds delay between what we say and the screencast. We can have almost live interaction with other sites by using pad to comment and ask questions

http://tinyurl.com/RRW-pad4

Foreword about the organization (2/2)

No particular prerequisites: we will use command line and demo with a GUI

- Please install `Git` and `SmartGit` by following the instructions given on the RR_webinars GitHub page

1. General introduction plus basic Git usage (≈ an hour) At any time, feel free to ask questions on the pad. Some of these questions may be addressed "silently" by the other attendees, but do not hesitate to ask it out loudly for the remote ones
2. A short break
3. Slightly more advanced Git usage The actual part that is more devoted to practices favoring reproducible research

Many other tutorials on Git but with a different perspective

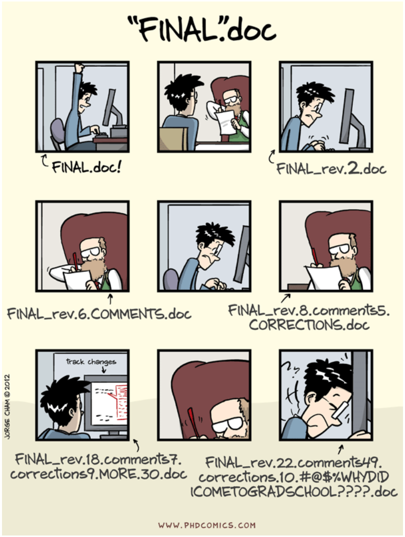
- Introduction to Git internals by Scott Chacon (GitHub)
- Please. Stop Using Git by Matthew McCullough 😉

- http://try.github.com/
- http://gitimmersion.com/
- http://git-scm.com/docs/gittutorial/

Outline

Challenges: History and Parallelism

- Printed doc+handwritten revisions:
  - Many versions of the file
  - One writer, multiple reviewers
- Doc+email+contributions:
  - Many versions of the file
  - Never sure which one is the latest
  - Not aware of others corrections
  - No clear history
  - Merging contributions
  - Problems editing same paragraphs
- Doc+Dropbox or google-doc:
  - Limited history through autosaves (30 days on Dropbox)
  - Limited parallelism
  - Coworker deletes everything. . .


"FINAL".doc
FINAL.doc!
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track changes
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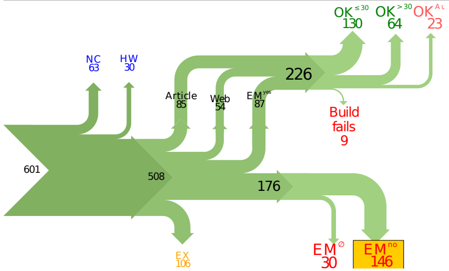
FINAL_rev.22.comments49.corrections.10.#@$%WHYDID ICOMETOGRADSCHOOL????.doc
JORGE CHAM © 2012
WWW.PHDCOMICS.COM

You need a real version control system
that allows for a truly parallel asynchronous edition

Remember "*The Dog Ate my Homework !!!*"

Collberg, Christian *et Al.*, *Measuring Reproducibility in Computer Systems Research*, http://reproducibility.cs.arizona.edu/ 2014,2015



- 8 ACM conferences (ASPLOS'12, CCS'12, OOPSLA'12, OSDI'12, PLDI'12, SIGMOD'12, SOSP'11, VLDB'12) and 5 journals
- More than 80% of non reproducible work

Common issues: Versioning Problems and Bad Backup Practices

Thanks for your interest in the implementation of our paper. The good news is that I was able to find some code. I am just hoping that it is a stable working version of the code, and matches the implementation we finally used for the paper. Unfortunately, I have lost some data when my laptop was stolen last year. The bad news is that the code is not commented and/or clean.

