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Bioinformatics

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Version control with Git - first steps

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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 (available at end of day), command summary (cheat sheet), feedback.

Google doc: register for collaborative exercises (and optionally for exam), FAQ, ask questions.

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

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, ...), and 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.

Course slides

- 3 categories of slides:



Slide covered in detail during the course.



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.



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

Learning objective



source: <https://xkcd.com/1597>

version control

a brief introduction

Why use version control ?

Version control systems (VCS), often 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.
 - Team and product management tool (e.g. issue tracking, continuous integration).

A (very brief) history of Git

- Created 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).
- **First release in 2005** - in a self-hosting Git repository... of course :-).

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 "lines of development" (a.k.a. branches) 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.

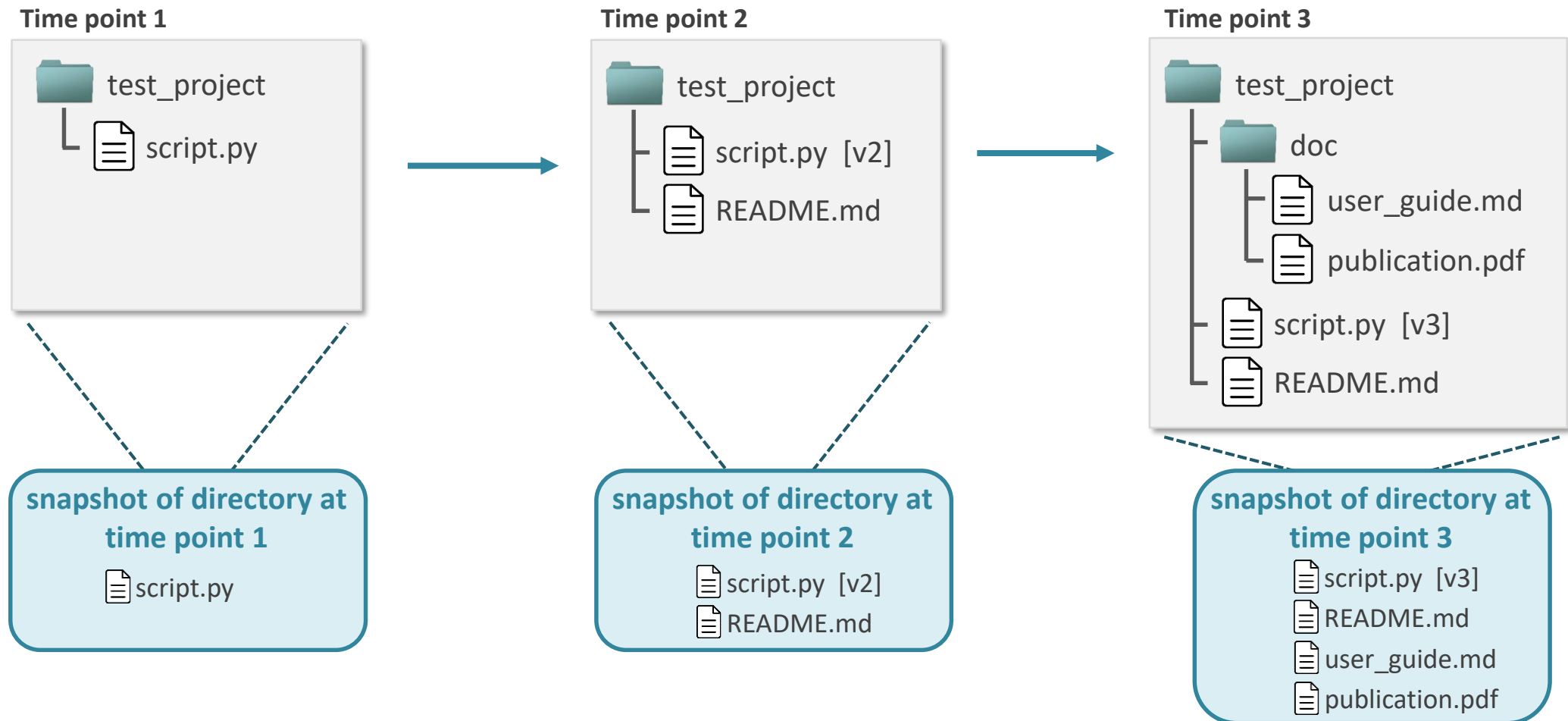
Git basics

Working principle and definitions

Basic principle of Git (and VCS in general)

Our objective: version control the content of a directory on our **local** machine. For this we:

- Take **snapshots** (current content of files) **at user defined time points**.
- Keep track of **the order of snapshots** so their history can be recreated.

