

SIB
Swiss Institute of
Bioinformatics

www.sib.swiss

Version control with Git - first steps

Robin Engler

Vassilios Ioannidis

Lausanne, 16-17 Oct 2024

First steps with Git: course outline

- **Introduction** to Version Control Systems and Git.
- **Git basics:** your first commit.
- **Git concepts:** commits, the HEAD pointer and the Git index.
- **Git branches:** introduction to branched workflows and collaborative workflow examples.
- **Branch management:** merge, rebase and cherry-pick.
- **Retrieving data from the Git database:** git checkout.
- **Working with remotes:** collaborating with Git.
- **GitHub:** an overview.

Course resources

Course home page: Slides, exercises, exercise solutions, command summary (cheat sheet), setting-up your environment, link to feedback form, links to references.

https://gitlab.sib.swiss/rengler/git_course_public

Google doc: Register for collaborative exercises (and optionally for exam), FAQ, ask questions. Link sent via email before the course.

Questions: feel free to interrupt at anytime to ask questions, or use the Google doc.

Course slides

- 3 categories of slides:

Regular slide [Red]

Slide covered in detail during the course.

Supplementary material [Blue]

Material available for your interest, to read on your own.
Not formally covered in the course.
We are of course happy to discuss it with you if you have questions.

Reminder slide [Green]

Material we assume you know.
Covered quickly during the course.

GitHub-specific [Purple]

Some slides are specific to GitHub or GitLab.

GitLab-specific [orange]

Learning objective

- Learn the concepts behind Git.
- Understand when and why to use each command.
- Collaborative workflows using GitHub/GitLab.
- Learn to re-write history (day 2).

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 MEMORIZIZE 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.



Command line vs. graphical interface (GUI)

- This course focuses exclusively on **Git concepts** and **command line** usage.
- Many GUI (graphical user interface) software are available for Git, often integrated with code or text editors (e.g. Rstudio, Visual Studio Code, PyCharm, ...).

It will be easy for you to start using them (if you wish to) once you know the command line usage and the concepts of Git.

version control

a (very) brief introduction

Why use version control ?

Version control systems (VCS), sometimes also referred to as *source control/code managers* (SCM), are software designed to:

- Keep a **record of changes** made to (mostly) text-based content by **recording specific states** of a repository's content.
- **Associate metadata to changes**, such as author, date, description, tags (e.g. version).
- **Share** files among several people and allow **collaborative, simultaneous, work** on the repository's content.
- **Backup** strategy:
 - Repositories under VCS can typically be mirrored to more than one location.
 - The database allows to retrieve older versions of a document: if you delete something and end-up regretting it, the VCS can restore past content for you.
- In the case of Git, entire ecosystems such as GitHub or GitLab have emerged to offer **additional functionality**:
 - **Distribute** software and **documentation**.
 - **Run automated pipelines** for code testing and deployment (CI/CD).
 - Team and **project management tool** (e.g. issue tracking, continuous integration).

A brief history of Git

- First release in 2005.
- Initially written by **Linus Torvald** (who also wrote the first Linux kernel in his spare time...).
- Created to support the development of the Linux kernel code (> 20 million lines of code).

The first commit of Git's own repository by Linus Torvalds in 2005.

```
commit e83c5163316f89bfbde7d9ab23ca2e25604af29
Author: Linus Torvalds <torvalds@ppc970.osdl.org>
Date: Thu Apr 7 15:13:13 2005 -0700
```

Initial revision of "git", the information manager
from hell

(some of) The principles that guided the development of Git

Linus wasn't satisfied with existing version control software, so he wrote his own...

He had the following objectives (among others) in mind:

- **Distributed development:** allow parallel, asynchronous work in independent repositories that do not require constant synchronization with a central database. **Each local Git repo is a full copy of the project** so users can work independently and offline.
- **Maintain integrity and trust:** since Git is a distributed VCS, maintaining integrity and trust between the different copies of a repositories is essential. **Git uses a blockchain-like approach to uniquely identify each change to a repository**, making it impossible to modify the history of a Git repo without other people noticing it.
- **Enforce documentation:** in Git, **each change to a repo must have an associated message**. This forces users to document their changes.
- **Easy branching/merging:** Git makes it **easy to create new branches** (i.e. lines of development) in a project. This encourages good working practices.
- **Free and open source:** users have the freedom to run, copy, distribute, study, change and improve the software.

Part I

Git basics

Working principle, definitions and
making your first commit

Git working principles and definitions

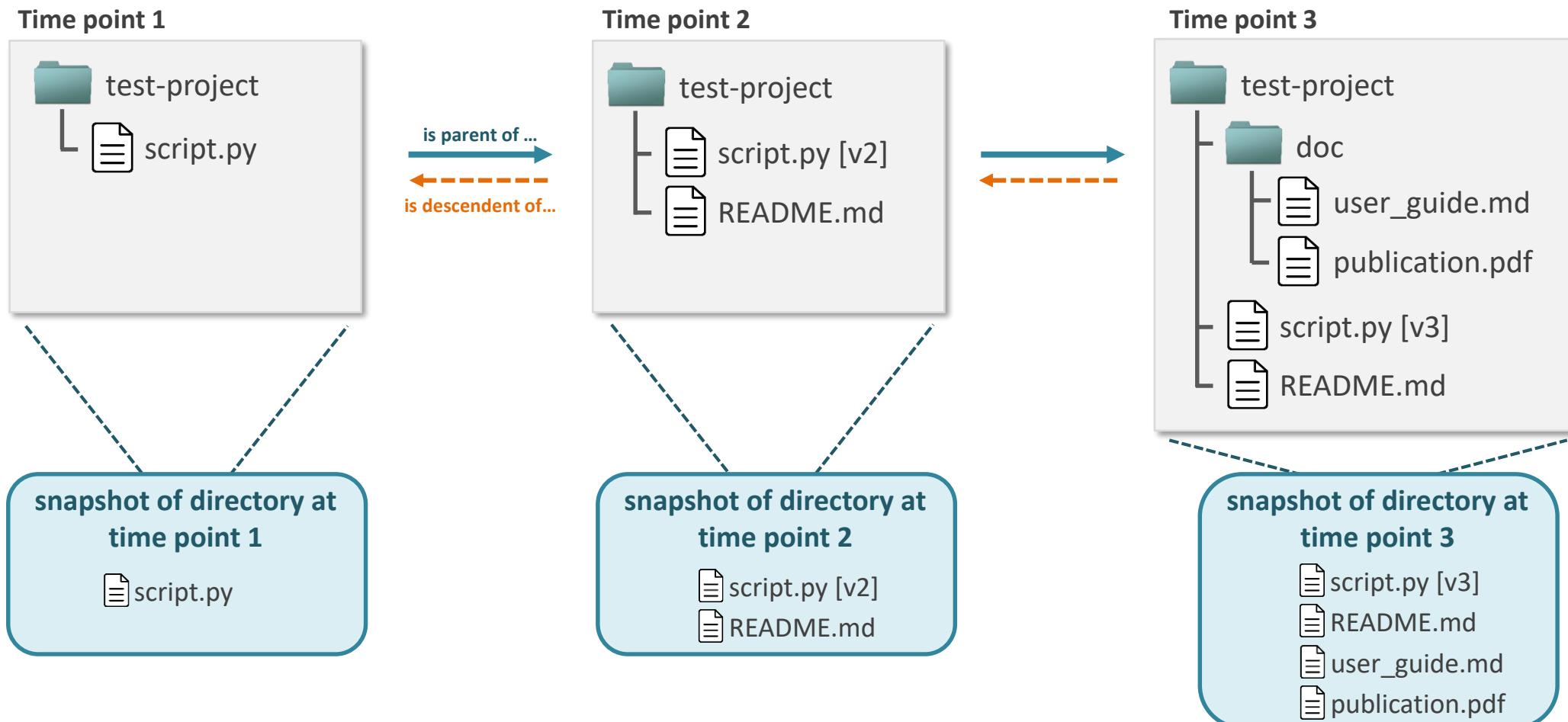
Basic principle of Git

Our objective: record the changes made to the content of a directory on our **local machine**.

How we proceed:

- Take **snapshots** (current content of files) at user defined time points – they are not taken automatically.
- Keep track of the **order of snapshots** (the relation between them) so their history can be recreated.
- Associate **metadata** with each snapshot: who made it, when, description, ...

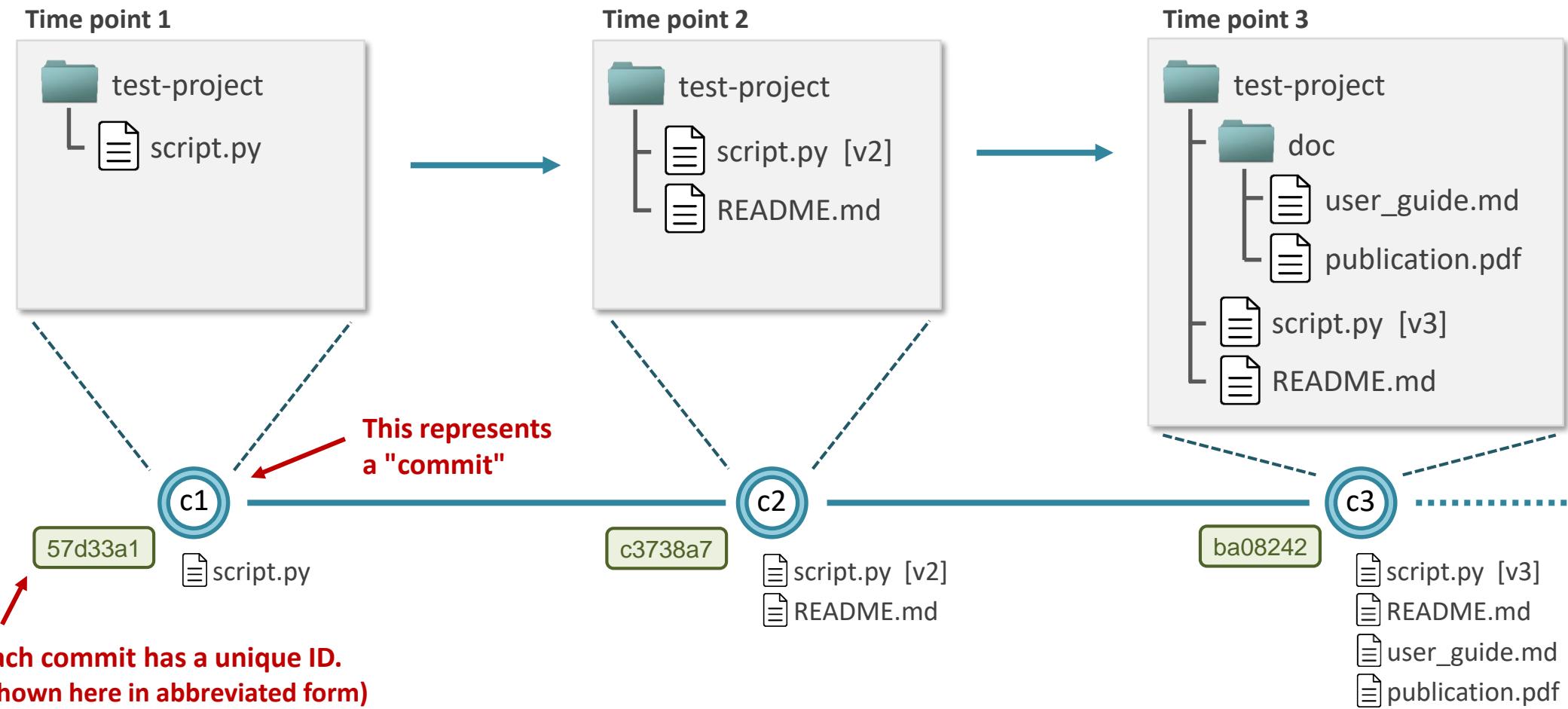
Git can track any types of files (text or binary), but is optimized to work with not-too-large text files.



Definitions: snapshots are called “commits”

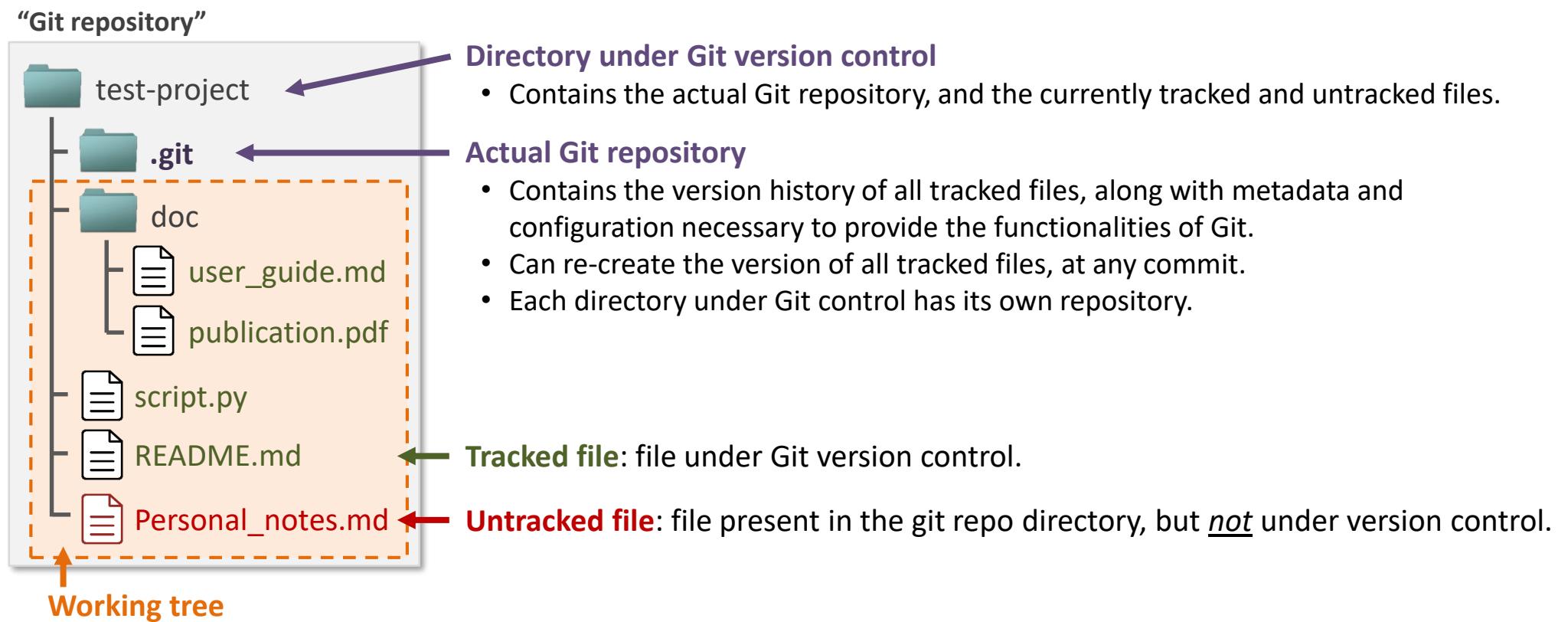
* As will be seen in later slides, this statement is not 100% correct, but is a good-enough approximation for now.

- **Commit = snapshot + metadata** (author, time, commit message, parent commit ID, etc. ...).
- Create a new commit = record a new state of the directory’s content *.
- Each commit has a unique **ID number / hash** (40 hexadecimal characters): **3c1bb0cd5d67dddc02fae50bf56d3a3a4cbc7204**



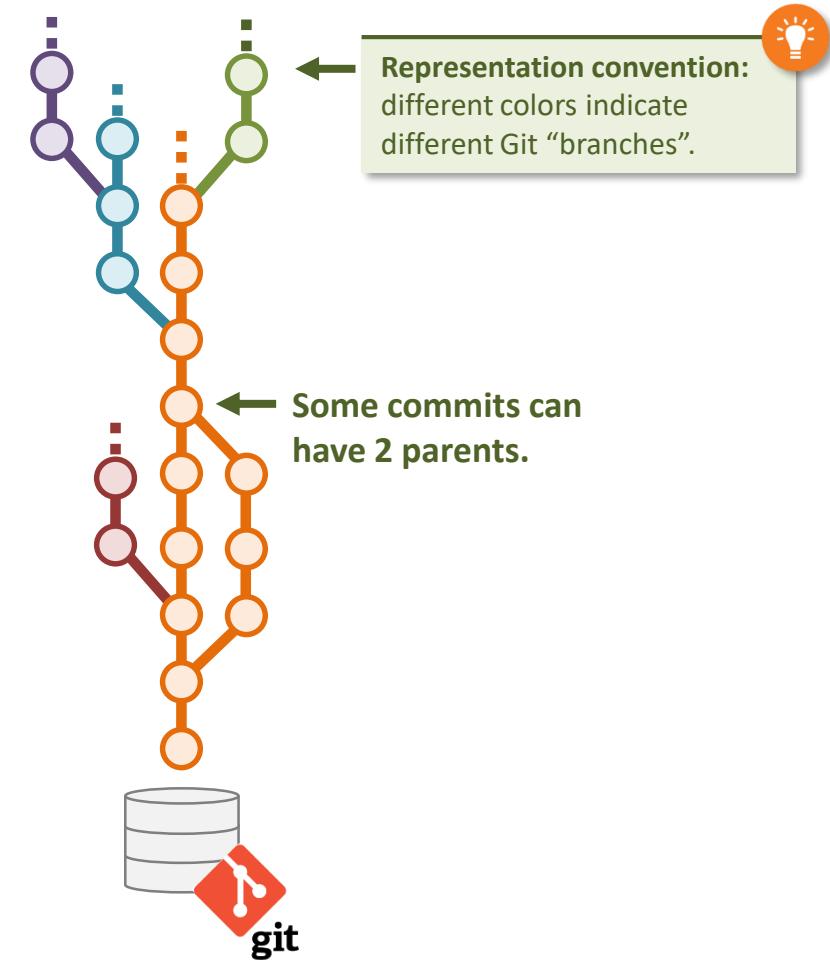
Definitions: commits are stored in a repository (or “repo”)

- **Git repository/repo**: version history of files in a directory under Git version control, along with metadata, and configurations necessary for version tracking and collaboration.
 - Technically, a Git repository is only the hidden “.git” directory (see figure below), but often the term is also used to refer to the entire directory under Git control (“test_project” in the example below).
 - Not all files in a directory under Git control have to be tracked: there can be a mix of **tracked** and **untracked** files.
- **Working Tree**: current content (on your computer) of a directory under Git control.
 - More exhaustive definition: state of the project files corresponding to the branch/commit that is currently checked out, augmented with uncommitted changes made to files, as well as untracked files.



Definitions: branches

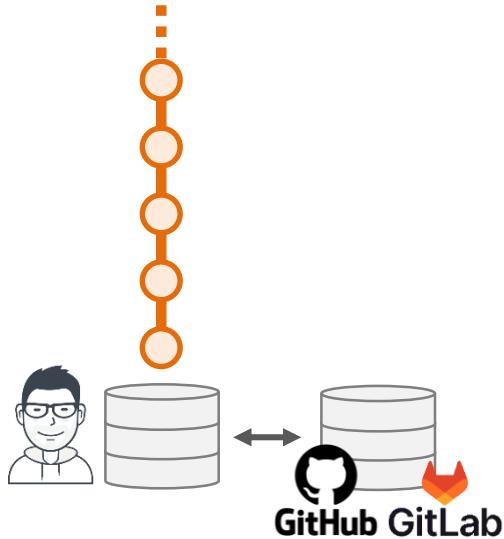
- **Repository history:** history of commits (chronology of commits).
- **Branch:** refers to a “line of development” within the commit history.
 - Technically a branch is simply a reference to a commit.



Examples of Git use cases

Exercise 1

Single repo, single branch

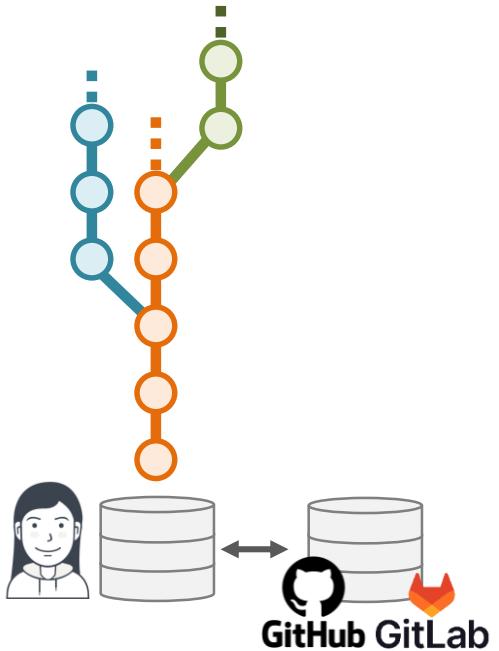


Use case

- Keep a documented log of your work.
- Go back and compare to earlier versions.
- Backup (if a paired with a remote).
- Distribute your code (if paired with remote)

Exercises 2 and 3

Single repo, branched workflow (multiple development lines)

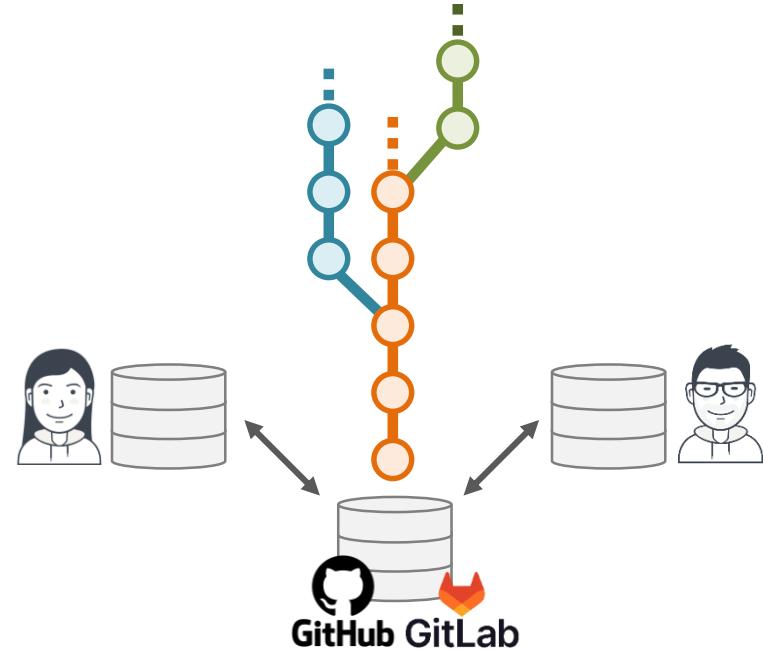


Use case

- Service in production with continued development in parallel (e.g. adding new feature).
- + all benefits of the previous use case.

Exercise 4

Collaboration with distributed and central repos.



Use case

- Collaborate with others (distributed development).
- + all benefits of the previous use case.



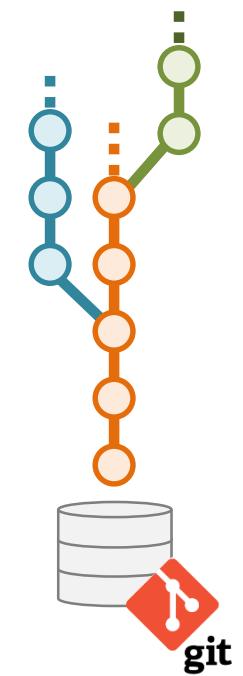
The local repo must be associated to a remote repository to provide backup functionality (and new commits must be regularly pushed). Highly recommended.

Each user has a full copy of the data*.

* Provided they regularly sync their local repo.

Local vs. Remote repository

- When creating a new Git repository on your computer, **everything is only local**.
- To get a copy of your repository online, you must take the active steps of:
 - **Creating** a new repository on a hosting service (e.g. GitHub, GitLab, Bitbucket, ...).
 - **Associate** the online repository with your local repo.
 - **Push** your local content to the remote.
- By design, Git **does not automatically synchronize** a local and remote repo. Download/upload of data must be triggered by the user.



Using Git with large files: the problem

Git can store any type of file, “plain text” or binary.

It would be nice if we could store data (large files) together with code ...

Tracking large files together with code is an attractive proposition, e.g. in scientific applications:

- Data analysis/processing pipeline.
- Machine learning applications (training data and code in the same place).

... but Git does not work well with large files

- Git was designed for tracking code – i.e. relatively small text files.
- Adding large files to a Git repo is technically possible, however:
 - Since Git is a distributed VCS (version control system), **each local copy of a repository will contain a full copy of all versions of all tracked files**. Therefore, **adding large files will quickly inflate the size of everyone's repository**, resulting in higher disk space usage (on local hosts).
 - **Git's internal data compression** (i.e. packfiles) is **not optimized to work with binary data** (e.g. image or video files). Each change to a binary file will (more or less) add the full size of the file to the repo, taking disk space and slowing down operations such as repo cloning or update fetching.
 - Commercial **hosting platforms impose limits on the size of files** that can be pushed to hosted Git repos (GitHub: 100 MB, GitLab: no file limit but 10 GB repo limit).

Using Git with large files: possible solutions

Git LFS (Large File Storage)

Git LFS (Large File Storage) is an extension for Git, specifically **designed to handle large files**.

- Open source project: <https://git-lfs.github.com>

Basic principle: large files are not stored in the Git database (the `.git` directory), instead:

- Only a **reference/pointer to large files** is stored in the Git database.
- The actual **files are stored in a separate repository** or “object store”.



Not all hosting services support Git LFS, and when they do, storage space is limited (additional space may be purchased).

DVC (Data Version Control)

DVC (Data Version Control) is a software that integrates with Git (a sort of layer used on top of Git) to allow versioning and storage of large files.

- Open source project: <https://dvc.org>

Git configuration

```
git config
```

Configuring Git

- The minimum configuration is setting a **user name** and **email**. These will be used as default author for each commit.
- Setting user name and email:

```
git config --global user.name <user name>
git config --global user.email <email>
```



The **--global** option/flag tells Git to store the setting at the “global” (user wide) scope. Global settings apply to all Git repos on your machine.

If you don’t add the **--global** option, then the setting will only apply to the current Git repo.

Global settings are stored in the following file:

- Linux: /home/\$USER/.gitconfig
- Windows: C:/Users/<user name>/.gitconfig
- Mac OS: /Users/<user name>/.gitconfig

- Config values can be retrieved by using the **--get** option.

- Examples:

```
# Set user name and email at the global (user-wide) scope:
[alice@local ~]$ git config --global user.name "Alice"
[alice@local ~]$ git config --global user.email alice@redqueen.org

# Retrieve setting values:
[alice@local ~]$ git config --get user.name
Alice
[alice@login1 ~]$ git config --get user.email
alice@redqueen.org
```

Configuring Git: changing the default text editor

On most systems, the default editor that Git uses is “**vim**”.

However, this can be configured with the following **git config** command:

```
git config --global core.editor <editor cmd>
```

- Display the current default editor used by Git:

```
git config --global --get core.editor
```

- Example: changing the default editor to “nano” (another command line editor).

```
# Change the default editor to "nano".  
$ git config --global core.editor nano  
  
# Display the current default editor.  
$ git config --global --get core.editor  
nano
```

Configuring Git: scopes and their config file locations

Depending on their scope, Git configurations apply to all Git repositories of a user, or only to a specific repository.

The main 3 scopes are:

- **Global (user wide):** settings apply to all Git repositories controlled by the user.
 - To save a setting as part of the global scope, add the `--global` flag to the `git config` command:
`git config --global ...`
 - Stored in `/home/<user name>/.gitconfig` (**Linux**), `C:\Users\<user name>\.gitconfig` (**Windows**) or `/Users/<user name>/.gitconfig` (**Mac OS**).
- **Local (repo specific):** settings apply only to a specific Git repo.
 - Stored in the `.git/config` file of the repository.
- **System (system wide):** settings apply to all users and all repos on a given machine. This can only be modified by a system administrator.

To show the list of all Git configurations, along with their scope and the location of the file they are stored-in:

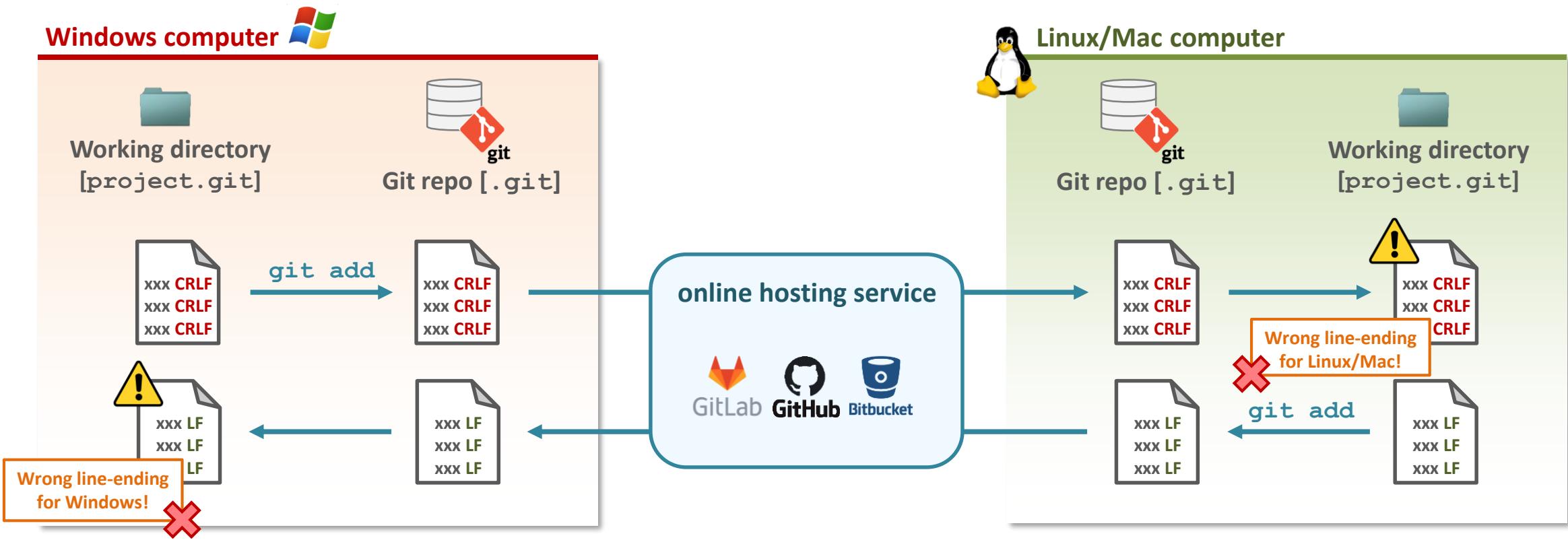
```
git config --list --show-origin --show-scope
```

Cross-platform collaboration: the line-end problem

Linux/Mac and Windows do not use the same “line-end” characters: this can cause problems when collaborating with people who use a different operating system.

- **Linux/Mac:** uses **LF** (linefeed; `\n`) as line-ending character.
- **Windows:** uses **CRLF** (carriage-return + linefeed; `\r\n`) as line-ending character.

→ Problem: text files created on Windows will not work well on Linux/Mac and vice versa.



Cross-platform collaboration: solution

The solution is to ask Git to automatically convert between LF and CRLF during add/checkout operations using the configuration option:

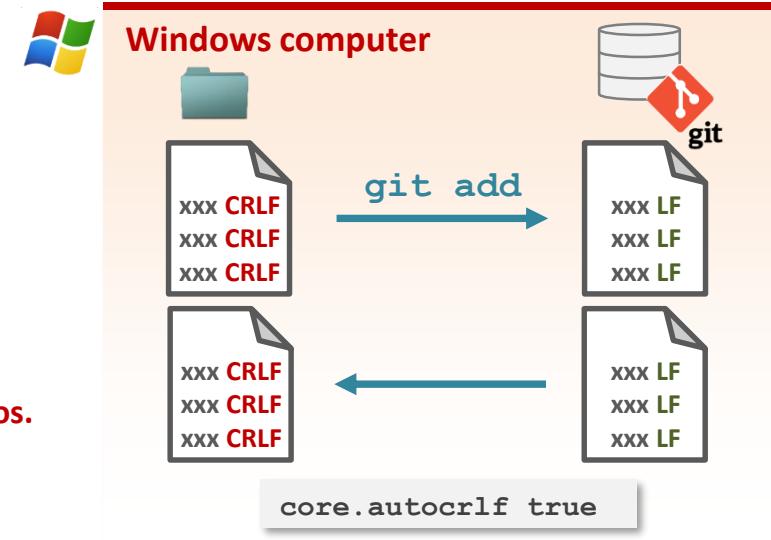
```
git config core.autocrlf
```

- On Windows computers: `core.autocrlf true` should be set so that LF are automatically changed to CRLF each time a file is checked-in or checked-out.

```
git config core.autocrlf true
git config --global core.autocrlf true
```

 Change setting for current repo.

 --global = change setting for all repos.

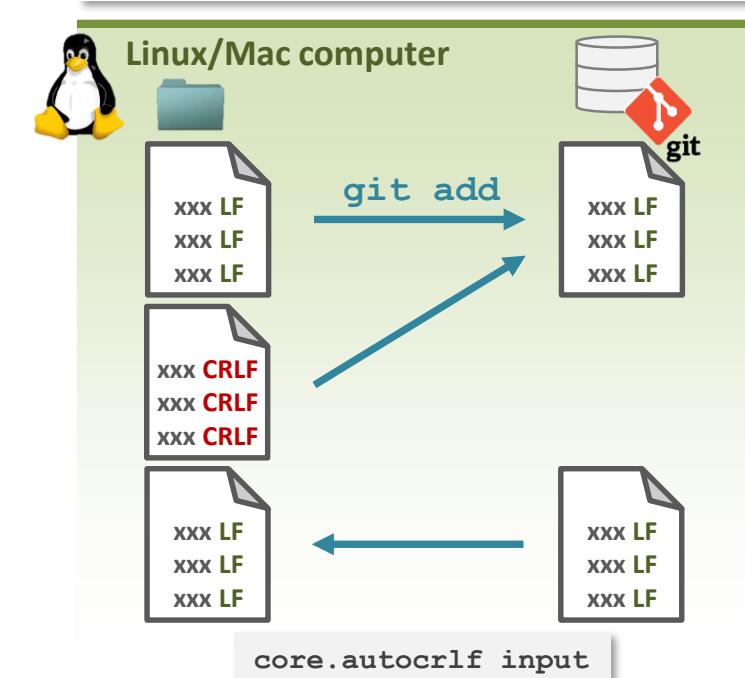


- On Linux/Mac computers: `core.autocrlf input` should be set so that LF line-endings (LF) are left untouched, and that CRLF are converted to LF when a file is added (this will only be useful in the rare cases when a file with CRLF ending is somehow present on the machine, e.g. because it was sent via email by a Windows user).

```
git config core.autocrlf input
git config --global core.autocrlf input
```

- `core.autocrlf false` to disable LF/CRLF auto-modifications (this is the default):

```
git config core.autocrlf false
git config --global core.autocrlf false
```



core.autocrlf warnings

When `core.autocrlf` is set to `True` (this is in principle only for windows users), a warning is displayed when files are added/checked-out to/from the git repo:

```
$ git add test_file.py
warning: LF will be replaced by CRLF in test_file.py
The file will have its original line endings in your working directory
```

Somehow the message is the same during adding and check-out of files... so when adding files to the index (`git add`), the message is actually the wrong way round: it should be something like "CRLF will be changed to LF in checked-in file".



Creating a **new repo**

```
git init
```

```
git clone
```

There are 2 main ways of obtaining a new Git repo...

Turn a local directory into a Git repo (start from scratch)

Enter the directory to version-control, then run:

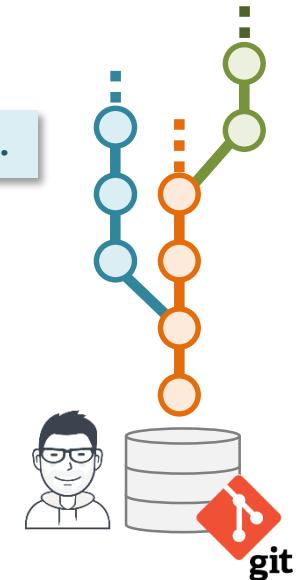
```
git init
```



- A new, empty, Git repository is created in the current directory.
- Files present in the directory can now be version-controlled. However, version-control of files is not automatic – more on that later.
- At this point there is no online remote associated with the new repo. Everything is only local.

Clone a repo from an online source (start from an existing repo)

```
git clone https://github.com/...
```



- The entire content of the online Git repository is “cloned” (i.e. downloaded) to the local machine.
- The online repo is automatically linked (i.e. setup as a “remote”) for the local repo: we can push commits with no additional setup.
- Starting a new project on GitHub/GitLab and cloning it can also be a way to create a new empty local repository and immediately link it to a remote.

Cloning and working with remotes will be presented in more details later in these slides.

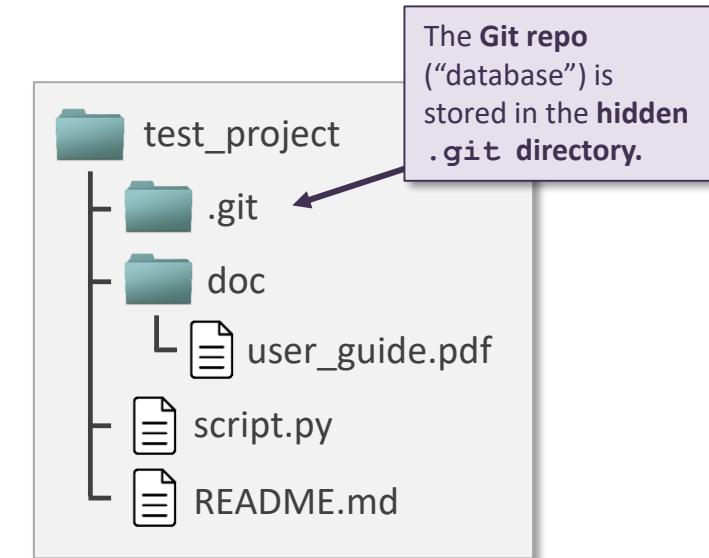
Creating a new Git repository (from scratch)

git init

Initializes a Git repository in the current working directory, turning it into a Git version controlled directory.

Example:

```
$ cd /home/alice/test_project # Enter directory to version control.  
$ git init  
Initialized empty Git repository in /home/alice/test_project/.git/  
  
# Listing the content of our directory, we now see a new .git directory.  
$ ls -a  
./ ../ .git/ doc/ src/ README.md
```



- You must be located **at the root of the directory to version control** before typing **git init**
- **git init** creates a hidden **.git** directory at the root of the directory.
- **Everything is stored in this single **.git** directory:**
 - Complete version history of all tracked files.
 - All other data associated to the Git repository (e.g. branches, tags).
 - The content of **.git** can re-create the exact state of all your files at any versioned time - e.g. if you delete a file accidentally or want to go back to an earlier version.

Never delete the ` `.git` directory
unless you intend to start again your repo from scratch



State of the working directory (here just after `git init`)

3 Useful commands to assess the current status of a Git repo:

- Show status of files in project directory (working tree).

`git status`

\$ `git status`

On branch main
No commits yet

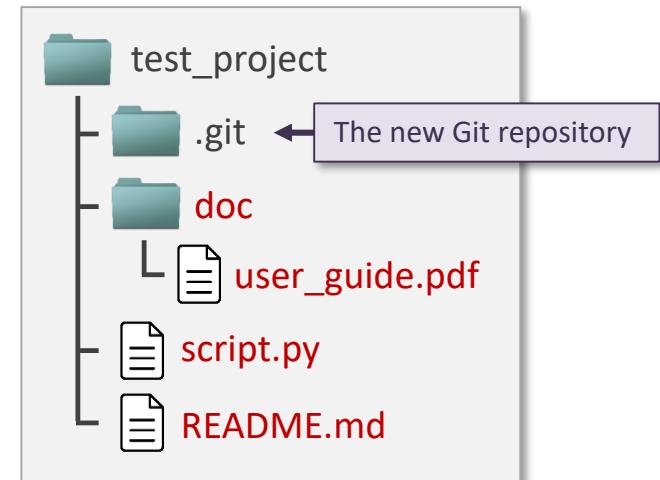
Untracked files:

`doc/`
`README.md`
`script.py`

“main” is the default
branch name.

red = untracked files

How it looks in the file system



- Commit history: show log of commits, i.e. the history of the repo.

`git log`

\$ `git log`

fatal: your current branch
'main' does not have any
commits yet

Since we just created a new repo there are no
commits yet, which is why we get this error.

- List files that are currently tracked by Git (i.e. part of the Git index).

`git ls-files`

\$ `git ls-files`

<empty output>

By default, files are untracked. This is why
there is currently no tracked file.

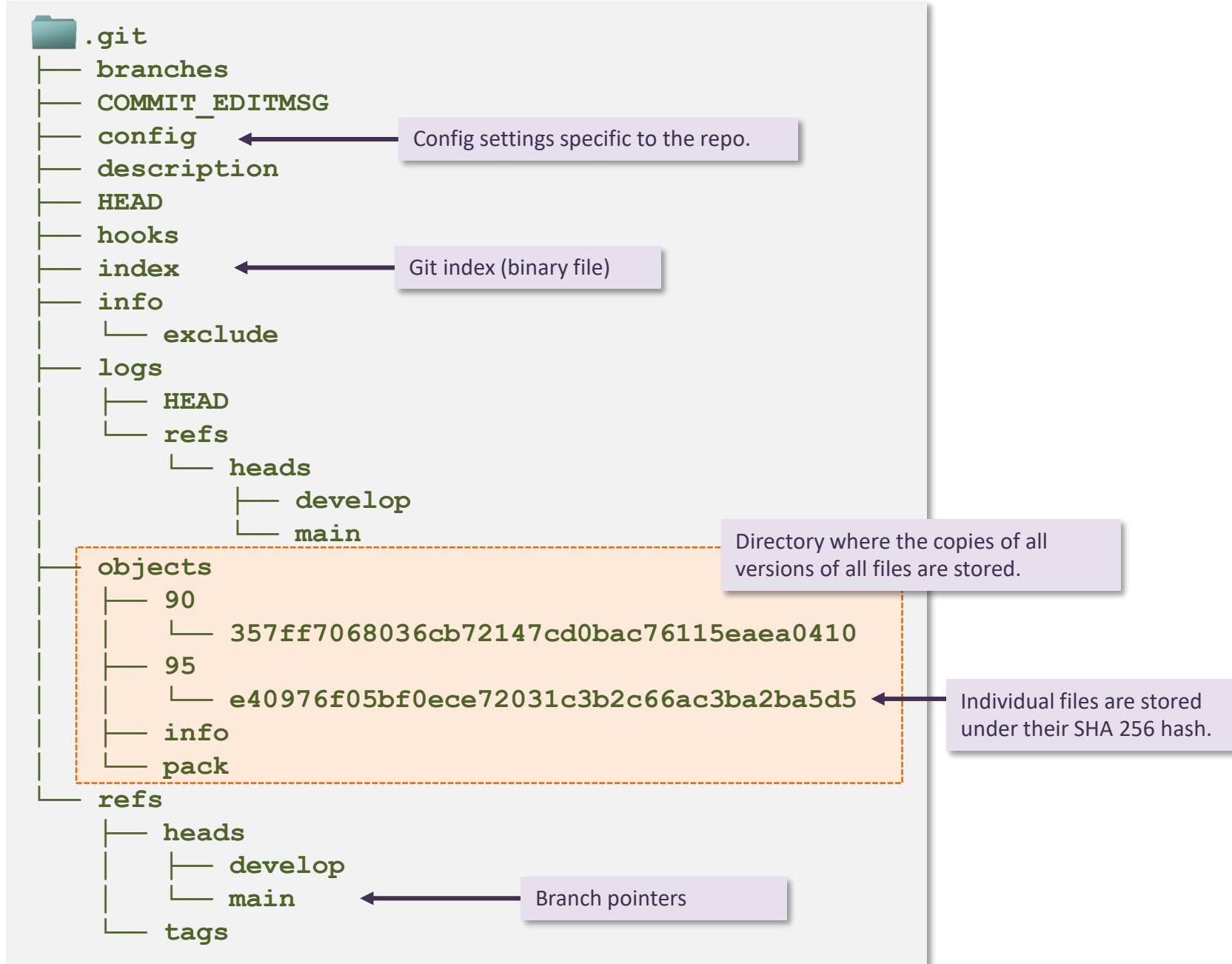
Summary: when creating a new Git repo...