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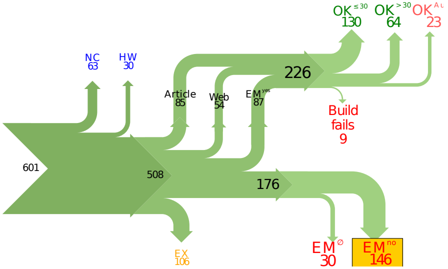

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Common issues: Versioning Problems and Bad Backup Practices

Attached is the ⟨system⟩ source code of our algorithm. I'm not very sure whether it is the final version of the code used in our paper, but it should be at least 99% close. Hope it will help.

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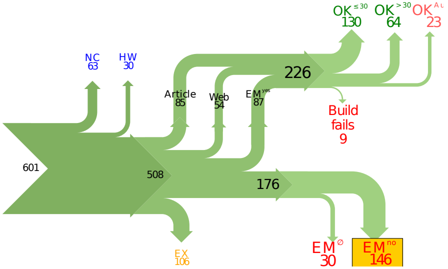

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Common issues: Versioning Problems and Bad Backup Practices

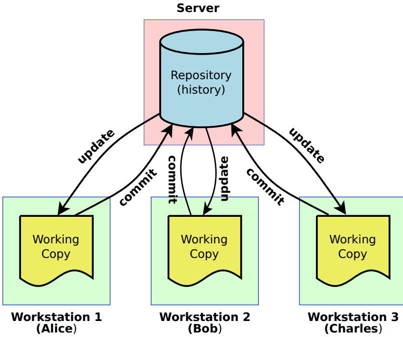
Unfortunately, the server in which my implementation was stored had a disk crash in April and three disks crashed simultaneously. While the help desk made significant effort to save the data, my entire implementation for this paper was not found.

History: Centralized Version Control System

- RCS (1982), CVS (1986), SVN (2000)
- Client/Server interactions
- Local copies of files/remote history

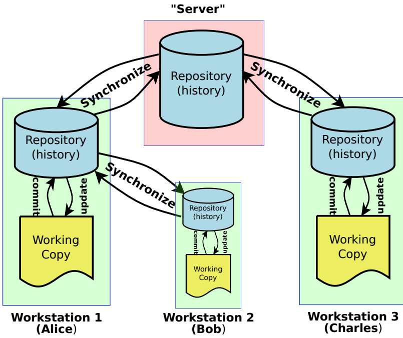
Main issues:

1. No local history
   - requires a permanent network connection
   - commits are immediately visible to everyone
     $\rightsquigarrow$ few (and large) commits, conflicts ☹
2. Managing Access (Read/Write)
   - `UNIX` groups and `ssh`. Forge makes your life so much easier
     - Web management and easy access to files and history
     - Bug Tracking System, Mailing Lists, Wikis, . . .
   - This does not scale (socially)
     $\rightsquigarrow$ send series of `patch`es ☹



History: Decentralized Version Control System

- BitKeeper (1998), Arch (2001), Darcs (2003), Bazaar/Git/Mercurial (2005)
- Peer-to-peer and/or Client/Server
- Full local history



Git birth:

- BitKeeper was used by the Linux kernel dev. community
- BK. withdrawn gratis use of the product for reverse-engineering reasons
- Torvalds needed performance. He coded Git in 2 weeks and used it for releasing the next kernel 2 weeks after ☺

Pros:

- Allows local commit without any access on the server
- Allows large scale collaboration (everyone pulls from Linus)
- Many web/cloud deployments: Gitorious, GitHub, BitBucket, GitLab

Setting up Git

Tools git originates from Linux so it is command line oriented

- There are many convenient GUIs. E.g., SmartGit or even magit 😉
- See the instructions given on the RR_webinars GitHub page

Accessing servers setup your SSH public/private key to avoid typing passwords all the time (see How do I setup ssh (even on windows?))