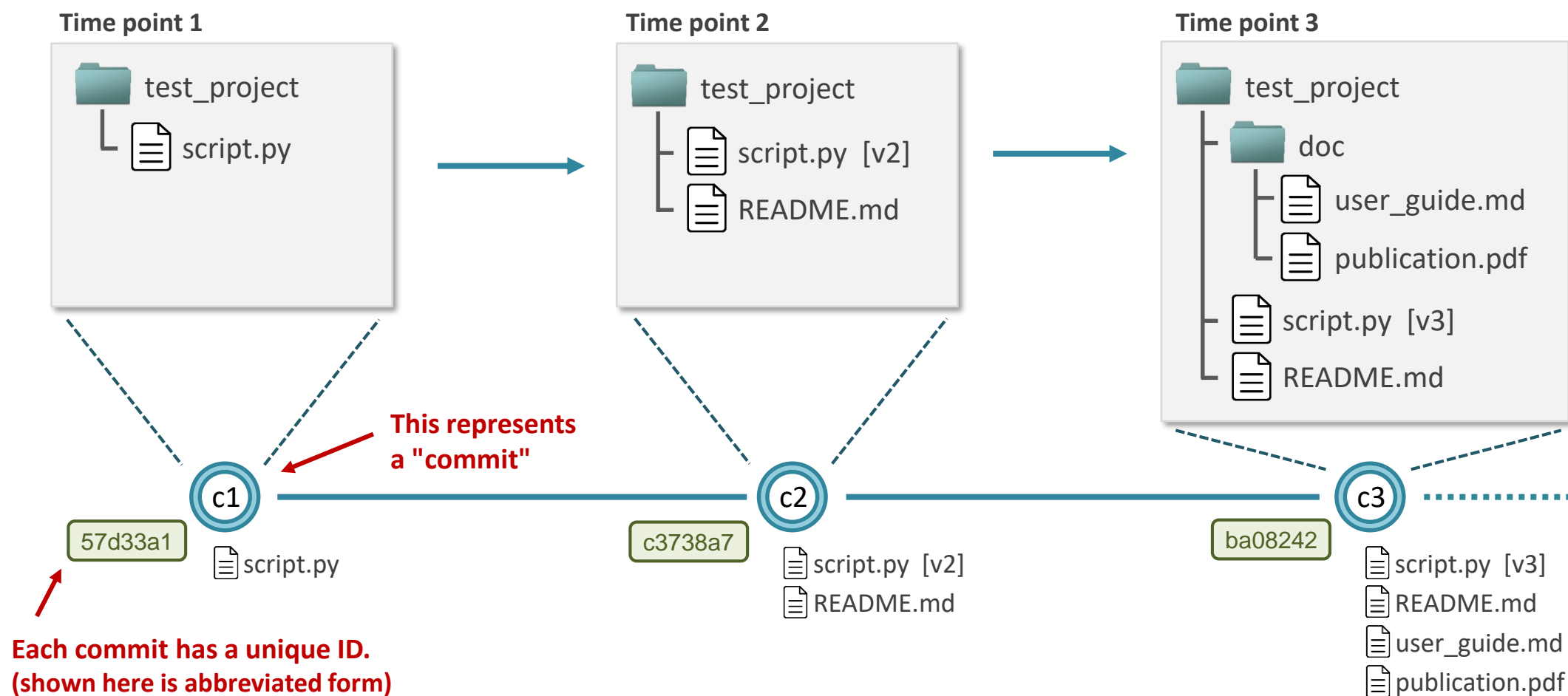


Definitions – snapshots are called “commits”

- **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):