- It does not matter whether the directory is empty or already contains files/sub-directories.
- Files in a project directory (working tree) are not automatically tracked by Git (files are untracked by default).
- You can have both tracked and untracked files in a project directory.
- Only files located in the project directory – or one of its sub-directories – can be tracked.
- Project directories are self-contained – you can rename them or move them around in your file system.
- You can (should) have multiple Git repositories on your system – typically one per project or per code/script you develop * - don't use a single Git repo to track the entire content of your computer!
- Nesting Git repositories (i.e. having one repo inside another) is technically possible, but should be avoided unless there is a clear use-case for it.

⚠️ Never delete the ` `.git` directory, you would lose the entire versioning history of your repository (along with all files not currently present in the working tree).

* An exception is the case of multiple projects that are tightly linked to another: in such cases it can be useful to have them all in a single repo – this is known as a **monorepo**.

Behind the scenes: the content of the .git directory



“Bare” Git repositories

A **bare repo** is a repo that has **no working tree**: it does not contain any instance of the files that are under Git version control, but only the content of the `.**git**` directory/database.

This type of repo is found on remote servers used to share and sync changes across multiple Git repositories. They can be initialized with the command:

```
git init --bare
```

Making a **commit**

git add

git commit

Definition: the Git index (or “staging area”)

In Git, creating a commit is a 2-step process:

Step 1 – Staging files

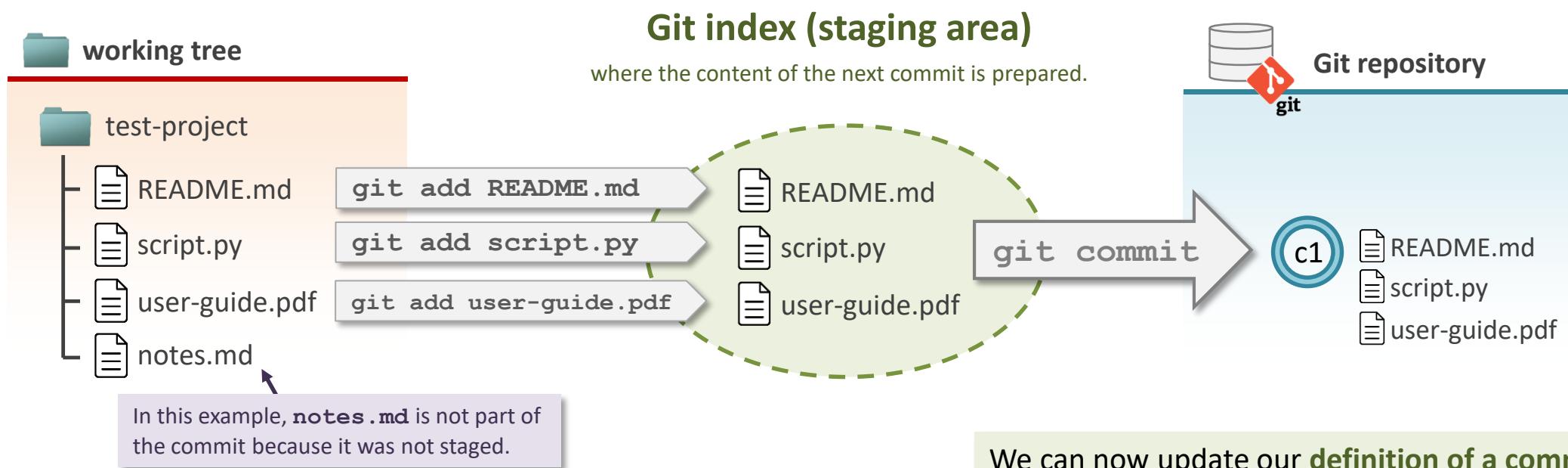
Selection of files to commit. To make a new or modified file part of the next commit, it must be added to the **Git index** (also known as the **staging area**).

```
git add <file or directory>
```

Step 2 – Commit

Create a commit with the current content of the Git index. A new commit (containing the current content of the Git index) is added to the repository.

```
git commit -m "commit message..."
```



We can now update our **definition of a commit**:

Commit = snapshot of the Git index at a given time.

Git index = content of your next commit.

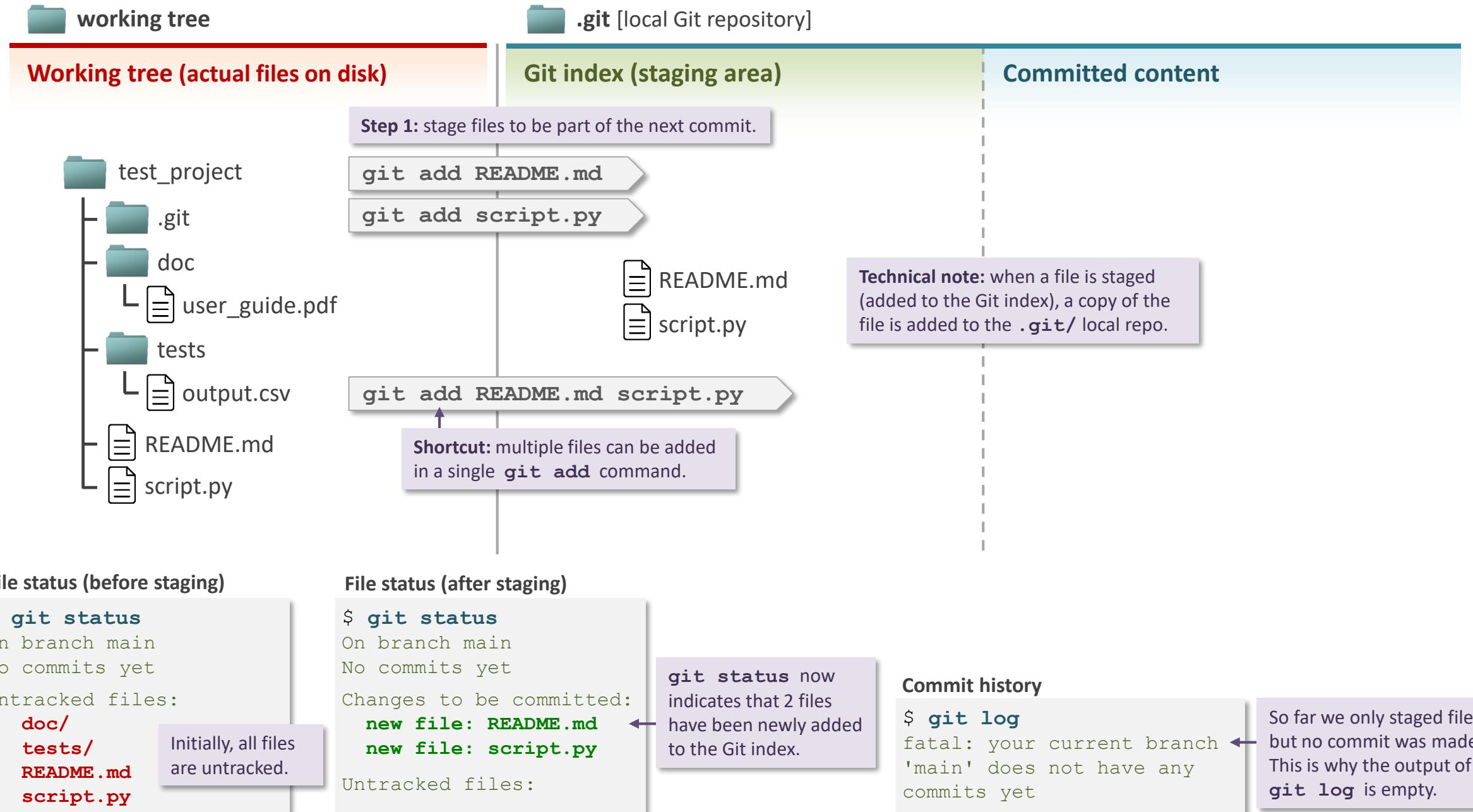


Why do we need this 2-step process ?

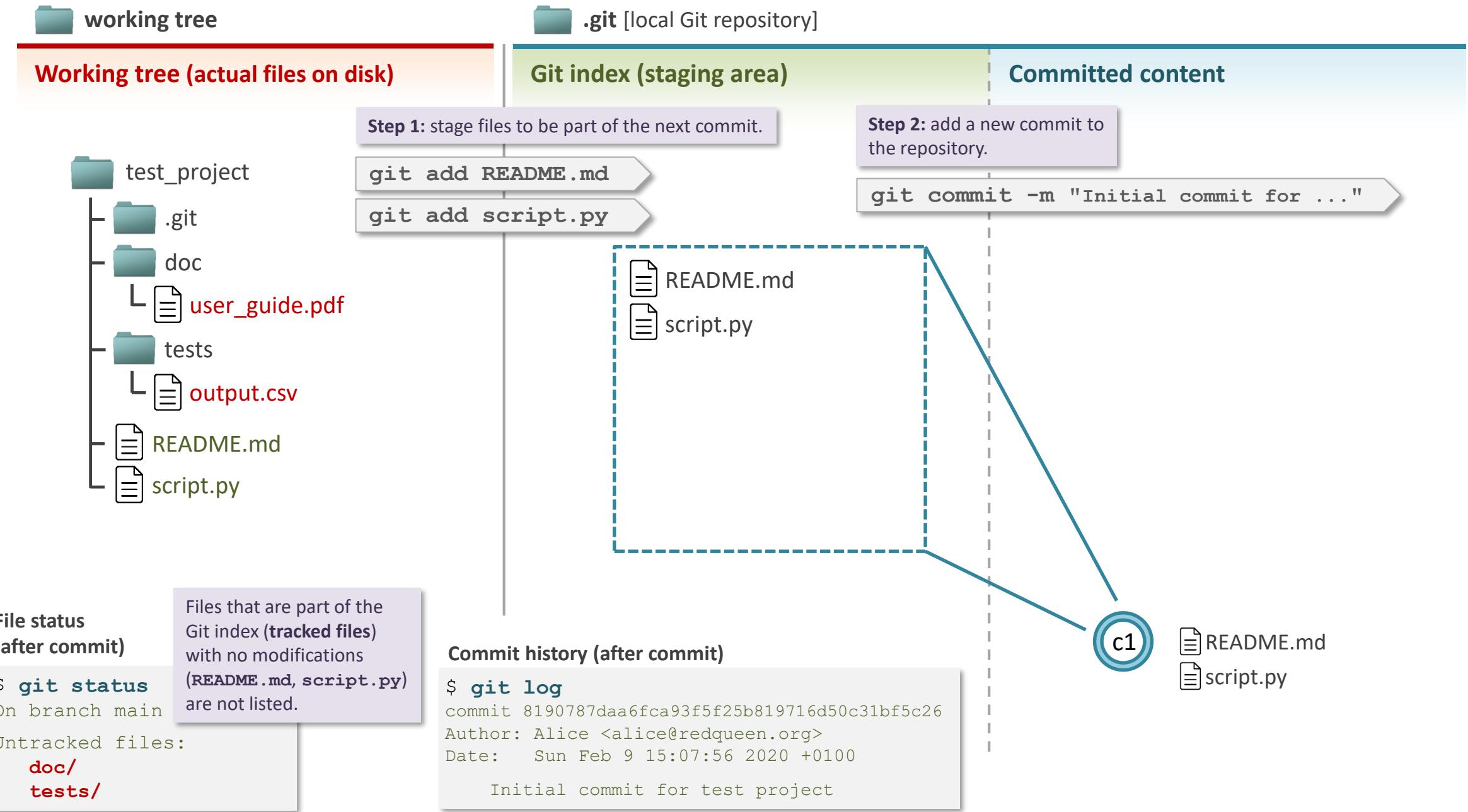
- Why do we need the Git index ?
 - Why not simply commit the entire content of our directory ?
- ➡ The objective of this 2-step procedure is to let users craft “well thought” commits.
- Commits are meant to be meaningful units of change in your code base (or the content you track).
 - Not all current changes in the working tree need to be part of the next commit.



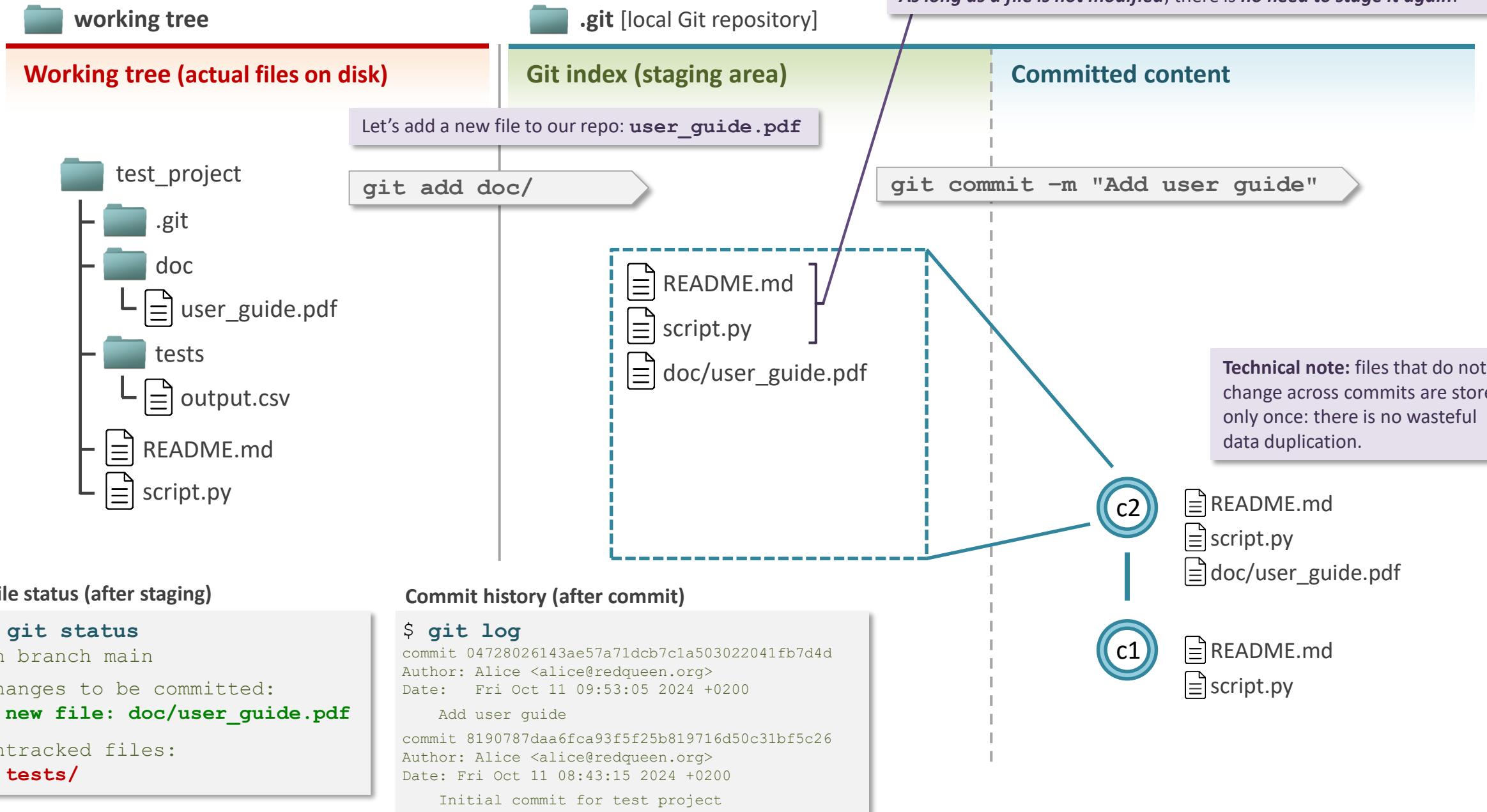
Staging and making a commit: step-by-step example



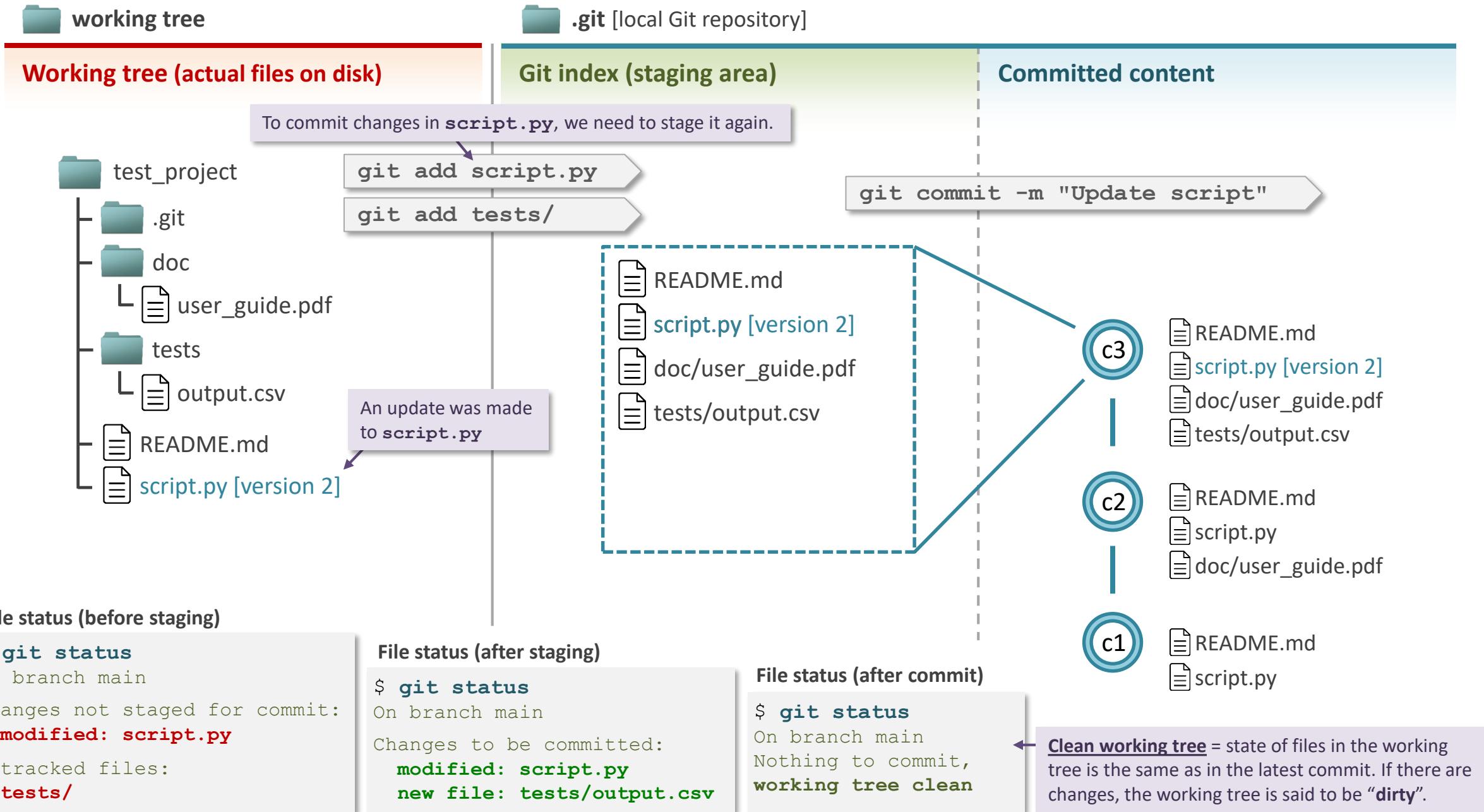
Staging and making a commit: step-by-step example



Staging and making a commit: step-by-step example



Staging and making a commit: step-by-step example



Summary: staging files (git add)

- By default, files in a directory under Git control are **untracked**.
- To include a file (in its current state) – or a change in file content – to the next commit, the file **must be added to the Git index (staged)** with:

```
git add <file/directory>      # Add the specified files/directories to the Git index.
```

- Multiple files/directories can be added in a single command (by passing multiple file/directory names).
- By default, the entire content of a file is added.
Adding only part of a file is possible with the **--edit** or **--patch** options.

- Staged files remain staged, unless explicitly removed (with **git rm** or **git rm --cached**).
- **Modified files must be staged (added to the index) again**, if the new content is to be added to the next commit.
- Some useful **git add** options

```
git add -u / --update    # Stages all already tracked files, but ignore untracked files.  
git add -A / --all       # Stages all files/directories in the working tree (except ignored files), including file deletions.  
git add .                 # Stages entire content of the current directory, except file deletions.
```

Reminder:

commit = snapshot of the Git index

The Git index (staging area) can therefore be thought of as a “virtual stage” where the content of the next commit is prepared.

Summary: committing content (git commit)

```
git commit -m/--message "your commit message"  
git commit
```

If no commit message is given, Git will open its default editor and ask you to enter it interactively.

Useful shortcuts:

```
git commit -m "commit message" <files or dirs> # Stage and commit the specified files/directories in a single command.  
git commit --all -m "commit message" # Stage and commit all modified tracked files in a single command.
```

--all is a shortcut for:

```
git add -u  
git commit -m "commit message"
```

It will not stage/commit untracked files.

This is a shortcut for:

```
git add <file or dir>  
git commit -m "commit message"
```

Example

```
$ git commit -m "Initial commit for test_project"  
[main (root-commit) 8190787] Initial commit for test_project  
3 files changed, 6 insertions(+)  
create mode 100644 README.md  
create mode 100644 script.py  
create mode 100644 doc/quick_start.md
```

+ 4 (empty lines also count)

6 insertions = 6 lines added in total (across all files)

README.md

+ 1 | # Quick-start guide for the test_project software

script.py

+ 1 | #! /usr/bin/env python3

doc/quick_start.md

Test project: testing version control with Git

A small test project to illustrate the use of Git.
Maybe I will add more content to it later.

Making commits: some advice

Git does not impose any restrictions on what and when things can be committed.

One exception being that, by default, commits with zero changes are not allowed, but they are possible by using the `--allow-empty` option: `git commit --allow-empty`

However, it's best if you:

- Make commits at *meaningful points* of your code/script development, for instance:
 - When a new feature was added (or a few related functions).
 - When a bug was fixed.
- Make *multiple small commits instead of a large one* if you are making changes that affect different functionalities of your code (this can make it easier to e.g. revert changes).
- *Don't commit broken code on your main/master branch*, as this is the branch that others might use to get the latest version of your code.
If you have partial work, you can commit it to a *temporary/feature* branch, and later merge it into *main/master* (more on branch management will follow later).

Committing content: interactive commit message with the “vim” editor

```
$ git commit
```

Initial commit for test_project

```
# Please enter the commit message for your changes. Lines starting
# with '#' will be ignored, and an empty message aborts the commit.
#
# On branch main
# Changes to be committed:
#   new file: README.md
#   new file: script.py
#   new file: doc/quick_start.md
#
```



When no commit message is specified,
Git automatically opens a text editor.
By default, this editor is “vim”.

- In the “vim” editor, press on the key “i” to enter edit mode
- In edit mode, you can now type your commit message.

Committing content: interactive commit message with the “vim” editor

Initial commit for test_project

This is the very first commit in this Git repo.

Way to go!

```
# Please enter the commit message for your changes. Lines starting
# with '#' will be ignored, and an empty message aborts the commit.
#
# On branch main
# Changes to be committed:
#   modified: README.md
#   new file: script.py
#   new file: doc/quick_start.md
#
~
~
:wq
```

- Commit message can be entered over multiple lines.
- By convention, try to keep lines reasonably short (<= 80 chars)

- Press “**Esc**” to exit “edit” mode.
- Type “**:wq**” in the vim “command” mode.



Press “**Enter**” to exit vim and save your commit message.

- You are now back in the shell and your commit is done.

```
[main (root-commit) 8190787] Initial commit for test_project
3 files changed, 6 insertions(+)
create mode 100644 README.md
create mode 100644 script.py
create mode 100644 doc/quick_start.md
```

Demo

- Initializing a new Git repo.
- Adding content to the Git repo.
- Making a commit with interactive commit message.

exercise 1 – part A

Your first commit



This exercise has helper slides

Exercise 1 help: bash (shell) commands you may need during this course

cd <directory>	Change into directory (enter directory).
cd ..	Change to parent directory.
ls -l	List content of current directory.
ls -la	List content of current directory including hidden files.
pwd	Print current working directory.
cp <file> <dest dir>	Copy a file to directory “dest dir”.
mv <file> <new name>	Rename a file to <new name>.
mv <file> <directory>	Move a file to a different directory.
cat <file>	Print a file to the terminal.
less <file>	Show the content of a file (type “q” to exit).
vim <file>	Open a file with the “vim” text editor.
nano <file>	Open a file with the “nano” text editor.

Inspecting file status

git status

git diff

Display file status

git status

Display the status of files in the working tree.

- * **Modified files:** files with changes in content as compared to the latest commit.
- ** **Staged files that have not been modified since the last commit (unmodified files)** are not listed, but they are still in the index and will be part of the next commit.
- **Ignored files** are also not listed.

```
$ git status
```

On branch main

Changes to be committed:

(use "git restore --staged <file>..." to unstage)

new file: LICENSE.txt modified: README.md modified: script.py deleted: test/test_output.csv	← new file = file is not present in latest commit. ← modified = file is modified compared to latest commit. ← deleted = file is present in latest commit and will now be removed
--	--

Staged files **

Green = files with (changes in) content (compared to the latest commit) that has been staged and will be part of the next commit.

Red = files with (changes in) content (compared to the latest commit) that is not staged. These changes will not be part of the next commit.

Changes not staged for commit:

(use "git add <file>..." to update what will be committed)
 (use "git restore <file>..." to discard changes in working directory)

modified: README.md modified: doc/user_guide.md deleted: test/log.txt	← modified = file is modified compared Git index. ← deleted = file is deleted on disk, but is still present in the Git index (and the latest commit).
--	--

Unstaged files

Untracked files:

(use "git add <file>..." to include in what will be committed)

untracked_file.txt

untracked files



Note: the (new) content of a file can be **partially staged**: some changes in the file are staged (added to the index), while some remain unstaged. This is the case in the example above for the **README .md** file (which is why it's listed in both the staged and unstaged sections). **Only the staged content will become part of the next commit.**

File status in Git: summary

Possible statuses for files in Git:

- **Tracked** – file that is currently under version control. More specifically, it is currently part of the Git index (staging area) and therefore also generally part of the latest commit *. Tracked files can be further categorized as:
 - **Unmodified** – the file is part of the latest commit * (and the Git index), and no change was made to the file since then. In other words, the content of the file in the working directory (working tree) is the same as in the latest commit. Unmodified files are not listed by the `git status` command.
 - **Modified** – the content of the file in the working directory (working tree) differs from the latest commit *. Modified files can be staged, unstaged, or partially staged.
 - **Staged**: the difference in content has been added to the Git index (staging area), and will therefore be committed with the next commit.
 - **Unstaged**: the difference in content has not been staged (not part of the Git index), and will therefore not be part of the next commit.
 - **Partially staged**: some differences (but not all) have been staged (added to the Git index). Only the staged differences will be part of the next commit.
- **Untracked** - file present in the project directory (working tree), but not currently under version control by Git. More specifically, the file is not currently present in the Git index – but could be part of an earlier commit.
- **Ignored** - untracked file that is part of the repository's "ignore list" (`.gitignore` or `.git/info/exclude` file). Ignored files are not listed by the `git status` command.

* more precisely: the commit to which the HEAD pointer is currently pointing – this concept is explained later in the slides.

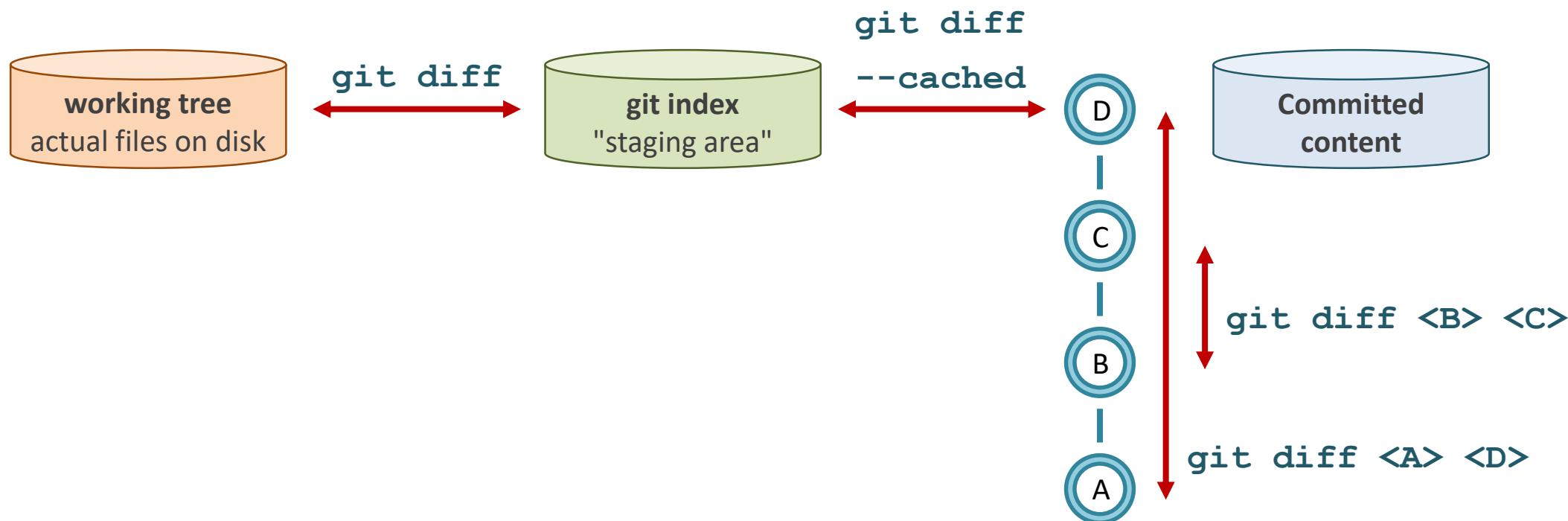
How do I know what changed and which *changes* are staged ?

git diff Show differences between two states of a Git repo.

```
git diff <file>          # show diff only for a specific file.  
git diff --cached  
git diff <commit 1 (older)> <commit 2 (newer)>  
git diff --name-only      # show only file names, not the changes.
```

Example:

```
$ git diff  
diff --git a/README.md b/README.md  
index f5e333d..844d178 100644  
--- a/README.md  
+++ b/README.md  
@@ -1,2 +1,3 @@  
Project description:  
-This is a test  
+This is a demo project  
+and it's pretty useless
```



Inspecting **commits** and **history**

`git show`

`git log`

Display the “content” of a commit

git show Display the changes in file content introduced by a commit.

git show <commit reference>

git show

with no argument, the latest commit on the current branch is shown (i.e. HEAD)

Example:

```
$ git show 89d201f
commit 89d201fd01ead6a499a146bc6da5aa078c921ecf
Author: Alice <alice@redqueen.org>
Date:   Wed Feb 19 14:00:02 2020 +0100

    Add stripe color option to class Cheshire_cat

diff --git a/script.sh b/script.sh
index d7bfdcc8..fa99250 100755
--- a/script.sh
+++ b/script.sh
@@ -7,13 +7,28 @@
# def Cheshire_cat():
-  def __init__(self, name, owner="red queen"):
+  def __init__(self, name, owner="red queen", stripe_color="orange"):
+    self.stripe_color = stripe_color
```

Examples of commit references:

- A commit ID (hash): **89d201f**
- A branch name: **develop**
- A tag name: **1.0.7**
- The **HEAD** pointer.
- A relative reference: **HEAD~3**

If no commit reference is given, **HEAD** is used as default.



The detail of changes can only be shown for plain text files.

git show --name-only <ref>

Only display file names (without the changes)

```
$ git show --name-only 89d201f
commit 89d201fd01ead6a499a146bc6da5aa078c921ecf
Author: Alice <alice@redqueen.org>
Date:   Wed Feb 19 14:00:02 2020 +0100
```

Add stripe color option to Cheshire_cat

script.sh

Display commit history

Print the commit history of the repository, newest commit to oldest (i.e. newest commit at the top)



`git log` has many options to format its output.
See `git log --help`

```
git log  
git log --oneline  
git log --all --decorate --oneline --graph
```

Example: default view (detailed commits of current branch).

```
$ git log  
commit f6ceaac2cc74bd8c152e11b9c12ada725e06c8b9 (HEAD -> main, origin/main)  
Author: Alice alice@redqueen.org  
Date:   Wed Feb 19 14:13:30 2020 +0100  
  
        Add stripe color option to class Cheshire_cat  
  
commit f3d8e2280010525ba29b0df63de8b7c2cd7daeaf  
Author: Alice alice@redqueen.org  
Date:   Wed Feb 19 14:11:56 2020 +0100  
  
        Fix off_with_their_heads() so it now passes tests  
  
commit cfd30ce6e362bb4536f9d94ef0320f9bf8f81e69  
Author: Mad Hatter mad.hatter@wonder.net  
Date:   Wed Feb 19 13:31:32 2020 +0100  
  
        Add .gitignore file to ignore script output
```

Example: compact view of current branch

```
$ git log --oneline
f6ceaac (HEAD -> main, origin/main) peak_sorter: add authors to script
f3d8e22 peak_sorter: display name of highest peak when script completes
cf30ce Add gitignore file to ignore script output
f8231ce Add README file to project
821bcf5 peak_sorter: add +x permission
40d5ad5 Add input table of peaks above 4000m in the Alps
a3e9ea6 peak_sorter: add first version of peak sorter script
```

Example: compact view of entire repo (all branches)

```
$ git log --all --decorate --oneline --graph
* fc0b016 (origin/feature-dahu, feature-dahu) peak_sorter: display highest peak at end of script
* d29958d peak_sorter: add authors as comment to script
* 6c0d087 peak_sorter: improve code commenting
* 89d201f peak_sorter: add Dahu observation counts to output table
* 9da30be README: add more explanation about the added Dahu counts
* 58e6152 Add Dahu count table
| * f6ceaac (HEAD -> main, origin/main) peak_sorter: add authors to script
| * f3d8e22 peak_sorter: display name of highest peak when script completes
|
* cf30ce Add gitignore file to ignore script output
* f8231ce Add README file to project
| * 1c695d9 (origin/dev-jimmy, dev-jimmy) peak_sorter: add check that input table has the ALTITUDE and PEAK columns
| * ff85686 Ran script and added output
|
* 821bcf5 peak_sorter: add +x permission
* 40d5ad5 Add input table of peaks above 4000m in the Alps
* a3e9ea6 peak_sorter: add first version of peak sorter script
```



Adding custom shortcuts to Git

Some git commands can be long and painful to type, especially when you need them often!

To shorten a command, you can create **custom aliases**:

```
git config --global alias.<name of your alias> "command to associate to alias"
```

Example:

```
git config --global alias.adog "log --all --decorate --oneline --graph"
```

With the alias set, you can now simply type:

```
git adog
```



Editing the Git index (staging area)

Summary: removing content from the Git index

- Remove newly staged content from the index (one file at a time).

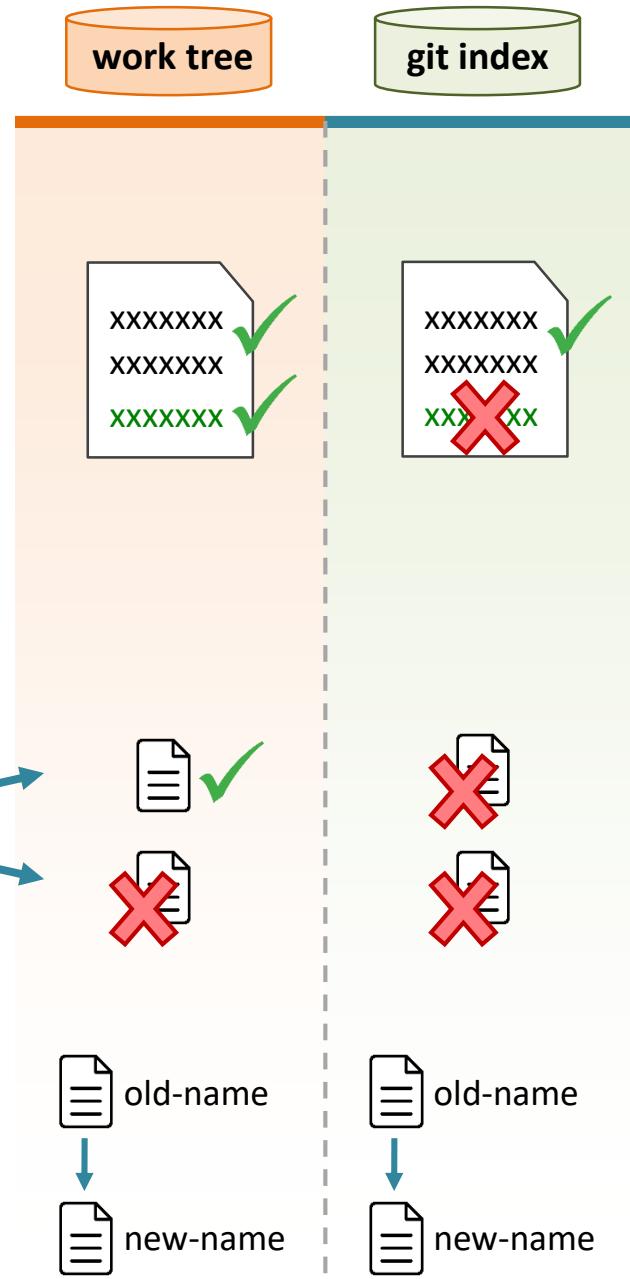
```
git restore --staged <file> # Remove newly staged content of the specified file.
```

⚠ Without the `--staged` option => resets file in work tree to the its version in the Git index.

The same can also be achieved using the `git reset` command. This is a specific use of the `reset` command, which has a wider scope.

```
git reset HEAD <file> # Remove newly staged content of a specific file.  
git reset HEAD # Remove all newly staged content (all files).
```

Useful to unstage all changes in a single command.



- Delete entire files from the index and the working tree.

```
git rm --cached <file> # Delete file from index only.  
git rm <file> # Delete file from both index and working tree.
```

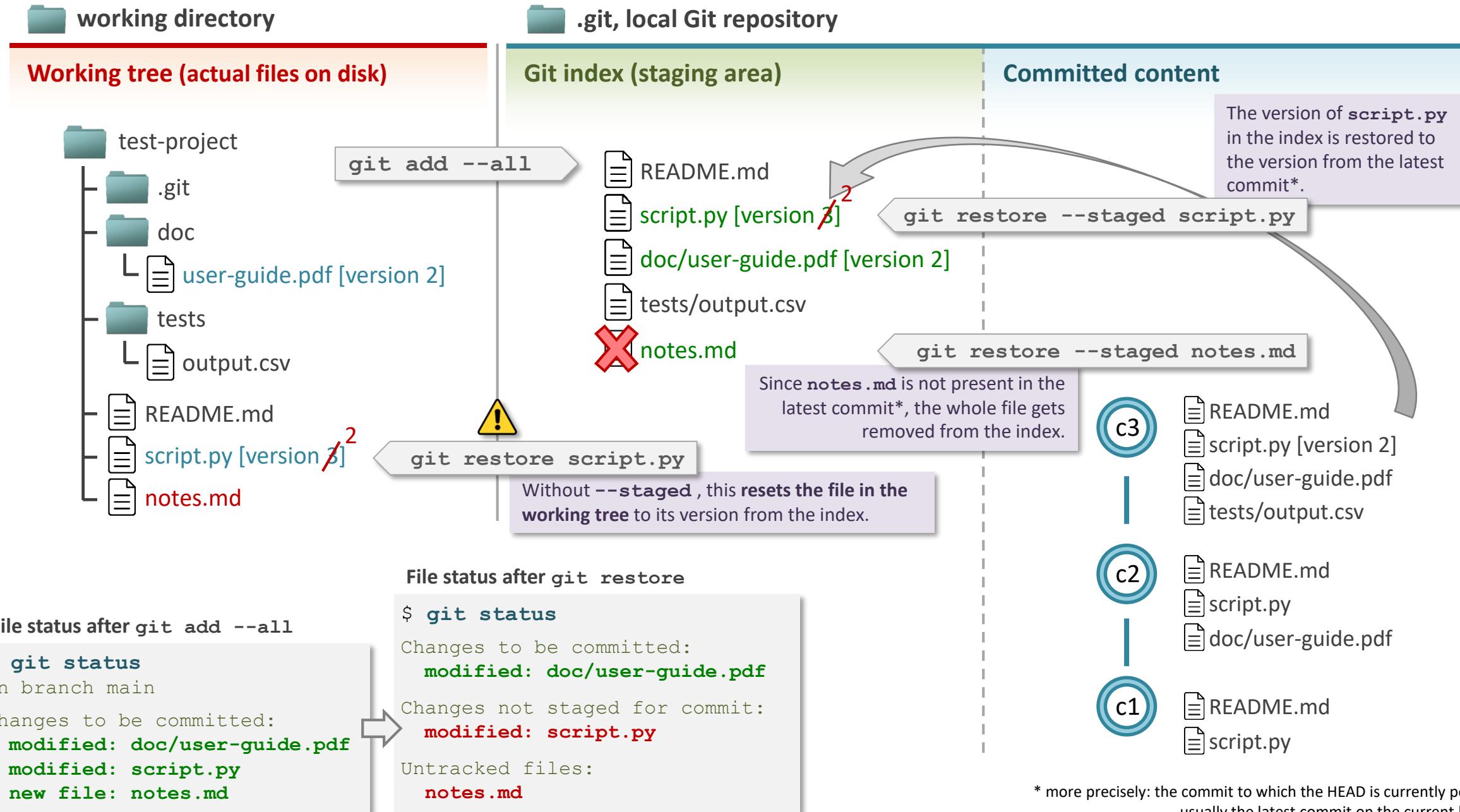
⚠ Without the `--cached` option => deletes file in working tree (i.e. on disk) !