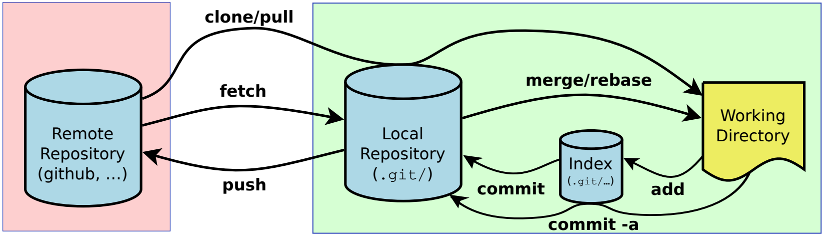
Provide your name All this will go in your ~/.gitconfig

```
git config --global user.name "Your Name Comes Here"
git config --global user.email you@yourdomain.example.com
```

Customize even more

```
[color]
        diff = auto
        status = auto
        branch = auto
[alias]
        wdiff = diff --color-words
        hist = log --pretty=format:'%h %ad | %s%d [%an]' --graph --date=short
[branch]
        autosetuprebase = always        # you may not want this...
[push]
        default = simple                # you may not want this...
```

Basic usage (demo)



Inspired by HackBerkeley

You have a complete stand-alone local history!

- `git clone` / `git init` (initialize the DB)
- `git pull` sync from the remote repos
  - (actually `git pull` = `git fetch ; git rebase` in simple contexts)
- `git push` sync to the remote repos
- `git add` and `git commit` (or `git commit -a` if you really don't care)

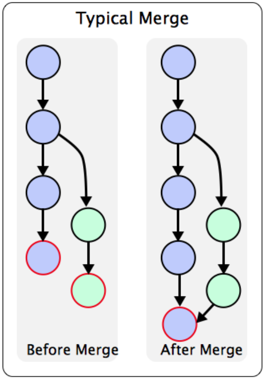
This is the basic linear history, very similar to an incremental backup.

- If you put such commands in a `crontab -e`, you will get a `timemachine/backuppc/...`

But `git` is much more than this

Actually there are branches. . . (demo)

- `git merge`
- `gitk` or equivalent
  - `git checkout` allows to switch from a branch to an other
  - You can easily create a (local) branch to mess around. You're safe! ☺
- `git pull` = `git fetch; git rebase` or `git fetch; git merge`
  - Question: What is the difference? ☺



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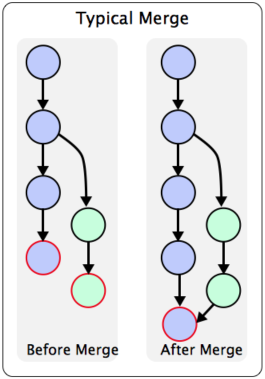
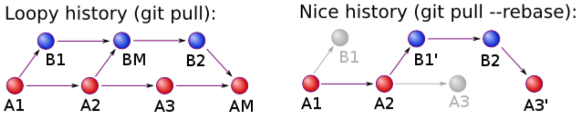




It's is a matter of taste... ☺

Outline

Collaborative Writing using Git

- Multiple collaborators editing the same file simultaneously offline
- Everyone commits locally, occasionally merging to remote
- If editing different paragraphs $\rightsquigarrow$ automatic merge
- If editing same paragraphs $\rightsquigarrow$ need to handle conflicts

Everyone has a clean history of the whole article writing process, with all intermediary versions

Working with Textual Files

- Necessary so Git can make difference between commits
- Common solutions: LaTeX, markdown, Org-mode, etc.
- Nowadays many user-friendly environments for LaTeX
- No dependencies on (proprietary) software tools

Advanced usage

Alternatively convert binaries into text files:

- `git oodiff` (based on odt2txt conversion) for OpenOffice files (.odt, .odp, etc.)
- rakali (based on pandoc conversion) for Office files (.doc, .docx, etc.)