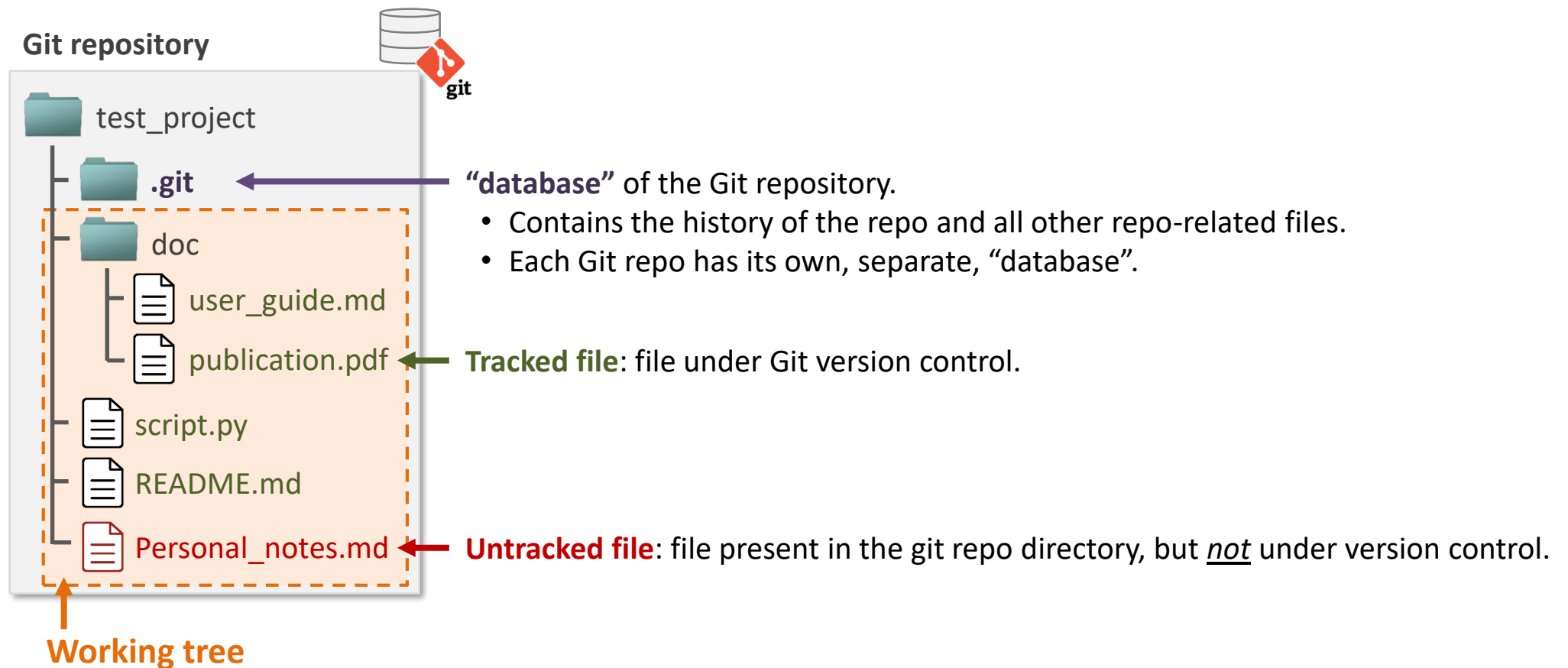
commit ID

3c1bb0cd5d67dddc02fae50bf56d3a3a4cbc7204



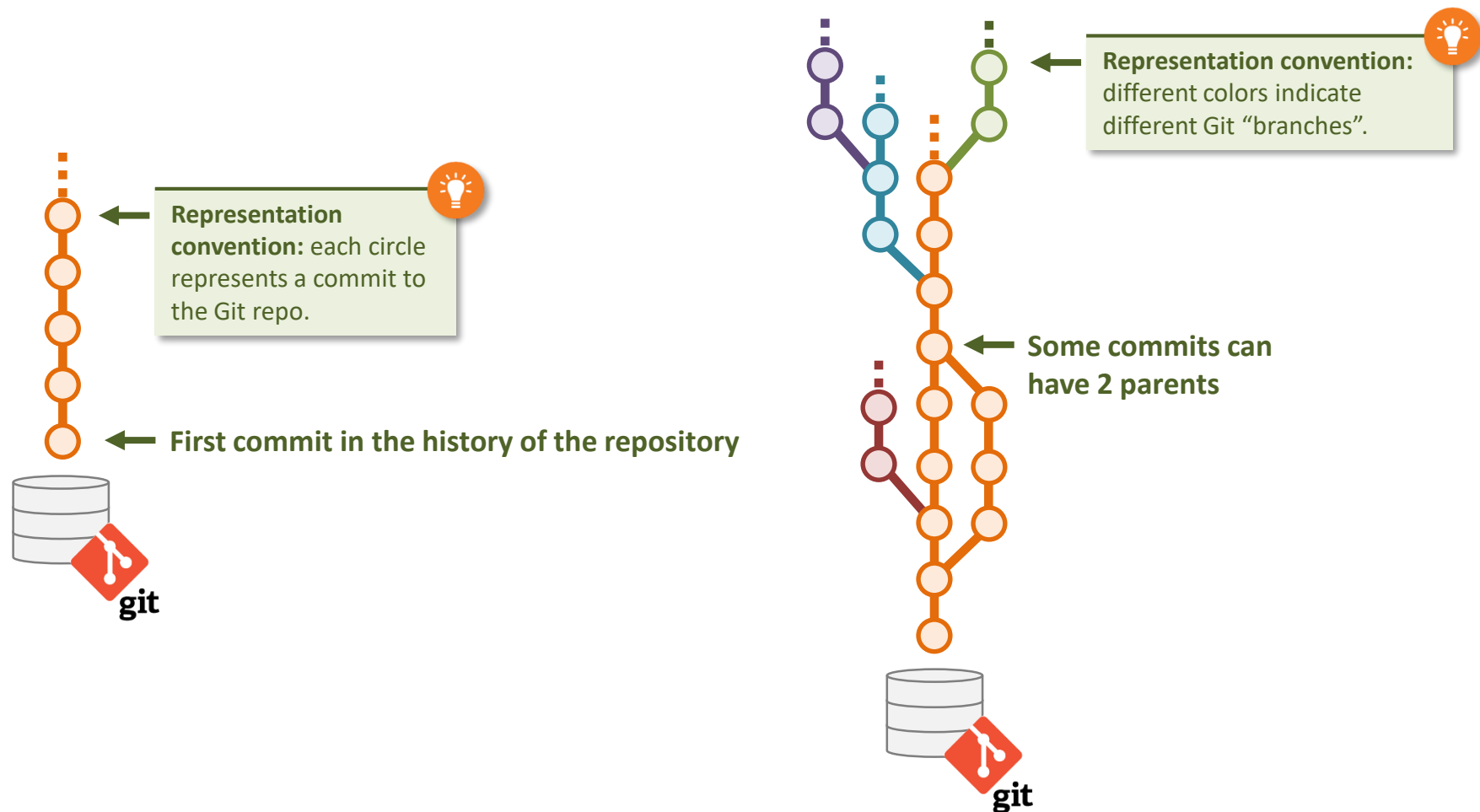
Definitions: commits are stored in a repository (or “repo”)

- **Repository/repo**: directory under Git control (a collection of commits).
 - 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 Git repository.



Definitions

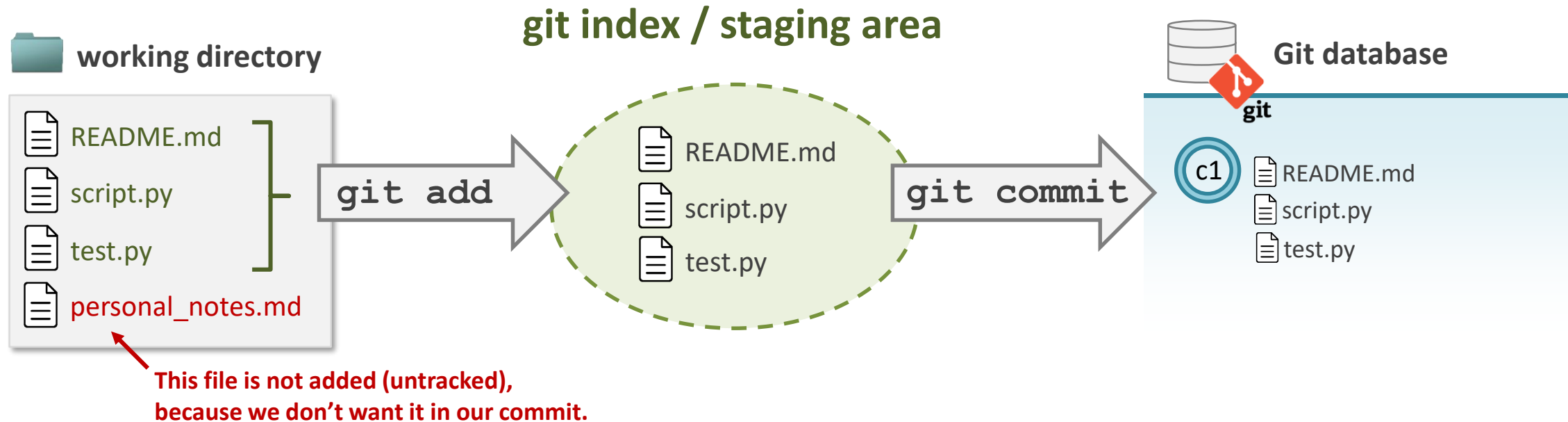
- **Repository history:** history of commits (chronology or commits).
- **Branch:** refers to a “**line of development**” within the commit history.
(technically a branch is simply a reference to a commit)