- Rename and/or move files both in the working tree and the Git index.

```
git mv <file> <new location/new name>
```

Removing content from the Git index: example

Scenario: an update was made to `user-guide.pdf` and `script.py`. We want to commit the new version of `user-guide.pdf` (version 2), but not the changes to `script.py` and not `notes.md`.



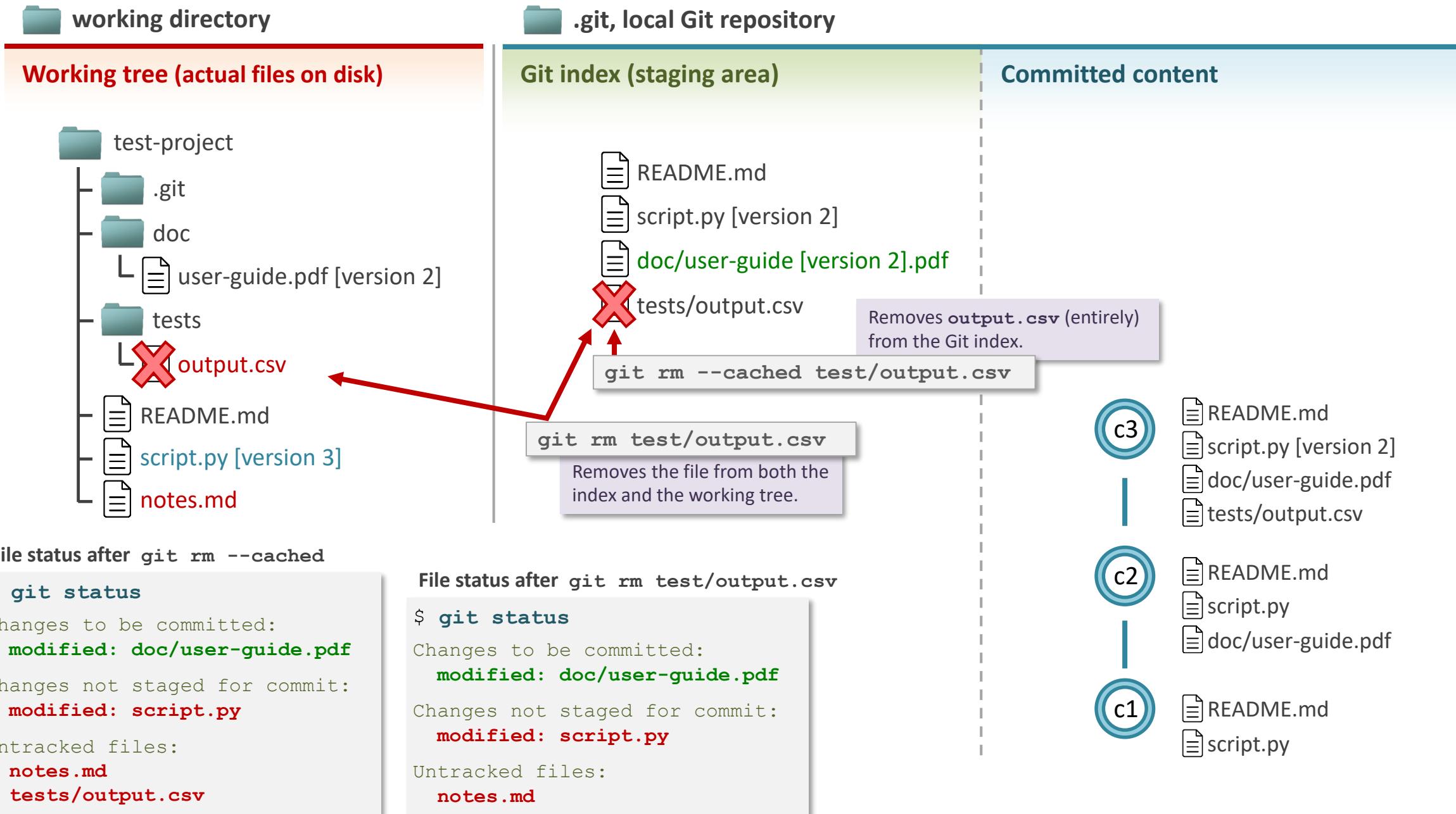
File status after `git add --all`

```
$ git status
On branch main
Changes to be committed:
  modified: doc/user-guide.pdf
  modified: script.py
  new file: notes.md
```

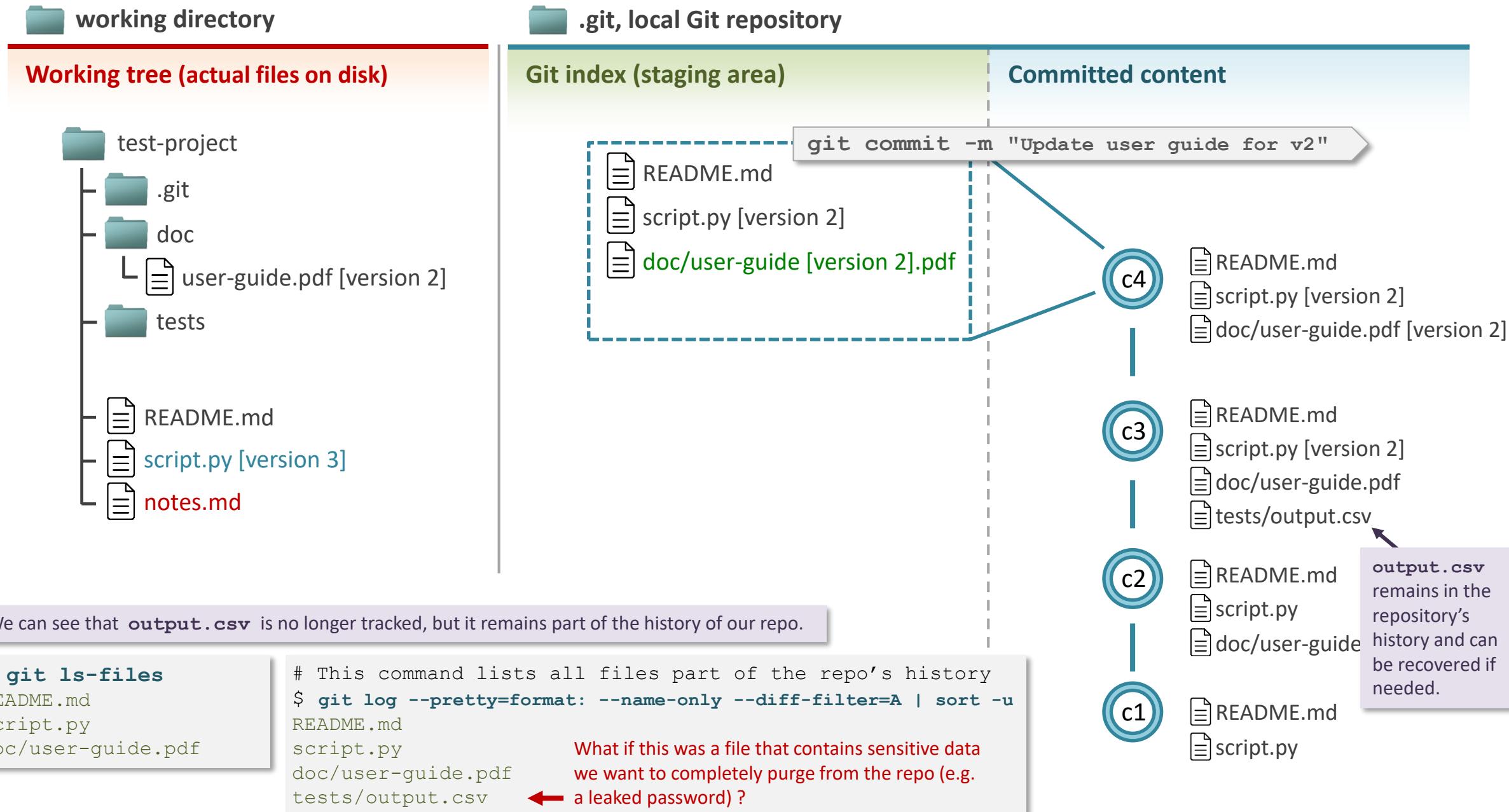
File status after `git restore`

```
$ git status
Changes to be committed:
  modified: doc/user-guide.pdf
Changes not staged for commit:
  modified: script.py
Untracked files:
  notes.md
```

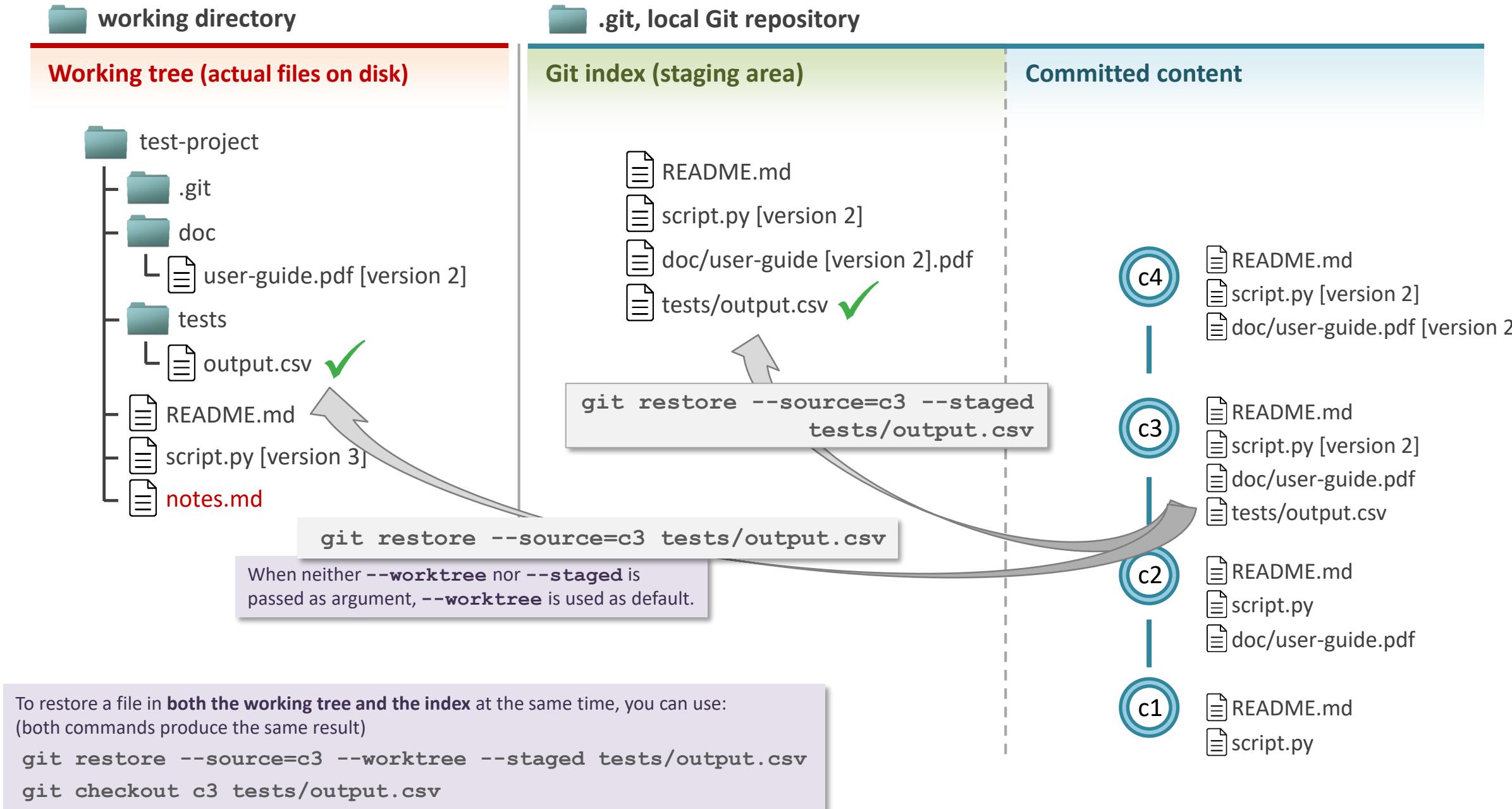
* more precisely: the commit to which the HEAD is currently pointing, usually the latest commit on the current branch.



Removing content from the Git index: example



I would now like to retrieve the file `output.csv` from the Git repository.



OMG ! How will I remember all these fantastic commands ??

The `git status` command provides helpful hints on how to stage/unstage files.

```
$ git status
On branch main
Changes to be committed:
  (use "git restore --staged <file>..." to unstage)
    modified:   user-guide.pdf

Changes not staged for commit:
  (use "git add <file>..." to update what will be committed)
  (use "git restore <file>..." to discard changes in working directory)
    modified:   script.py

Untracked files:
  (use "git add <file>..." to include in what will be committed)
    notes.md
    tests/output.csv
```

Warning: without the `--staged` option, `git restore` will **reset (overwrite)** the file in the **working tree** with the version of the file from the Git index.

Only run it if you intend to delete the current version of your file.



ignoring untracked files

.gitignore

.git/info/exclude

Ignoring files

- By default, files that are not added to a Git repo are considered **untracked**, and are always listed as such by `git status`.
- To stop Git from listing files as **untracked**, they can be added to one of the following "ignore" files:

.gitignore

- For files to be **ignored by every copy of the repository**.
- `.gitignore` is meant to be tracked: `git add .gitignore`
- Examples:
 - outputs of tests
 - `.Rhistory`, `.RData`
 - `.pyc` (compiled version of python code)

Most of the time, this is the method you will want to use to ignore files.

Example of a `.gitignore` file

```
my_tests.py
.Rdata
.Rhistory
*.pyc
test_outputs/
```

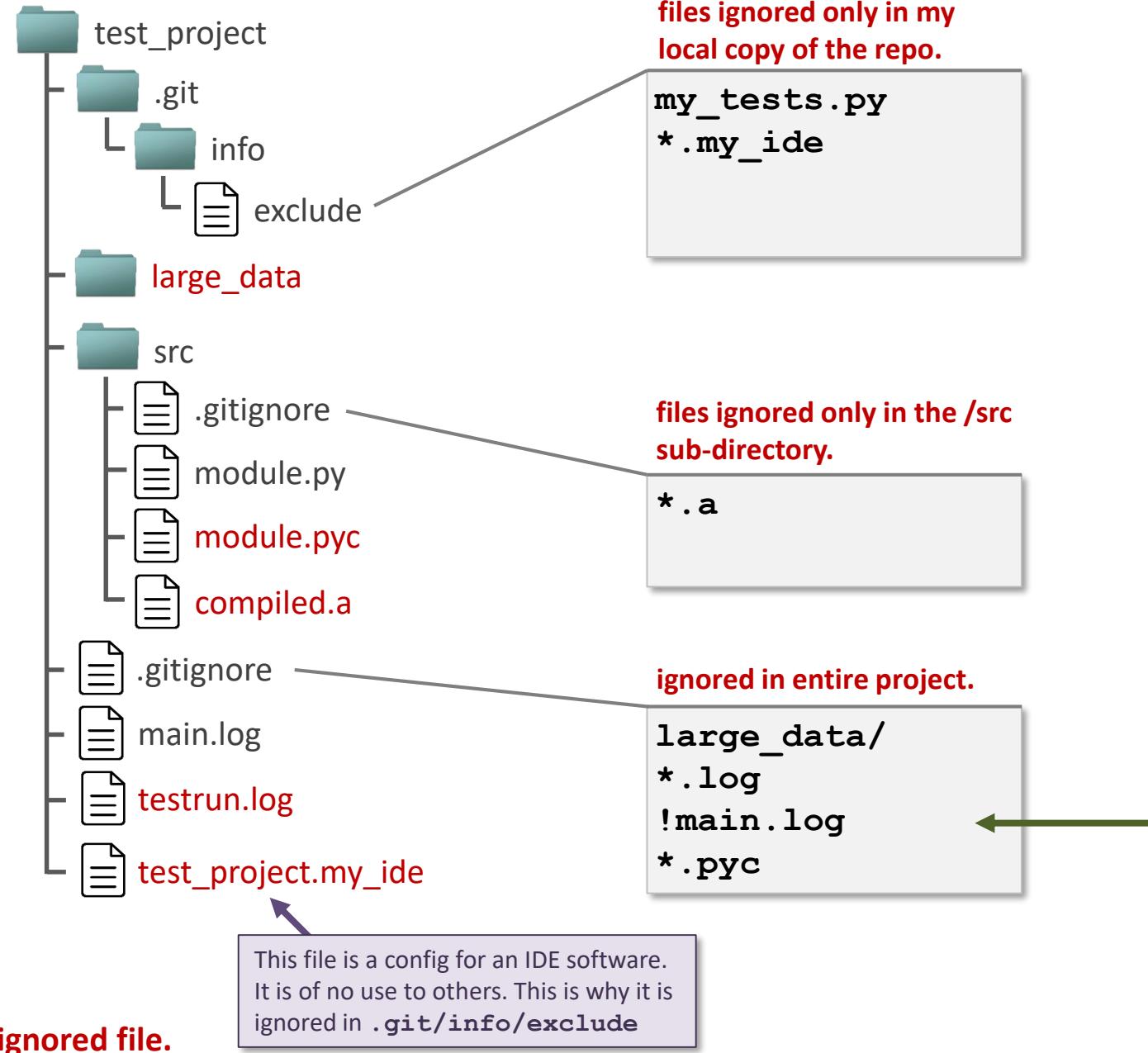
- Files to ignore are added by manually editing the two above-mentioned files.
- Files can be ignored based on their full name, or based on glob patterns (see next slide for examples).
 - `*.txt` ignore all files ending in ".txt"
 - `*.[oa]` ignore all files ending either in ".o" or ".a"
 - `logs/` appending a slash indicates a directory. The entire directory and all of its content are ignored.
 - `!dontignorethis.txt` adding a ! In front of a file name means it should not be ignored (exception to rule).

.git/info/exclude

- For files that should be **ignored only by your own local copy of the repository**.
- Not versioned and not shared.
- Examples:
 - Files with some personal notes.
 - Files specific to your development environment (IDE).

Use this method for **special cases** where a file should **only be ignored in your local copy of the repo**.

Ignoring files: example



- There can be multiple `.gitignore` files per project, to create custom per-directory ignore rules.
- Ignore rules in sub-directories are inherited from the `.gitignore` of their parent directory(ies).
- The `.gitignore` files themselves should not be ignored: add them to the Git repo so they are tracked.

- **Order (sometimes) matters:** here the rule to not ignore `main.log` must be placed after the general rule to ignore `*.log` files.

Demo

- Ignoring files with `.gitignore`

exercise 1 – part B and C

Your first commit

A detailed look at **commits**

Introducing SHA-1

- SHA-1 stands for **Secure Hashing Algorithm 1**.
- This algorithm turns any binary input into an (almost*) unique 40 character hexadecimal **hash/checksum value** (hexadecimal = base 16 number, 0-9 + a-f).

```
e83c5163316f89bfbde7d9ab23ca2e25604af290
```

- Important: for a given input, SHA-1 always computes the exact same and (almost*) unique hash.
- Example: running "This is a test" through the SHA-1 algorithm, will always produce the hash shown below:

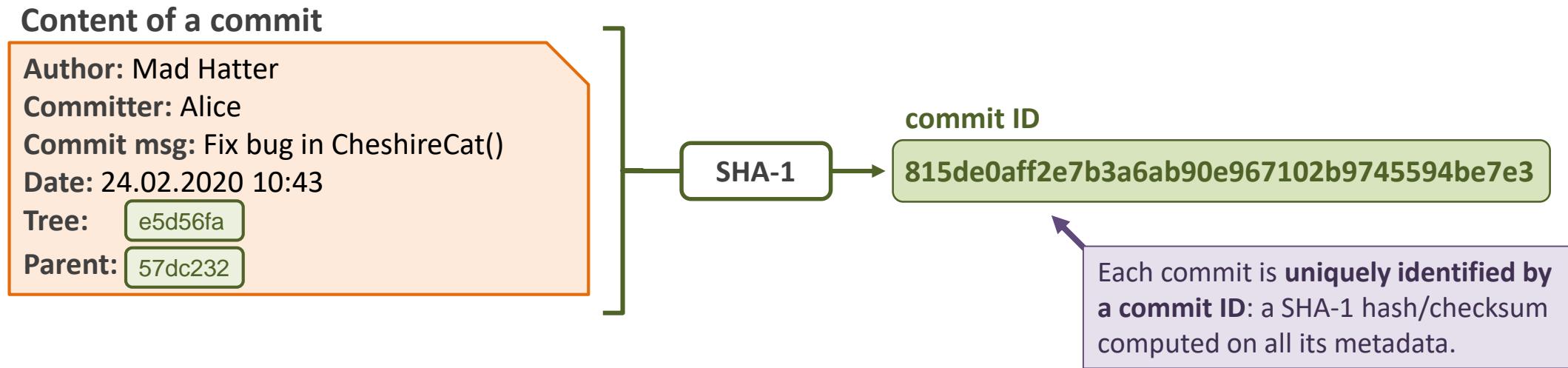
```
echo "This is a test" | openssl sha1 → 3c1bb0cd5d67dddc02fae50bf56d3a3a4cbc7204
```

```
echo "This is a Test" | openssl sha1 → 7500c6645cb9cdb20b32002cb82bbe067cc77d6e
```

* With current hardware, SHA-1 collisions can be reasonably easily created. SHA-1 is no longer considered secure for cryptographic purposes, but is good enough for usage in Git. It is also fast to compute.

Commits: immutable snapshots of a repository's state

- A commit represents the **state of a repository at a given time** => **snapshot of Git index + metadata**.
- A commit is **the only way to enter a change** into a Git repository.
This **enforces accountability** as you cannot have untraceable modifications.
- Each commit has an associated author, committer, commit message and date - this **enforces documentation**.
- Commits are **lightweight**:
 - They **do *not* contain the tracked files' data**, only a **reference to the data** (specifically, a **Tree*** object that represents the state of the Git index at the time the commit was made).
- Commits contain a **reference to their parent** commit.

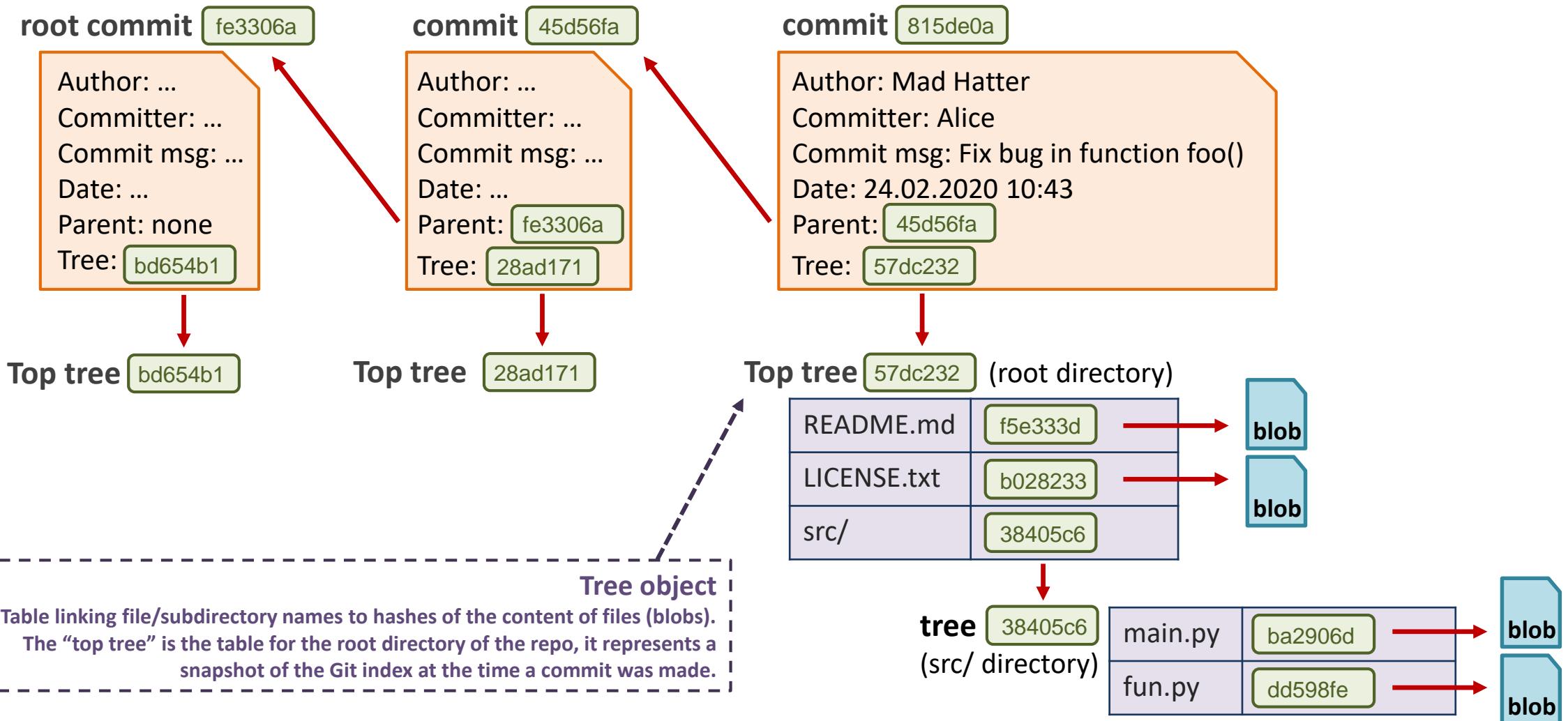


* Tree = reference to the state of all files at a given time point = snapshot of repository state.

- Commits contain a reference to the top “Tree object”** – a table linking file names and hashes of the Git index at the time the commit was made. This is a “snapshot” of the index, and is how Git can retrieve the state of every file at a given commit.
- Commits point to their direct parent** – forming a DAG (directed acyclic graph) where no commit can be modified without altering all of its descendants.

If two commits have the same ID, their content is identical !

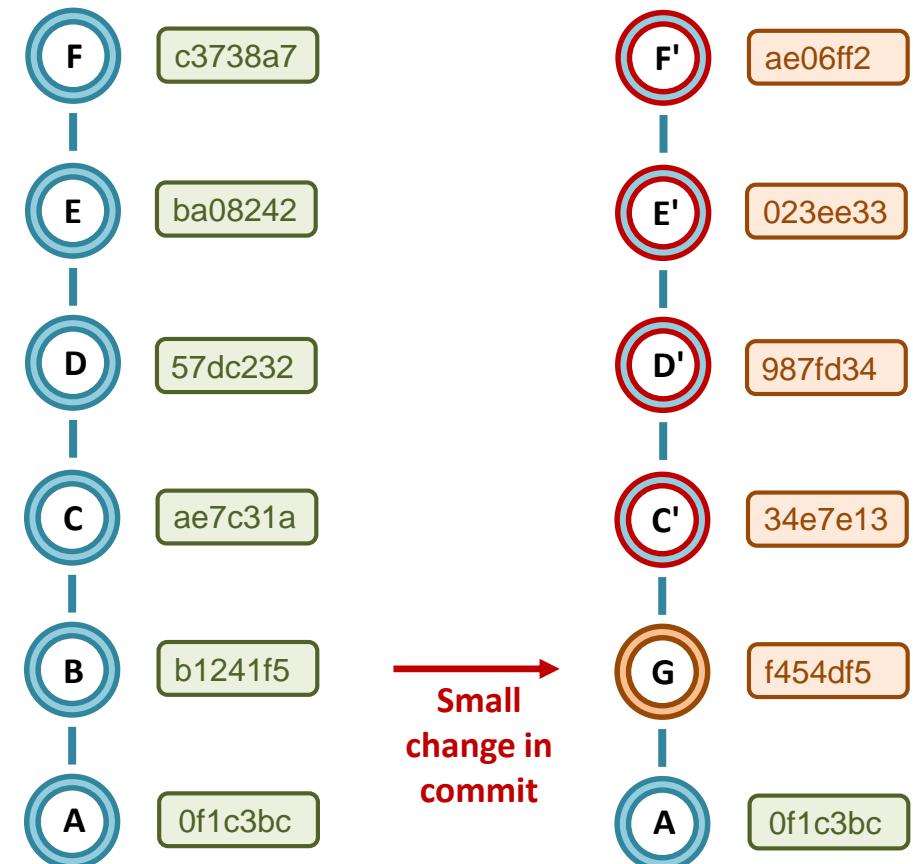
If two commits have the same ID, their entire history is identical !



- Because of how a commit ID is computed, **commits are immutable**: once a commit is made, it cannot be modified without its commit ID being modified too - which would then make it a different commit !
- Modifying a commit** will modify all of its descendants. It **creates a completely new history** of the Git repo.
- This ensures the **integrity of a Git repository's history**, something that **is important due to the distributed nature of Git**. It can be seen as a sort of blockchain.

Examples of things that change a commit's ID:

- Changing the content of a file.
- Changing the time a commit was made.
- Changing the parent commit of a commit.



Git versioning

- Git stores a complete copy of each file's version*.
- Optimized for speed rather than disk space preservation.
- Sub-optimal for tracking large files, as they will quickly inflate the size of the `.git` repo.

As counter-intuitive as it may sound, Git stores a complete copy of each file version. Not just a diff.

What ??

Yes! It may not be space efficient, but it's fast :-)

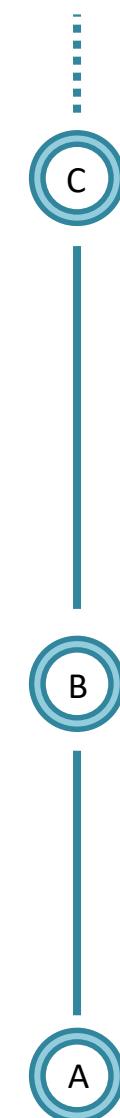
most VCS versioning

```
--- version2 diff
+++ version3 diff
+ Yes! It may not be space
+ efficient, but it's + fast :-)
```

```
--- version1 diff
+++ version2 diff
+ What ??
```

version1

As counter-intuitive as it may sound, git stores a complete copy of each file version. Not just a diff.



Git versioning

version3

As counter-intuitive as it may sound, Git stores a complete copy of each file version. Not just a diff.

What ??

Yes! It may not be space efficient, but it's fast :-)

SHA1 – e78bf23...

version2

As counter-intuitive as it may sound, Git stores a complete copy of each file version. Not just a diff.

What ??

SHA1 – 8fb24d3...

version1

As counter-intuitive as it may sound, Git stores a complete copy of each file version. Not just a diff.

SHA1 – 27da79b...

* At least for a while - at some point Git also stores things as diffs, see "packfiles".

Git packfiles: compressing old history

- For older commits, Git uses a few tricks to decrease disk space usage:
 - Differences between similar files are stored as diffs.
 - Multiple files are compressed into a single “packfile” (`.pack` extension).
 - Each packfile has an associated packfile index (`.idx` extension), that associates filenames to blobs.

The **HEAD** pointer

HEAD: a pointer to the most recent commit on the currently active branch

Looking at the output of `git log`, we see a **HEAD ->** label: this shows the position of the **HEAD** pointer.

Commit ID (SHA1 hash)

Here shown in a shortened
form (7 first chars).

HEAD pointer

Local branch name

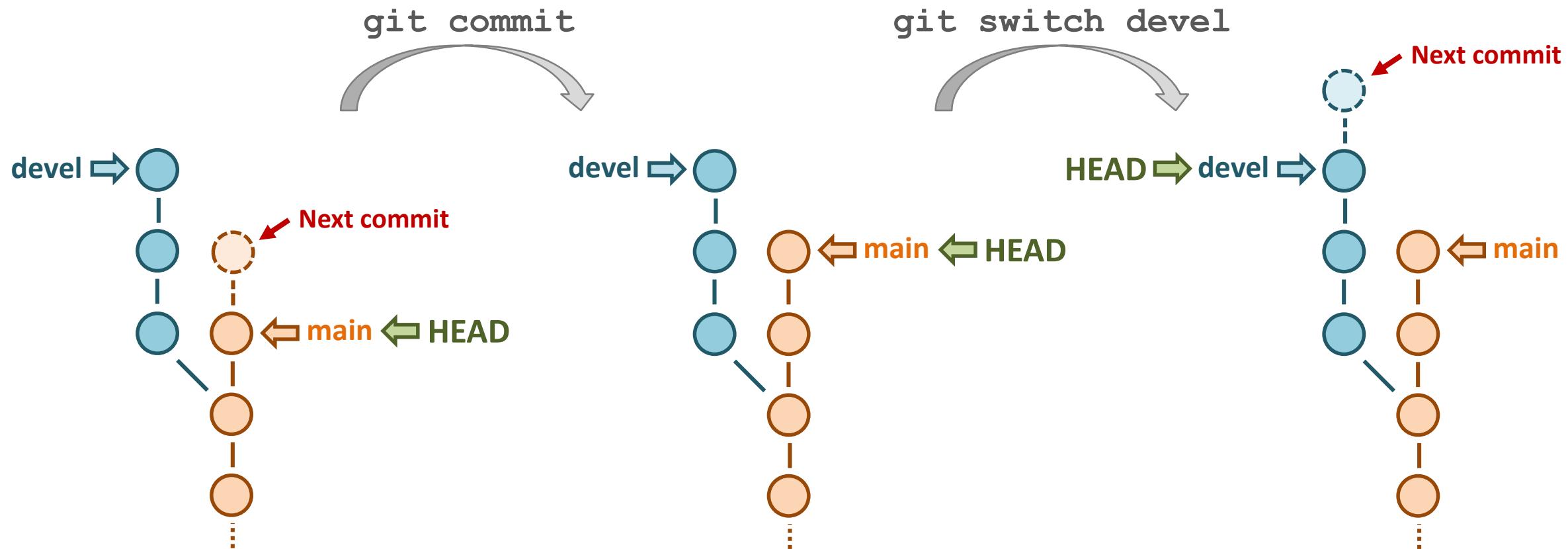
Remote branch name

First line of commit message

```
> git log --all --decorate --oneline --graph
* 351dca6 (HEAD -> main, origin/main, origin/HEAD) peak_sorter: added authors to script
* f3d8e22 peak_sorter: display name of highest peak when script completes
| * 076aa80 (origin/feature-dahu, feature-dahu) peak_sorter: display highest peak at end of script
| * d29958d peak_sorter: added authors as comment to script
| * 6c0d087 peak_sorter: improved code commenting
| * 89d201f peak_sorter: add Dahu observation counts to output table
| * 9da30be README: add more explanation about the added Dahu counts
| * 58e6152 Add Dahu count table
|
* cfd30ce Add gitignore file to ignore script output
* f8231ce Add README file to project
| * 8e0d4fe (origin/dev-jimmy) peak_sorter: add check that input table has the ALTITUDE and PEAK columns
| * ff85686 Ran script and added output
|
* 821bcf5 peak_sorter: add +x permission
* 40d5ad5 Add input table of peaks above 4000m in the Alps
* a3e9ea6 peak_sorter: add first version of peak sorter script
```

HEAD: a pointer to the currently checked-out branch/commit

- **HEAD** is – most of the time – a pointer to the latest commit on your current branch.
(Sometimes it is also described as a pointer to the current branch – which is itself a pointer to the latest commit on the branch)
- The **HEAD** position is how Git knows what is the currently “active” branch.
- New commits are added “under” the current **HEAD**, i.e. a new commit is the “child” of the commit pointed-to by **HEAD**.
- When a new commit is added, **HEAD** is automatically moved by Git to point to that new commit.



Another way to look at it, is that **HEAD** always points to the parent of your next commit.

Relative references to commits

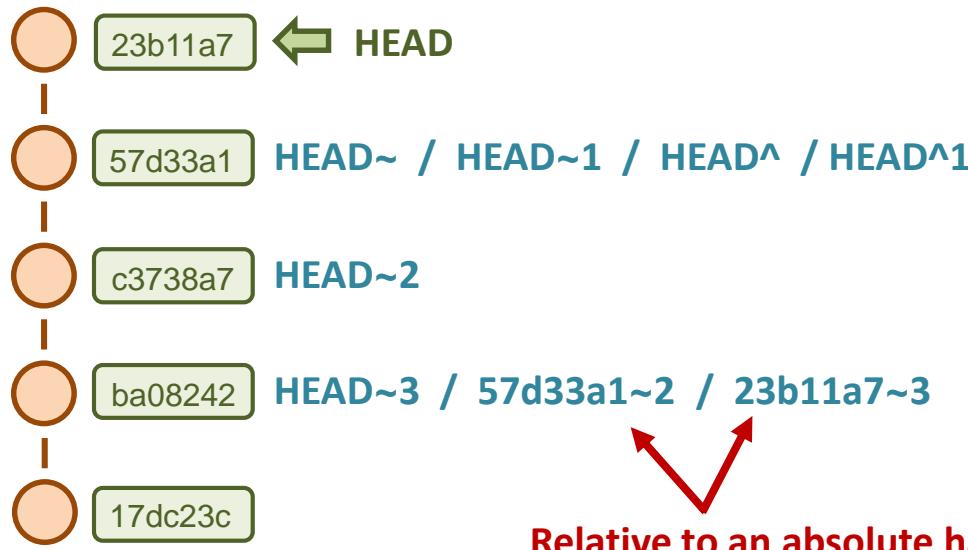
- Using `~` and `^` symbols, Git allows to refer to a commit by its position relative to another commit, rather than by its absolute hash.
- `Ref` can be any reference, such as `HEAD`, a commit hash, a branch name, or even another Ref.

`Ref~X` refers to the **Xth generation before** the commit: `~1` = parent, `~2` = grand-parent, etc.

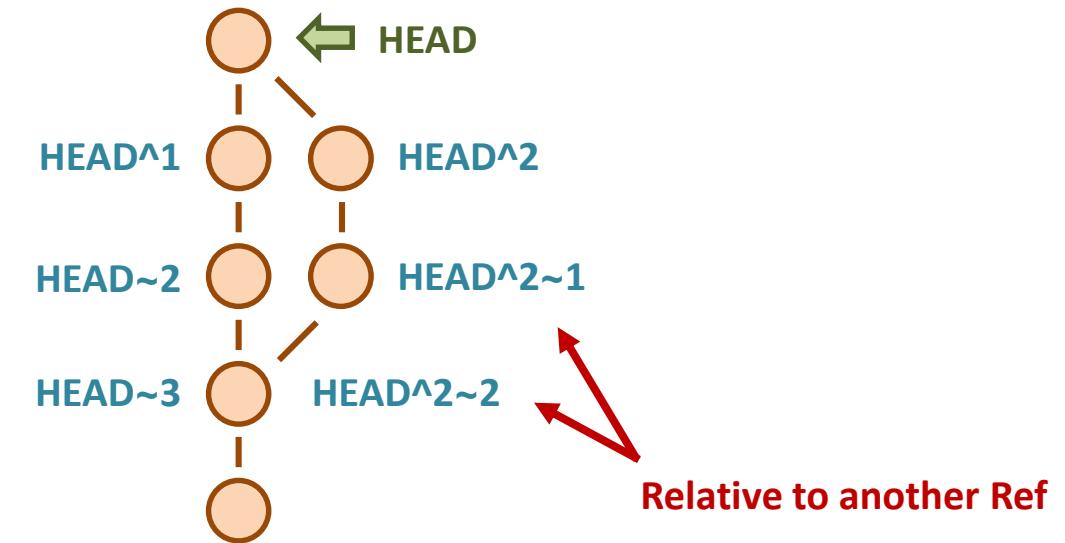
`Ref~` is a shortcut for `Ref~1`

`Ref^X` refers to the **Xth direct parent** of the `HEAD` commit (but most commits have only a single parent).

`Ref^` is a shortcut for `Ref^1`



Relative to an absolute hash



Relative to another Ref

Part II

Git branches

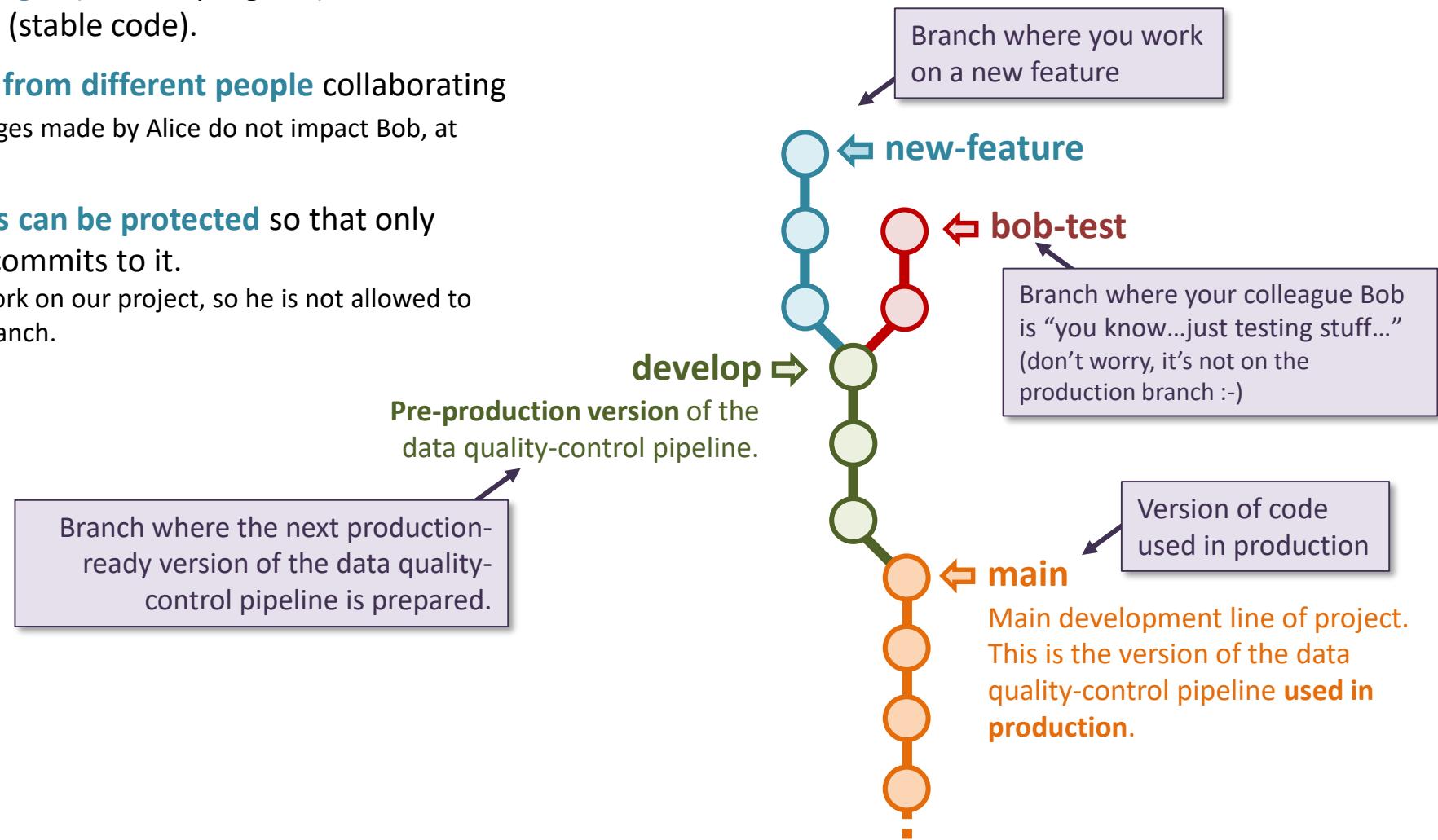
Managing multiple lines of development

Why branches? An illustration with a data quality-control pipeline project

“Branching” means to **diverge from the main line of development**.