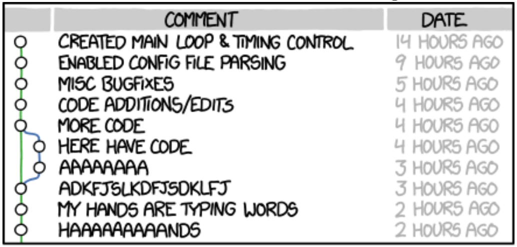
Typical Workflow

- Basic commands:
  1. Setup repository (`git config`, `git clone`)
  2. Update to the latest version (`git pull`, `git fetch`)
  3. Contribute with your changes (`git commit -a`, `git push`)
- Commands for handling conflicts:
  1. Compare two versions (`git diff`)
  2. Use conflict solvers
  3. Merge or rebase (`git merge`, `git rebase`)
- Commands for finding the previous version:
  1. Going for a particular version (`git checkout SHA1`)

Useful Tips and Tricks

- Use a descriptive commit message

Inspired by Michael Ernst



COMMENT	DATE
CREATED MAIN LOOP & TIMING CONTROL	14 HOURS AGO
ENABLED CONFIG FILE PARSING	9 HOURS AGO
MISC BUGFIXES	5 HOURS AGO
CODE ADDITIONS/EDITS	4 HOURS AGO
MORE CODE	4 HOURS AGO
HERE HAVE CODE	4 HOURS AGO
AAAAAAAA	3 HOURS AGO
ADKFJSLKDFJSDKLFJ	3 HOURS AGO
MY HANDS ARE TYPING WORDS	2 HOURS AGO
HAAAAAAAANDS	2 HOURS AGO

AS A PROJECT DRAGS ON, MY GIT COMMIT MESSAGES GET LESS AND LESS INFORMATIVE.

Seriously... don't fake it 😉

```
git commit -m"‘curl -s http://whatthecommit.com/index.txt‘"
```

Useful Tips and Tricks

Inspired by Michael Ernst

- Use a descriptive commit message
- Make each commit a logical unit: `git add file1 file2 ; git commit`
- Avoid large indiscriminate commits (e.g., with `git commit -a`)
  - `git status`, `git diff` and `git wdiff`

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- Incorporate others' changes frequently (`git pull`)
- Share your changes frequently (`git push`)

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  - Never refill/rejustify paragraphs
  - Do not write excessively looooong lines (>80 characters)

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- Remember that the tools are line-based
  - Never refill/rejustify paragraphs
  - Do not write excessively looooong lines (>80 characters)
- Don't commit generated files
  - Don't version temporary LaTeX files (.aux, .toc, etc.), use `.gitignore`
  - Don't version the result .pdf (unless your collaborators have problems generating it). Add only the final version of the .pdf, possibly with a unique name

Advanced usage

If you collaborate with SVN users, you may enjoy `git svn`

Outline

Git for Coding: History Matters!

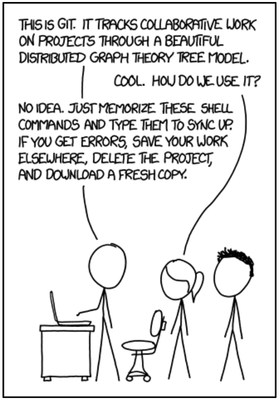
- Remember: commit often. In this context, the `git stash` command can be useful.
    - Allows you to code/test/... with no fear
    - `git reset` / `git revert`
- Region based committing (`git commit --patch` although nobody does that through the CLI)
    - Working at a fine granularity allows the next ones to better understand what was done and decreases the risks of conflicts
- Locally rewriting your history (`git rebase -i bc23b0f`) before publishing it with `git push`
- Such history can then be exploited:
    - `git log` (`git hist`), `git blame`, `git bisect`

```
git config --global alias.hist \
    'log --pretty=format:"%h %ad | %s%d [%an]" --graph --date=short'
```

Rescue!