Definitions: the git index

In Git, committing content is a 2-step process:

1. **Staging**: new content that should be part of the next commit must first be added to the **git index** (sometimes also called **staging area**). This process is referred to as **staging**.
2. **Committing**: a new commit containing the content of the index is added to the repository.



git index = content of your next commit.
commit = snapshot of the git index at a given time.

Definitions: the git index (continued)

- Why do we need the git index ?
- Why not simply commit the content of the directory directly ?

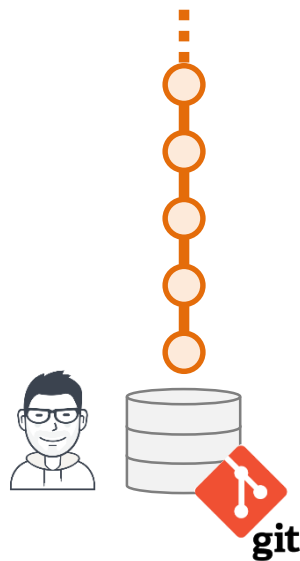
- ➡ The objective of this 2-step procedure is to let users craft **“well thought” commits**.
- **Commits are** meant to be **meaningful units of change** in your code base (or the content you track).
 - Not all changes in the working directory need to be part of the commit.



Examples of Git use cases

Exercise 1

Local repo, single branch

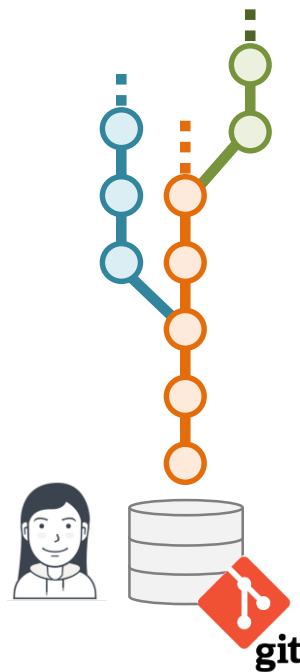


Use case

- Keep a documented log of your work.
- Go back to earlier versions.

Exercises 2 and 3

Local repo, branched workflow
(multiple development lines)

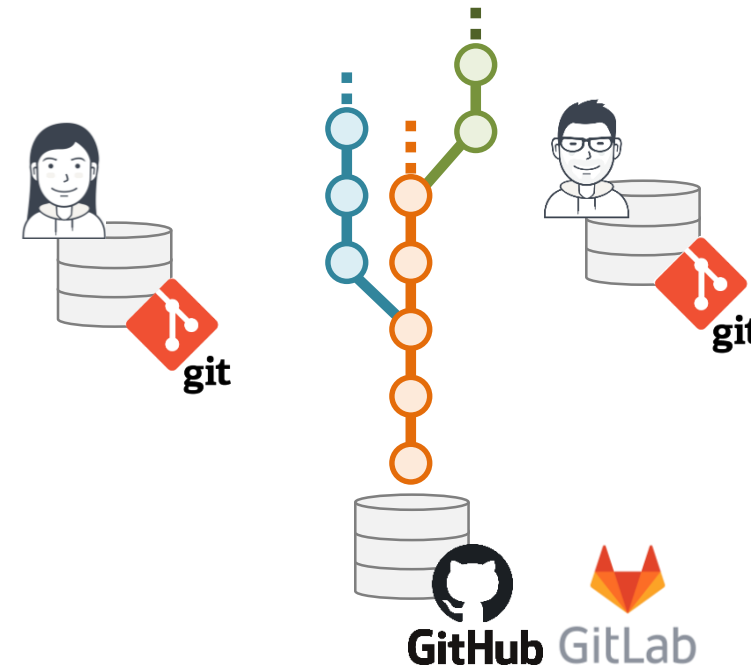


Use case

- Service in production with continuing development in parallel (e.g. new feature).

Exercise 4

Collaboration with
distributed and central repos.



Use case

- Collaborate with others.
- Distributed development.



These two cases provide no backup !! only versioning.

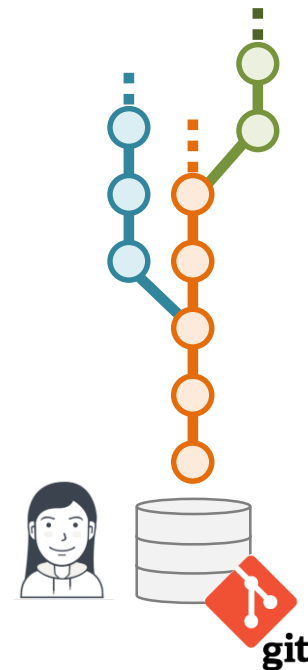
Each user has a full copy of the data*.

*** 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).
 - Associating 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.

By default, everything stays local.