- Branches **isolate new changes** (work in progress) from the main line of development (stable code).
- Branches **isolate changes from different people** collaborating on a same project (so changes made by Alice do not impact Bob, at least not immediately).
- On online repos, **branches can be protected** so that only selected people can add commits to it.

Use case: Bob just started to work on our project, so he is not allowed to make changes to the “main” branch.



Git is **designed to encourage branching**: branches are “cheap” (don’t take much disk space) and switching between them is fast.

What are branches?

- A branch is just a pointer to a commit.
- A branch is **very lightweight** (41 bytes).
- By convention, the **main/master** branch is the branch representing the stable version of your work.
- To know which is the currently active branch, Git uses the **HEAD** pointer. The **HEAD** pointer always points to the currently active branch (except for the special case of “detached HEAD” mode, discussed later in the second part of this course).
- New commits are always added at the top of the currently active branch*.



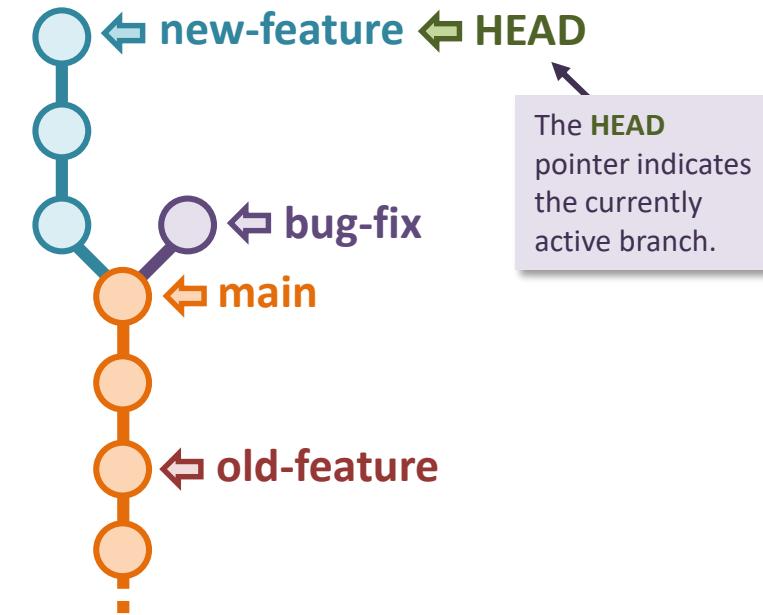
The **main** branch is no special branch. It is simply the default name given to the branch created when initializing a new repo [`git init`]. It has become a convention to use this branch as the stable version of a project.

Note: in earlier versions, the “**main**” branch used to be called the “**master**” branch.



Illegal characters in branch names

Spaces and some characters such as `,~^:?:*[]\` are not allowed in branch names. It is strongly recommended to stick to lowercase letters, numbers and the “dash” character [`-`].



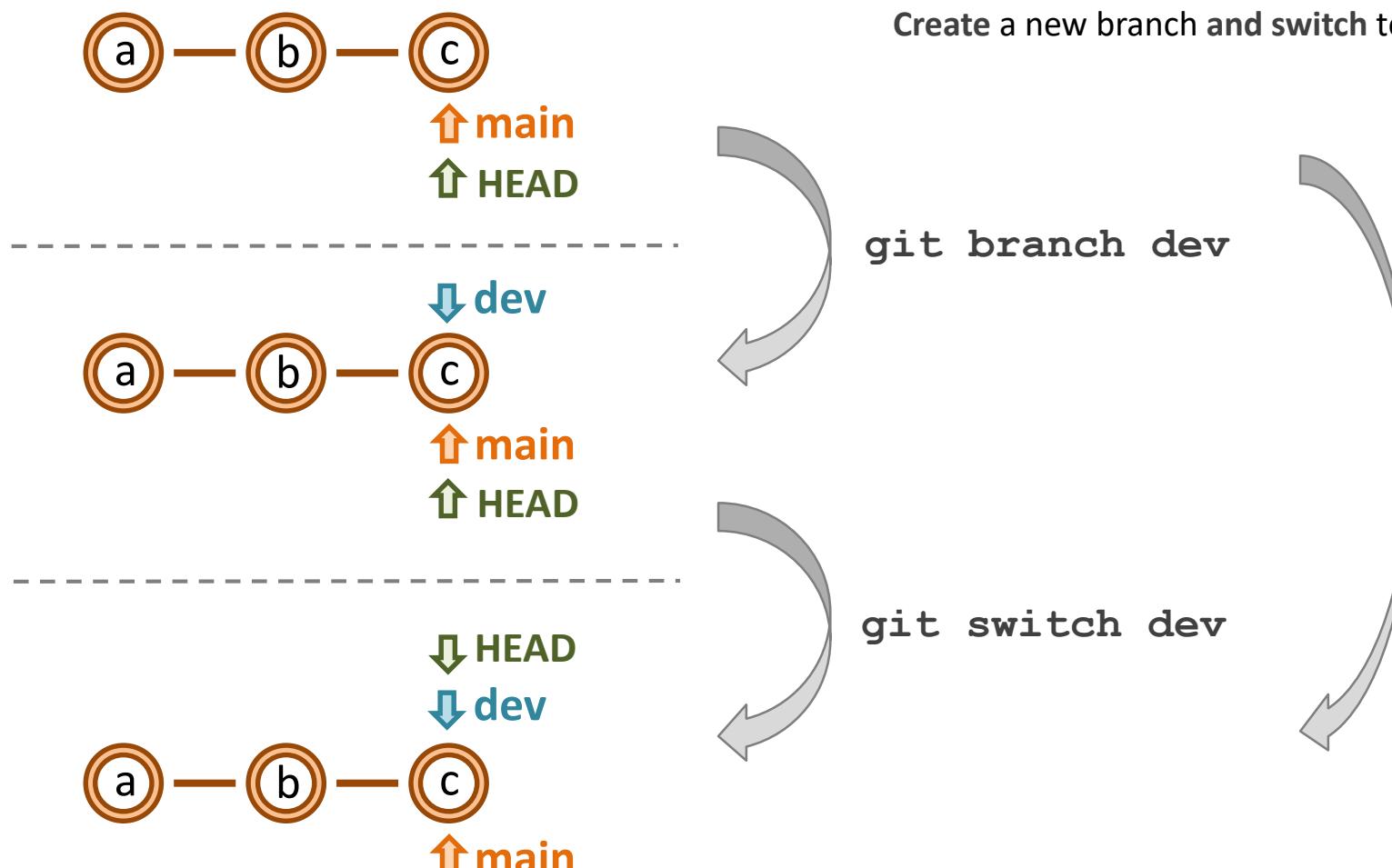
```
> ls -l .git/refs/heads/*
-rw-rw-r-- 1 41 Feb 1 .git/refs/heads/devel
-rw-rw-r-- 1 41 Feb 1 .git/refs/heads/main

> cat .git/refs/heads/main
8508bc698498861c036636dba40ac28b6c7f3a7a

> cat .git/refs/heads/devel
4aefde0735e0f95de9969fa660265f71d6a95ebd

> ls -l .git/HEAD
-rw-rw-r-- 1 21 Feb 1 .git/HEAD
> cat .git/HEAD
ref: refs/heads/main
```

Switching and creating new branches



Create a new branch: `git branch <branch name>`

Switch to another branch: `git switch <branch name>`

Create a new branch and switch to it: `git switch -c <branch name>`

The `-c` option is to create and switch to the new branch immediately.

`git switch -c dev`

switch vs. checkout

On older Git versions the `git switch` command does not exist.

Instead, `git checkout` is used to switch branches:

`git checkout <branch name>`
`git checkout -b <branch name>`

The `git switch` command was introduced in Git version 2.23 as a replacement to `git checkout` for switching branches. This was done because the `checkout` command already has other uses (e.g. to extract older files from the Git database), and it was deemed confusing that a same command would have multiple usages. It remains nevertheless possible to switch branches with the `git checkout` command in recent Git versions.

Switching and creating new branches (continued)

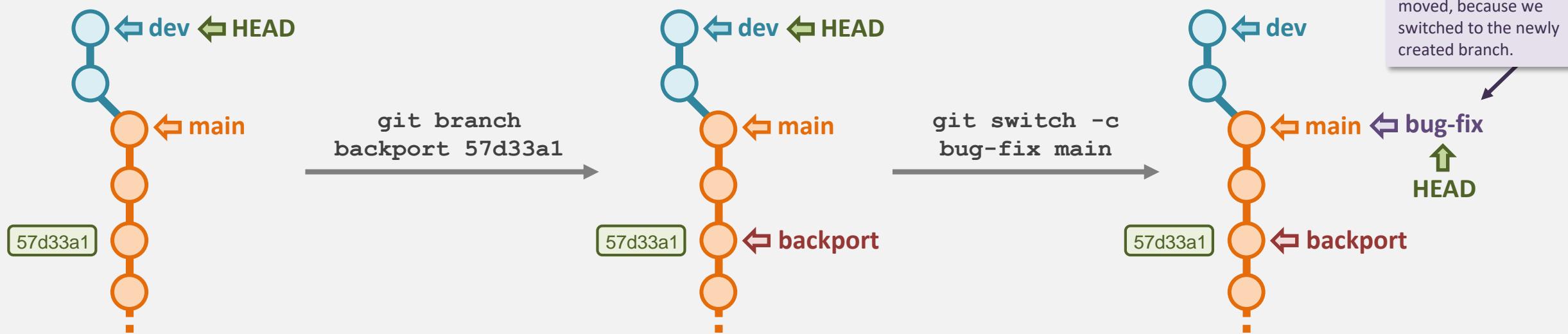
- By default new branches are created at the current position of the **HEAD** pointer (i.e. the current commit).
- But they can be created at any specified reference.

Create a new branch: `git branch <branch name> <reference>`

Reference to a commit, branch or tag.
The default reference is **HEAD**.

Create a new branch and switch to it: `git switch -c <branch name> <reference>`

Example:



List branches and identify the currently active branch

`git branch`

List local branches

`git branch -a`

List local and remote branches

Examples

```
$ git branch  
devel  
* main ←  
new-feature
```

The * denotes the currently checked-out (active) branch. Generally it is displayed in green.

```
$ git branch -a  
devel  
* main  
new-feature  
remotes/origin/main ←  
remotes/origin/devel
```

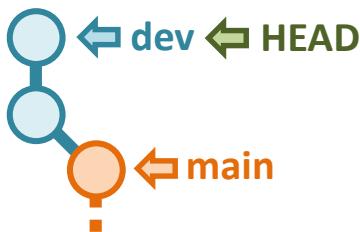
Remote branches (to be precise, pointers to remote branches) are shown in red and are named `remotes/<remote name>/<branch name>`

As a handy alternative, “git adog” (`git log --all --decorate --oneline --graph`) will also show all branches. The currently active branch can be identified as it has the `HEAD` pointing to it.

```
* 351dca6 (HEAD -> main, origin/main, origin/HEAD) peak_sorter: added authors to script  
* f3d8e22 peak_sorter: display name of highest peak when script completes  
| * 076aa80 (origin/feature-dahu, feature-dahu) peak_sorter: display highest peak at end of script  
| * d29958d peak_sorter: added authors as comment to script  
| * 6c0d087 peak_sorter: improved code commenting  
| * 89d201f peak_sorter: add Dahu observation counts to output table  
| * 9da30be README: add more explanation about the added Dahu counts  
| * 58e6152 Add Dahu count table  
/  
* cfd30ce Add gitignore file to ignore script output
```

What happens in the working tree when switching branches

- When switching to different branch, the content of your working directory (working tree) is updated as to reflect the state of the commit the active branch (i.e. the branch you just switched to).
- This means that when switching branches, you can have files appear/disappear or be modified in your working directory.
- A copy of committed files is kept at all times in the .git database so they can be restored when switching branches.



```
> ls -l
4096 Jan 29 22:45 user_guide.md
108 Jan 29 22:30 personal_notes.md
53 Jan 29 22:30 README.md
77 Jan 29 22:45 script.py
```

#!/usr/bin/env python3
print("Hello World")
print("Git branches are great")

Untracked files (here in red) are unaffected by branch switches.



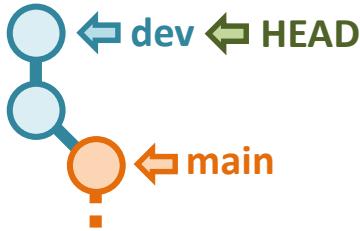
```
> ls -l
108 Jan 29 22:30 personal_notes.md
53 Jan 29 22:30 README.md
45 Jan 29 22:43 script.py
```

#!/usr/bin/env python3
print("Hello World")

Size and last modified date has changed!

What has changed:
• user_guide.md has disappeared...
• script.py was reverted to the older version...

`git switch main`



```
> ls -l
4096 Jan 29 22:45 user_guide.md
108 Jan 29 22:30 personal_notes.md
53 Jan 29 22:30 README.md
77 Jan 29 22:45 script.py
```

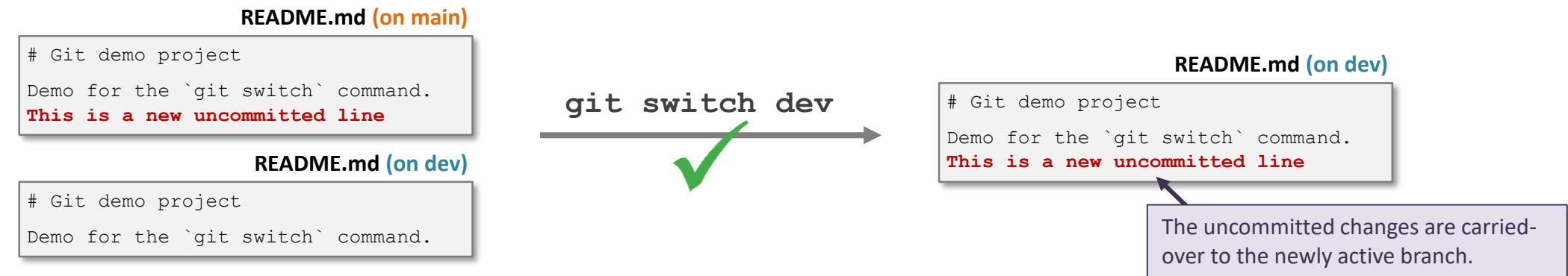
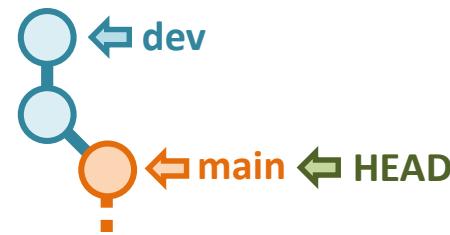
What has changed:
• user_guide.md is back.
• script.py reverted to newer version.

`git switch dev`

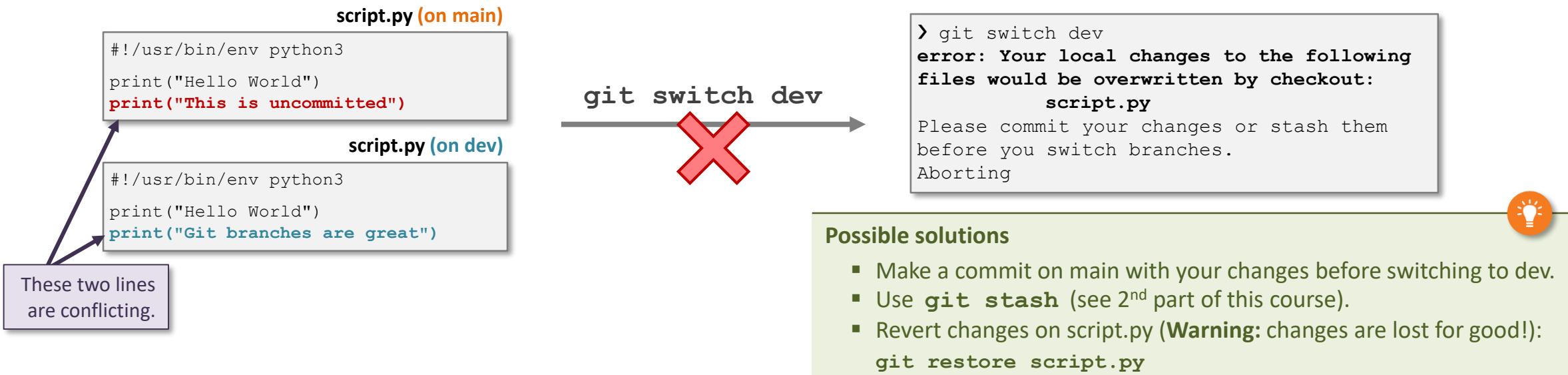
What happens in the working tree when switching branches

What if you have uncommitted changes ?

- If the changes do not conflict between the branches, they are “carried-over” with the switch.



- If the changes conflict between the branches, Git will not allow you to switch.



Demo: git switch

- What happens in the working directory when switching branches

git merge

get branches back together

Branch merging

- Merge: incorporate changes from the specified branch into the currently active (checked-out) branch.

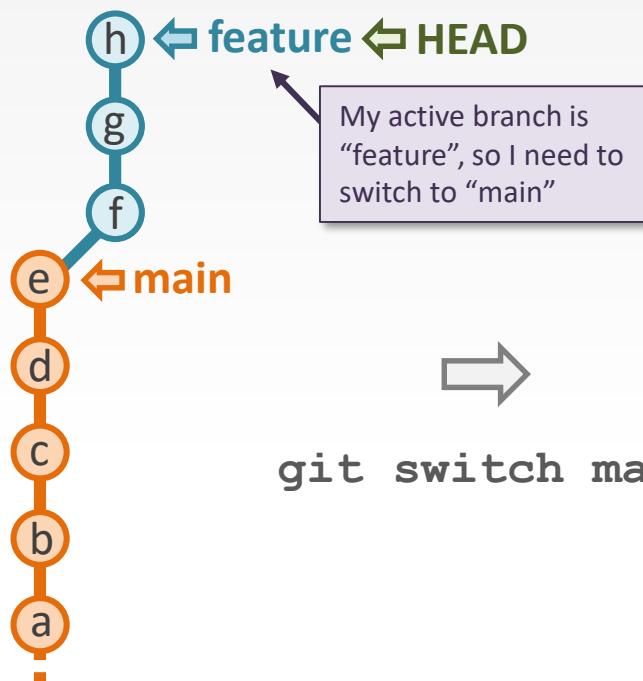
```
git merge <branch to merge into the current branch>
```



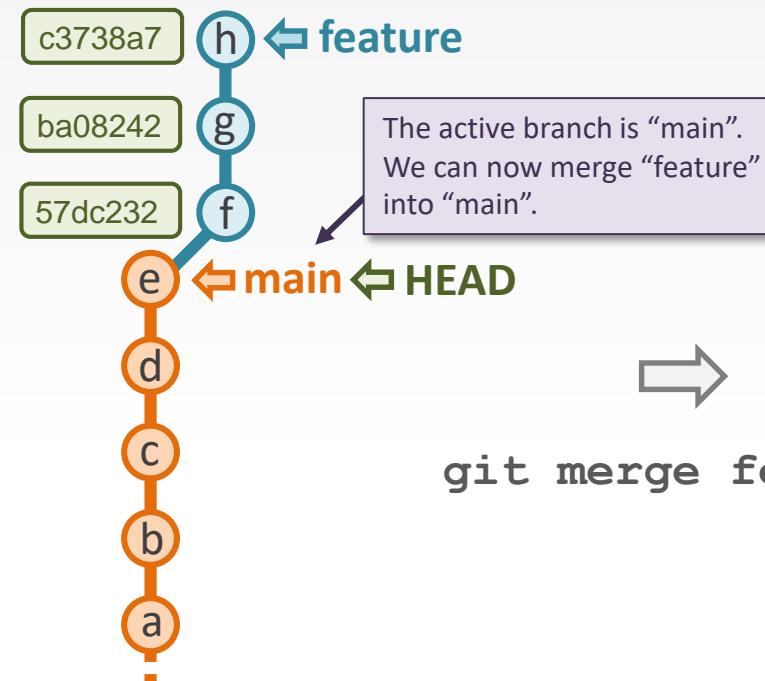
Before running the command, make sure that the branch into which the changes should be merged is the currently active branch.

If not, use `git switch <branch>` to checkout the correct branch.

Example: merge changes made on branch **feature** into the branch **main**.



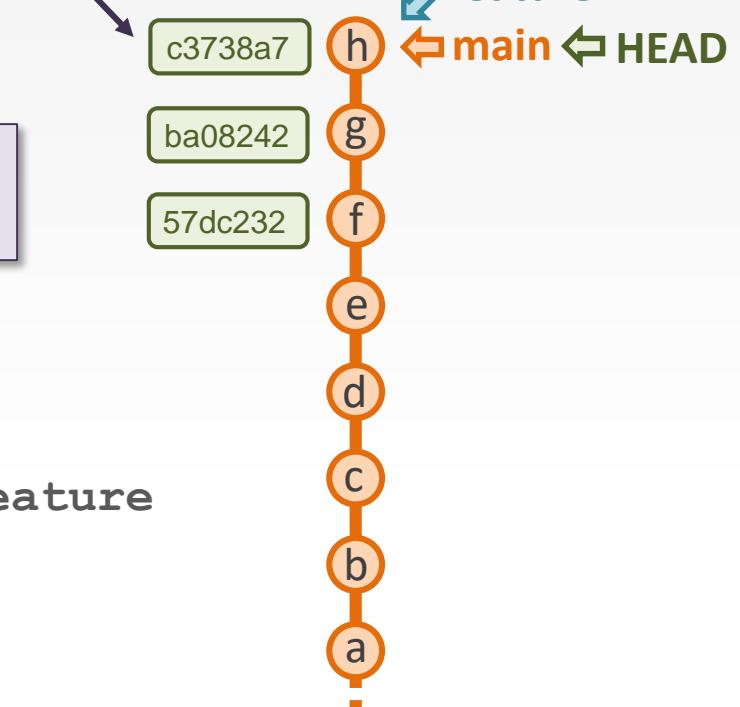
`git switch main`



`git merge feature`

Merging has not made any changes to my commit history. All my commits remain the same (no change in hash).

At this point, the “feature” branch can be deleted.
`git branch -d feature`



Two types of merges

- **Fast-forward merge:** when branches **have not diverged**.

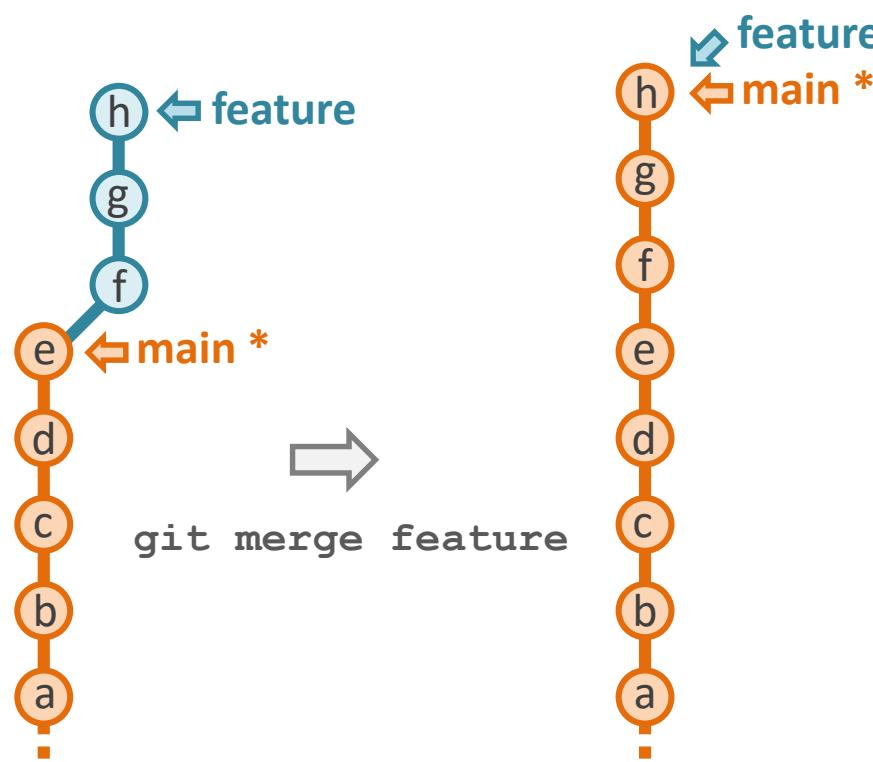
The branch that is being merged (here **feature**) is rooted on the latest commit of the branch that it is being merged into (here **main**).

- **3-way merge:** when branches **have diverged**. This introduces an extra “**merge commit**”.

The **common ancestor** of the 2 branches is not the last commit of the branch we merge into (here **main**).

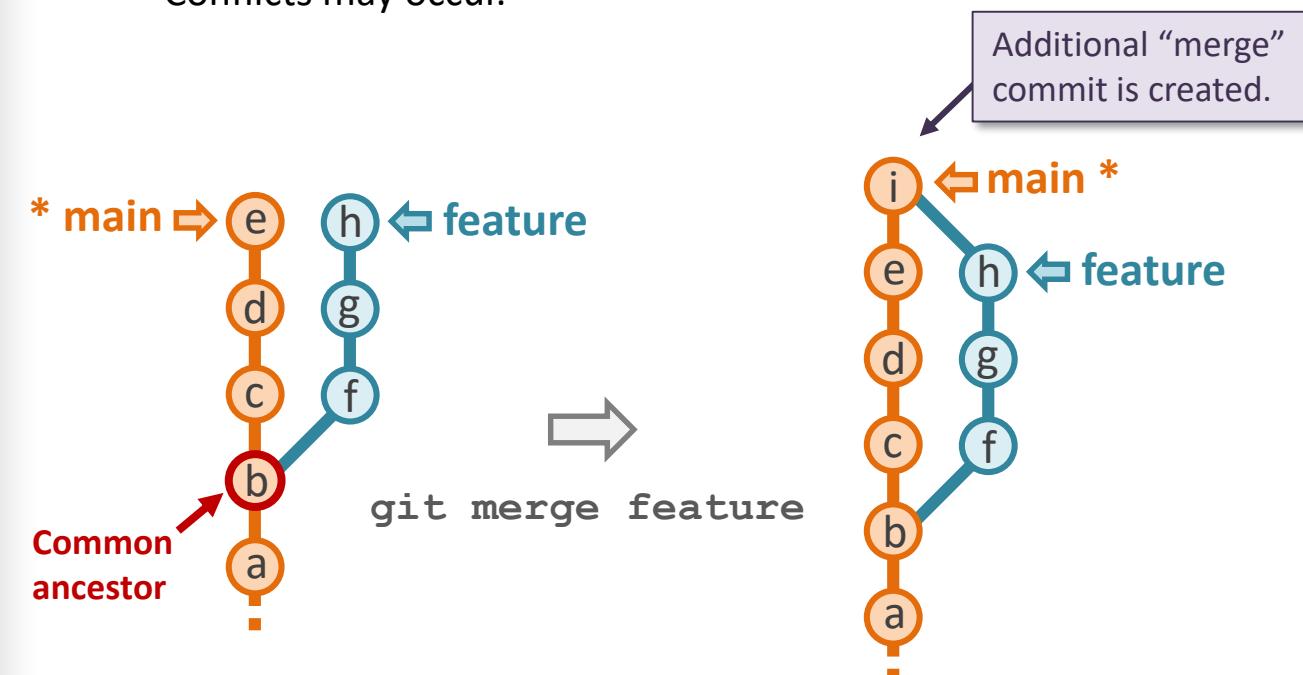
Fast-forward merge

- Guaranteed to be conflict free.



3-way merge (non-fast-forward)

- Creates an additional “**merge commit**” (has 2 parents).
- Conflicts may occur.



Additional “merge” commit is created.

* denotes the currently active (checkout-out) branch.

Conflicts in 3-way merges (non fast-forward)

If a same file is modified at (or around) the same place in the two branches being merged, Git cannot decide which version to keep. There is a conflict, and you need to manually resolve it.

README.md version of **main** branch.

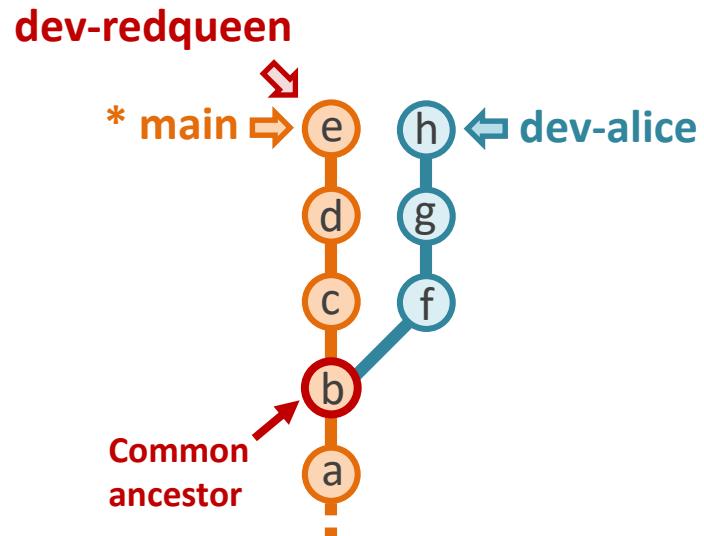
```
# Tea pot quality-control pipeline
Check and approve tea pots for use in
unbirthday parties.
```

Authors: Mad Hatter, Red Queen
Date modified: 2022 Oct 10

```
## Step 1: physical integrity check
* Check exterior for cracks and uneven
  painting.
* Check for mice inside of pot.
* Verify the Mad Hatter is on time.
```

```
## Step 2: tea-brewing integration test
* Brew tea for 7 min.
* Add 2 cubes of sugar.
* Probe tea.
```

Story background: the Red Queen has just merged changes from her branch **dev-redqueen** into **main**. Now Alice wants to merge her branch **dev-alice** into **main**.



Let's merge **dev-alice** into **main**...

```
$ git merge dev-alice
```

Auto-merging README.md

CONFLICT (content): Merge conflict in README.md

Automatic merge failed; fix conflicts and then commit the result.

README.md version of **dev-alice** branch.

```
# Tea pot quality-control pipeline
Check and approve tea pots for use in
unbirthday parties.
```

Authors: Mad Hatter, Alice
Date modified: 2022 Oct 11

```
## Step 1: physical integrity check
* Check exterior for cracks and uneven
  painting.
* Check for mice inside of pot.
```

```
## Step 2: tea-brewing integration test
* Brew tea for 7 min.
* Add 2 cubes of sugar.
* Probe tea.
* Make sure we still have no idea why
  a raven is like a writing desk.
```

Resolving conflicts

1. Open the conflicting files in the text editor of your choice.

2. Look for the text between <<<<< and >>>>> .

There can be more than one of such sections, if there is more than one conflict in the file.

- The text between <<<<< and ===== is the version of the current branch, i.e. the branch into which we merge (main, in this example).
- The text between ===== and >>>>> is the version from the branch we are merging (dev-alice, in this example).

Version from the current branch (here main).

Version from branch being merged into the current branch (here dev-alice).

Note: there is no conflict for these 2 lines, because the edits were made at different locations in the file. Git is able to auto-merge such changes.

```
# Tea pot quality-control pipeline
Check and approve tea pots for use in
unbirthday parties.
```

<<<<< HEAD

Authors: Mad Hatter, Red Queen
Date modified: 2022 Oct 10

=====

Authors: Mad Hatter, Alice

Date modified: 2022 Oct 11

>>>>> dev-alice

Step 1: physical integrity check
* Check for mice inside of pot.
*** Verify the Mad Hatter is on time.**

Step 2: tea-brewing integration test
* Brew tea for 7 min.
* Add 2 cubes of sugar.
* Probe tea.
*** Make sure we still have no idea why a raven is like a writing desk.**

\$ git merge dev-alice

Auto-merging README.md

CONFLICT (content): Merge conflict in README.md ← File with conflicts
Automatic merge failed; fix conflicts and then commit the result.



3. Manually edits the file(s)...

```
# Tea pot quality-control pipeline
Check and approve tea pots for use in
unbirthday parties.
```

Authors: Mad Hatter, Red Queen, Alice
Date modified: 2022 Oct 11

Step 1: physical integrity check
* Check for mice inside of pot.
* Verify the Mad Hatter is on time.

Step 2: tea-brewing integration test
* Brew tea for 7 min.
* Add 2 cubes of sugar.
* Probe tea.
* Make sure we still have no idea why a raven is like a writing desk.



4. Stage the conflict-resolved file(s).
5. Commit

Hash of the added "merge" commit.

\$ git add README.md

\$ git commit

[main a317d38] Merge branch 'dev-alice'

An editor will open with a pre-set commit message. You can accept it as is, or modify it.

Resolving conflicts: if you get lost...

- If you are lost at some point, run `git status` and it will give you some hints and commands.
- A merge can be aborted at anytime with `git merge --abort`
- Completed merges can be reverted (with the `git reset` commands – see the “git advanced” slides).

Examples

```
$ git status
On branch main
You have unmerged paths.
  (fix conflicts and run "git commit")
  (use "git merge --abort" to abort the merge)

Unmerged paths:
  (use "git add <file>..." to mark resolution)
    both modified: README.md
```

Git tells you what to do and reminds you of commands.

Running `git status` before conflicts are resolved in the file.

```
$ git status
On branch main
All conflicts fixed but you are still merging.
  (use "git commit" to conclude merge)

Changes to be committed:
  modified: README.md
```

Git tells you what to do and reminds you of commands.

Running `git status` after conflicts are resolved in the file and the file was staged.

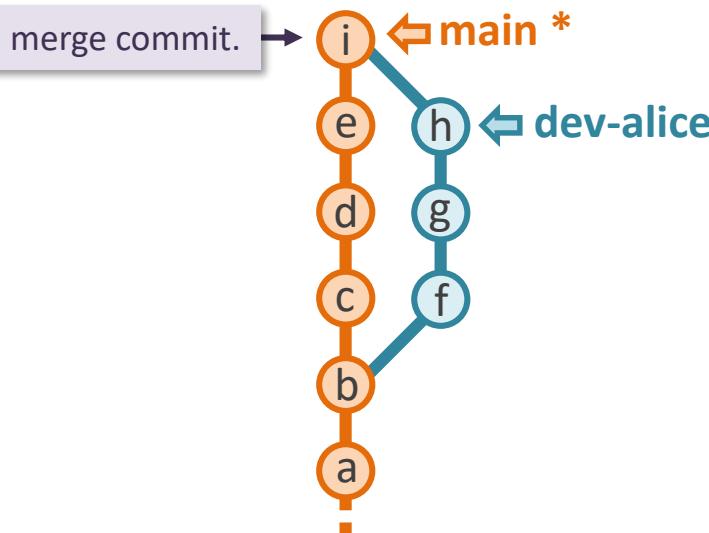
What's in a merge commit ?

If there was no conflict, the **merge commit** contains nothing but the commit message (and other metadata).

```
$ git show HEAD
commit 10fa3ad505821b0ea628b811143af47343a4d8dc (HEAD -> main)
Merge: 7446b3e b4fb462
Author: Red Queen <off.with.their.heads@wonder.org>
Date:   Tue Oct 11 15:16:39 2022 +0200

Merge branch 'dev-redqueen'
```

If there was a conflict, the **merge commit** contains the conflict resolution changes made to the conflicted file(s).



```
$ git show HEAD
commit a317d38448dae4e6bd9b4862dcaccf4e416cc46c (HEAD -> main)
Merge: 10fa3ad 7999c7c
Author: Alice <alice@redqueen.org>
Date:   Tue Oct 11 15:27:35 2022 +0200

Merge branch 'dev-alice'

diff --cc README.md
index 647be0c,74edef5..3ce8aa7
--- a/README.md
+++ b/README.md
@@@ -1,8 -1,8 +1,8 @@@
    # Tea pot quality-control pipeline
    Check and approve tea pots for use in unbirthday parties.

- Authors: Mad-Hatter, Red Queen
- Date modified: 2022 Oct 10
- Authors: Mad-Hatter, Alice
++Authors: Mad-Hatter, Red Queen, Alice
+ Date modified: 2022 Oct 11

## Step 1: physical integrity check
* Check exterior for cracks and uneven
```

Demo

- Merging branches (fast-forward and 3-way merge)

Deleting branches

Branches that are merged and are not used anymore can (should) be deleted.

```
git branch -d <branch name>
```

← **safe option:** only lets you delete branches that are fully merged.

```
git branch -D <branch name>
```

← **YOLO option:** lets you delete any branch.

- Note: A currently active (checked-out) branch cannot be deleted.
You must switch to another branch before deleting it.

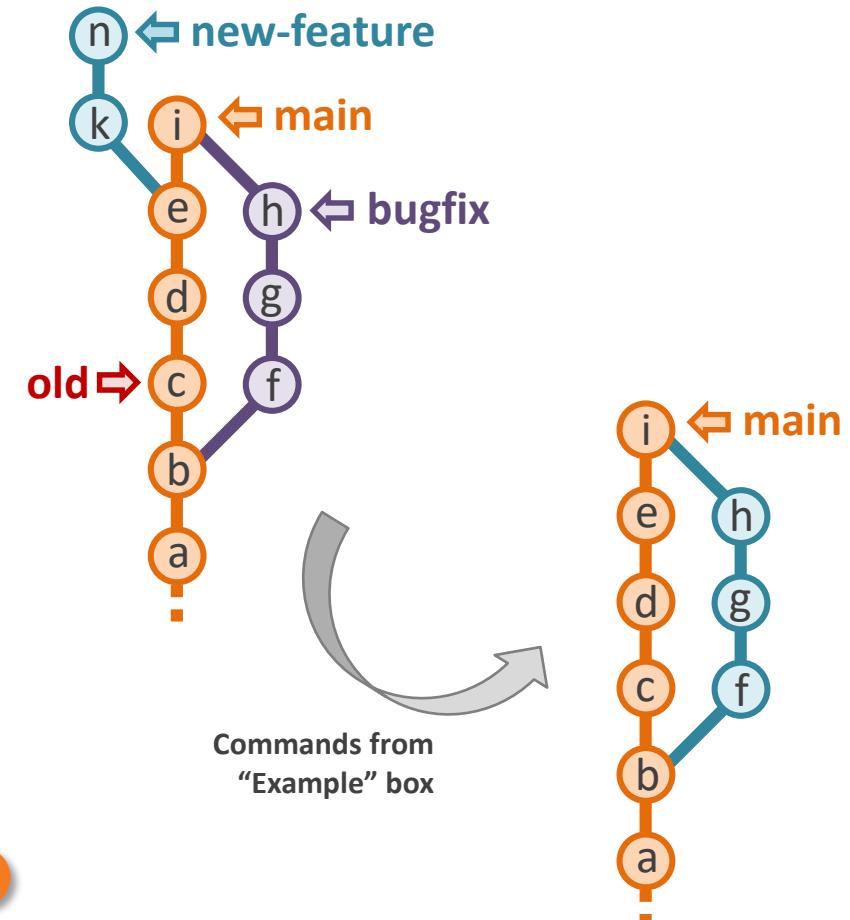
Example

```
# The 'bugfix' and 'old' branches are fully merged.
$ git branch -d bugfix
Deleted branch bugfix (was bd898dc)
$ git branch -d old
Deleted branch old (was 75d3fed)

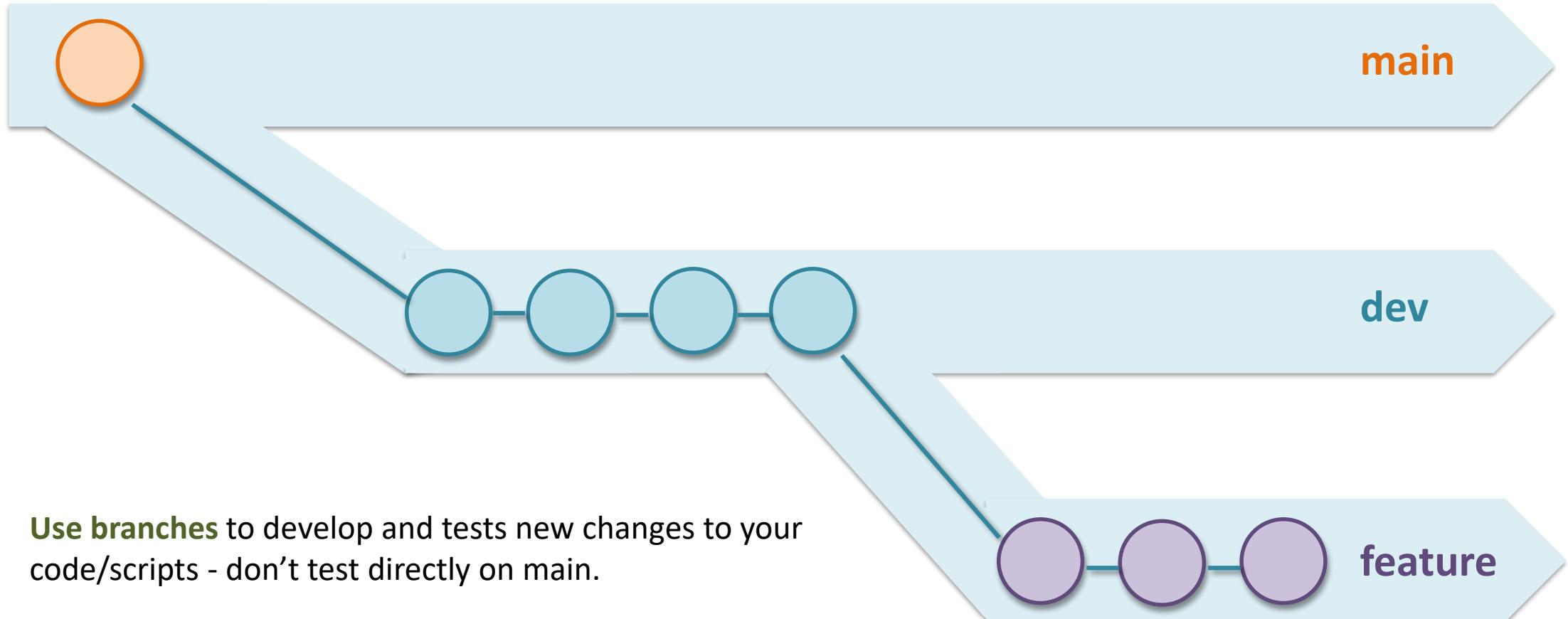
# Trying to delete a non-merged branch with -d will fail:
$ git branch -d new-feature
error: The branch 'testing' is not fully merged.
If you are sure you want to delete it, run 'git branch -D testing'.

# Using -D will allow deletion of a non-merged branch:
$ git branch -D new-feature
Deleted branch new-feature (was f2a898b)
```

Deleted a branch by mistake ? – no panic !
This hash can be used to re-create it:
`git branch new-feature f2a898b`



Branch management: best practices



- **Use branches** to develop and tests new changes to your code/scripts - don't test directly on main.
- **Don't hesitate to create branches**, they are “cheap” (they don't add any overhead to the git database).
- Delete branches that are no longer used.