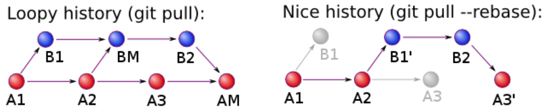
Git is really pretty simple, just think of branches as homeomorphic endofunctors mapping submanifolds of a Hilbert space ☺

- Don't force it and don't panic... Call a friend.
  - Everything is stored in Git backend and identified by a SHA1
  - Anything is saved as soon as it is in the backend (`git add`)
- Several ways to recover objects/files states that cannot be reached by the classical history:
  - `git fsck` to find unreachable files/commits/...
  - `git reflog` (for emergency) generally more useful than `git fsck` for recovering a previous repository state (i.e., a previous commit)
- A few dangerous commands:
  - `git gc` removes unreachable old objects (>2 weeks)
  - `git prune` removes unreachable objects...
  - `rm -rf` without pushing (or cloning elsewhere) before


THIS IS GIT. IT TRACKS COLLABORATIVE WORK ON PROJECTS THROUGH A BEAUTIFUL DISTRIBUTED GRAPH THEORY TREE MODEL.
COOL. HOW DO WE USE IT?
NO IDEA. JUST MEMORIZE THESE SHELL COMMANDS AND TYPE THEM TO SYNC UP. IF YOU GET ERRORS, SAVE YOUR WORK ELSEWHERE, DELETE THE PROJECT, AND DOWNLOAD A FRESH COPY.

Merging Branches

- Why? Long term work to keep in sync with the rest of the world (e.g., translating some code for internationalization)
- Merging ("public" branch but where you're the only developer) vs. re-basing (cleaner final set of patches, but the backup is more complex to set up)



- Depends on the meaning of the history wished within the project. Re-basing can be better for code review (sometimes, some part of the history are useless).

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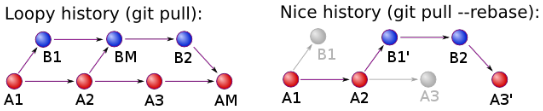
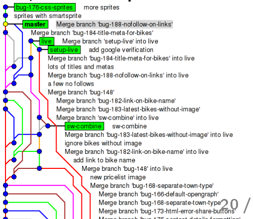


- Depends on the meaning of the history wished within the project. Re-basing can be better for code review (sometimes, some part of the history are useless).

Developers who do not understand this mechanism quickly end up with a huge plate of spaghetti ☹

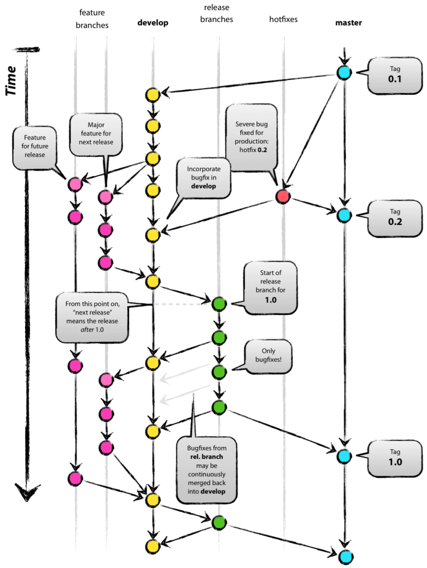
- `git workflow` (supported by SmartGit)



```
more sprites
sprites with smartsprite
Merge branch 'bug-188-nofollow-on-links'
Merge branch 'bug-184-title-meta-for-bikes'
Merge branch 'setup-live' into live
add google verification
Merge branch 'bug-184-title-meta-for-bikes' into live
lots of titles and metas
Merge branch 'bug-188-nofollow-on-links' into live
a few no follows
Merge branch 'bug-148'
Merge branch 'bug-182-link-on-bike-name'
Merge branch 'bug-183-latest-bikes-without-image'
Merge branch 'sw-combine' into live
sw-combine
Merge branch 'bug-183-latest-bikes-without-image' into live
ignore bikes without image
Merge branch 'bug-182-link-on-bike-name' into live
add link to bike name
Merge branch 'bug-148' into live
new pricelist image
Merge branch 'bug-168-separate-town-type'
Merge branch 'bug-166-default-opengraph'
Merge branch 'bug-168-separate-town-type'
Merge branch 'bug-173-html-error-share-buttons'
```