Git basics

your first commit

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>
```

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

- Examples:

```
[alice@local ~]$ git config --global user.name "Alice"
[alice@local ~]$ git config --global user.email alice@redqueen.org
[alice@local ~]$ git config --global --get user.name
Alice
[alice@login1 ~]$ git config --global --get user.email
alice@redqueen.org
```

- User related settings are stored in:
 - Linux: **/home/\$USER/.gitconfig**
 - Windows: **C:/Users/<user name>/.gitconfig**
 - Mac OS: **/Users/<user name>/.gitconfig**

Git config: changing the default text editor

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

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

```
git config --global core.editor <editor name>
git config --global --get core.editor
```

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

```
[alice@local ~]$ git config --global core.editor nano
[alice@local ~]$ git config --global --get core.editor
nano
```


Git config: scopes and 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
```


Creating a new Git repository

- Typing `git init` in any directory **initializes a Git database** in the directory, and thereby turn it into a “Git repository”.
- This creates a hidden `.git` directory - i.e. an empty Git database - at the root of the directory.

```
$ cd /home/alice/test_project
$ git init
Initialized empty Git repository in /home/alice/test_project/.git/
$ ls -a
./ ../ .git/ doc/ src/ README.md
```

The Git database is stored in this “hidden” directory.



- **Everything** is stored in this single `.git` directory:

- Content of all tracked files.
- Complete versioning history.
- All other data associated to the Git repository (e.g. branches, tags).

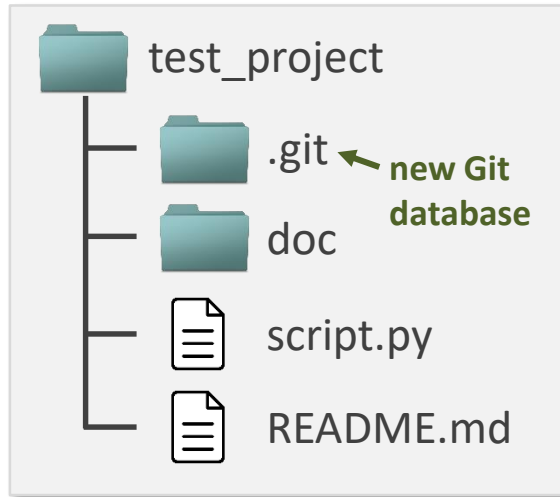


Never delete the `.git` directory

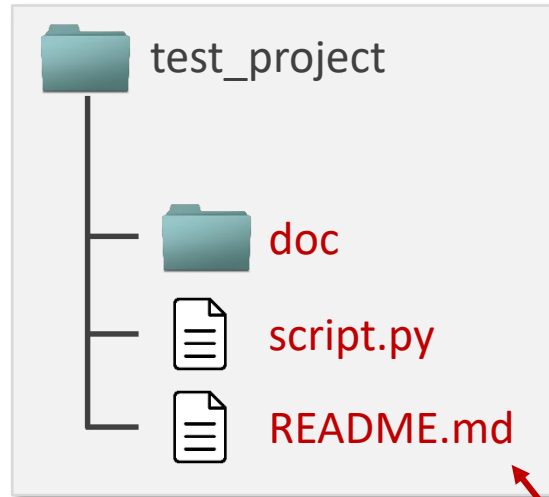
- The content of the `.git` database can re-create the exact state of all your files at any versioned time - e.g. if you delete a file accidentally or want to go back to an earlier version.

State of the working directory just after `git init`

How it look on your file system



How Git sees it



List of files tracked by Git

```
$ git ls-files  
<empty output>
```

Commit history

```
$ git log  
fatal: your current branch  
'master' does not have any  
commits yet
```

`git status`

show status of files in project directory.

`git ls-files`

show files tracked by Git.

`git log`

Show log of commits (i.e. history of repo).

```
$ git status  
On branch master ← default branch name  
No commits yet  
Untracked files:  
  doc/  
  README.md  
  script.py
```

red = untracked file

Summary: when creating new Git repo...

- It does not matter whether the directory is empty or already contains files/sub-directories.
- Files in your git repo (project directory) are **not automatically tracked** by Git. They must be manually added.
- Only files located in the git repo (or one of its sub-directories) can be tracked.
- You can have both tracked and untracked files in a project directory.
- You can have multiple Git repositories on your system – e.g. one per project or one per code/script you develop.
- Git repos are self-contained – you can rename them or move them around on your file system.
- The ensemble of all files that are under Git control in a given git repository is generally referred to as the repository's **working tree**.



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).

“Bare” repositories

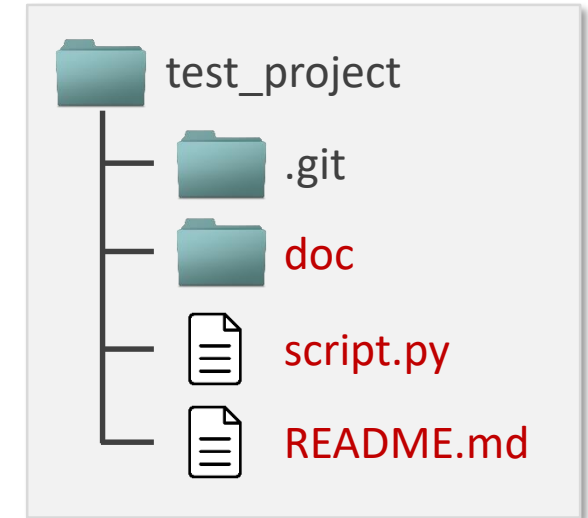


A **bare repo** is a repo that has **no working tree**: it does not contain any instance of the files that are under Git version control, but only the content of the `.git` directory/database.

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`

Adding content to a Git repository

- By default, files in a directory under Git control are **untracked**.
- To add a new file – or a change in file content – to the Git repository, the file **must be explicitly added** with the `git add` command.
- This allows to **separate important files** of your project - that you want to be tracked by Git - **from unimportant ones** that should not be tracked or shared (e.g. a test file of your own).
- After a file has been added once, it is considered as **tracked** by Git (unless you manually remove it).
- **Each time a file is modified, it must be added again** for the new content to get added to the next commit.