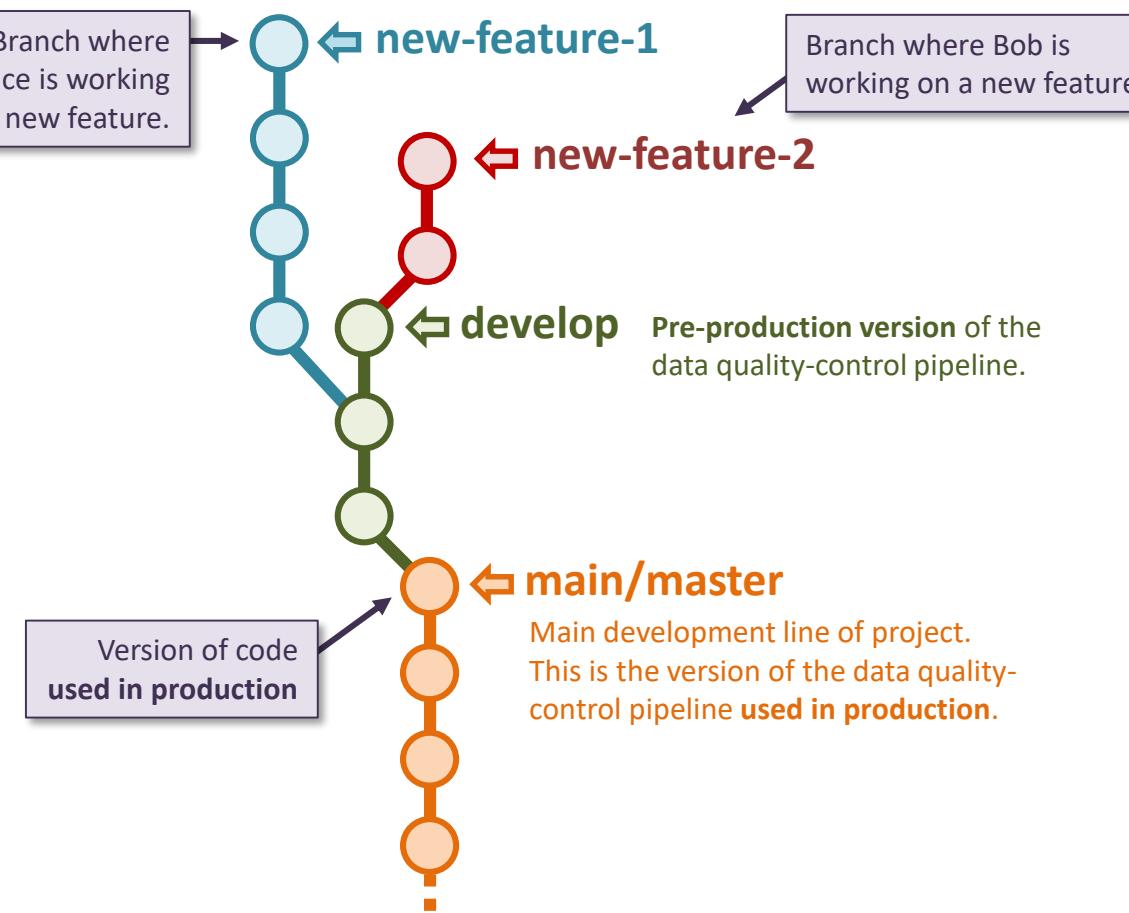


Don't change the history on the main branch if your project is used by others.

Branch management strategies: GitFlow vs. trunk-based development

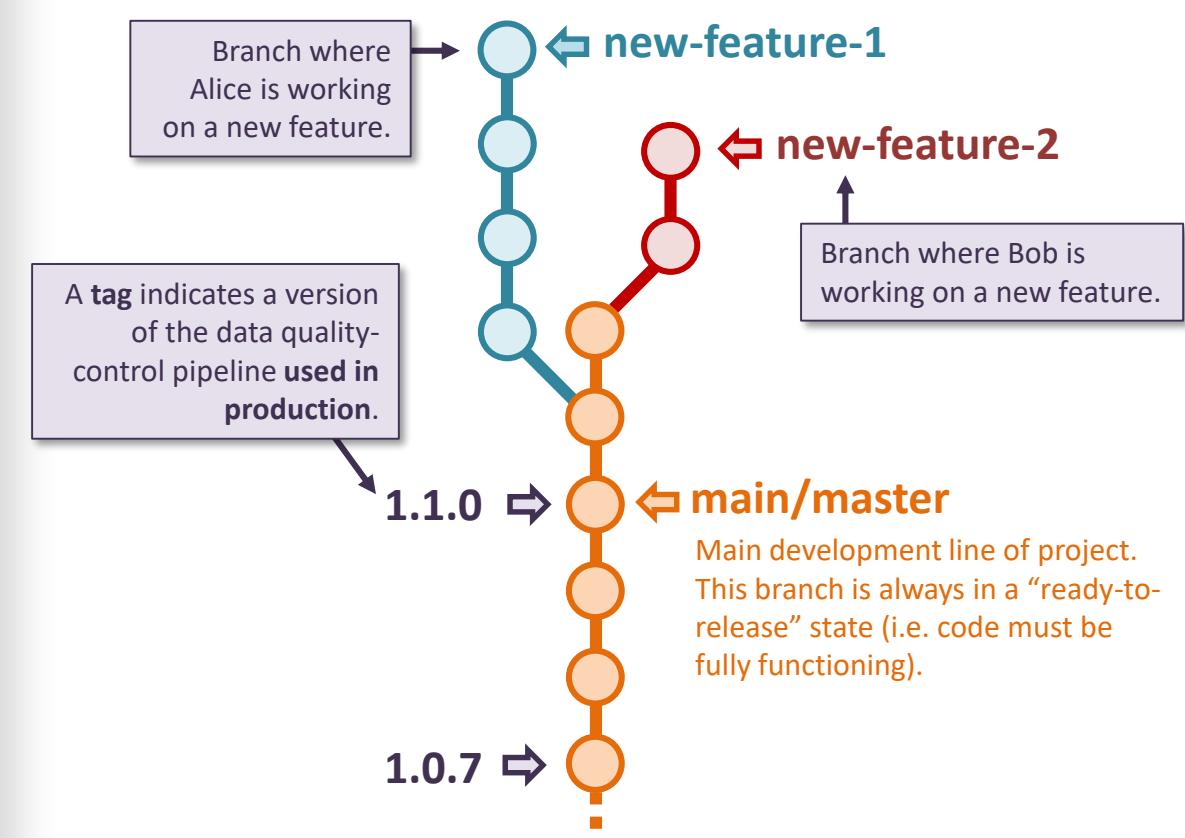
GitFlow: the idea is to have a long-lived **pre-production branch** (here “**develop**”), on which new features are added until ready for a new release, at which point the pre-production branch is merged into **main**.

- Useful if you distribute your code via the **main** branch of the Git repo, without making formal releases, i.e. your end-users use the latest version of **main** in production.

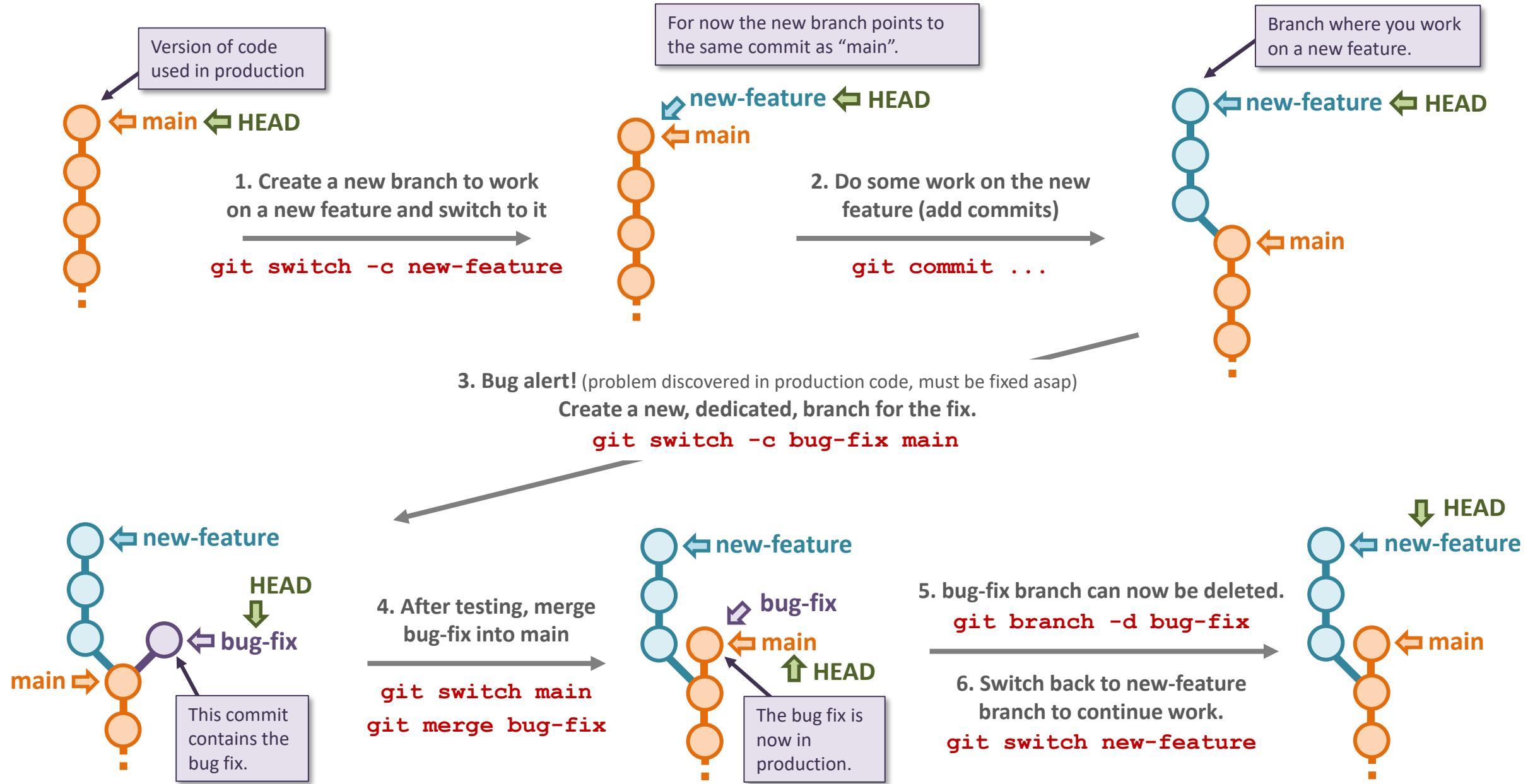


Trunk-based development: there is no long-lived branch outside of the **main** branch. All feature branches are directly merged into **main** once they are completed, and **main** should always be “production-ready”. **Tags** are generally added to denote commits corresponding to versions used in production.

- If you **distribute your code via formal releases**, then this strategy makes more sense as it avoids the overhead of managing an extra long-lived branch (the pre-release branch in GitFlow).



Recap: example of branched workflow: adding a new feature to an application and fixing a bug



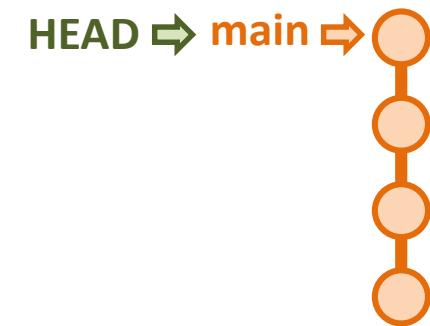
exercise 2

The Git reference webpage

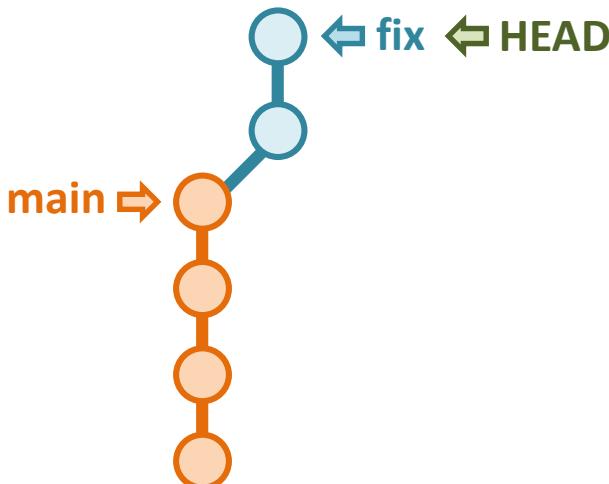
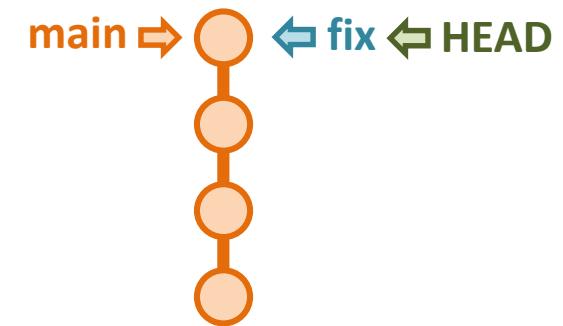


This exercise has helper slides

Exercise 2 help: workflow example

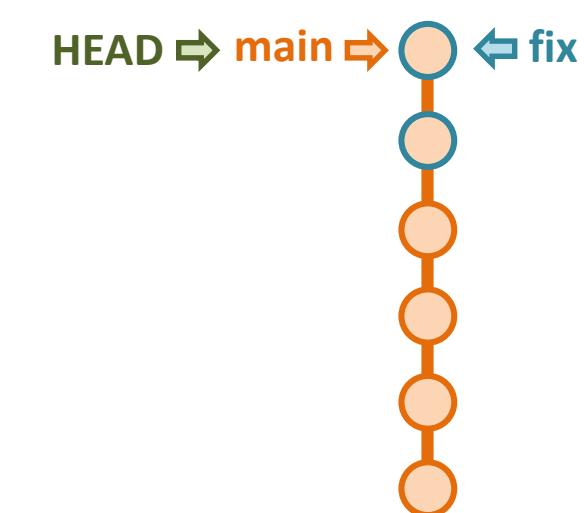


1. Create new branch *fix* and switch to it.



2. Do some work, add commits.

3. Test new feature, then merge branch *fix* into *main*.



git rebase

make a linear history

git rebase: replay commits* onto a different base

- **git rebase**: move/re-root a branch onto a different base commit.
- **Important**: the rebase command must be executed when on the branch to rebase, not the branch you rebase on.

```
git rebase <branch to rebase on>
```

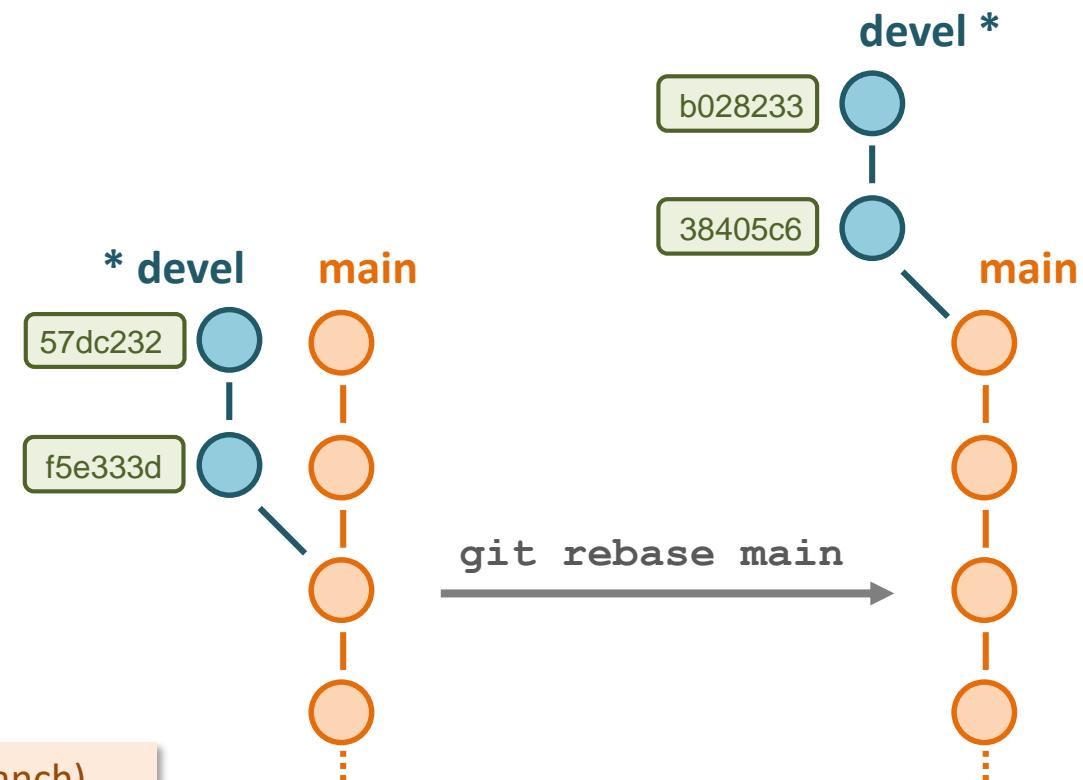
Example:

```
$ git branch
* devel      ← ! Make sure you are on the
main

$ git rebase main
```

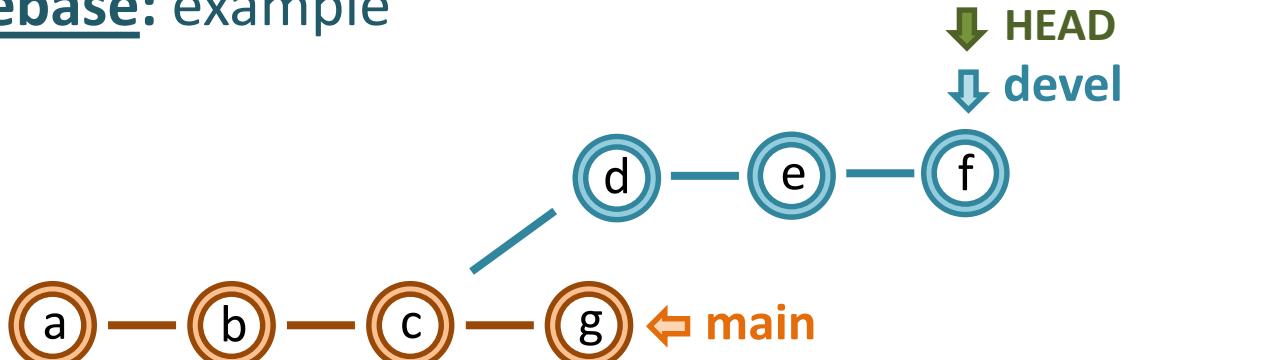
The branch you want to rebase on.

* To be completely correct, we should actually say that we replay the **differences between commits** (i.e. the changes that commits introduce to our code base), not the commits themselves (a commit is a state of the repo at a given time, it does not directly contain the information of changes to the codebase).

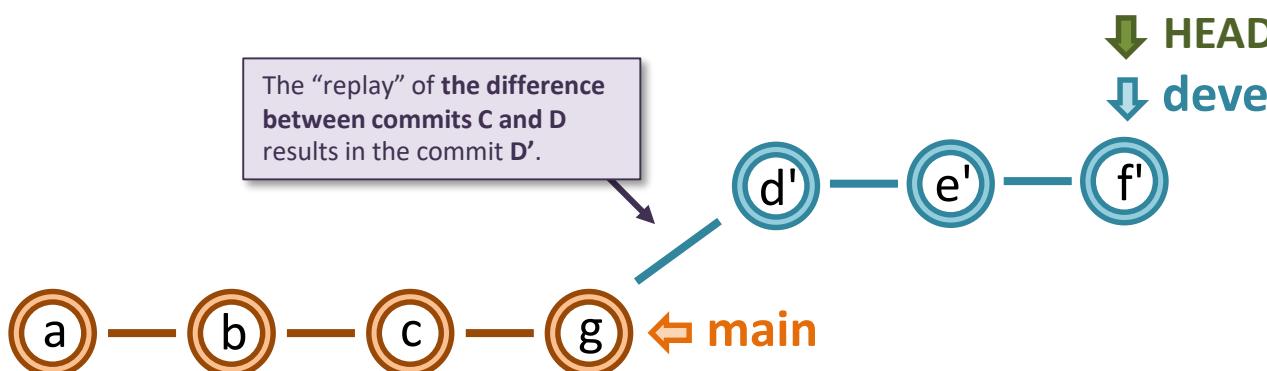


Rebase will modify your commit ID values (history of the rebased branch).
It's best to **only** rebase commits that have never left your own computer.

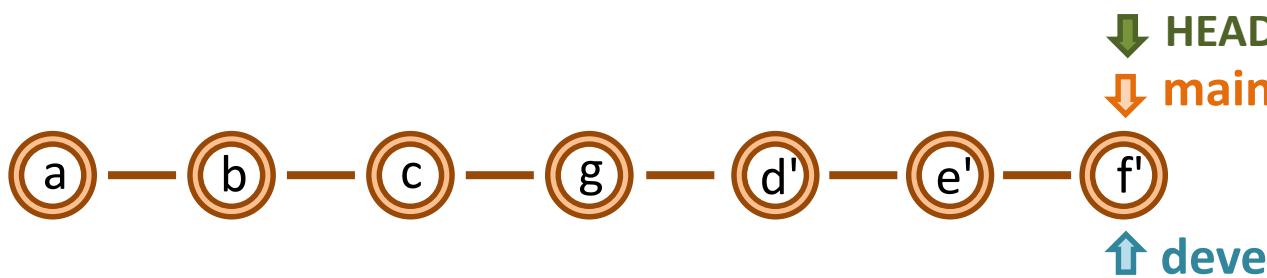
git rebase: example



Before starting the rebase: make sure you are on the branch to rebase!
In this case, if we are not on *devel*:
`git switch devel`



`git rebase main`



`git switch main`
`git merge devel`

Resolving conflicts with rebase

- Rebase re-applies all commit to rebase sequentially: **at each step** there is a potential for conflict...
- To resolve conflicts, you will have to (same as for conflict resolution during merges):

1. Edit the conflicting files, choose the parts you want to keep, then remove all lines containing <<<<<, ===== and >>>>>.

2. Mark the files as resolved with
`git add <file>`

1. Continue the rebase with
`git rebase --continue`

When a conflict arises, Git will provide guidance:

```
$ git rebase main
```

First, rewinding head to replay your work on top of it...

Applying: first commit on new branch

Using index info to reconstruct a base tree...

M new.txt

Falling back to patching base and 3-way merge...

Auto-merging new.txt

CONFLICT (content): Merge conflict in new.txt

error: Failed to merge in the changes.

Patch failed at 0001 first commit on new branch

Use 'git am --show-current-patch' to see the failed patch

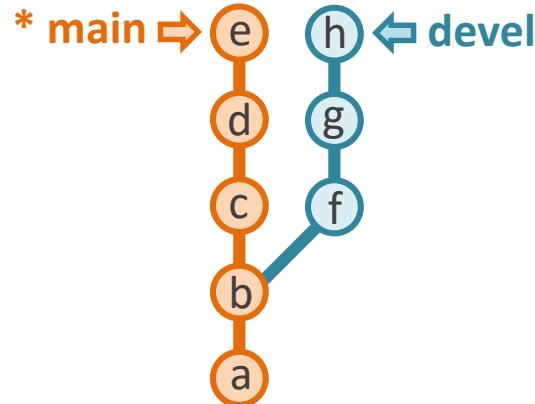
1. → Resolve all conflicts manually,
2. → mark them as resolved with "git add/rm <conflicted_files>" , then run "git rebase --continue".

You can instead skip this commit: run "git rebase --skip".
To abort and get back to the state before "git rebase",
run "git rebase --abort".

Branch reconciliation strategies when history has diverged: merge vs. rebase

merge (3-way merge)

- + Preserves history perfectly.
- + Potential conflicts must be solved only once.
- Creates an additional merge commit.
- Often leads to a "messy" history.

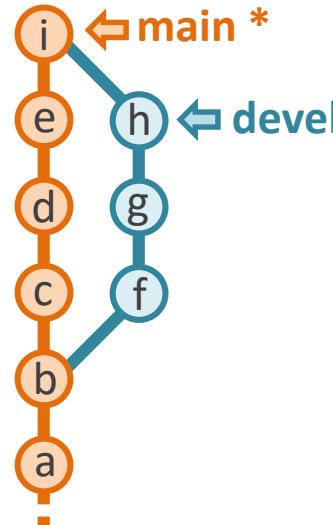


rebase + fast-forward merge

- + Cleaner history = easier to read and navigate.
 - Conflicts may have to be solved multiple times.
 - Loss of branching history.
- History of rebased branch is rewritten, not a problem in general.

Additional "merge commit".

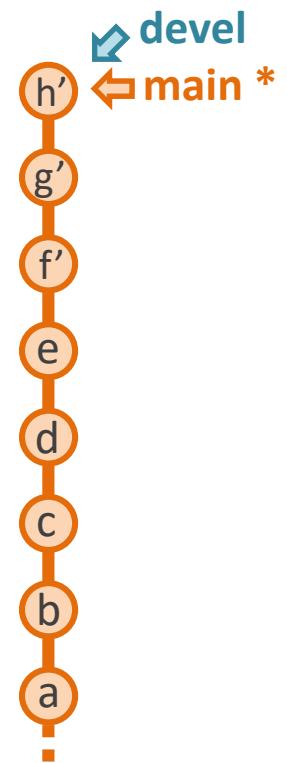
git merge devel



git switch devel
git rebase main



git switch main
git merge devel



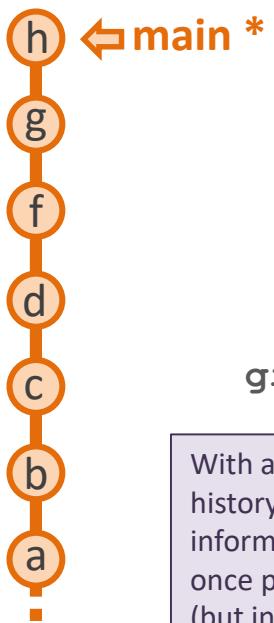
Spoiler-alert: the end result is the same, **i** and **h'** have the same content.

Ultimate history preservation: force the addition of a merge commit with --no-ff

If keeping an **exact record** of how the history of a Git repo came into existence is of prime importance, some people like to **add a merge commit even if a fast-forward merge is possible**.

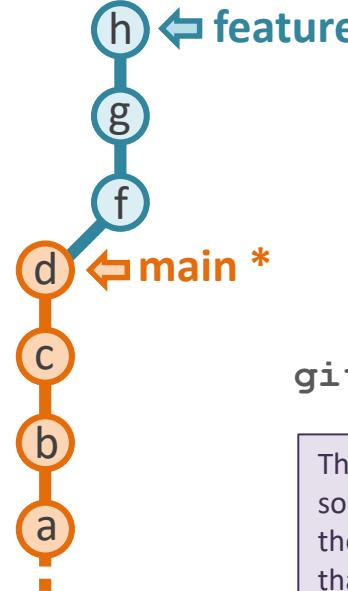
This is possible by adding the **--no-ff** option ("no fast-forward") to git merge.

```
git merge --no-ff <branch to merge>
```



git merge feature

With a regular fast-forward merge, the history is cleaner. However, the information that "f", "g" and "h" were once part of a different branch is lost (but in most cases this doesn't matter).

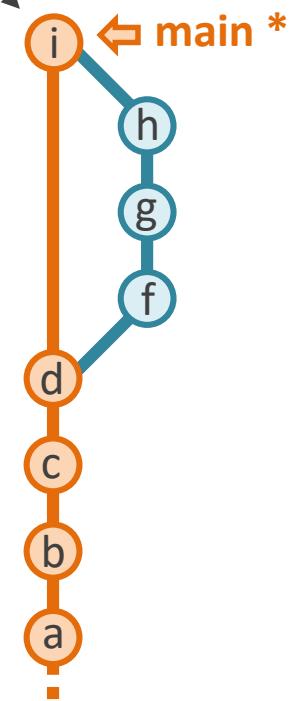


git merge --no-ff feature

The merge commit "i" is added for the sole purpose of allowing us to reconstruct the exact history of the repo: it tells us that commits "f", "g" and "h" were once part of a different branch, which was then merged into "main".

```
$ git show 10fa3ad
commit 10fa3ad505821b0ea628b8
Merge: 7446b3e b4fb462
Author: Alice <alice@redqueen.org>
Date: Tue Oct 11 15:16:39 2022 +0200
```

Merge branch 'feature'



Readability vs. history preservation tradeoff

Screenshots of two versions of a **same repository** (in the sense that it contains the exact same content with mostly the same commits).

```
* a317d38 (HEAD -> main) Merge branch 'dev-alice'  
|  
| * 7999c7c (dev-alice) improvement: add success message to QC pipeline  
| * da96caa fix: update README  
| * ccea24b improvement: better tea-brewing checks  
| | 10fa3ad Merge branch 'dev-redqueen'  
| |  
| |  
| |  
| |  
| | * b4fb462 (dev-redqueen) update: add timing module  
| | * d37df05 improvement: check that Mad Hatter is on time  
| |  
| |  
* 7446b3e update: add tea-brew integration test  
* b82c9c9 update: add physical integrity check to pipeline  
* 96d19d4 Initial commit
```

← Here, history has been fully preserved, by always using merges and forcing extra merge commits (--no-ff) when needed.

Here, having a linear history has been prioritized (better readability), by rebasing branches before (fast-forward) merging them.

```
* 77d8354 (HEAD -> main, dev-alice) improvement: add success message to QC pipeline  
* e48c71a fix: update README  
* 51ae05e improvement: better tea-brewing checks  
* b4fb462 (dev-redqueen) update: add timing module  
* d37df05 improvement: check that Mad Hatter is on time  
* 7446b3e update: add tea-brew integration test  
* b82c9c9 update: add physical integrity check to pipeline  
* 96d19d4 Initial commit
```

Supplementary material...



```
* 2501d8d417 (origin/test_node, test_node) Merge pull request #14830 from migueldiascosta/20220124105343_new_pr_EasyBuild452
| * a7f24f6f0c adding easyconfigs: EasyBuild-4.5.2.eb
| * aaa77532dc resume running test suite with Python 3.5 by using actions/setup-python@v2
| * 925fc73a7 add quotes to avoid that Python 3.10 is interpreted as Python 3.1 ...
| * d780bb7cae stop running easyconfigs test suite with Python 3.5, also test with Python 3.8-3.10
| * 2585d099b8 sync with main + bump version to 4.5.3dev
| * f1de981545 (tag: easybuild-easyconfigs-v4.5.2, origin/main, eb-source/main) Merge pull request #14829 from easybuilders/4.5.x
| * 4440893abe (eb-source/4.5.x) Merge pull request #14828 from migueldiascosta/eb452
| * de2a8651cc minor tweak release notes for v4.5.2
| * 0a205792b7 prepare release notes for EasyBuild v4.5.2 + bump version to 4.5.2
| * 5f7f1e103e Merge pull request #14821 from branfosj/20220121150125_new_pr_X1120210518
| * 9390faedad add libXfont2 patch to fix build when libbsd is present
| * f497a23162 (origin/scicore) Merge pull request #14743 from sib-swiss/20220117153155_new_pr_RDKit2021034
| * 33c378c1be Update RDKit-2021.03.4: update comic-neue-checksum patch checksum
| * 1c52b4bf3 Update RDKit-2021.03.4: add comic-neue-checksum patch description and author
| * cf0bacffd7 Add patch for hard-coded checksum value of downloaded source file in the source code
| * 73275792fb add missing binutils build dependency to namedlist easyconfig
| * 55ec7565aa adding easyconfigs: namedlist-1.8-GCCcore-11.2.0.eb
| * 0ea31891d9 Merge pull request #14806 from boegel/20220120190948_new_pr_R-bundle-Bioconductor314
| * bbfa623c8c add pathview extension to R-bundle-Bioconductor 3.14
| * 45acf59f55 Merge pull request #14711 from ItIsI-Orient/20220113183646_new_pr_Short-Pair20170125
| * 70bfefbaca Added required changes
| * be0006d48b Fixed error + edited patch desc
| * 6f85ffb535 adding easyconfigs: Short-Pair-20170125-foss-2021b.eb and patches: Short-Pair-20170125-Python3fix.patch
| * ab3099a9df Merge pull request #14792 from branfosj/20220119163605_new_pr_Pillow-SIMD832
| * c2f8c0ee7c the Pillow v8 patch also works for Pillow-SIMD v7
| * 9e333911ca fix CVE-2021-23437 in Pillow-SIMD v8 + add Pillow-SIMD v8.3.2 in easyconfigs using a 2021b toolchain
| * aa46b3ecf1 Merge pull request #14548 from shot0829/20211213195043_new_pr_elbencho203
```

Never rebasing your changes before merging can lead to a hard to read history...

Demo

- Rebasing a branch (feat. manual conflict resolution)

Cherry-picking: copy-pasting commits

```
git cherry-pick
```

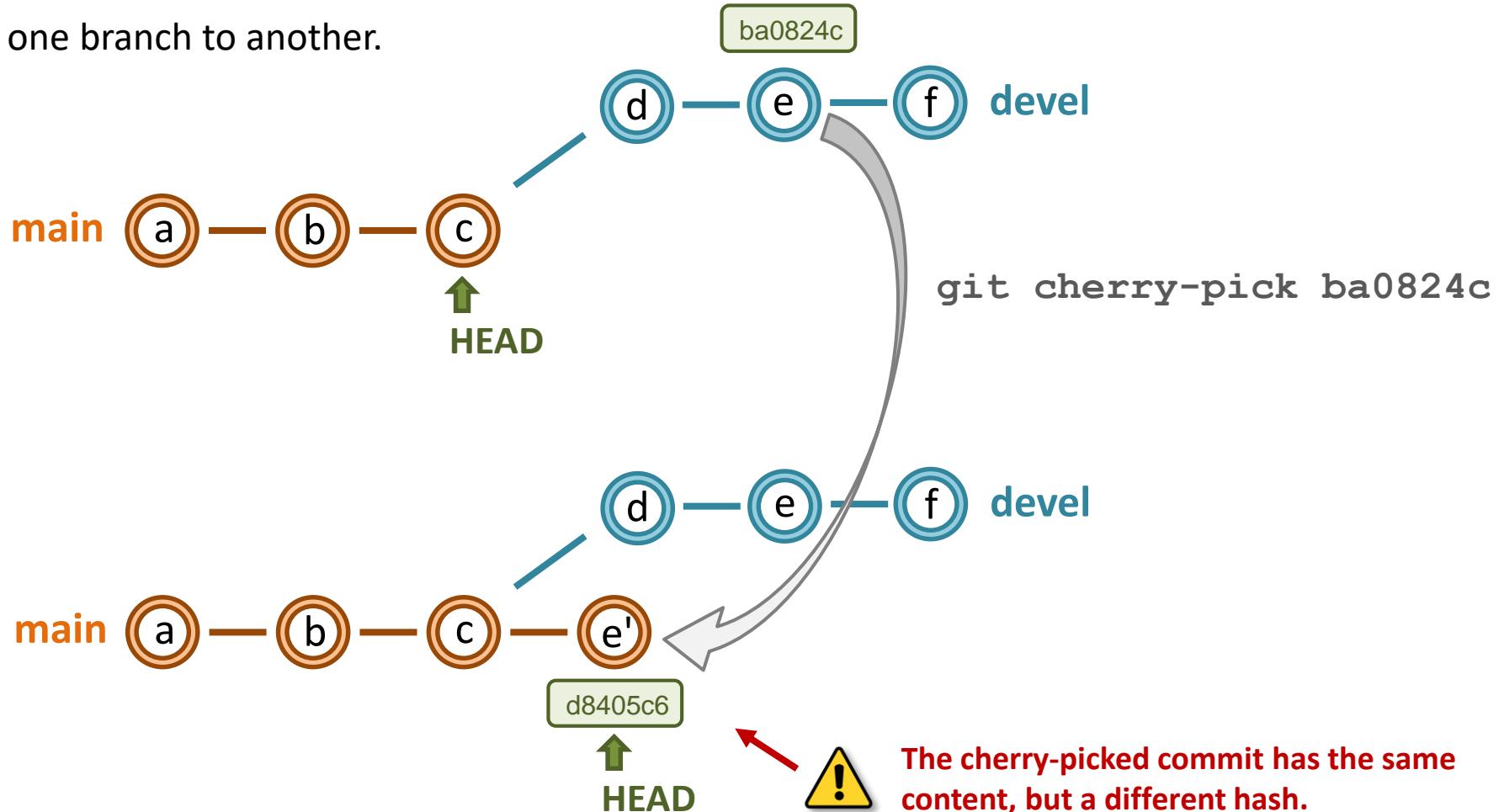
Cherry-pick: merge a single commit into the current branch

- **git cherry-pick**: "copy" a commit (or several) to the current branch.

```
git cherry-pick <commit to pick>
```

Example:

"copy" a fix from one branch to another.



Retrieve data from earlier commits

git restore

git checkout

Un-stage file modifications (restore file in index)

```
git restore --staged <file name>
```

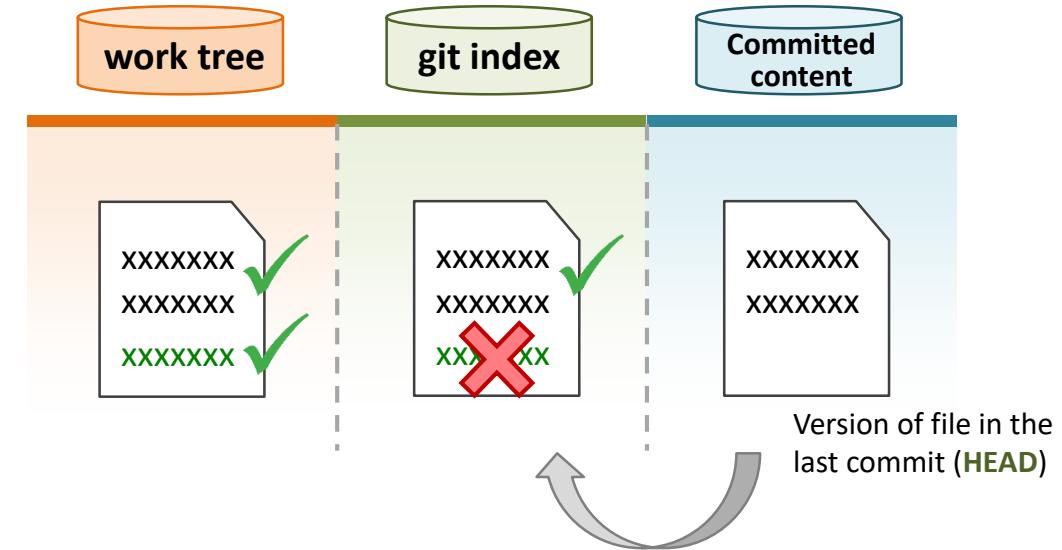
- Restores the content of a file in the Git index back to the latest commit (**HEAD** commit).
- Does not modify files in the working tree.

Example: un-stage changes to README.md file.

```
$ git status
On branch main
Changes to be committed:
(use "git restore --staged <file>..." to unstage)
    modified:   README.md
```

```
$ git restore --staged README.md
```

```
$ git status
On branch main
Changes not staged for commit:
(use "git add <file>..." to update what will be committed)
(use "git restore <file>..." to discard changes in working directory)
    modified:   README.md
```



```
git restore --staged README.md
```

The file is still modified in the working directory, but the changes are no longer staged.

Restore / checkout of individual files

Retrieving the content of a file from an earlier commit can be done with either:

```
git restore -s/--source <commit reference> <file name>
```

or

```
git checkout <commit reference> <file name>
```

Warning: these commands will overwrite existing versions of the retrieved file in your working tree (without any sort of warning). Make sure you don't have uncommitted changes you want to keep.



➤ If no commit references is specified, the file is retrieved from the index.