Git Workflow

http://nvie.com/posts/a-successful-git-branching-model/

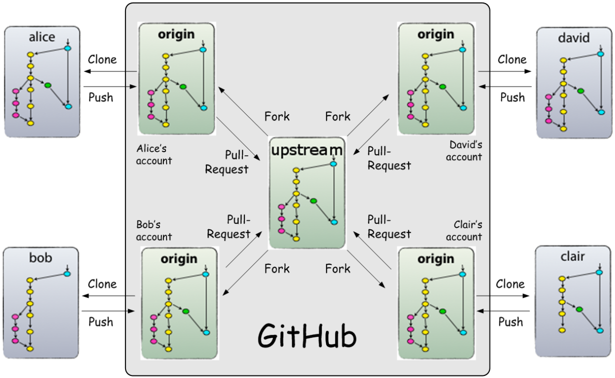

feature branches
develop
release branches
hotfixes
master
Time
Tag 0.1
Feature for future release
Major feature for next release
Severe bug fixed for production: hotfix 0.2
Incorporate bugfix in develop
Tag 0.2
Start of release branch for 1.0
From this point on, "next release" means the release *after* 1.0
Only bugfixes!
Bugfixes from rel. branch may be continuously merged back into develop
Tag 1.0

Access Rights

Forge
: the UNIX groups philosophy still works

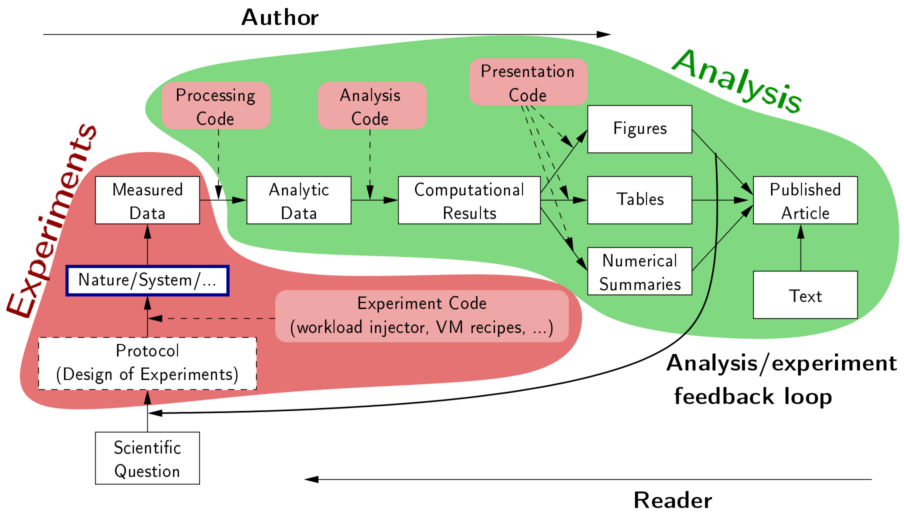
Linux
: - Linus Torvalds integrates from a few trusted developpers who themselves turn integrate from various developpers
  - Everyone pulls from Linus Torvalds

GitHub
: organization (similar to UNIX groups) are possible but encourages fork and pull requests done through their interface



Outline

General Reproducible Research Workflow



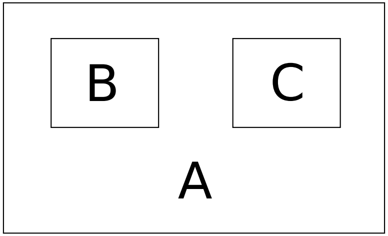
Git as a Complement to a Laboratory Notebook