Only files/directories located inside the project's directory can be tracked.

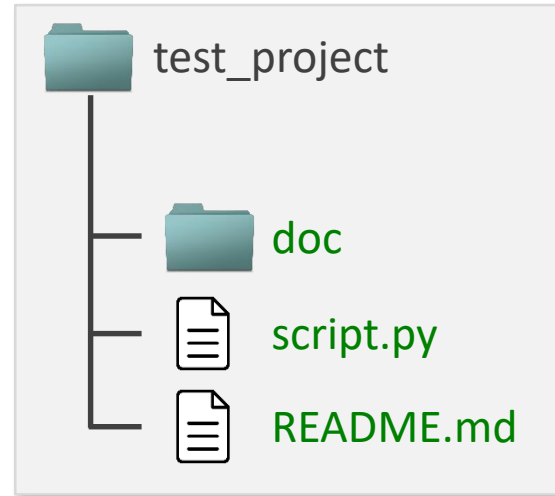
State of the project directory after content is added with `git add`

```
$ git add script.py README.md doc
```

How it look on your file system



How Git sees it



List of files tracked by Git

```
$ git ls-files  
README.md  
script.py  
doc/quick_start.md
```

Commit history

```
$ git log  
fatal: your current branch  
'master' does not have any  
commits yet
```

green = new or modified file

```
$ git status  
On branch master  
No commits yet  
Changes to be committed:  
  new file: README.md  
  new file: script.py  
  new file: doc/quick_start.md
```



Files/changes are added,
but not committed yet.

Committing content

```
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.



Example

```
$ git commit -m "Initial commit for test_project"
[master (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
```

README.md

```
# Quick-start guide for the test_project software
```

| + 1

script.py

```
#!/usr/bin/env python3
```

| + 1

doc/quick_start.md

```
# Test project: a project to test version control with git
```

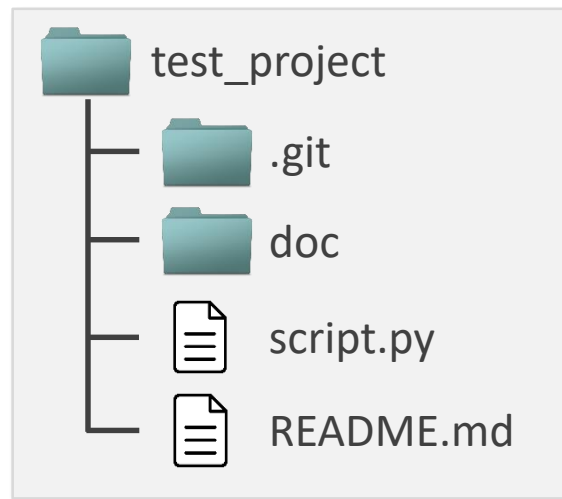
```
This is a small test project to illustrate the use of git.
Maybe I will add more content to it later.
```

| + 4 (empty lines also count)

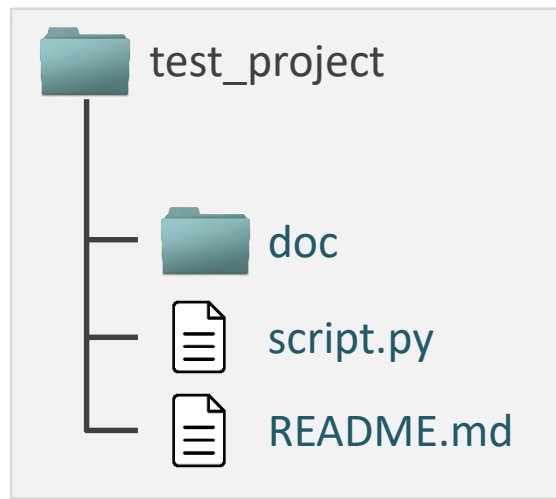
6 insertions = 6 lines added in total (across all files).

State of the project directory after `git commit`

How it look on your file system



How git sees it



List of files tracked by Git

```
$ git ls-files
README.md
script.py
doc/quick_start.md
```

Commit history

```
$ git log
commit 8190787daa6fca93f5f25b819716d50c31bf5c26
Author: Alice <alice@redqueen.org>
Date:   Sun Feb 9 15:07:56 2020 +0100
```

Initial commit for test_project

↑
Now `git log` has finally something to display (just 1 commit, for now).

↓

```
$ git status
On branch master
Nothing to commit, working tree clean
```


↓
Clean working tree = current state of working tree matches exactly with the latest commit.

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 master
# 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 master
# Changes to be committed:
#   modified:   README.md
#   new file:   script.py
#   new file:   doc/quick_start.md
#
~
~
:wq
```

```
[master (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
```

- 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.

Live demo

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

Making commits: some basic advice.

Git does not impose any restrictions on what and when things can be committed.
(the only exception being you cannot commit zero changes)

However, it's best if you:

- Make **commits at meaningful points of** your code/script **development**.
For instance:
 - a new function/feature was added (or a few related functions)
 - a bug was fixed.
- **Don't commit broken code on your *main/master* branch** (i.e. the main branch).
You can commit them to a *devel / feature* branch, and later consolidate them before merging with *main/master* (more on branch management later).