Examples: the <commit reference> can be e.g. a commit ID, a relative reference, a tag or a branch name.

```
$ git restore -s ba08242 output.txt
$ git restore -s HEAD~10 output.txt
$ git restore -s v2.0.5 output.txt
$ git restore -s devel-branch output.txt
```

using a branch name, implicitly refers
to the latest commit on the branch.

```
$ git checkout ba08242 output.txt
$ git checkout HEAD~10 output.txt
$ git checkout v2.0.5 output.txt
Updated 1 path from 2a7fac8
$ git checkout devel-branch output.txt
Updated 1 path from e55fa6f
```

A small difference between these two commands is that **restore** updates the file only in the working tree (i.e. the files in your working directory), while **checkout** updates both the working tree and the index.

```
$ git restore --source ad26560 README.md
$ git status
Changes not staged for commit:
(use "git restore <file>..." to discard changes
in working directory)
modified: README.md
```

```
$ git checkout ad26560 README.md
Updated 1 path from e55fa6f
$ git status
Changes to be committed:
(use "git restore --staged <file>..." to unstage)
modified: README.md
```



Checkout of the entire repo state at an earlier commit

- Checking out a commit will restore both the working tree and the index to the exact state of the specified commit.
- It will also move the **HEAD** pointer to that commit.

```
git checkout <commit reference>
```

Examples:

```
$ git checkout ba08242  
$ git checkout HEAD~10  
$ git checkout v2.0.5
```

Make sure to have a clean working tree before doing a checkout!

```
$ git checkout ad26560  
error: Your local changes to the following files would be  
overwritten by checkout:  
        README.md  
Please commit your changes or stash them before you switch branches
```

- After a checkout, you enter a "detached HEAD" state....
- To get back to a “normal” state you should go back to a regular branch:

```
git switch <branch> or git checkout <branch>
```



```
$ git checkout ba08242  
Note: checking out 'ba08242'.
```

You are in 'detached HEAD' state. You can look around, make experimental changes and commit them, and you can discard any commits you make in this state without impacting any branches by performing another checkout.

```
$ git add --all  
$ git commit --message "c3"
```

← File remains available in the Git database

```
$ git rm output.txt  
$ git rm --cached private_tests.py  
$ git commit --message "c4"
```

```
$ git checkout c3 output.txt  
$ git restore -s c3 output.txt
```

These 2 commands are almost equivalent: the difference is that **git restore** will not update the git index with the retrieved file.

exercise 3

The crazy peak sorter script



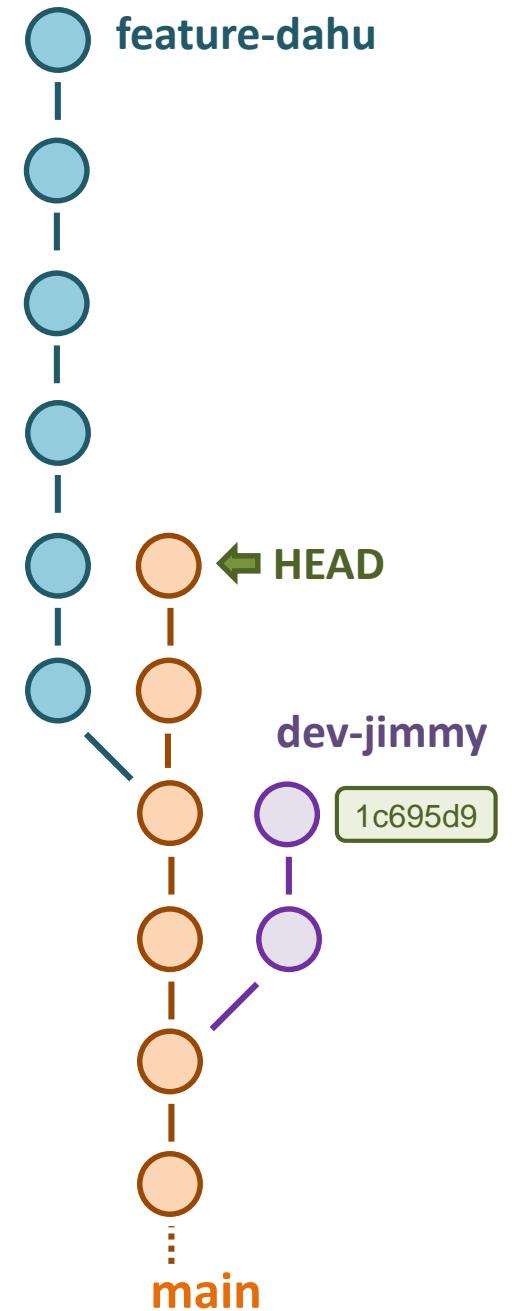
This exercise has helper slides

Exercise 3 help: history of the peak-sorter repo

This slide shows the history of the repo for exercise 3, both as the command line output and as a schematic representation (on the right).

This can help you understand the command line representation of a repo's history.

```
[rengler@local peak_sorter]$ git log --all --decorate --oneline --graph
* fc0b016 (origin/feature-dahu) peak_sorter: display highest peak at end of script
* d29958d peak_sorter: added authors as comment to script
* 6c0d087 peak_sorter: improved code commenting
* 89d201f peak_sorter: add Dahu observation counts to output table
* 9da30be README: add more explanation about the added Dahu counts
* 58e6152 Add Dahu count table
| * f6ceaac (HEAD -> master, origin/master, origin/HEAD) peak_sorter: added authors to script
| * f3d8e22 peak_sorter: display name of highest peak when script completes
|
* cfd30ce Add gitignore file to ignore script output
* f8231ce Add README file to project
| * 1c695d9 (origin/dev-jimmy) peak_sorter: add check that input table has the ALTITUDE and PEAK columns
| * ff85686 Ran script and added output
|
* 821bcf5 peak_sorter: add +x permission
* 40d5ad5 Add input table of peaks above 4000m in the Alps
* a3e9ea6 peak_sorter: add first version of peak sorter script
```



Part III

Working with remotes

Linking your local repo with an
online server

What is a “remote” ?

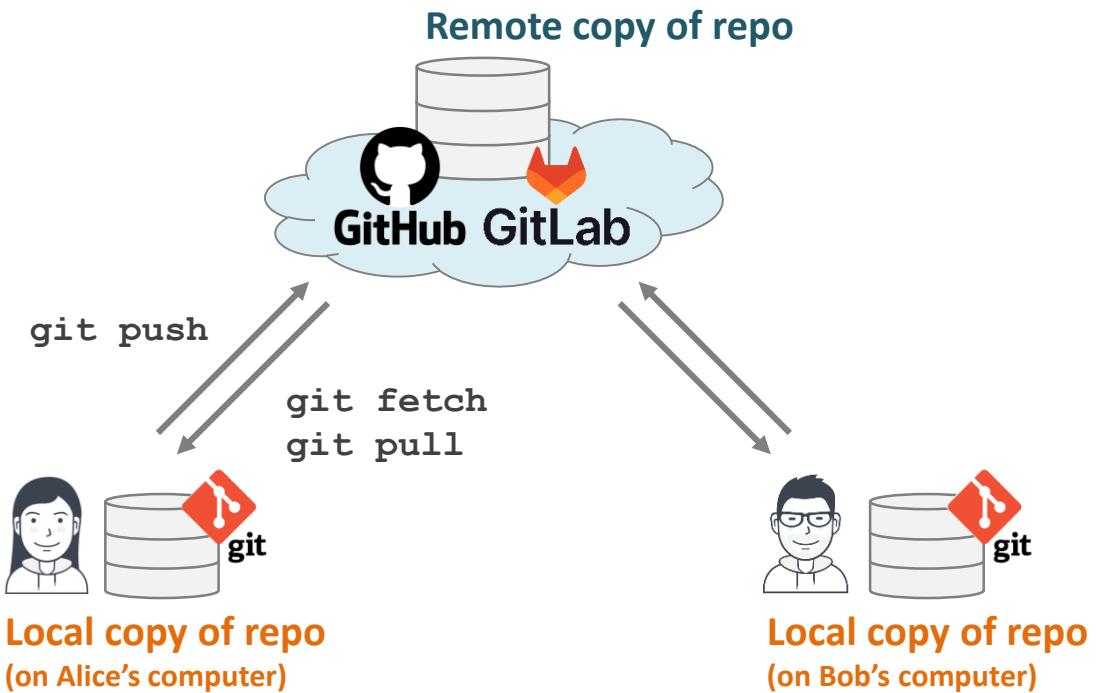
A **remote** is a copy of a Git repository that is stored on a server (i.e. online).

Remotes are very useful, as they allow you to:

- **Backup** your work.
- **Collaborate** and synchronize your repo with other team members.
- **Distribute** your work – i.e. let other people clone your repo (e.g. like the repo of this course).

Good to know:

- Each copy of a Git repo (local or online) is a **full copy of the entire repo’s history** (provided it has been synced).
- Git does not perform any automatic sync between the local and remote repos. All **sync operations must be manually triggered**.



Remotes are generally hosted on dedicated servers/services, such as GitHub, GitLab (either gitlab.com or a self-hosted instance), BitBucket, ...

Add a remote to an existing project (or update a remote's URL)

- **Case 1:** your local repo was cloned from a remote – *nothing to do* (the remote was automatically added by Git).
- **Case 2:** your local repo was created independently from the remote – it must be linked to it.

Add a new remote: `git remote add <remote name> <remote url>`

Change URL of remote: `git remote set-url <remote name> <remote url>`

Note: by convention, the `<remote name>` is generally set to `origin`.

Examples

```
# Add a new remote (named origin) to the local repo:  
$ git remote add origin https://github.com/sibgit/test.git
```

```
# Update the URL of the existing origin remote.  
# In this example, the remote was moved GitLab.  
$ git remote set-url origin https://gitlab.sib.swiss/sibgit/test.git
```

Example – part 1: creating a new remote and pushing new branches



Alice's computer

GitHub GitLab Remote



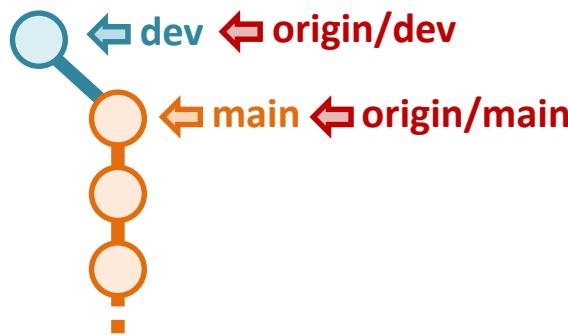
Alice has a Git repo with 2 branches: **main** and **dev**. She now wants to store her work on GitHub, to collaborate and have a backup.

1. She creates a remote on GitHub and links it to her local repo using `git remote add origin <URL of remote>`
2. She pushes her branch **main** to the remote using `git push -u origin <branch name>`
(at this point the branch has no upstream, so the `-u/--set-upstream` option must be used).
3. She pushes her branch **dev** to the remote.

Example – part 2: cloning a remote and checking-out branches

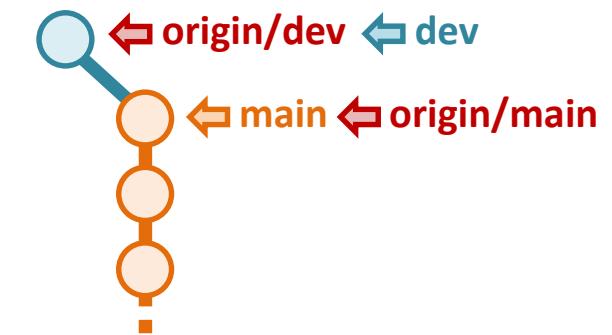
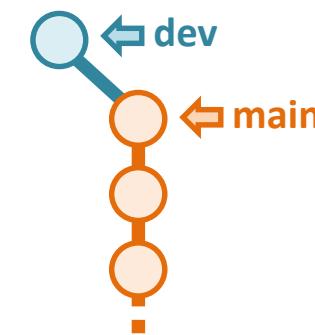


Alice's computer



Bob's computer

```
git clone https://github.com/...  
git switch dev
```



Bob has now joined the team to work with Alice.

1. He **clones** the repo from GitHub using `git clone <URL of remote>`. At this point, Bob has no local **dev** branch - only a pointer to **origin/dev**.
2. Bob checks-out the **dev** branch to work on it. Because there is already a remote branch **origin/dev** present, Git automatically creates a new local branch **dev** with **origin/dev** as upstream (no need add the `--create/-c` option to `git switch`).

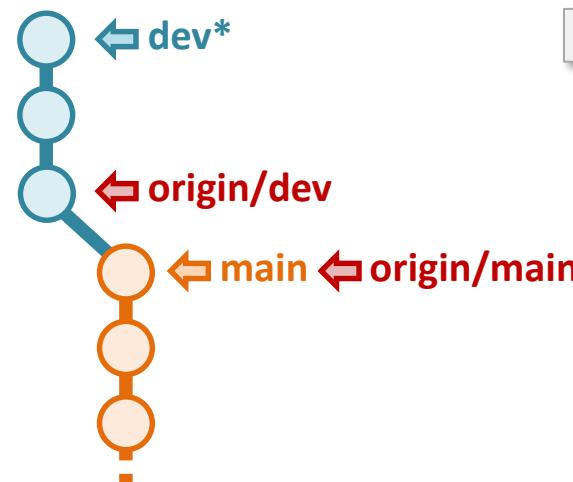
Example – part 3: pushing and pulling changes



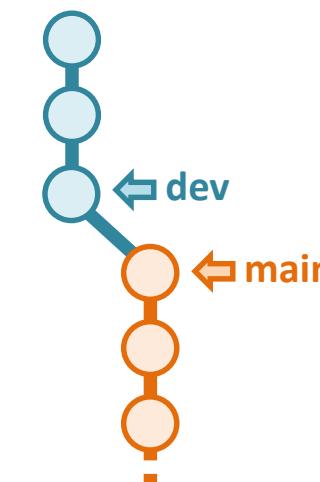
Alice's computer

When using `git push` without specifying a remote and branch name, the branch you wish to push must be the currently active branch.

`git push`



Remote

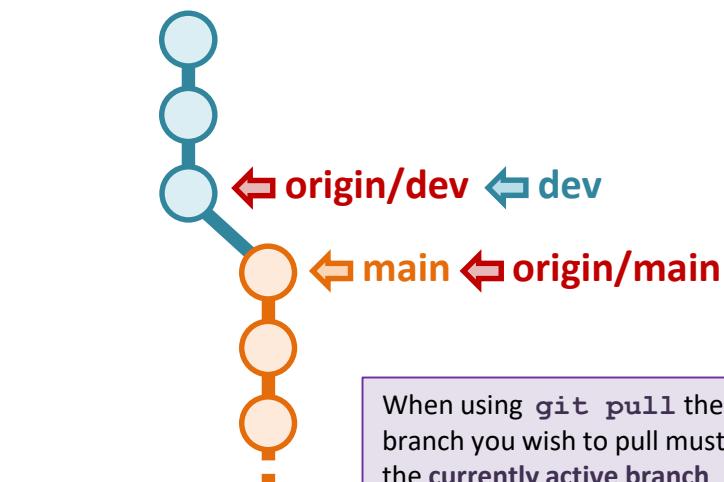


Bob's computer

`git fetch`

`git merge`

`git pull`



After fetching, if you want to merge changes, you can also simply run `git pull` instead of `git merge`.

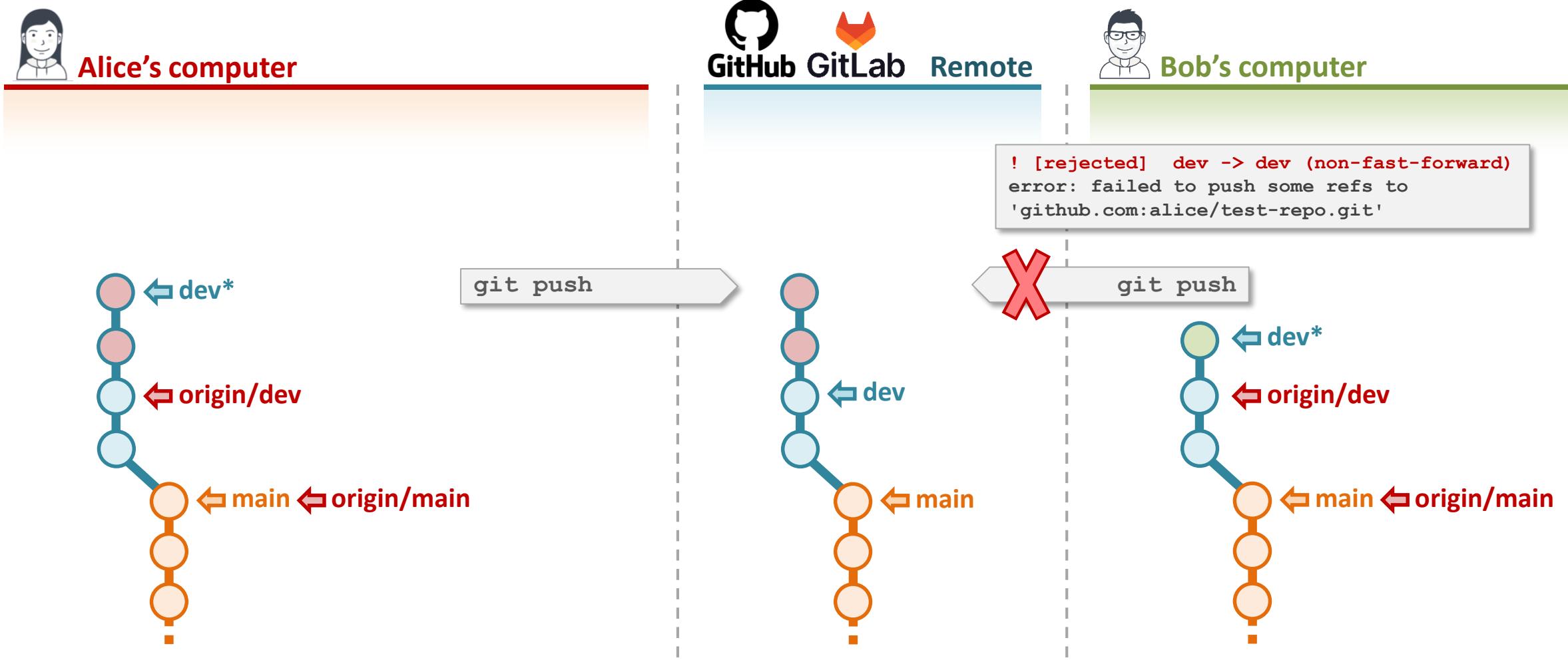


- In the mean time, Alice added 2 new commits to `dev`. She pushes her changes to the remote using `git push` (since her `dev` branch already has an upstream, there is no need to add the `-u/--set-upstream` option this time).
- To get Alice's updates from the remote, Bob runs `git pull`, which is a combination of `git fetch + git merge`.
Important: `git fetch` downloads all new changes/updates from the remote, but does not update your local branches.

When using `git pull` the branch you wish to pull must be the **currently active branch** (otherwise Git will fetch but not merge changes)



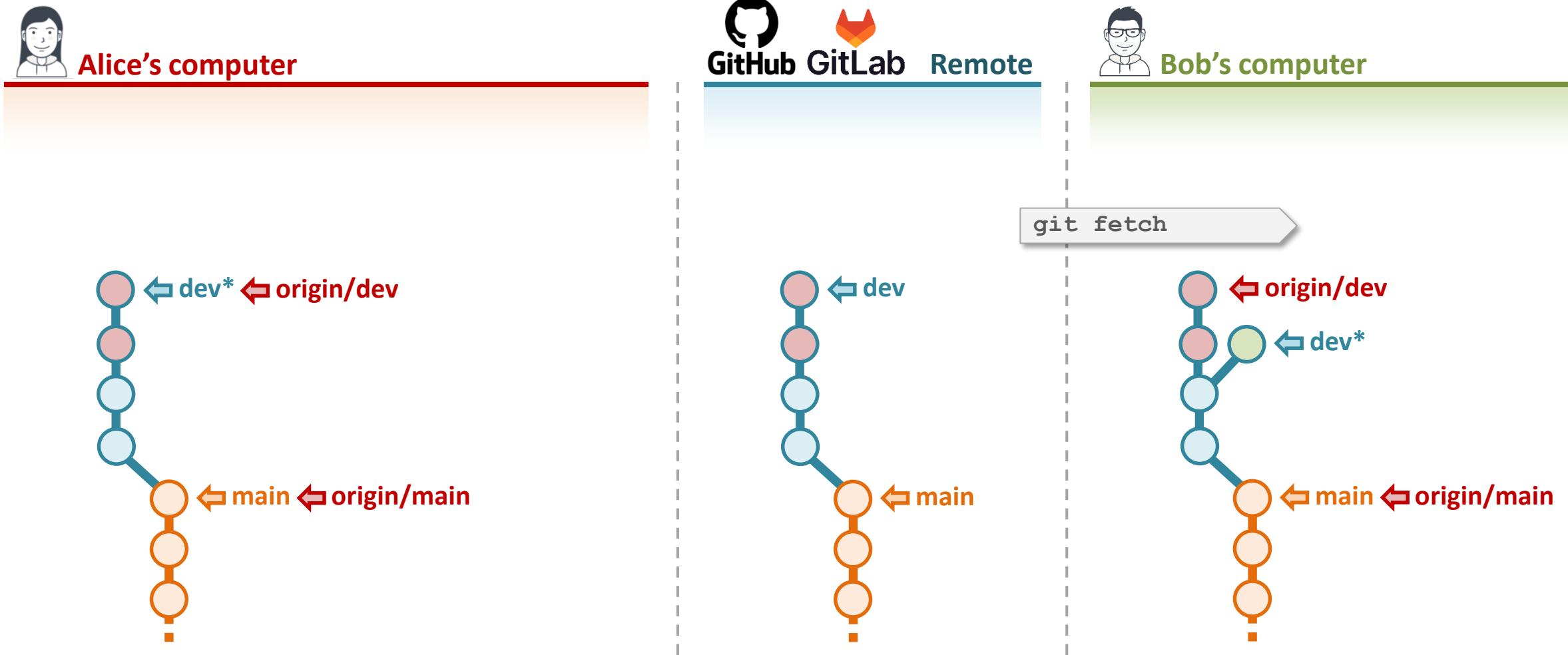
Example – part 4: reconciliation of a diverging history



Both Alice and Bob have now both added some commits to their local `dev` branch. As a result, the history of their branches has diverged.

1. Alice pushes her changes to the remote with `git push`, as usual.
2. When Bob tries to `git push`, his changes are rejected because the history between his local `dev` branch and the remote have **diverged!**

Example – part 4: reconciliation of a diverging history (continued)

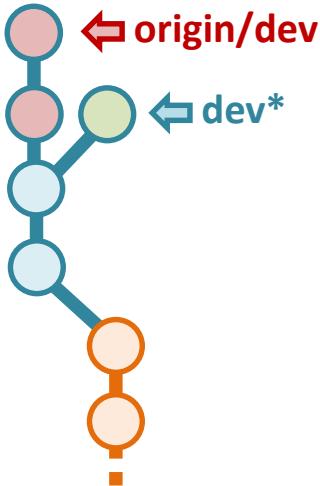


In order to be able to push his changes to the remote, Bob must first reconcile his local `dev` branch with the remote...

1. Bob starts by performing a `git fetch`, just to get the new commits from the remote and see how his local branch diverges from the remote (**important:** this operation does not impact/update his local `dev` branch).

Example – part 4: reconciliation of a diverging history (continued)

To reconcile his local `dev` branch with the remote, Bob must decide to either perform a merge or a rebase.



In this situation, a regular pull raises an error *

```
$ git pull
fatal: Need to specify how to
reconcile divergent branches
```

Option 1 - reconciliation using `merge`.

This is equivalent to:

```
git fetch
git merge origin/dev
```

git pull --no-rebase

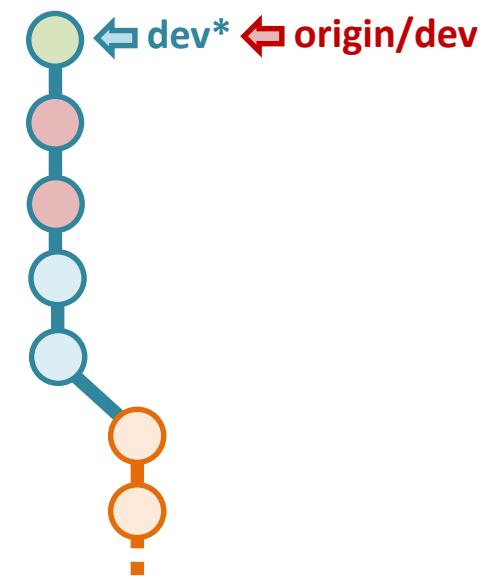


Option 2 - reconciliation using `rebase`.

This is equivalent to:

```
git fetch
git rebase origin/dev
```

If you don't remember the `--no-rebase` and `--rebase` options of `git pull`, simply `fetch` and then `merge` or `rebase` on `origin/dev`.



* On recent Git versions (>= 2.33), the default pull behavior is to abort if history diverged. On older versions, the default behavior is to merge (as in `git pull --no-rebase`).

git pull: a shortcut for fetch + merge

The `git pull` command is a shortcut for:

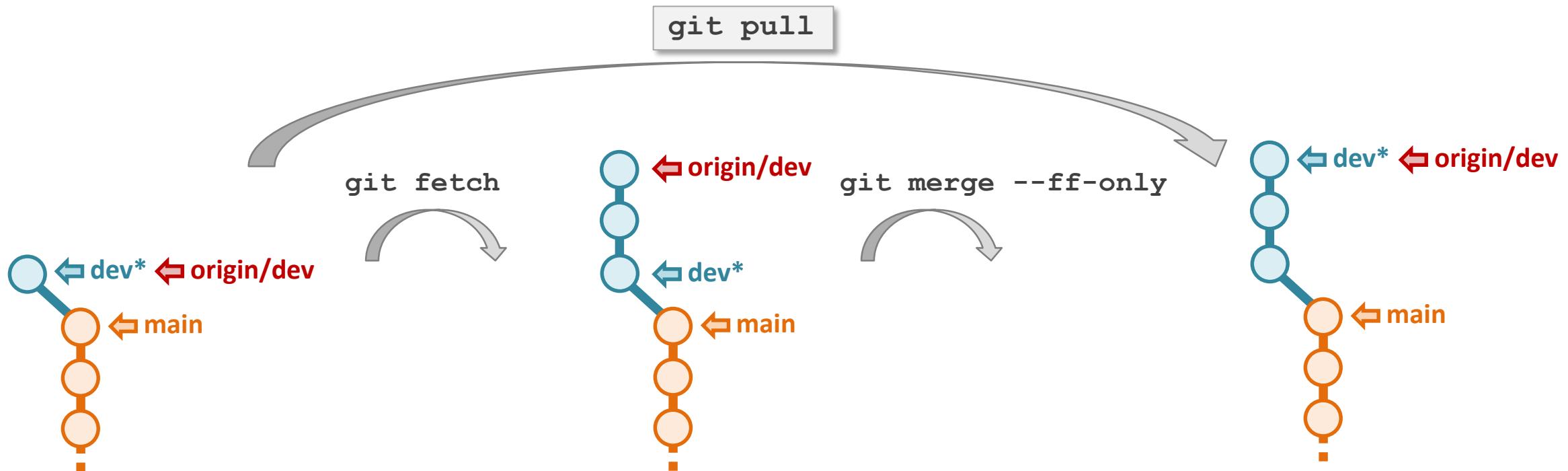
1. `git fetch` : fetches all updates from the remote.
2. `git merge -ff-only` : merge the currently active branch with its upstream branch (`origin/<branch>`).



Having the `git pull` command use `--ff-only` as default merge option is a recent behavior (Git >= 2.33). In older versions, to force `git pull` to only allow fast-forward merges, the following option must be set:

```
git config --global pull.ff only
```

↑ Fast-forward only -> any divergence in history will cause the command to fail and report an error.

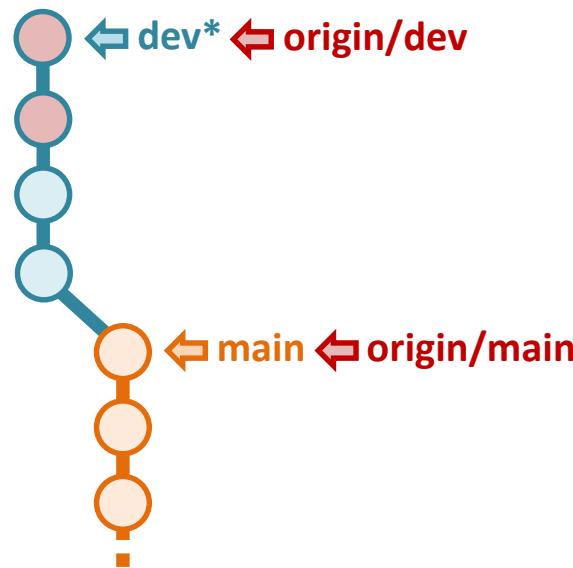


By default, git merges a branch with its upstream branch, so `git merge` is the same as `git merge origin/<branch>`.

Example – part 4: reconciliation of a diverging history (continued)



Alice's computer

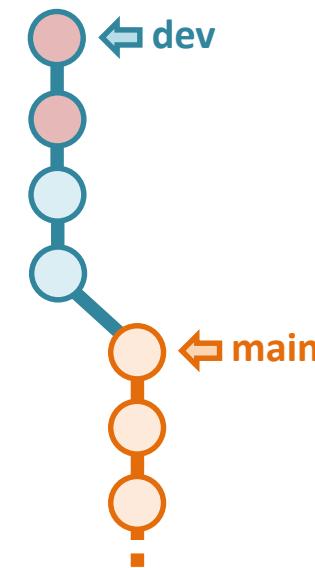


GitHub GitLab Remote



Bob's computer

`git pull --no-rebase`



`dev* ← origin/dev`

Bob decides to merge without rebase and runs `git pull --no-rebase`.

Note: depending on the version of Git, the default behavior of `git pull` is different:

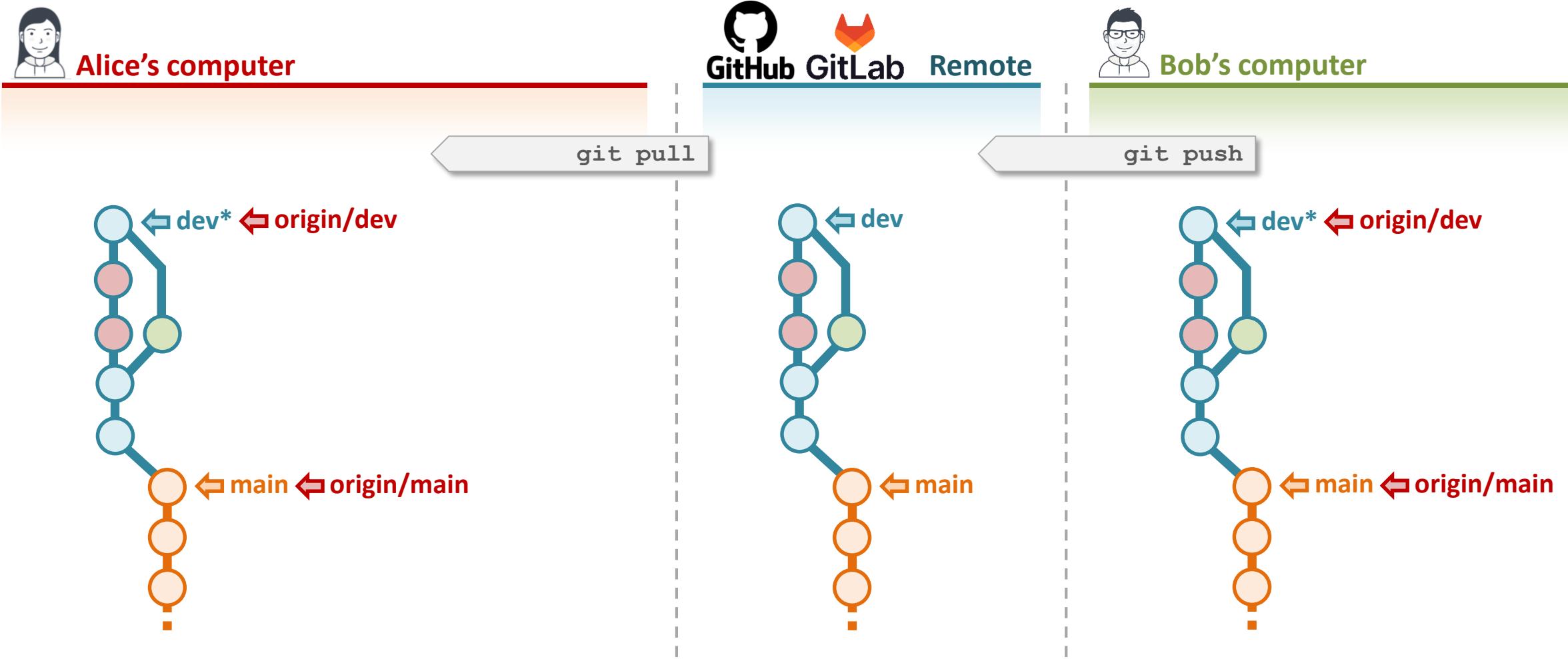
- Newer versions default to `git pull --ff-only` (i.e. raise an error if a fast-forward merge is not possible)
- Older versions default to `git pull --no-rebase` (i.e. the automatically merge)

The default behavior can be modified in the git config.

```

git config pull.rebase false      # merge
git config pull.rebase true       # rebase
git config pull.ff only          # fast-forward only
  
```

Example – part 4: reconciliation of a diverging history (the end!)



Finally, Bob can `git push` his changes to the remote - there are no more conflicts.

Alice can then `git pull` them.

Example – part 5: deleting branches on the remote

The `--prune` option also works with `git pull --prune`.



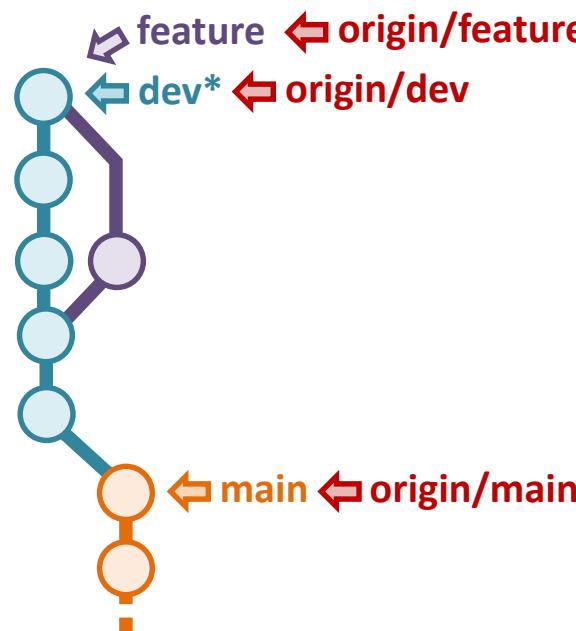
Alice's computer



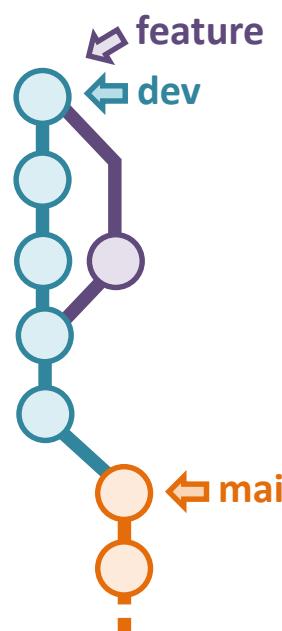
Remote



Bob's computer

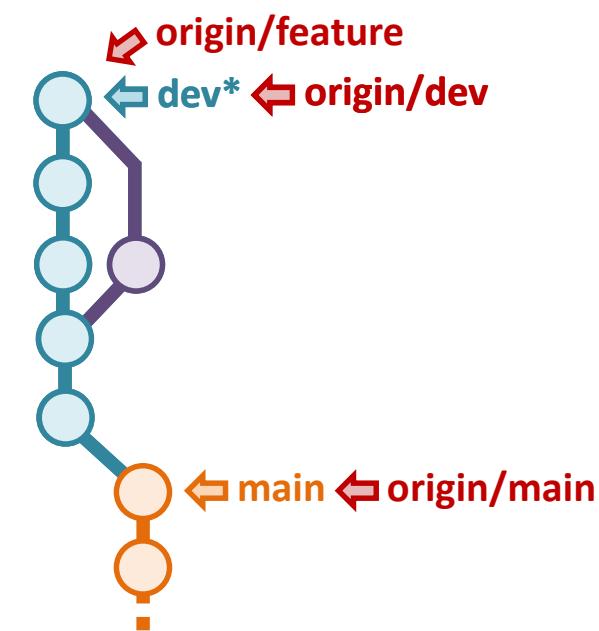


Remote



`git fetch --prune`

`git fetch`

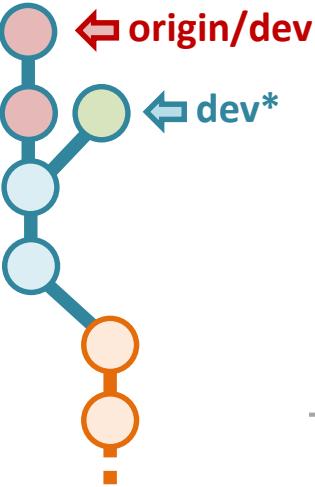


We are now at a later point in the development... Alice has just completed a new feature on her branch `feature`, and merged it into `dev`. She now wants to delete the `feature` branch both locally and on the remote.

1. Alice deletes her local branch with `git branch -d <branch name>`.
2. Alice deletes the feature branch on the remote with `git push origin --delete <branch name>`. This also deletes her `origin/feature` pointer.
3. Bob runs `git fetch`, but this does not delete references to remote branches, even if they no longer exist on the remote.
4. To delete his local reference to the remote feature branch (`origin/feature`), Bob has to use `git fetch --prune`.

Example – part 6: overwrite history on the remote

Example, if you made some history-rewriting change locally, typically a rebase of a branch.



`git push
--force`

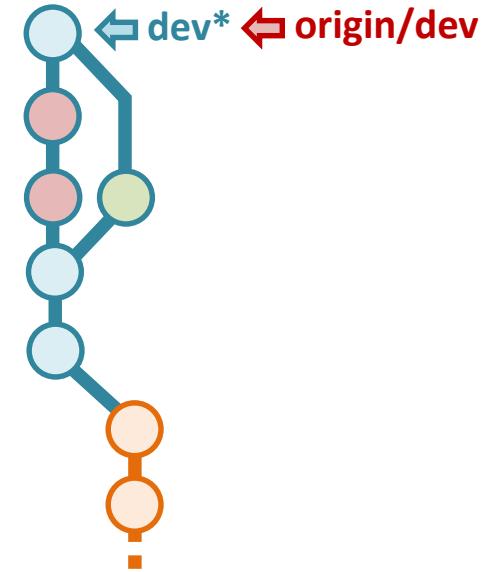
Option 3 – overwrite the remote
with `git push --force`

`dev* ← origin/dev`



This will permanently
delete data on the
remote !!

`git pull --no-rebase`



`git pull --rebase`

`dev* ← origin/dev`



Interacting with remotes: commands summary

Command

What it does

Where to run and comments

git push

push new commits on the current branch to the remote.

Run on the branch that you wish to push.

(only changes on the active branch are pushed)

`git push -u origin <branch-name>`

Same as git push, but additionally sets the upstream branch to **origin/branch-name**. Only needed if no upstream is set.

`-u` option is only needed when pushing a branch to the remote for the very first time. It is not needed if you initially created the local branch from a remote branch.

`git push origin <branch-name>`

Push new commits on the specified branch to the remote.

When the remote (here **origin**) and branch names are specified, the push command **can be run from anywhere**.

`git push --force`

Overwrite the branch on the remote with the local version.

Warning: this deletes data on the remote!

git fetch

Download all updates from the remote to your local repo (even for non-active branches or branches for which there is no local version).

Can be run from any branch.

Does not update your local branch pointer to **origin/branch-name**.

git pull

Download all updates and **merge changes** the upstream **origin/branch-name** into the active branch (i.e. update the active branch to its version on the remote).

Run on the branch that you wish to update.

`git pull` is a shortcut for
`git fetch + git merge origin/branch-name`

`git pull --no-rebase`

Fetch + 3-way merge active branch with its upstream **origin/branch-name**.

On recent versions of Git (>= 2.33), the default pull behavior is to abort the pull if a branch and its upstream are diverging.

`git pull --rebase`

Fetch + rebase active branch on its upstream **origin/branch-name**.

On older versions, the default behavior is to merge them (same as `git pull --no-rebase`).

`git pull --ff-only`

Fetch + fast-forward merge active branch with its upstream **origin/branch-name**. If a fast-forward merge is not possible, an error is generated.



Interacting with remotes: commands summary

<u>Command</u>	<u>What it does</u>
----------------	---------------------

Create a local copy from an existing online repo. Git automatically adds the online repo as a remote.

Add a new remote to an existing local repo.

Change/update the URL of a remote associated to a local repo.

Display the remote(s) associated to a repo.

By convention, the <remote name> is generally set to `origin`, but it could be anything.



```
$ git remote -v
origin  https://github.com/alice/test-project.git (fetch)
origin  https://github.com/alice/test-project.git (push)
```

The fetch and push URLs should be the same.
To use different URLs (different remotes) for push and fetch, add two different remotes.

List branches of repo and their associated upstream (if any).

```
$ git branch -vv
manta-dev 18d8de0 [origin/manta-dev] manta ray: add animal name
main       6c8d731 [origin/main] Merge pull request #44 from sibgit/dahu-dev
* sunfish   18d8de0 manta ray: add animal name
```

We can see that the branches `main` and `manta-dev` have an upstream branch. The `sunfish` branch does not.

GitHub / GitLab

collaborate and share your work



GitHub / GitLab – an online home for Git repositories

- GitHub [github.com] and GitLab [gitlab.com] are hosting platforms for Git repositories.
- Very popular to share/distribute open source software.
- Allows to host public (anybody can access) and private (restricted access) repos.
- Hosting of projects is free, with some paid features.
- Popular alternatives include:
 - A local instance of GitLab, the same as GitLab.com but hosted by someone else.
 - BitBucket [bitbucket.org].



Project home page on GitHub

Example of the “home page” of a repository on GitHub

The screenshot shows the GitHub repository page for 'sibgit/test'. The 'Code' tab is selected, indicated by an orange arrow. A purple arrow points to the 'master' branch dropdown. Another purple arrow points to the file list, and a third points to the README.md content. A green arrow points to the 'Code' dropdown in the top right. A dashed orange box highlights the 'About' section, which contains project details like '0 stars' and '0 commits'. A purple box highlights the 'Clone' section with the URL 'https://github.com/sibgit/test.git'. A purple arrow points to the 'Download ZIP' button.

Code tab: the “home” page of your repo.

Branch you are currently viewing

List of files present in the repo.

If you have a **README.md** file, it is displayed here (with markdown rendering).

About
No description, website, or topics provided.
Readme
0 stars

Clone
HTTPS SSH GitHub CLI
<https://github.com/sibgit/test.git>
To copy the repo’s URL.