- Versioning all scripts for running experiments, pre-processing raw data, analysis and presentation
- Backing up read-only experiment results
- Commit often and separate different types of commits
- Git history helps in understanding and reproducing experiment results

Major Challenges

1. May depend on other projects
2. Large files and thus repositories
3. Linear history hard to explore and thus exploit

Integrating Multiple Git Sources



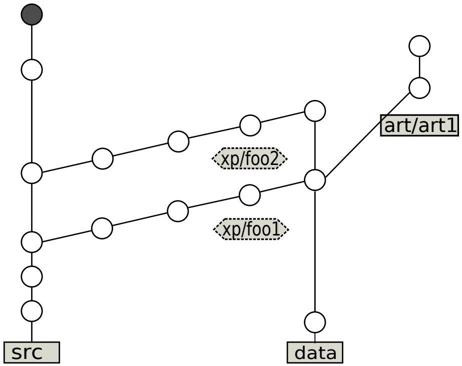
- Pulling and pushing changes to both projects
- Several solutions (`git submodule`, `git subrepo`)
- Work well for simple Git inside Git, but not for advanced use cases (SVN, complex branches, etc.)

Handling Large Files

- Cloning takes forever ☹
- Occupies a lot of disk space (especially for multiple projects)
- Several solutions (`git lfs`, `git annex`)
- Probably soon becoming part of the standard (similar to Mercurial)

Improving Git History: git-labbook (demo)

https://github.com/Git-labbook/git-labbook



- Get the data you are interested in
- Track provenance (can also be done in labbook)
- Explore and reset experiment conditions
- Expand to write an article

Improving Git History: git-labbook (demo)

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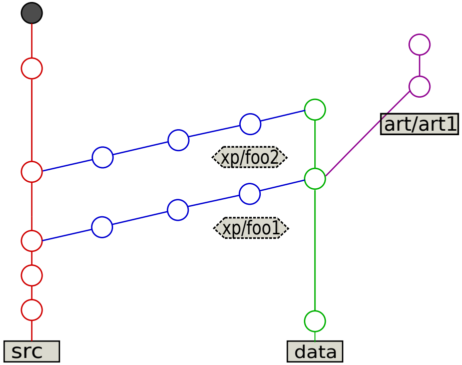

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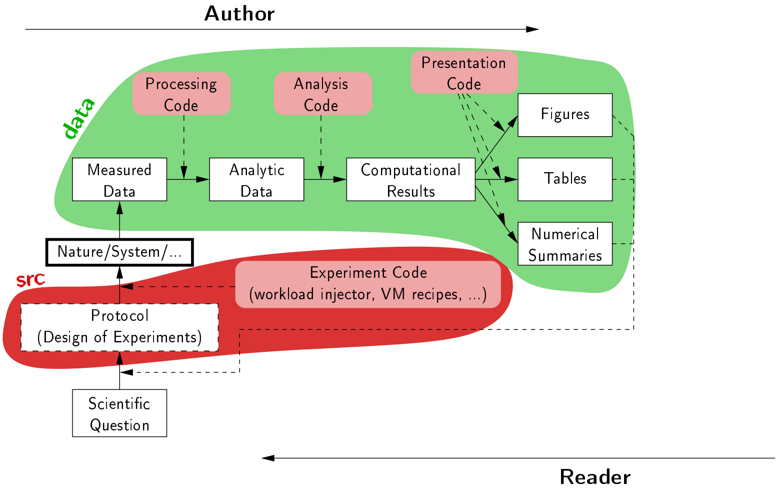
Benefits from this Branching System