Ignoring files

- By default, files that are not added to the Git repo are considered by Git as "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" lists:

`.gitignore`

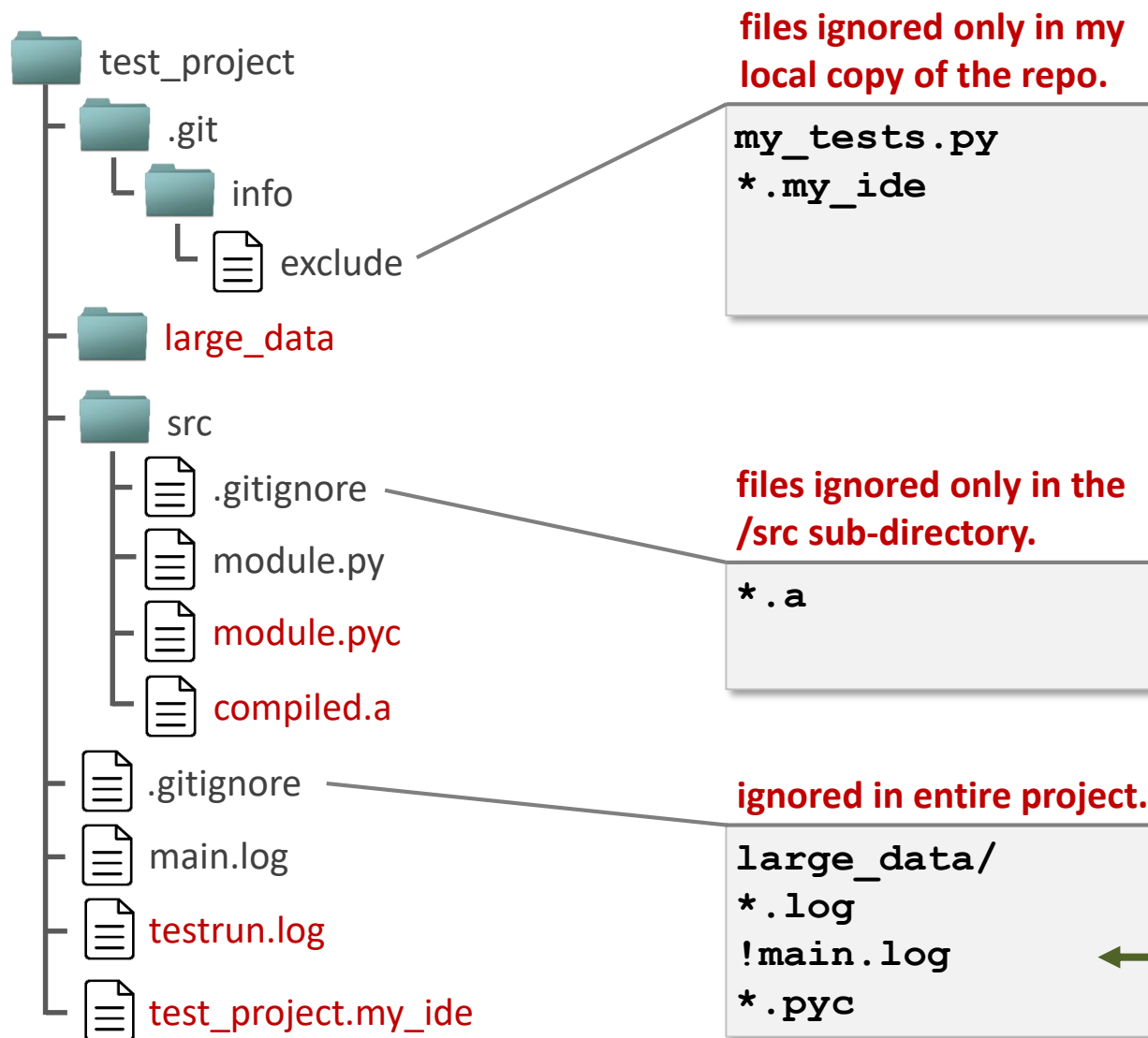
- For files to be **ignored by every copy of the repository**.
- `.gitignore` is meant to be tracked: `git add .gitignore`
- Examples:
 - outputs of tests
 - `.Rhistory`, `.RData`
 - `.pyc`
 - `.o`, `.a`

`.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).

- Files are added by manually editing the two above-mentioned files.
- Files can be ignored based on their full name, or based on glob patterns.
 - `*.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).

Ignoring files: example



red = ignored file.

This file is a config for my IDE software. It is of no use to others. This is why it is ignored in `.git/info/exclude`

- The **.gitignore** files themselves should not be ignored: add them to the Git repo so they are tracked.
- 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).