Download ZIP

Repository settings (only available if you are the owner)

Repository settings (only available if you are the owner)

View with no collaborator added yet

Who has access

PRIVATE REPOSITORY
Only those with access to this repository can view it.
[Manage](#)

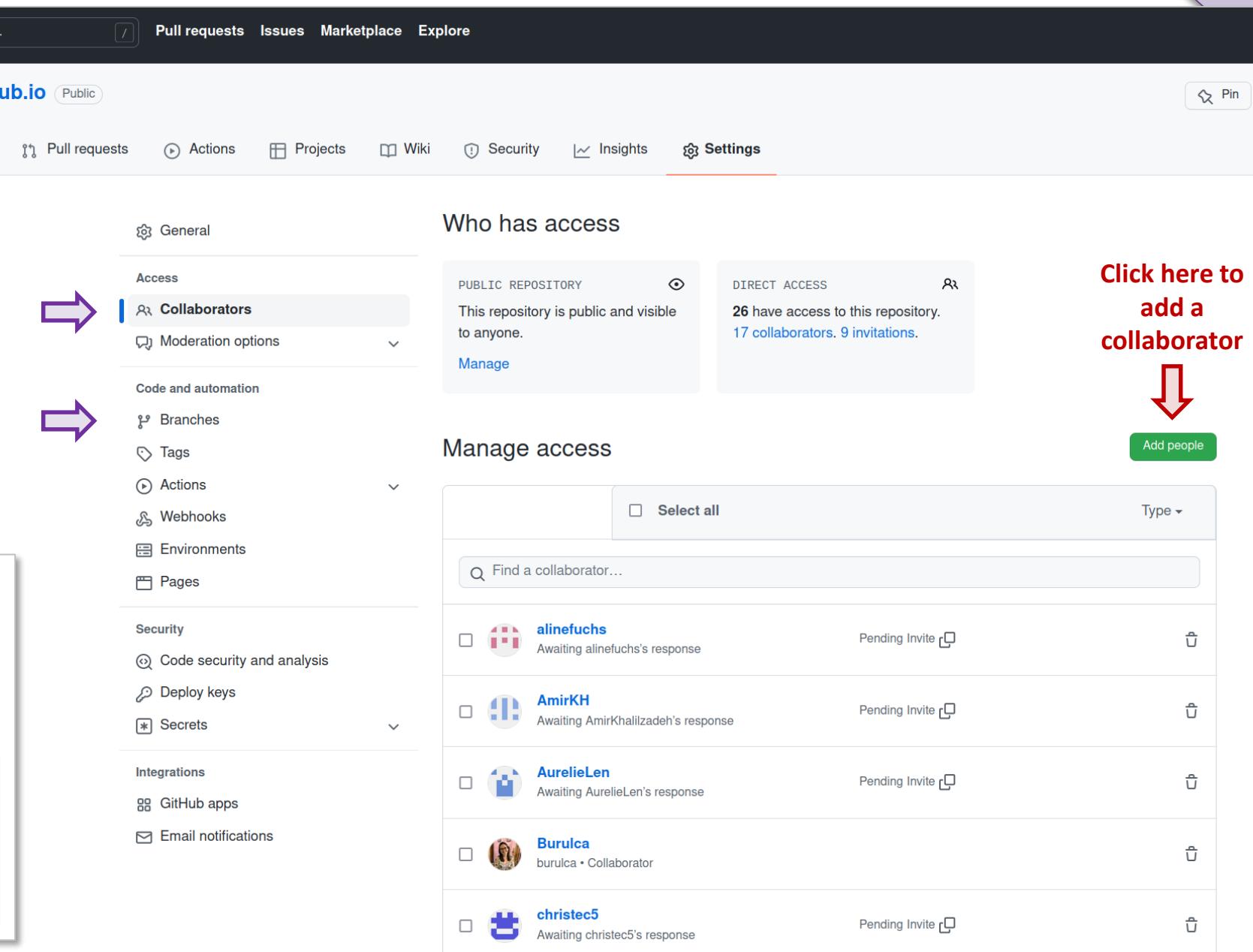
DIRECT ACCESS
0 collaborators have access to this repository. Only you can contribute to this repository.

Manage access

You haven't invited any collaborators yet

Click here to add a collaborator

[Add people](#)



Here you can set diverse settings concerning your repository, e.g. :

- Invite **collaborators**.
- Setup **branch protection**.

Who has access

PUBLIC REPOSITORY
This repository is public and visible to anyone.

DIRECT ACCESS
26 have access to this repository.
17 collaborators. 9 invitations.

Manage

Click here to add a collaborator

Add people

General

Access

Collaborators

Moderation options

Code and automation

Branches

Tags

Actions

Webhooks

Environments

Pages

Security

Code security and analysis

Deploy keys

Secrets

Integrations

GitHub apps

Email notifications

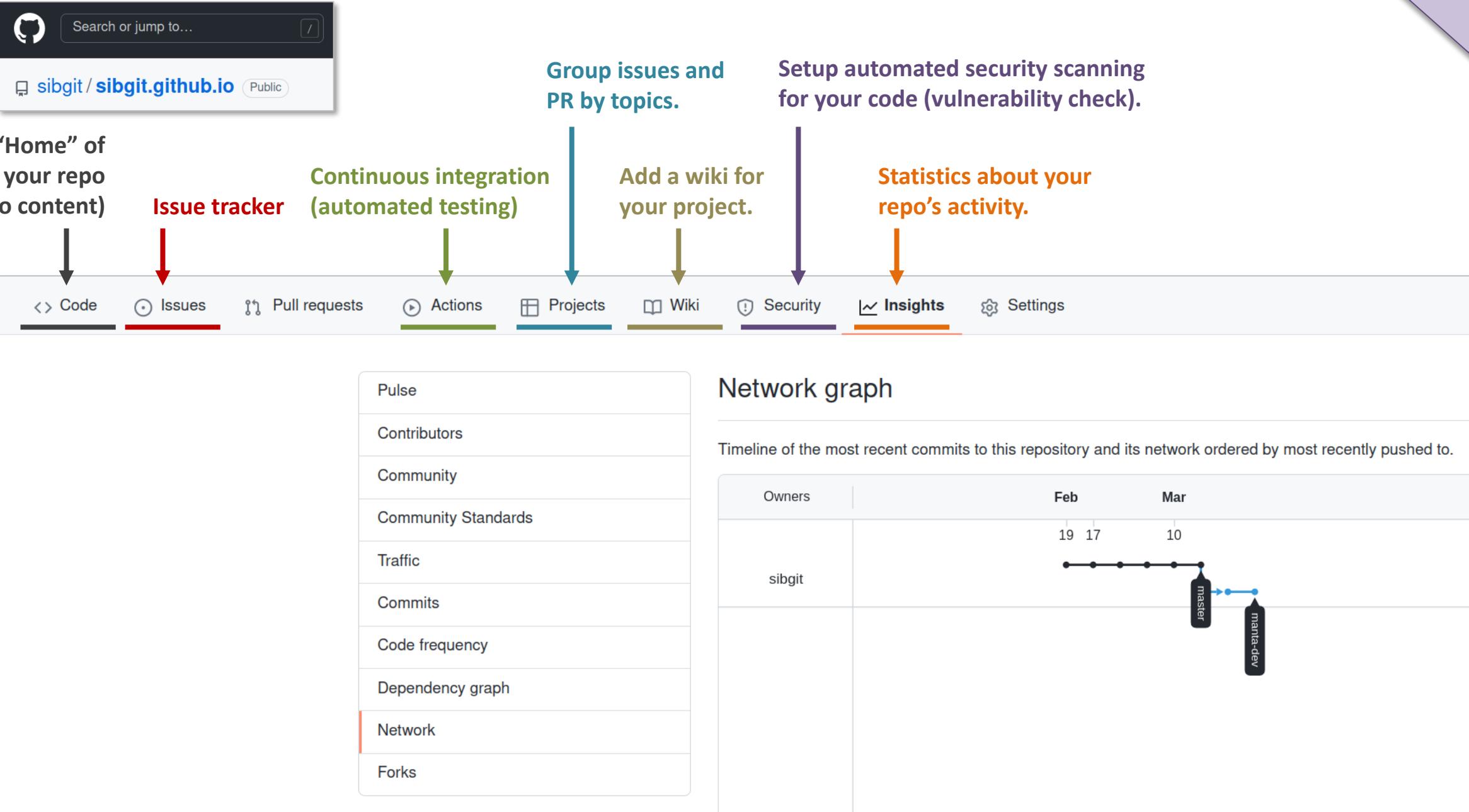
Manage access

Select all

Find a collaborator...

Collaborator	Status	Action
alinefuchs	Awaiting alinefuchs's response	Pending Invite
AmirKH	Awaiting AmirKhalilzadeh's response	Pending Invite
AurelieLen	Awaiting AurelieLen's response	Pending Invite
Burulca	burulca • Collaborator	
christec5	Awaiting christec5's response	Pending Invite

Other GitHub features (some of them)



The diagram illustrates various GitHub features and their locations on a repository page:

- “Home” of your repo (repo content)**: Points to the **Code** tab.
- Issue tracker**: Points to the **Issues** tab.
- Continuous integration (automated testing)**: Points to the **Actions** tab.
- Group issues and PR by topics.**: Points to the **Projects** tab.
- Add a wiki for your project.**: Points to the **Wiki** tab.
- Setup automated security scanning for your code (vulnerability check).**: Points to the **Security** tab.
- Statistics about your repo’s activity.**: Points to the **Insights** tab.

Network graph
Timeline of the most recent commits to this repository and its network ordered by most recently pushed to.

Owners	Feb	Mar
sibgit	19 17	10
		master → manta-dev

Pulse
Contributors
Community
Community Standards
Traffic
Commits
Code frequency
Dependency graph
Network
Forks



Project home page on GitLab

Example of the “home page” of a repository on GitLab

The screenshot shows the GitLab interface for the repository 'awesome-animal-awareness'. On the left, a sidebar lists various project management and monitoring options. The main area displays the repository details, including the branch 'main' (highlighted with a red arrow), a list of files (highlighted with a red arrow), and the contents of the 'README.md' file (highlighted with a red arrow). A large red dashed box highlights the 'Code' dropdown menu and the 'Clone' section. Within this section, two URLs are shown: one for SSH cloning and one for HTTPS cloning, each with a 'Copy URL' button (highlighted with red arrows). A red arrow also points to the 'Copy the project's URL' text at the bottom right.

Branch you are currently viewing

List of files present in the repo.

If you have a **README.md** file, it is displayed here (with markdown rendering).

Copy the project's URL (e.g. to git clone it)

A awesome-animal-awareness

main / awesome-animal-awareness / +

web: add img subdirectory to store images
Robin Engler authored 3 hours ago

Name	Last commit	Last update
img	web: add img subdirectory to store ima...	1 minute ago
.gitlab-ci.yml	cicd: add .gitlab-ci.yml file	1 minute ago
README.md	doc: add README.md	1 minute ago
alpaca.html	web: add animal page templates	1 minute ago
blue_whale.html	web: add animal page templates	1 minute ago
dahu.html	web: add animal page templates	1 minute ago
gorilla.html	web: add animal page templates	1 minute ago
index.html	web: rename home page to Awesome A...	1 minute ago
kiwi_bird.html	web: add animal page templates	1 minute ago
manta_ray.html	web: add animal page templates	1 minute ago

README.md

Awesome Animal Awareness Project

Welcome to the Awesome Animal Awareness Project.
To visit our website, go to: <https://sib-git-training.gitlab.io/awesome-animal-awareness>

History Find file Edit Code

Project information

- 8 Commits
- 2 Branches
- 0 Tags
- 1.1 MiB Project Storage
- 1 Environment

Clone with SSH

git@gitlab.com:sib-git-training/ [Copy URL](#)

Clone with HTTPS

<https://gitlab.com/sib-git-train> [Copy URL](#)

Copy the project's URL (e.g. to git clone it)



GitLab “project” menu

The screenshot shows the main project navigation menu. Several items are highlighted with dashed orange boxes:

- Manage**: Under Project
- Plan**: Under Project
- Code**: Under Project
- Build**: Under Project
- Secure**: Under Project
- Deploy**: Under Project
- Operate**: Under Project
- Monitor**: Under Project
- Analyze**: Under Project
- Settings**: Under Project

The screenshot shows the 'Manage' section of the project menu. It includes:

- Activity
- Members (highlighted with a dashed orange box)
- Labels

Add people to your project

The screenshot shows the 'Code' section of the project menu. It includes:

- Merge requests
- Repository (highlighted with a dashed orange box)
- Branches
- Commits (highlighted with a dashed orange box)
- Tags
- Repository graph (highlighted with a dashed orange box)
- Compare revisions
- Snippets

Repo home page

List of commits

History graph of your project

The screenshot shows the 'Activity' section of the project menu. It displays a list of recent commits:

- Jan 31, 2024:
 - main: add img subdirectory to store images (Robin Engler authored 4 hours ago)
 - cicd: add .gitlab-ci.yml file (Robin Engler authored 22 hours ago)
 - web: rename home page to Awesome Animal Awareness Project (Robin Engler authored 1 year ago)
 - web: add animal page templates (rmylonas authored 3 years ago and Robin Engler committed 37 minutes ago)
 - styles: change paragraphs fonts (sibgit authored 3 years ago and Robin Engler committed 37 minutes ago)

The screenshot shows the 'Repository graph' of the project. It displays a timeline from Jan 31 to Feb 19, 2024, showing the commit history:

- Jan 31:
 - manta-ray: add behavior information
 - manta-ray: add distribution and image
 - manta-ray: add animal name and diet
 - main: add img subdirectory to store images
 - cicd: add .gitlab-ci.yml file
 - web: rename home page to Awesome Animal Awareness Project
 - web: add animal page templates
 - styles: change paragraphs fonts
 - styles: add styles.css file
 - doc: add README.md
 - first commit
- Feb 19:

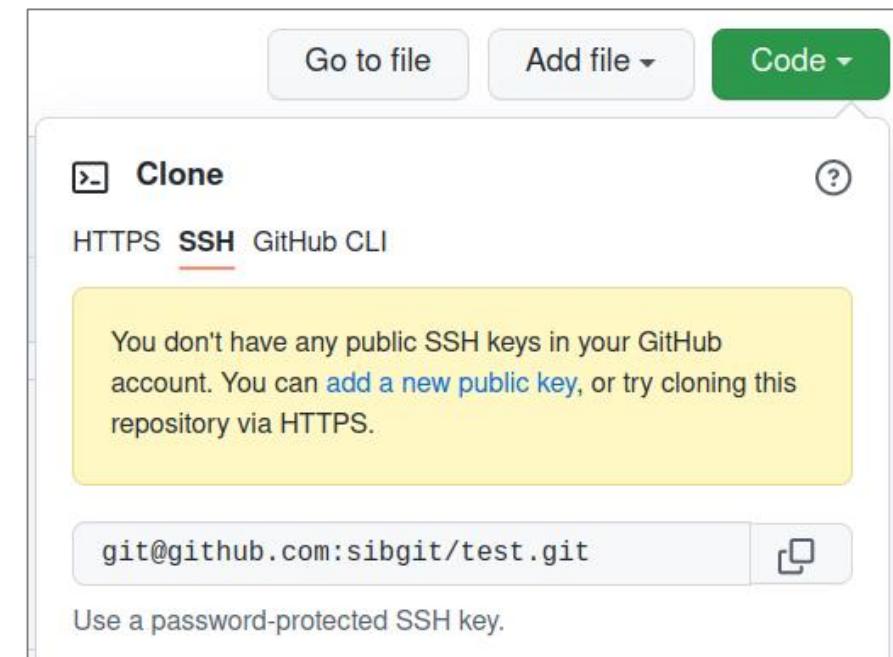
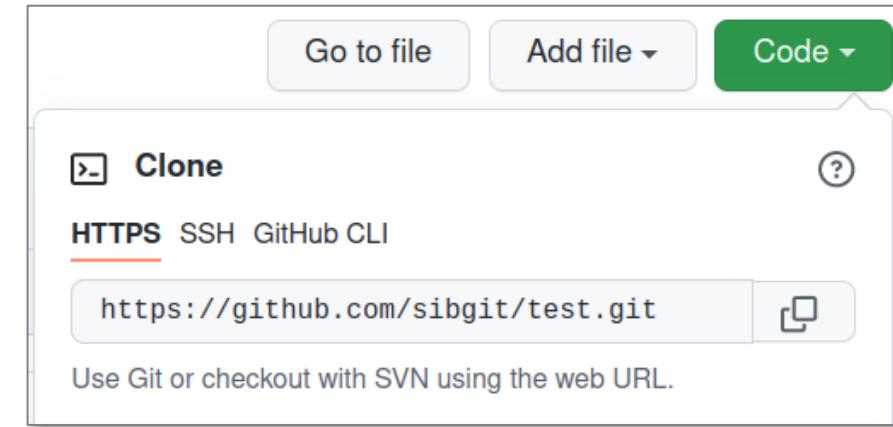
All settings of your project

Cloning a repo: HTTPS vs. SSH

HTTPS and SSH are two different network protocols that machines can use to communicate.

When cloning (or adding a remote) via:

- **HTTPS**, you will need to provide a **personal access token (PAT)** as authentication credential.
 - If the repo is public, credentials are only needed to push data to the remote (not to pull).
 - Your local Git repo will in principle store the login credentials, so you need to provide them only once.
- **SSH**, you will need to add your **public SSH key** to your GitHub account.



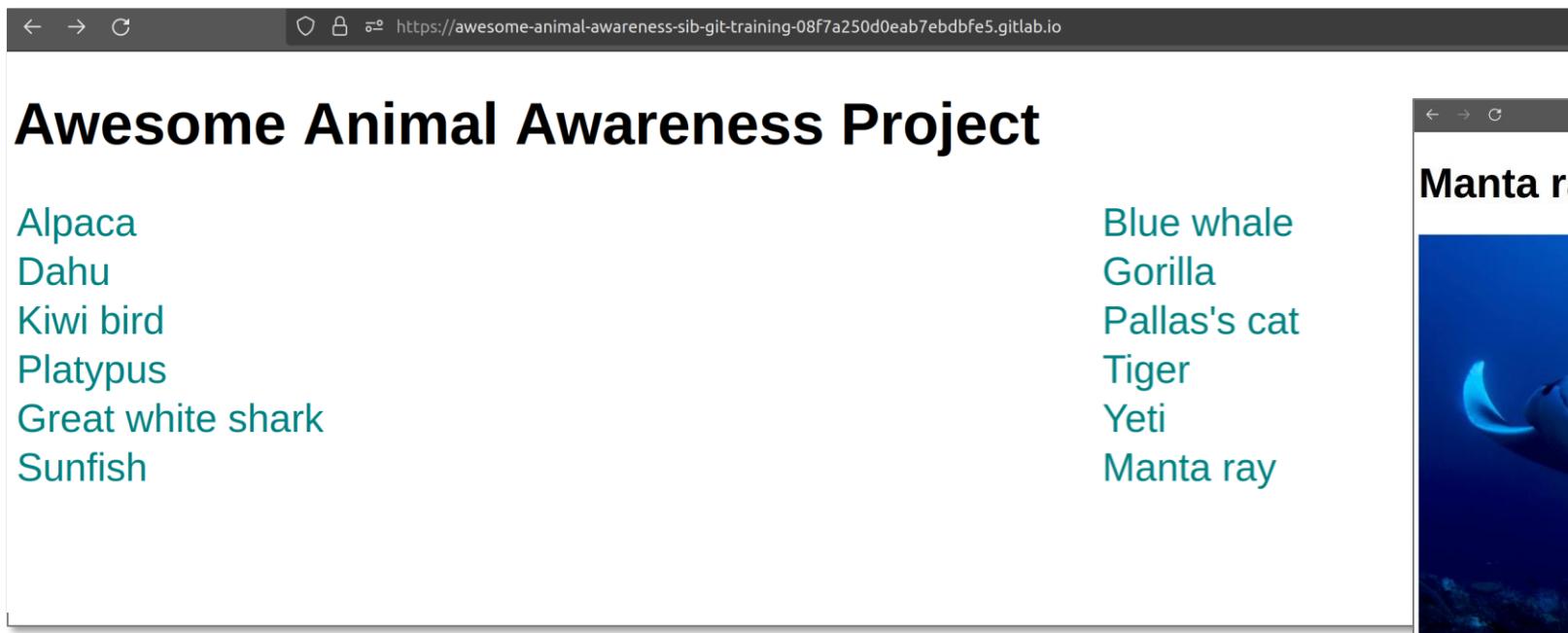
Reminder: command to clone a repo (here via https)

```
$ git clone https://github.com/sibgit/test.git
```

Pull Requests (GitHub) and Merge Requests (GitLab)

An introduction to the upcoming exercise 4...

In exercise 4, we will all work together on building a website for the **Awesome Animal Awareness project!**

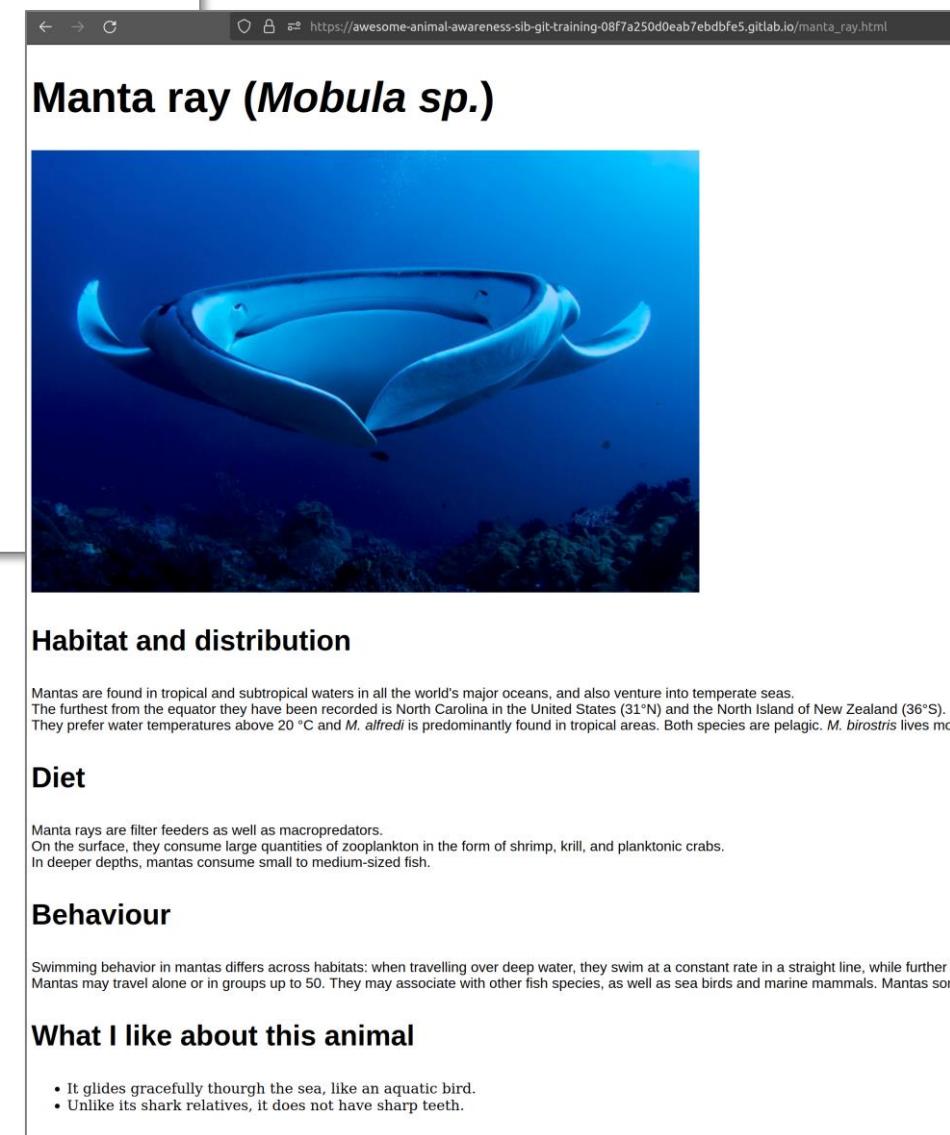


The screenshot shows a web browser window with the URL <https://awesome-animal-awareness-sib-git-training-08f7a250d0eab7ebdbfe5.gitlab.io>. The page title is "Awesome Animal Awareness Project". On the left, there is a list of animals: Alpaca, Dahu, Kiwi bird, Platypus, Great white shark, Sunfish. On the right, there is another list: Blue whale, Gorilla, Pallas's cat, Tiger, Yeti, Manta ray.

How we will work:

- We will split into teams of 2-3 people.
- Each team will be responsible for creating the page of an (awesome!) animal *.
- Within a team, each person will work on a different part of the animal's page (e.g. one person works on the "Habitat and distribution" section, while another works on the "Diet" or "Behavior").

* Note: every animal in the list is awesome – you can't go wrong!



The screenshot shows a web browser window with the URL https://awesome-animal-awareness-sib-git-training-08f7a250d0eab7ebdbfe5.gitlab.io/manta_ray.html. The page title is "Manta ray (*Mobula* sp.)". It features a large, high-quality photograph of a manta ray swimming in deep blue water. Below the image, there are sections for "Habitat and distribution", "Diet", "Behaviour", and "What I like about this animal".

Habitat and distribution
Mantas are found in tropical and subtropical waters in all the world's major oceans, and also venture into temperate seas. The furthest from the equator they have been recorded is North Carolina in the United States (31°N) and the North Island of New Zealand (36°S). They prefer water temperatures above 20 °C and *M. alfredi* is predominantly found in tropical areas. Both species are pelagic. *M. birostris* lives more

Diet
Manta rays are filter feeders as well as macropredators. On the surface, they consume large quantities of zooplankton in the form of shrimp, krill, and planktonic crabs. In deeper depths, mantas consume small to medium-sized fish.

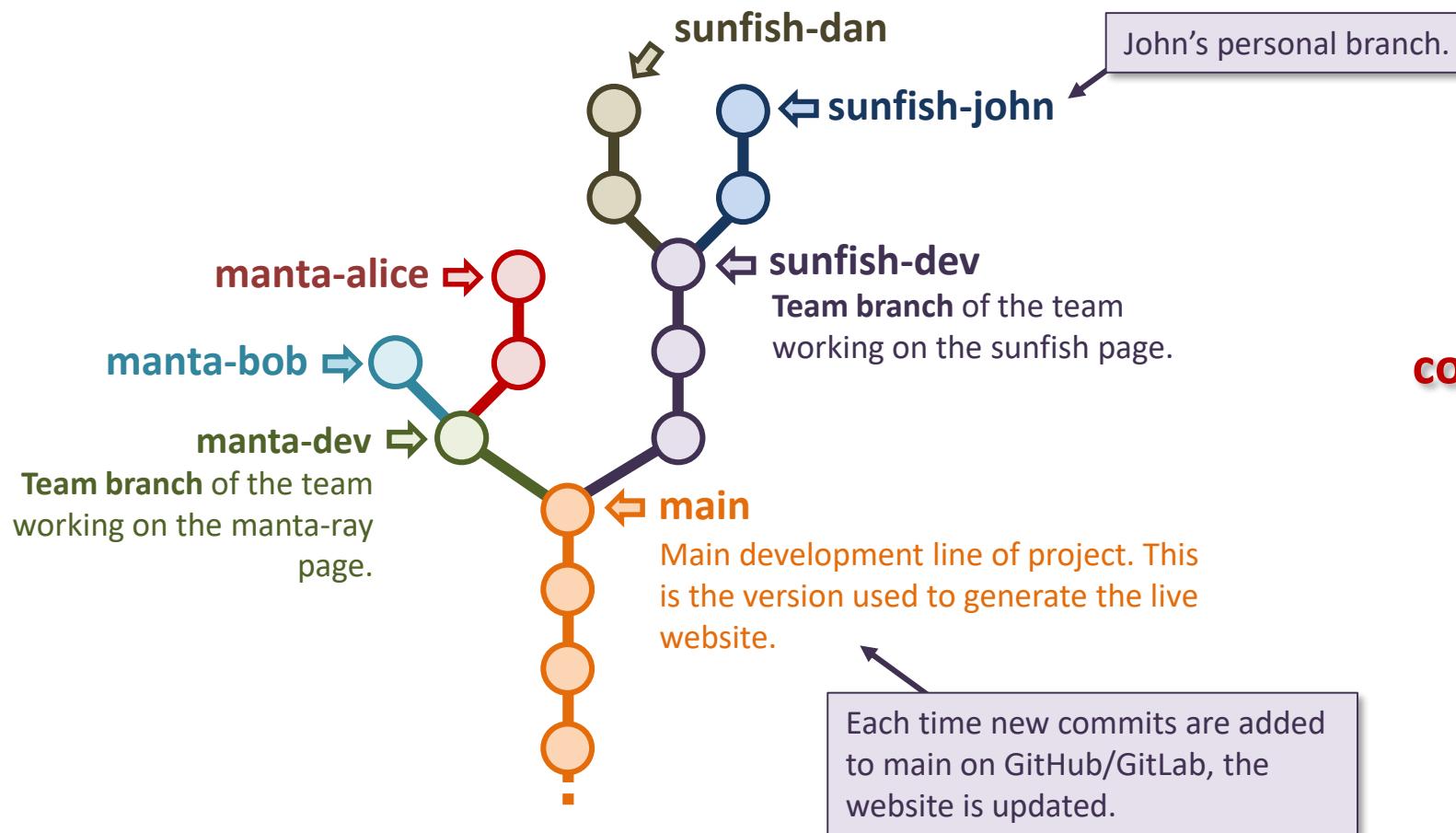
Behaviour
Swimming behavior in mantas differs across habitats: when travelling over deep water, they swim at a constant rate in a straight line, while further Mantas may travel alone or in groups up to 50. They may associate with other fish species, as well as sea birds and marine mammals. Mantas son

What I like about this animal

- It glides gracefully through the sea, like an aquatic bird.
- Unlike its shark relatives, it does not have sharp teeth.

An introduction to the upcoming exercise 4...

- This is how (more or less) our shared repository will look on GitHub/GitLab...
- Changes made to the **main** branch are directly reflected in the production website – so we don't want to mess-up **main** !!
- => You are **not allowed to push directly to main**.

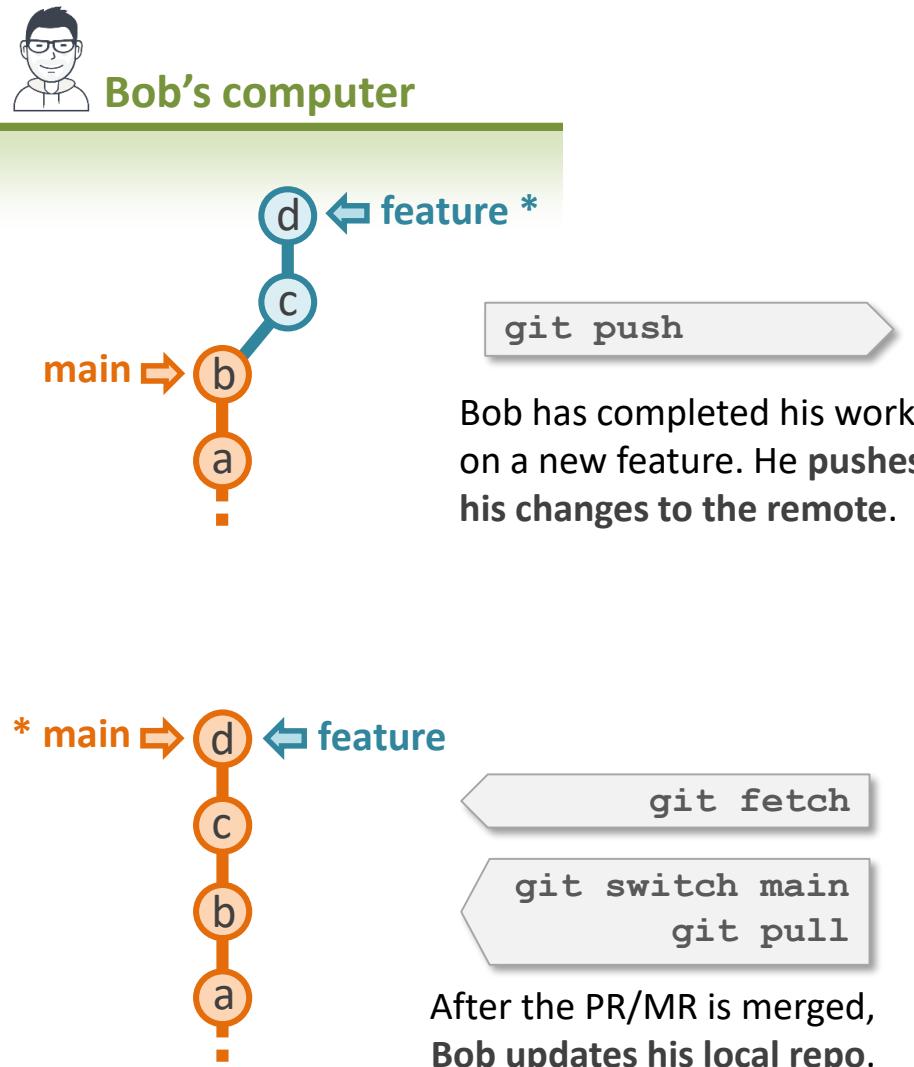


How are we going to contribute changes from our team branches ?

Pull Requests (GitHub) / Merge Requests (GitLab)

Pull Requests (PR) and Merge Requests (MR) are a way to perform a merge operation on the remote (on GitHub/GitLab) instead of in your local copy of the repository.

PR/MR are the same thing, they just have different names on GitHub/GitLab.



Why use a PR/MR instead of a local merge (and push) ?

- The branch you want to merge into (e.g. main) is **protected** *.
- Gives the opportunity to the repository owner(s) to **review changes** before merging them.
- Makes it easy to merge changes from a **forked** ** repository.

* **Protected** branches are branches where push operations are limited to users with enough privileges.

** A **fork** is a copy of an entire repository under a new ownership.

The PR/MR workflow:

- Bob opens a PR/MR on GitHub/GitLab.
- Alice reviews the changes made by Bob on branch **feature**.
- Alice approves the PR/MR.
- Bob (or Alice) merges the PR/MR.
- On the remote, the **feature** branch is now merged into **main**. Optionally, **feature** is then deleted.



After the PR/MR is merged, you can pull the changes from the remote to update your local repo (at this point the merge is only on the remote).

```
> git log --all --decorate --oneline --graph
* 9af6e4 (HEAD -> manta-dev, origin/manta-dev) manta-ray: add behavior information
* ba11531 manta-ray: add distribution and image
* 7b0516b manta-ray: add animal name and diet
* 65cb84f (origin/main, origin/HEAD, main) cicd: add .gitlab-ci.yml file
* 90c5dbe web: rename home page to Awesome Animal Awareness Project
* 4401bd7 web: add animal page templates
* 11a7390 styles: change paragraphs fonts
* 30b07cf styles: add styles.css file
* f1828a1 doc: add README.md
* 998ea08 first commit
```

```
> git log --all --decorate --oneline --graph
* 13c625f (origin/main, origin/HEAD) Merge branch 'manta-dev' into 'main'
|\ 
| * 9af6e4 (HEAD -> manta-dev) manta-ray: add behavior information
| * ba11531 manta-ray: add distribution and image
| * 7b0516b manta-ray: add animal name and diet
|/
* 65cb84f (main) cicd: add .gitlab-ci.yml file
* 90c5dbe web: rename home page to Awesome Animal Awareness Project
* 4401bd7 web: add animal page templates
* 11a7390 styles: change paragraphs fonts
```

```
> git log --all --decorate --oneline --graph
* 13c625f (HEAD -> main, origin/main, origin/HEAD) Merge branch 'manta-dev'
|\ 
| * 9af6e4 manta-ray: add behavior information
| * ba11531 manta-ray: add distribution and image
| * 7b0516b manta-ray: add animal name and diet
|/
* 65cb84f cicd: add .gitlab-ci.yml file
* 90c5dbe web: rename home page to Awesome Animal Awareness Project
* 4401bd7 web: add animal page templates
```

Using `git fetch` is optional, it's useful if you want to preview the position of `origin/main` before merging it into your local `main` with `git pull`.

`git fetch --prune`

--prune deletes local references to remote branches (`origin/manta-dev` has been deleted).

`git switch main`
`git pull --prune`
`git branch -d manta-dev`

`git switch main`
`git pull`
`git branch -d manta-dev`



How to open a Pull Request on GitHub: step-by-step

You will need to do this in exercise 4 !



1. On the project's page on GitHub, go to the **Pull requests** tab.

Pull requests tab

Label issues and pull requests for new contributors
Now, GitHub will help potential first-time contributors [discover issues](#) labeled with [good first issue](#). [Dismiss](#)

manta-dev had recent pushes 8 minutes ago [Compare & pull request](#)

Filters Labels 9 Milestones 0 New pull request

0 Open ✓ 25 Closed Author Label Projects Milestones Reviews Assignee Sort

Pending pull requests will be listed here...

There aren't any open pull requests.
You could search [all of GitHub](#) or try an [advanced search](#).

2. Click on **New pull request**.



3. Select the branches to merge:

The screenshot shows the GitHub interface for comparing branches. Two dropdown menus are highlighted with orange boxes and purple arrows pointing to them:

- base: master** (Branch to merge into)
- compare: manta-dev** (Branch to merge (your contribution))

Branch to merge into
Branch to merge (your contribution)

List of commits that will be merged ➡

In this example, there are 2 commits on branch "manta-dev" that will be merged into "master".

Summary of changes introduced by the pull request.

Green lines = new content.
Red lines = deleted content.

4. Click on **Create pull request**.

The screenshot shows the "Comparing changes" page on GitHub. At the top, it says "Able to merge. These branches can be automatically merged." A green arrow points from this text to the "Create pull request" button on the right. Below this, the commit history and file changes are listed.

Commits on Mar 10, 2022

- Add info on habitat and behavior for manta ray (sibgit committed 18 minutes ago)
- Add image for manta ray (sibgit committed 17 minutes ago)

Showing 2 changed files with 14 additions and 6 deletions.

```

 20 manta_ray.html
 ...
 4 4 <link rel="stylesheet" href="styles.css">
 5 5 </head>
 6 6 <body>
 7 - <h1>?? Animal name</h1>
 7 + <h1>Manta Ray - <i>Mobula sp.</i></h1>
 8 8
 9 - 
 9 + 
 10 10
 11 11 <h3>Habitat and distribution</h3>
 12 12 <p>
 13 - ?? Replace this with a few lines on the animal's habitat and distribution.
 13 + Mantas are found in tropical and subtropical waters in all the world's major oceans,
 14 + and also venture into temperate seas.
 15 + <br>
 16 + The furthest from the equator they have been recorded is North Carolina in the
 17 + United States, and the North Island of New Zealand.
 18 + <br>
 19 + They prefer water temperatures above 68 °F (20 °C)
 14 20 </p>

```

If there are conflicts, you probably need to rebase your branch and resolve them.



5. Optionally, enter ➔
a **message** for the
people that will
review your pull
request.

Open a pull request

Create a new pull request by comparing changes across two branches. If you need to, you can also [compare across forks](#).

base: master ▾ ← compare: manta-dev ▾ ✓ **Able to merge.** These branches can be automatically merged.

Manta dev

Write Preview

I worked hard to add these awesome changes to the manta ray page.
Please merge :smiley_cat:

Attach files by dragging & dropping, selecting or pasting them.

Create pull request ▾

Reviewers
sibgit

Assignees
No one—assign yourself

Labels
None yet

Projects
None yet

Milestone
No milestone

Development
Use [Closing keywords](#) in the description to automatically close issues

Remember, contributions to this repository should follow our [GitHub Community Guidelines](#).

6. Submit your pull request by clicking
Create pull request.

The pull request is now **created**, and **awaiting approval** from an authorized person.
(e.g. the repo owner or a colleague)

The screenshot shows a GitHub pull request page for a repository named 'Manta dev'. The pull request has been opened by 'robinengler' to merge two commits from the 'manta-dev' branch into the 'master' branch. The commit history shows two commits from 'sibgit': one adding info on habitat and behavior for manta ray (commit d0a01b1) and another adding an image for manta ray (commit 0677d8c). A comment from 'robinengler' encourages merging with a smiley face emoji. The status bar at the bottom indicates that merging is blocked because a review is required.

Manta dev #27

Open robinengler wants to merge 2 commits into master from manta-dev

Conversation 0 Commits 2 Checks 0 Files changed 2

robinengler commented now

I worked hard to add these awesome changes to the manta ray page.
Please merge 😊

sibgit added 2 commits 31 minutes ago

Add info on habitat and behavior for manta ray
Add image for manta ray

d0a01b1
0677d8c

Add more commits by pushing to the manta-dev branch on sibgit/sibgit.github.io.

This branch has not been deployed
No deployments

Review required
At least 1 approving review is required by reviewers with write access. [Learn more](#).

Merging is blocked
Merging can be performed automatically with 1 approving review.

Merge pull request or view command line instructions.

The **reviewer** of your PR will then have a look at your changes (the modifications introduced with your commits) and **approve them or request changes**.

The screenshot illustrates the GitHub pull request review process:

- Top Bar:** Shows the GitHub logo, search bar, and navigation links: Pull requests, Issues, Marketplace, Explore.
- Pull Requests List:** Shows 1 open and 26 closed pull requests. One open pull request, #27 titled "Manta dev", is highlighted with a purple dashed box and a purple arrow pointing from the main list to its detailed view.
- Detailed View of Pull Request #27:**
 - Header:** Shows the pull request is open and was created by **robinengler** 2 minutes ago, requiring review.
 - Comments:** A comment from **robinengler** says: "I worked hard to add these awesome changes to the manta ray page. Please merge 😊".
 - Commits:** Shows two commits from **sibgit**:
 - Add info on habitat and behavior for manta ray (commit d0a01b1)
 - Add image for manta ray (commit 0677d8c)
 - Deployment Status:** States "This branch has not been deployed" with "No deployments".
 - Review Requirements:** Shows "Review required" (At least 1 approving review is required by reviewers with write access) and "Merging is blocked" (Merging can be performed automatically with 1 approving review).
 - Action Buttons:** Includes "Merge pull request" and "or view command line instructions".
- Review Modal:** A modal window titled "Finish your review" with "Review changes" button. It contains a "Write" tab with the message "Looking good, thanks for the contribution !", a rich text editor toolbar, and a "Comment" section with options:
 - Comment**: Submit general feedback without explicit approval.
 - Approve**: Submit feedback and approve merging these changes.
 - Request changes**: Submit feedback that must be addressed before merging.A "Submit review" button is at the bottom.

Manta dev #27

[Open](#) robinengler wants to merge 2 commits into `master` from `manta-dev`

Conversation 1 Commits 2 Checks 0 Files changed 2

robinengler commented 7 minutes ago
I worked hard to add these awesome changes to the manta ray page.
Please merge 😊

sibgit added 2 commits 38 minutes ago

- Add info on habitat and behavior for manta ray d0a01b1
- Add image for manta ray 0677d8c

sibgit approved these changes 1 minute ago

sibgit left a comment
Looking good, thanks for the contribution !

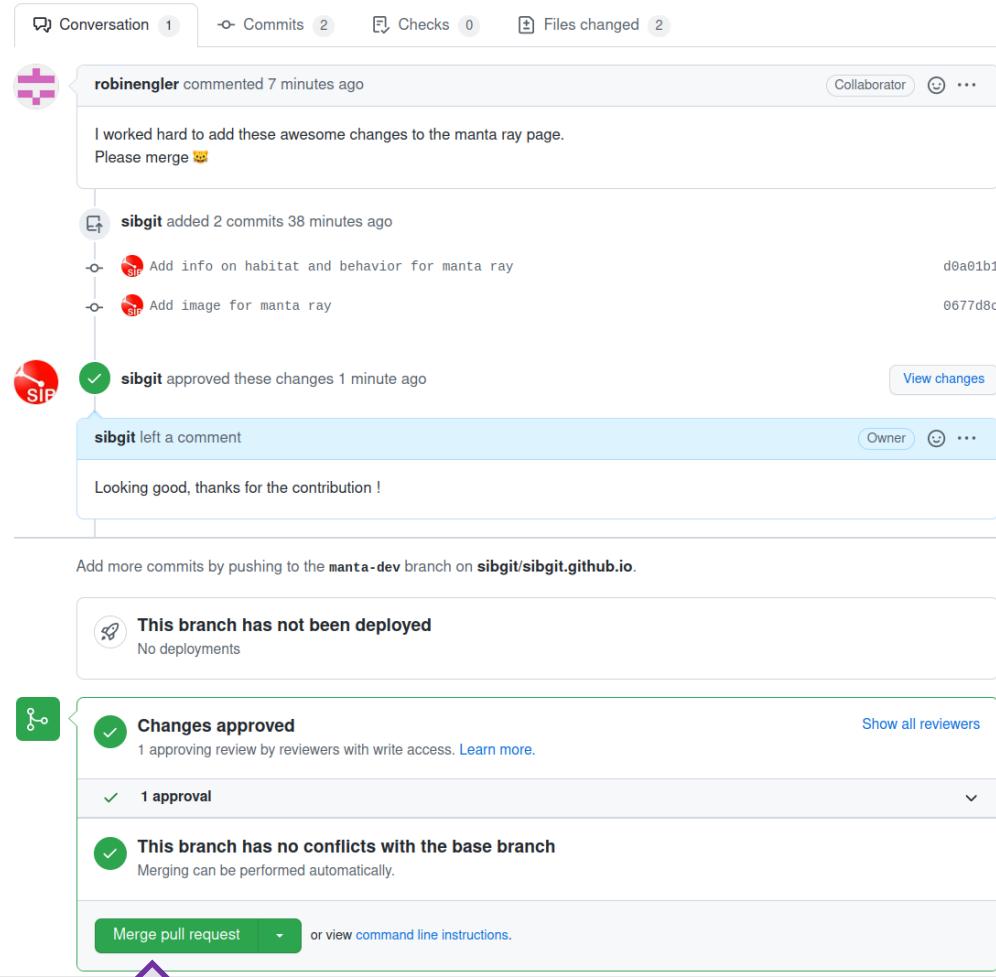
Add more commits by pushing to the `manta-dev` branch on sibgit/sibgit.github.io.