- Keeps data and code that generated it together, yet isolated

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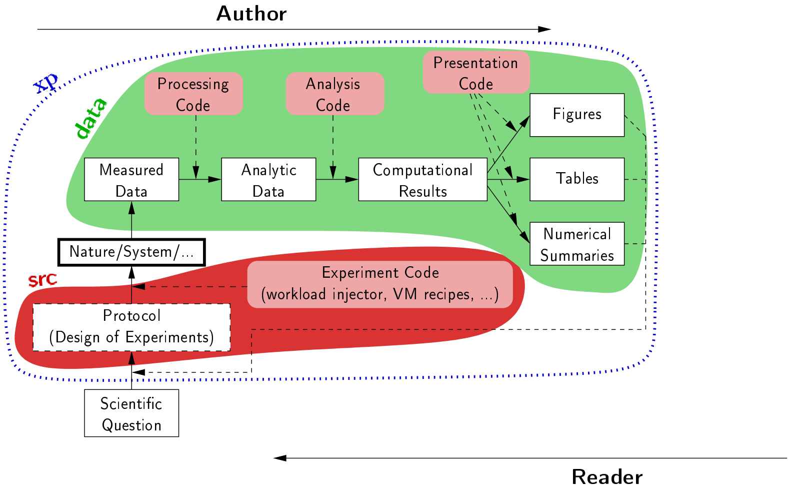

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- Facilitates experiment reproduction and analysis replication

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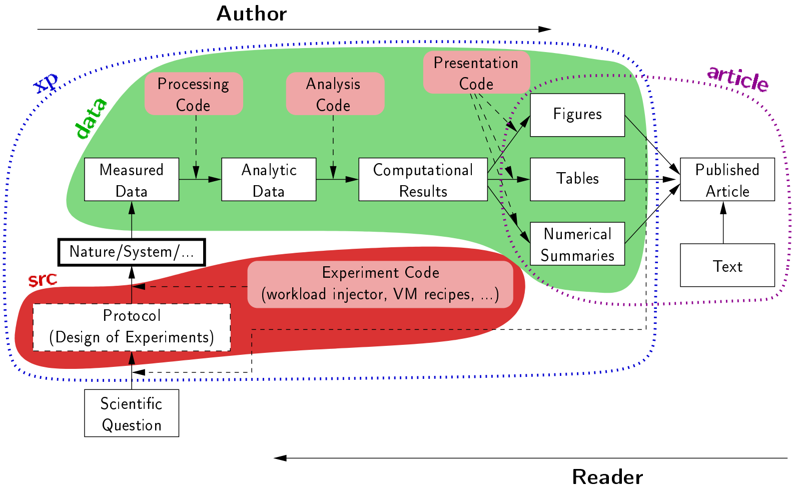

- Keeps data and code that generated it together, yet isolated
- Facilitates experiment reproduction and analysis replication
- Unites all phases of typical research study

Outline

Making Repository Publicly Available

- External researchers can improve or build upon your work
- Exploring Git history allows for deeper understanding of the project evolution, not only the final results $\rightsquigarrow$ improved reproducibility

- Comes as a natural step if the initial study was performed with a clean methodology (example)
- Some may have valid reasons for not doing so (copyright, company policy, implementation parts that the authors do not wish to disclose now, etc.)

Making Repositories Citeable and Durable

Citable: GitHub + Zenodo

- Providing DOI to the release of your GitHub

DOI 10.5281/zenodo.51269

- Your code becomes "citable" (although not necessarily easier to access ☺)
- Easy to use: follow the instructions
- GitHub+figshare: similar approach for figshare

Durable: Software Heritage

- None of this archiving is really durable (Google Code, Gitorious, Code Spaces, . . .)

Software Heritage
PRESERVING TECHNICAL KNOWLEDGE

- Impressive ongoing work lead by Roberto Di Cosmo

https://wg.softwareheritage.org/

Full development history of Debian, GitHub, GNU, Gitorious, . . .

Outline

Where do we stand now?

We did one such webinar per month. We will stop during summer and resume in mid September with other topics (workflows, data and software archiving, evaluation challenges, . . .).

- I need volunteers! ☺
- Announcement on recherche-reproductible@listes.univ-orleans.fr and a few others but do not hesitate to crosspost.

Next webinars: New season in September!

https://github.com/alegrand/RR_webinars