This branch has not been deployed
No deployments

Changes approved
1 approving review by reviewers with write access. [Learn more](#).
1 approval

This branch has no conflicts with the base branch
Merging can be performed automatically.

[Merge pull request](#) or view [command line instructions](#).



Now that the pull request is approved, it can be merged (either by the reviewer or by you) by clicking **Merge pull request**.

Manta dev #27

[Open](#) robinengler wants to merge 2 commits into `master` from `manta-dev`

Conversation 1 Commits 2 Checks 0 Files changed 2

robinengler commented 9 minutes ago
I worked hard to add these awesome changes to the manta ray page.
Please merge 😊

sibgit added 2 commits 40 minutes ago

- Add info on habitat and behavior for manta ray d0a01b1
- Add image for manta ray 0677d8c

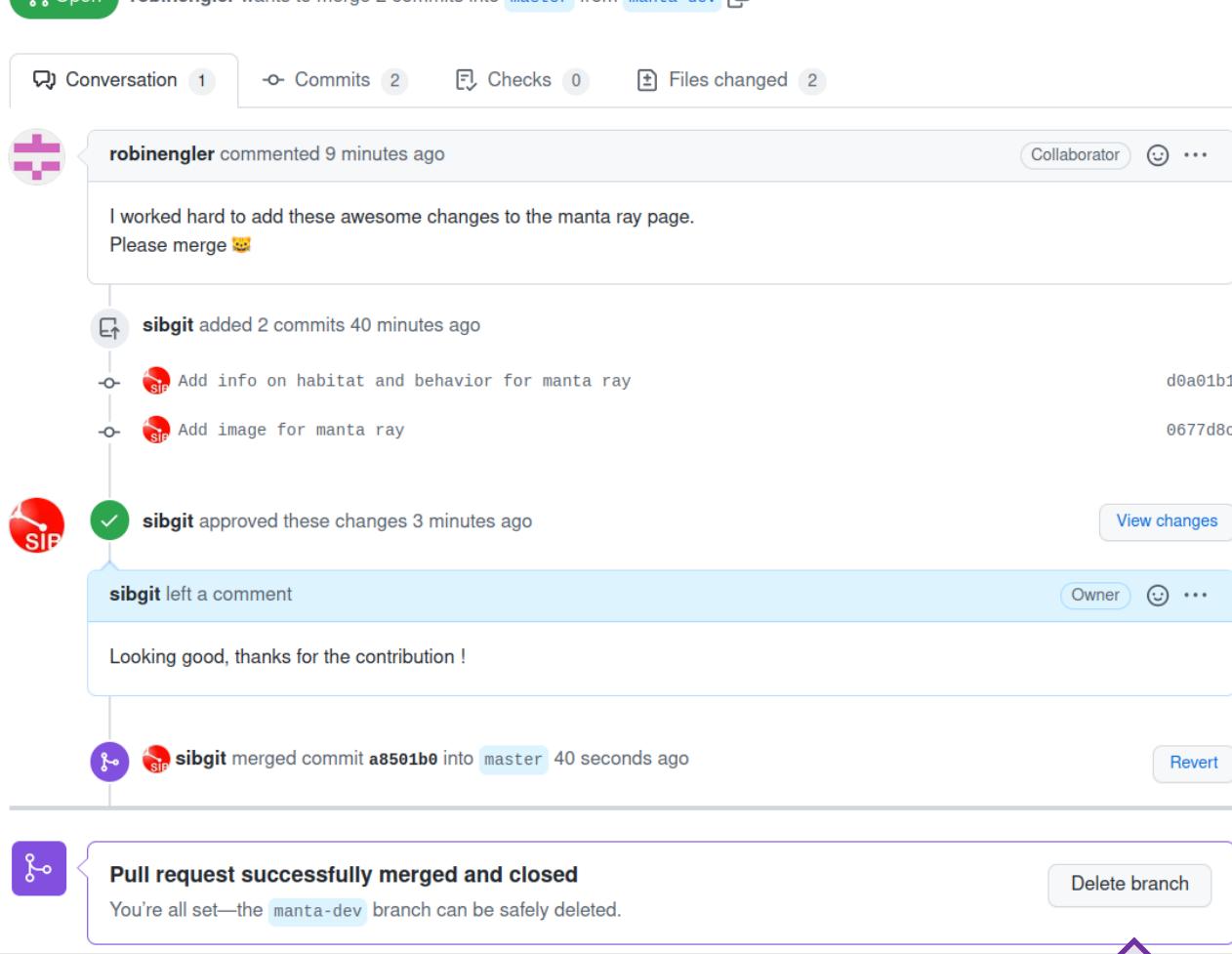
sibgit approved these changes 3 minutes ago

sibgit left a comment
Looking good, thanks for the contribution !

sibgit merged commit `a8501b0` into `master` 40 seconds ago

Pull request successfully merged and closed
You're all set—the `manta-dev` branch can be safely deleted.

Delete branch



Completed ! Optionally, you can **delete your branch** on the remote (this will not delete it locally).



How to open a Pull Request on GitLab: step-by-step

You will need to do this in exercise 4 !



1. On the project's page on GitLab, use the left-hand side menu to navigate to **Code > Merge requests**.
2. Click on **New merge request**, or on **Create merge request** if your branch is already listed (as is the case with “manta-dev” in the example).

The screenshot shows the GitLab interface for creating a merge request. It consists of three main parts:

- Left Panel (Project Navigation):** Shows the project "awesome-animal-awareness" and the "Merge requests" section is highlighted.
- Middle Panel (Merge Requests List):** Shows a single merge request titled "Manta dev" with status "Merged" and "Approved". A red arrow points to the "New merge request" button at the top right of the list.
- Right Panel (Merge Requests Details):** Shows the "Create merge request" button highlighted with a red dashed oval. A red arrow points from the "New merge request" button in the middle panel to this button. Below it is a circular icon with two nodes connected by arrows, and a descriptive text block.

Merge requests are a place to propose changes you've made to a project and discuss those changes with others

Interested parties can even contribute by pushing commits if they want to.

3. On the next screen, select the branch to merge (in exercise 4, this is your team branch branch) as **Source branch**, and “main” as **Target branch**.

Then click on **Compare branches and continue**.

Note: if you have clicked on **Create merge request** at step 2, this step will be skipped as the correct target and source branches will be automatically selected for you by GitLab.

The screenshot shows the "New merge request" form with several red arrows highlighting specific fields and buttons:

- Source branch:** A dropdown menu showing "sib-git-training/awesome-animal-aw..." and "manta-dev". A red arrow points to the "manta-dev" option.
- Target branch:** A dropdown menu showing "sib-git-training/awesome-animal-aw..." and "main". A red arrow points to the "main" option.
- Compare branches and continue:** A blue button at the bottom of the form. A red arrow points to this button.



New merge request

From manta-dev into main [Change branches](#)

Title (required)

Manta dev

Mark as draft

Drafts cannot be merged until marked ready.

Description

Preview | **B** *I* ~~S~~ ~~L~~ ~~C~~ ~~P~~ ~~U~~ ~~R~~ ~~T~~ ~~E~~ ~~N~~ ~~M~~ ~~H~~ ~~G~~ ~~W~~ ~~Y~~ ~~Z~~

Please merge my changes for the manta ray into main.

[Switch to rich text editing](#)

Add [description templates](#) to help your contributors to communicate effectively!

Assignee

[Assign to me](#)

Reviewer

Approvals are optional.

[Approval rules](#)

Milestone

Labels

Merge options

Delete source branch when merge request is accepted.

Squash commits when merge request is accepted. [?](#)

4. Give a **Title** to your merge request (MR). A default Title will be pre-set. Optionally you can enter a description.



5. At the bottom of the page, you can see the commits that are part of the MR (in this example, there are 3 commits).

Create merge request [Cancel](#)

Commits 3 Changes 3 [Jan 30, 2024](#)

- manta-ray: add behavior information
Robin Engler authored 22 minutes ago
- manta-ray: add distribution and image
Robin Engler authored 25 minutes ago
- manta-ray: add animal name and diet
Robin Engler authored 2 hours ago



6. Click on **Create merge request** to create the MR.



The pull request is now **created**, and awaiting approval from an authorized person (e.g. the repo owner or a colleague).

Manta dev

Open Robin Engler requested to merge `manta-dev` into `main` 2 minutes ago

Overview 0 Commits 3 Pipelines 0 Changes 3

Please merge my changes for the manta ray into main.

0 0

8✓ Approve Approval is optional

Ready to merge!

Delete source branch Edit commit message
3 commits and 1 merge commit will be added to main.

Merge

Activity

Preview |

Write a comment or drag your files here...

Switch to rich text editing

Make this an internal note

Comment **Close merge request**

SIB Git training / awesome-animal-awareness / Merge requests / !1

Open Manta dev `manta-dev` into `main`

Overview 0 Commits 3 Pipelines 0 Changes 2

Search (e.g. *.vue) (Ctrl+P)

img

- `img_manta.jpg` +0 -0
- `manta_ray.html` +32 -6

manta_ray.html

4	4	00	-4,28 +4,54 @0
5	5		<link rel="stylesheet" href="styles.css">
6	6		</head>
7	-		<h1>?? Animal name</h1>
8	+		<h1>Manta ray (Mobula sp.)</h1>
9	-		
10	+		
11	11		<h3>Habitat and distribution</h3>
12	12		<p>
13	-		?? Replace this with a few lines on the animal's habitat and distribution.
14	+		Mantas are found in tropical and subtropical waters in all the world's major oceans, and also venture into temperate seas.
15	+		
16	+		The furthest from the equator they have been recorded is North Carolina in the United States (31°N) and the North Island of New Zealand (36°S).
17	+		
18	+		They prefer water temperatures above 20 °C and M. alfredi is predominantly found in tropical areas. Both species are pelagic.
19	+		M. birostris lives mostly in the open ocean, travelling with the currents and migrating to areas where upwellings of nutrient-rich water increase prey concentrations.
20	+		
21	+		
22	+		
23	+		
24			</p>

The **reviewer** of your PR will then have a look at your changes (the modifications introduced with your commits) and **approve them or request changes**.



When the merge request is **approved**, it can be merged by clicking on **Merge**.

Manta dev

Open Robin Engler requested to merge [manta-dev](#) into [main](#) 7 minutes ago

Overview 0 Commits 3 Pipelines 0 Changes 2

Please merge my changes for the manta ray into main.

0 0

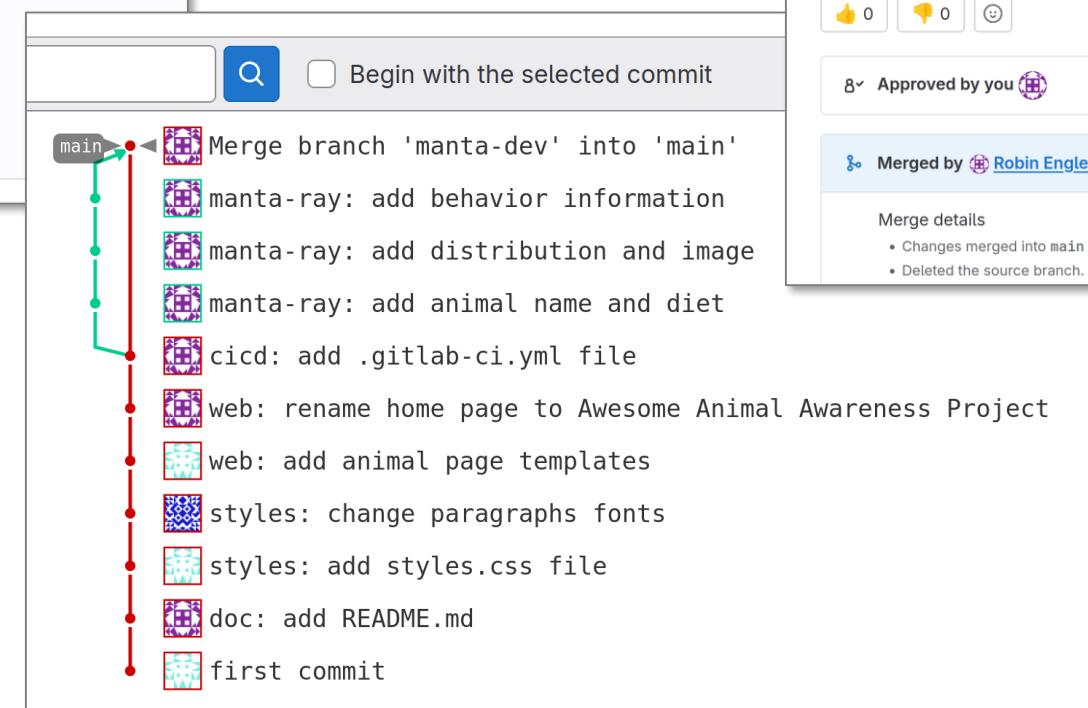
8✓ Revoke approval Approved by you

Ready to merge!

Delete source branch Edit commit message

3 commits and 1 merge commit will be added to main.

Merge



Manta dev

Merged Robin Engler requested to merge [manta-dev](#) into [main](#) 7 minutes ago

Overview 0 Commits 3 Pipelines 0 Changes 2

Please merge my changes for the manta ray into main.

0 0

8✓ Approved by you

Merged by [Robin Engler](#) just now

Merge details

- Changes merged into main with [13c625fe](#).
- Deleted the source branch.

Done! The MR is now merged, the changes from the branch are now part of the “main” branch of the repository.

Personal Access Tokens (PAT)

on GitHub or GitLab

Personal access tokens (PAT) on GitHub/GitLab

Pushing data to a remote requires **some form of authentication...**
... otherwise anyone could push anything to your remotes!

For security reasons, GitHub does not allow using your user name and password for authentication when running a git push command. Instead you need to use a **personal access token (PAT)**.

In **exercise 4** you will need a PAT to push commits to GitHub/GitLab *.

Let's generate a PAT together now...

* Alternatively, you can also authenticate to GitHub/GitLab using SSH keys. If your account is already setup to use SSH keys, then you don't need a PAT.

Select scopes

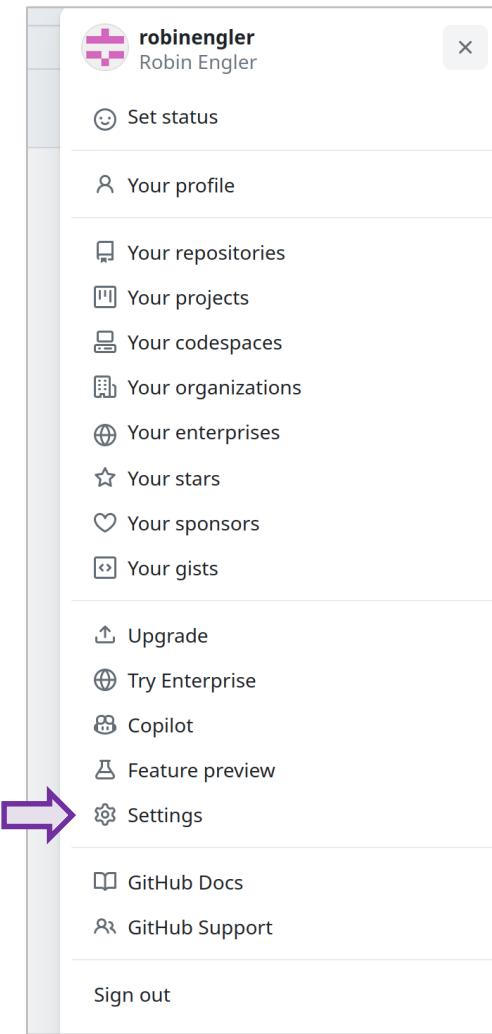
Scopes define the access for personal tokens. [Read more about OAuth scopes.](#)

<input checked="" type="checkbox"/> repo	Full control of private repositories
<input type="checkbox"/> <code>repo:status</code>	Access commit status
<input type="checkbox"/> <code>repo_deployment</code>	Access deployment status
<input type="checkbox"/> <code>public_repo</code>	Access public repositories
<input type="checkbox"/> <code>repo:invite</code>	Access repository invitations
<input type="checkbox"/> <code>security_events</code>	Read and write security events
<input type="checkbox"/> workflow	Update GitHub Action workflows
<input type="checkbox"/> write:packages	Upload packages to GitHub Package Registry
<input type="checkbox"/> <code>read:packages</code>	Download packages from GitHub Package Registry
<input type="checkbox"/> delete:packages	Delete packages from GitHub Package Registry
<input type="checkbox"/> admin:org	Full control of orgs and teams, read and write org projects
<input type="checkbox"/> <code>write:org</code>	Read and write org and team membership, read and write org projects
<input type="checkbox"/> <code>read:org</code>	Read org and team membership, read org projects
<input type="checkbox"/> <code>manage_runners:org</code>	Manage org runners and runner groups
<input type="checkbox"/> admin:public_key	Full control of user public keys
<input type="checkbox"/> <code>write:public_key</code>	Write user public keys
<input type="checkbox"/> <code>read:public_key</code>	Read user public keys
<input type="checkbox"/> admin:repo_hook	Full control of repository hooks
<input type="checkbox"/> <code>write:repo_hook</code>	Write repository hooks
<input type="checkbox"/> <code>read:repo_hook</code>	Read repository hooks
<input type="checkbox"/> admin:org_hook	Full control of organization hooks
<input type="checkbox"/> gist	Create gists
<input type="checkbox"/> notifications	Access notifications
<input type="checkbox"/> user	Update ALL user data
<input type="checkbox"/> <code>read:user</code>	Read ALL user profile data
<input type="checkbox"/> <code>user:email</code>	Access user email addresses (read-only)
<input type="checkbox"/> <code>user:follow</code>	Follow and unfollow users
<input type="checkbox"/> delete_repo	Delete repositories
<input type="checkbox"/> write:discussion	Read and write team discussions
<input type="checkbox"/> <code>read:discussion</code>	Read team discussions
<input type="checkbox"/> admin:enterprise	Full control of enterprises
<input type="checkbox"/> <code>manage_runners:enterprise</code>	Manage enterprise runners and runner groups
<input type="checkbox"/> <code>manage_billing:enterprise</code>	Read and write enterprise billing data
<input type="checkbox"/> <code>read:enterprise</code>	Read enterprise profile data

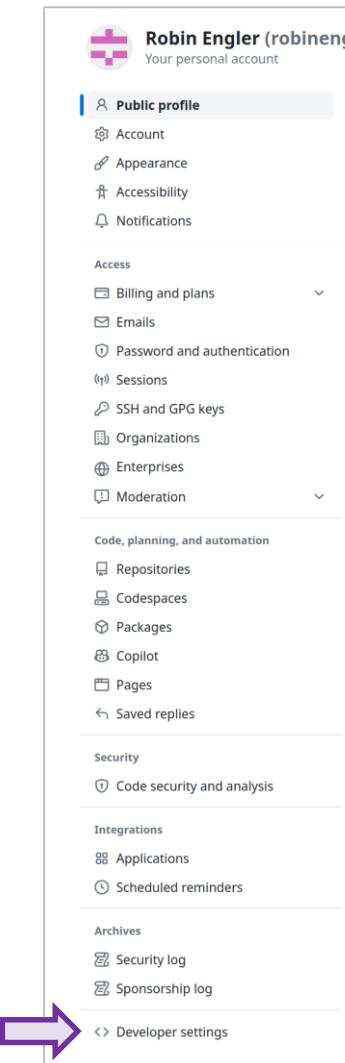
Generating a “personal access token” (PAT) on GitHub

In order to push data (commits) to GitHub, you will need a **personal access token (PAT)**.

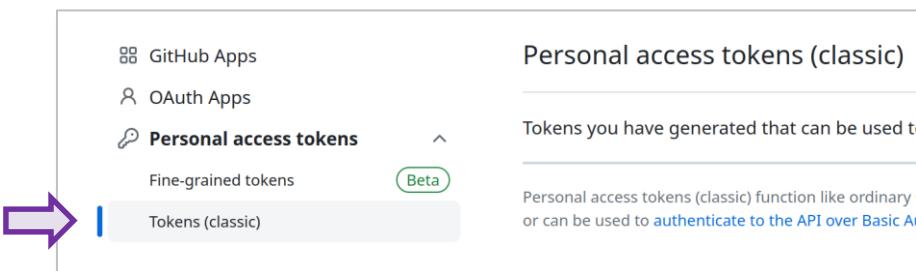
1. In your user profile (top right), click on **Settings**.



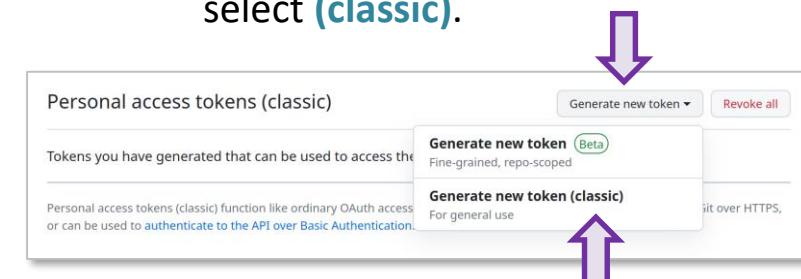
2. In your Account settings, click on **Developer settings** (at the very bottom of the list)



3. In **Developer settings**, click on **Personal access tokens**, and select **Tokens (classic)**.



4. Click on **Generate new token**, and select **(classic)**.



Go to next page 

5. Add a **Note** (description) to your token and select the **repo** scope checkbox. Then click **Generate token**.

New personal access token (classic)

Personal access tokens (classic) function like ordinary OAuth access tokens. They can be used instead of a password for Git over HTTPS, or can be used to [authenticate to the API over Basic Authentication](#).

Note

Repo access token

What's this token for?

Expiration *

30 days The token will expire on Thu, Nov 2 2023

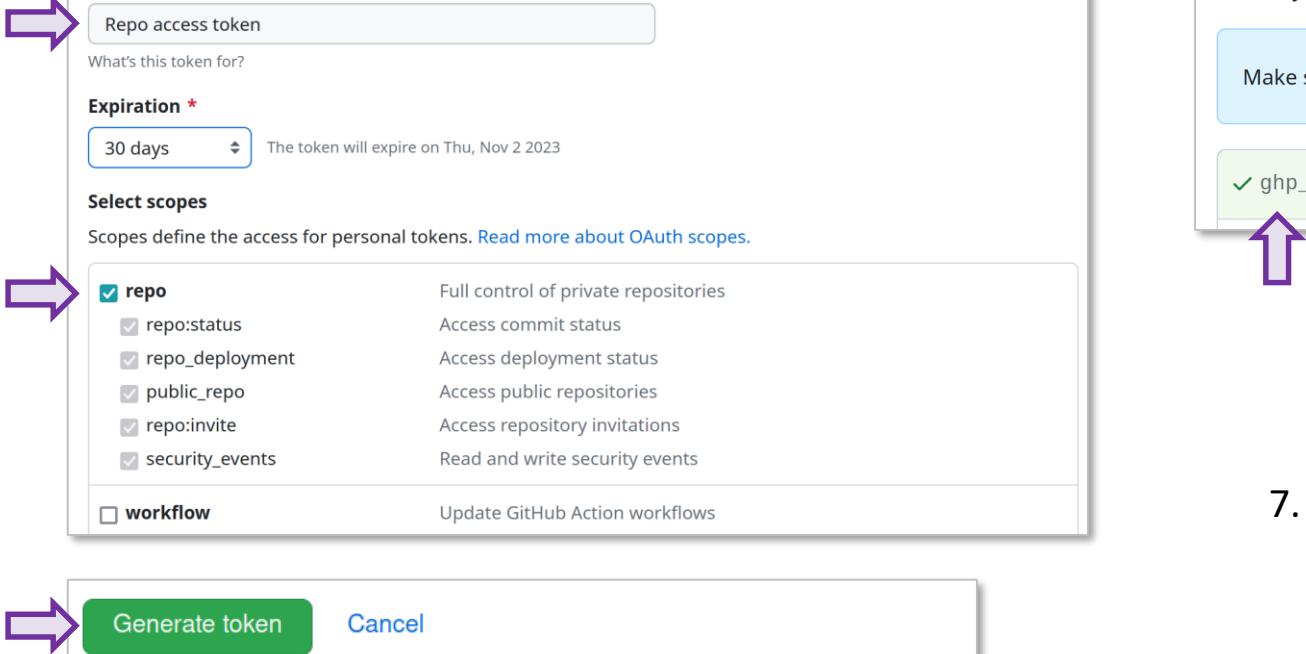
Select scopes

Scopes define the access for personal tokens. [Read more about OAuth scopes](#).

repo Full control of private repositories
 repo:status Access commit status
 repo_deployment Access deployment status
 public_repo Access public repositories
 repo:invite Access repository invitations
 security_events Read and write security events

workflow Update GitHub Action workflows

Generate token Cancel



6. **Copy the personal access token** to a safe locations (ideally in a password manager). You will not be able to access it again later.

Personal access tokens (classic)

Generate new token ▾ Revoke all

Tokens you have generated that can be used to access the [GitHub API](#).

Make sure to copy your personal access token now. You won't be able to see it again!

✓ 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 

Delete



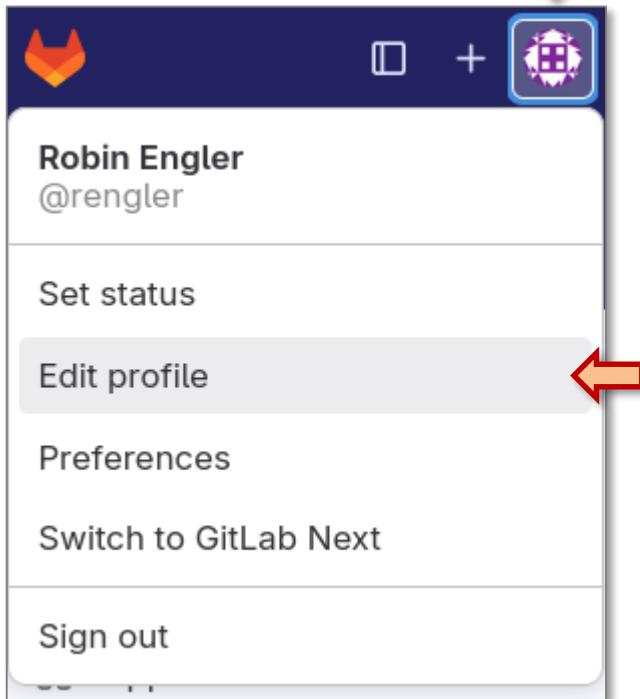
7. When you will push content to GitHub for the first time in the project, you will be asked for your user name and password. **Instead of the password**, enter the **personal access token** you just created.



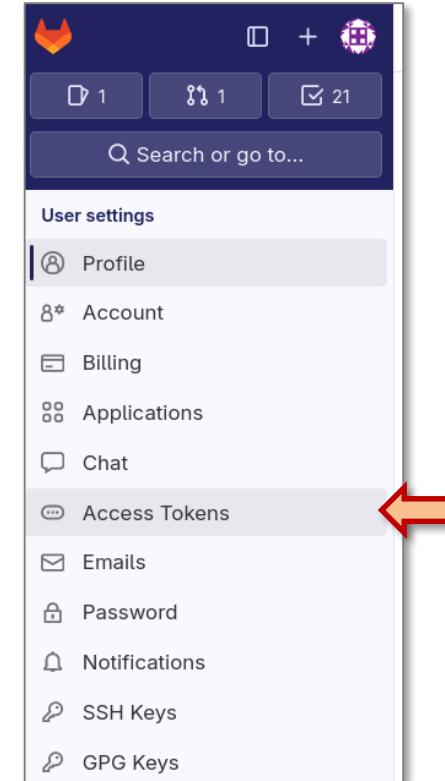
Generating a “personal access token” (PAT) on GitLab

In order to push data (commits) to GitLab, you will need a **personal access token (PAT)**.

1. Click on your user icon (top left), and select **Edit profile**.



2. In your User settings menu (on the left side), click on **Access Tokens**.



3. On the Personal Access Tokens page, click on **Add new token**.

A screenshot of the Personal Access Tokens page. The page title is "Personal Access Tokens". It states: "You can generate a personal access token for each application you use that needs access to the GitLab API. You can also use personal access tokens to authenticate against Git over HTTP. They are the only accepted password when you have Two-Factor Authentication (2FA) enabled." Below this is a table titled "Active personal access tokens" with two entries. At the bottom right of the table is a button labeled "Add new token" with a red arrow pointing to it.

Token name	Scopes	Created	Last Used	Expires	Action
GitLab container registry read-write	read_registry, write_registry	Mar 27, 2023	10 months ago	in 3 months	
GitLab repo access token	read_repository, write_repository	Oct 08, 2023	3 months ago	in 8 months	



4. Give a **Token name** to your token. You can leave the **Expiration date** empty, so your token will be valid for 1 year.

5. Select **read_repository** and **write_repository** as scopes.

6. Click **Generate personal access token**.

Personal Access Tokens

Active personal access tokens 2

Add a personal access token

Token name
GitLab repo read/write access

For example, the application using the token or the purpose of the token.

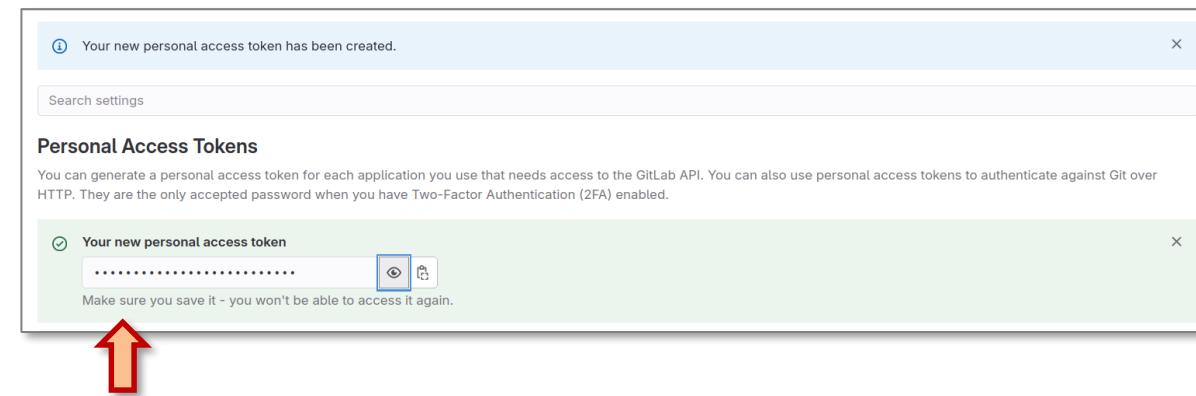
Expiration date
YYYY-MM-DD

Select scopes
Scopes set the permission levels granted to the token. [Learn more.](#)

- api**
Grants complete read/write access to the API, including all groups and projects, the container registry, the dependency registry, and the package registry.
- read_api**
Grants read access to the API, including all groups and projects, the container registry, and the package registry.
- read_user**
Grants read-only access to the authenticated user's profile through the /user API endpoint, which includes user API endpoints under /users.
- create_runner**
Grants create access to the runners.
- k8s_proxy**
Grants permission to perform Kubernetes API calls using the agent for Kubernetes.
- read_repository**
Grants read-only access to repositories on private projects using Git-over-HTTP or the Repository Files API.
- write_repository**
Grants read-write access to repositories on private projects using Git-over-HTTP (not using the API).
- read_registry**
Grants read-only access to container registry images on private projects.
- write_registry**
Grants write access to container registry images on private projects.
- ai_features**
Grants access to GitLab Duo related API endpoints.

Create personal access token **Cancel**

7. Copy the personal access token to a safe locations (ideally in a password manager). You will **not be able to access it again** later.



8. When you will push content to GitLab for the first time in the project, you will be asked for your user name and password. Instead of the password, enter the **personal access token** you just created.

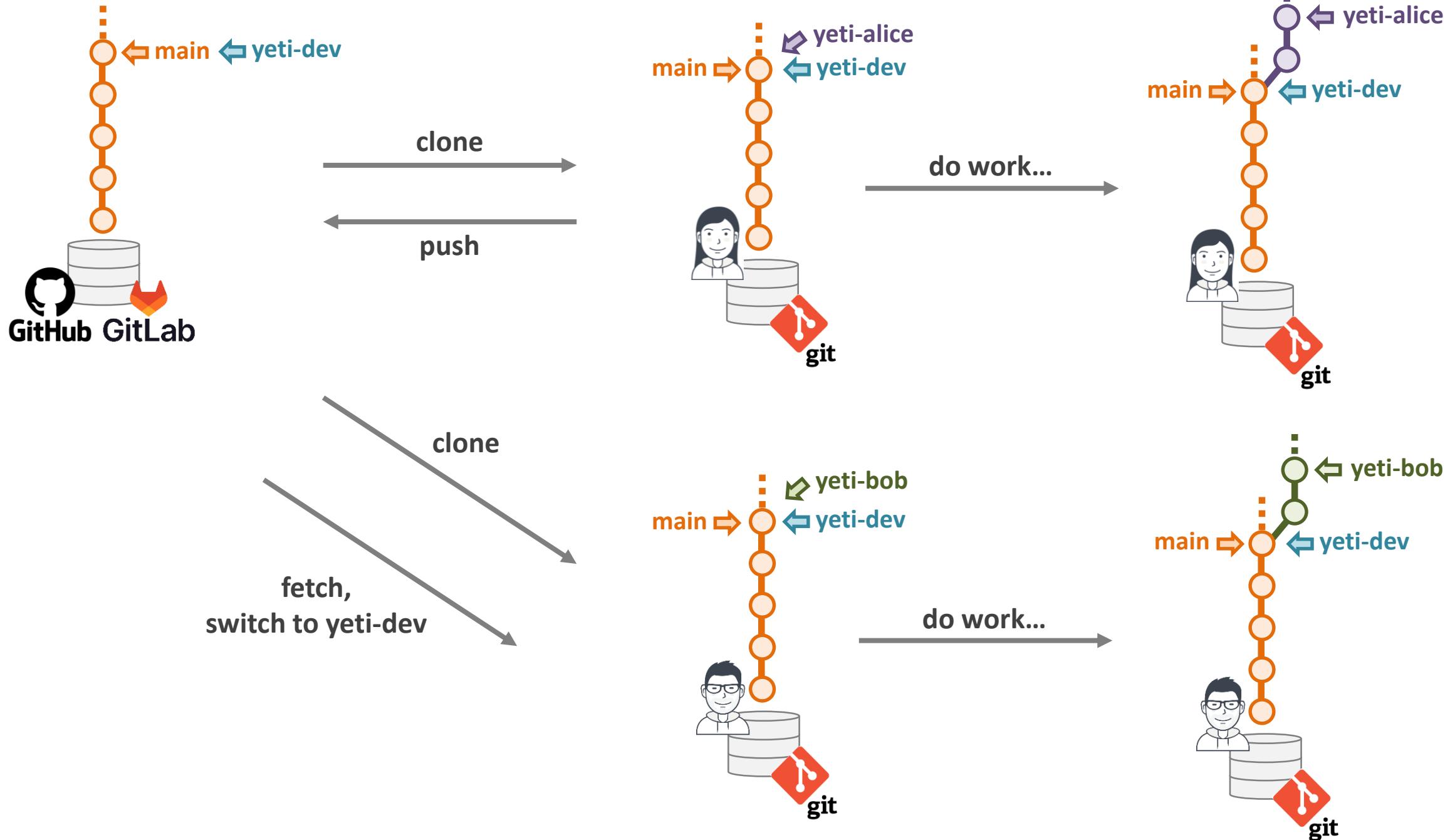
exercise 4

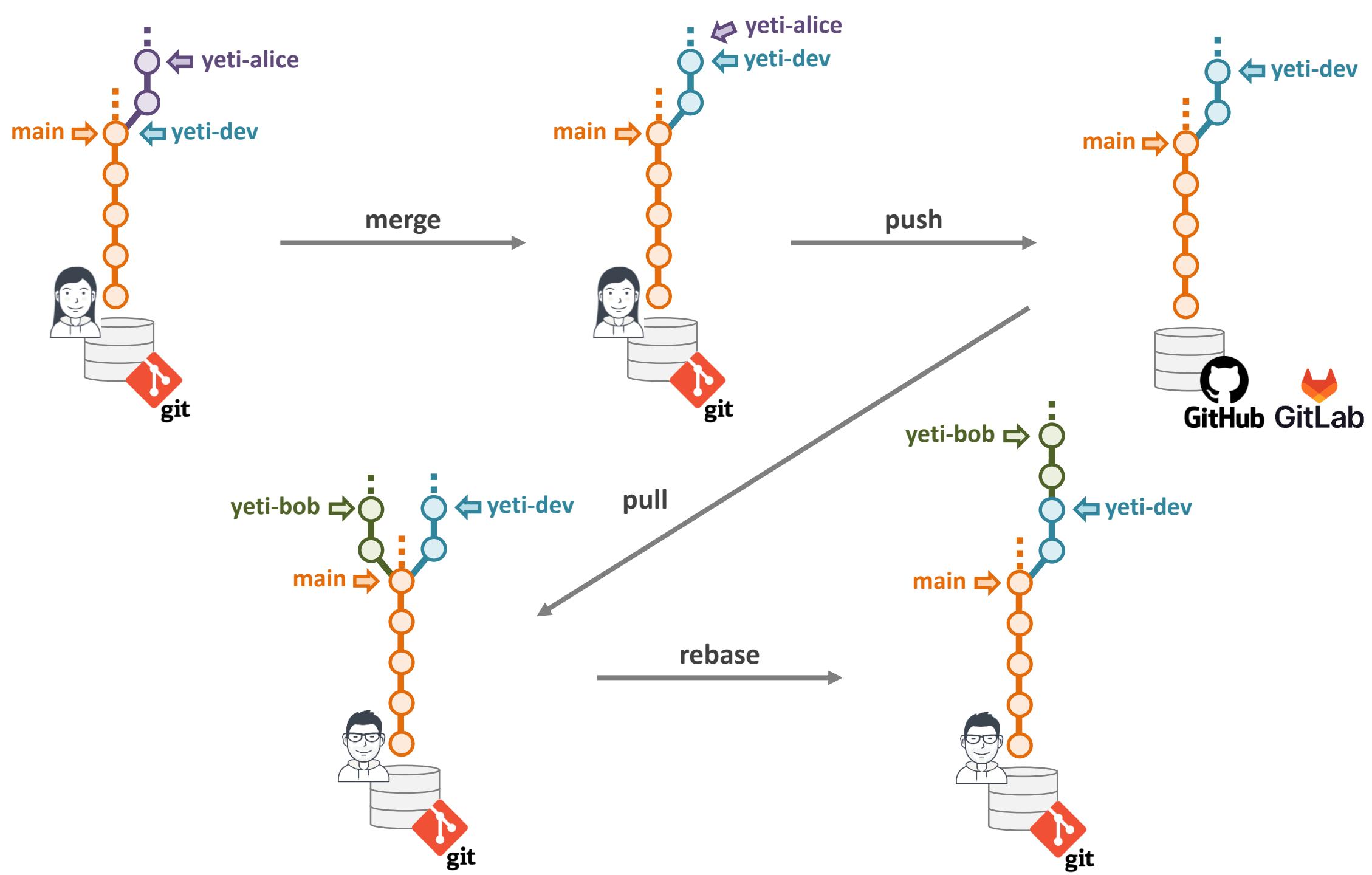
The Awesome Animal Awareness Project

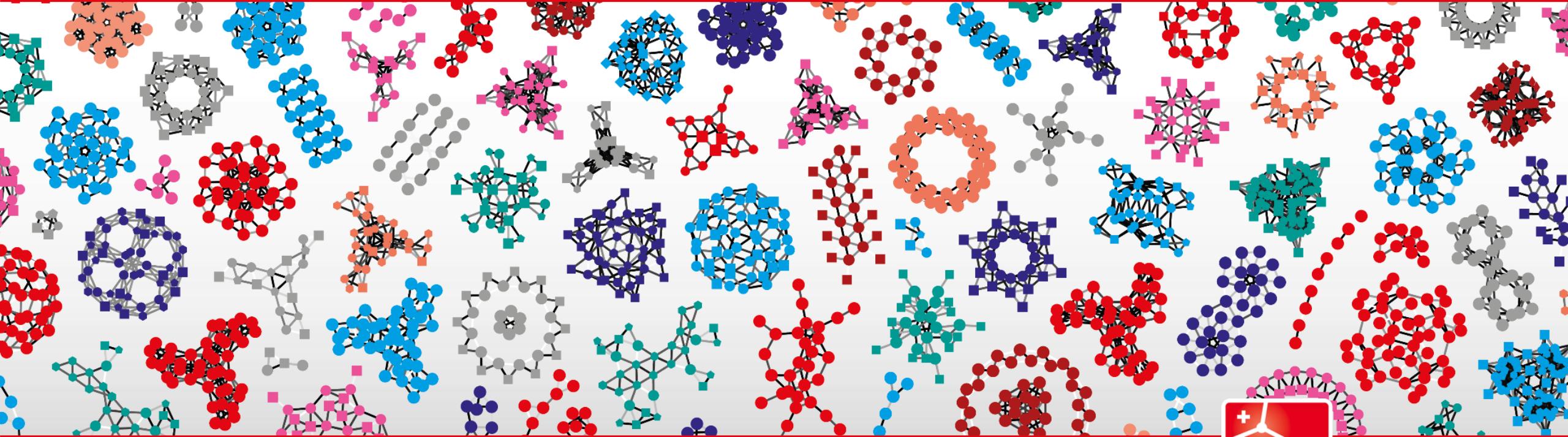


This exercise has helper slides

Exercise 4 help: branch – rebase – merge sequence







SIB

Swiss Institute of
Bioinformatics

Thank you for attending this course