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



Live demo

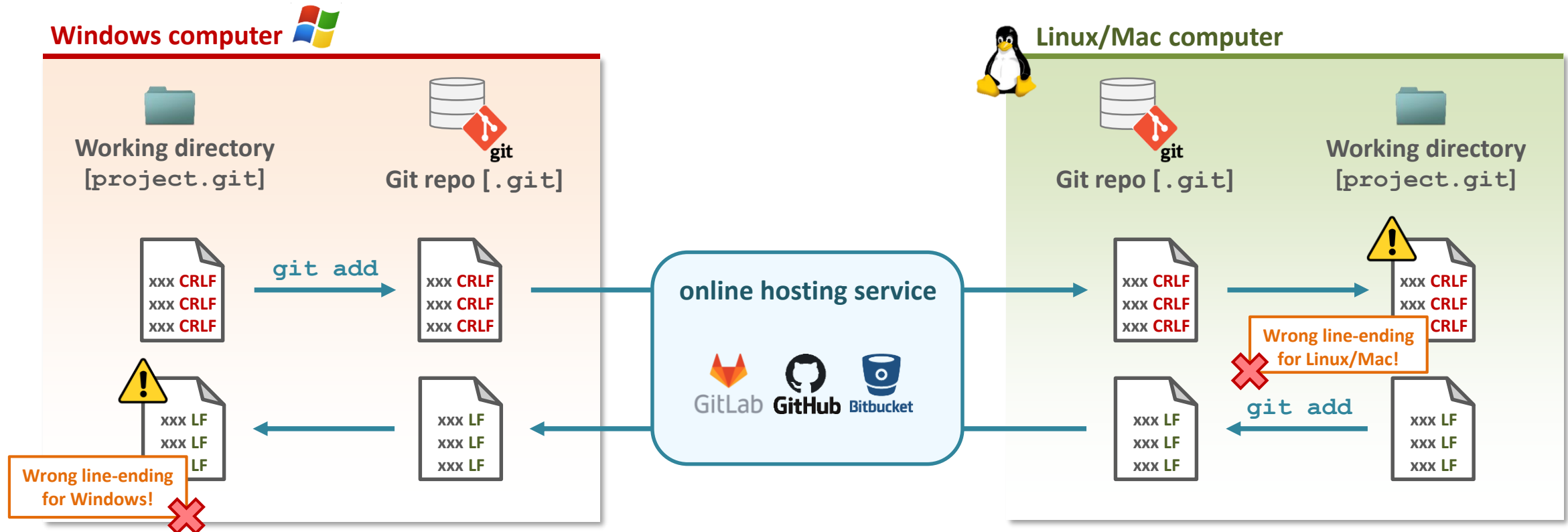
- Adding files to `.gitignore`

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.

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



Cross-platform collaboration: solution -> setting git config core.autocrlf

The solution is to ask Git to automatically convert between LF and CRLF during add/checkout operations.

- 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).

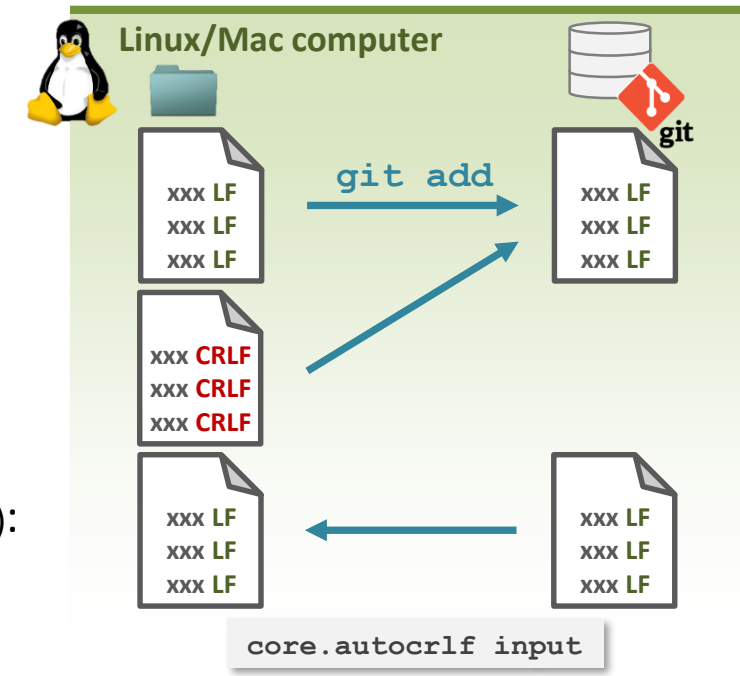
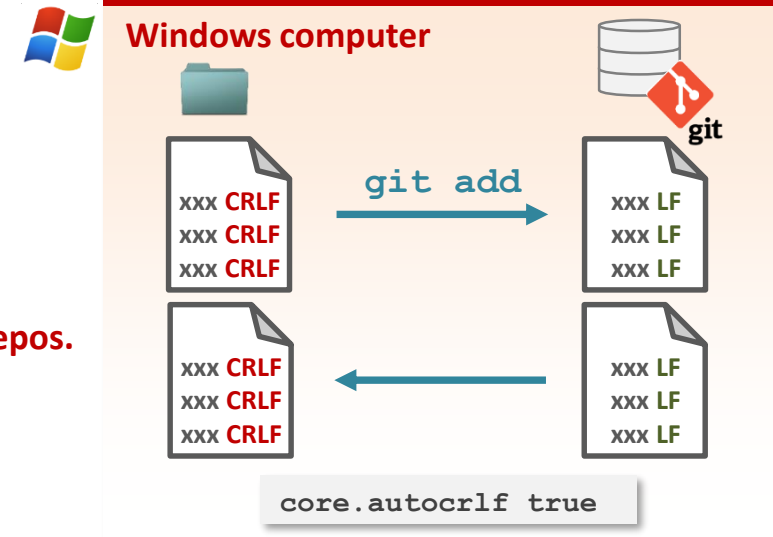
```
git config core.autocrlf input
```

```
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` (so 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 check-in/check-out of files... so when checking-in files (`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”.

Displaying a repository's state and history

git status, **git show** and **git log**

git status

- Display the status of files in the working directory.

```
git status
```

Green = new content in this file
has been staged and will be part
of the next commit.

Red = this file contains new content,
but it is not staged and will not be
part of the next commit.

```
$ git status
On branch master
Changes to be committed:
  (use "git reset HEAD <file>..." to unstage)

    modified:   LICENSE.txt
    modified:   README.md

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

    modified:   README.md

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

    untracked_file.txt
```

tracked files.

untracked files.

Note: new content in a file can be **partially committed**: i.e., it's possible to have some changes in the file staged (added to the index), and some unstaged.

This is the case in the example above for the **README.md** file. **Only the staged content will become part of the next commit.**

File status in Git

There are 4 possible statuses for files in Git:

- **Tracked**

File that is currently under version control by Git (i.e. it is in the Git index).

- **unmodified** - the content of the file is the same as in latest commit.
more precisely: the content is the same as in the commit to which HEAD is currently pointing.
- **modified** - the content of the file differs from the latest commit.
more precisely: it differs from the commit to which HEAD is currently pointing.

- **Untracked**

File that is in the working directory, but not under version control by Git.

- **Ignored**

Untracked file, but where Git is aware it should not be tracked.

git show

- Show the change in file content introduced by a commit.

```
git show <commit>
```

```
git show
```

→ with no argument, the latest commit on the current branch is shown

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 d7bfdc8..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
```


git log: display the commit history of a Git repo

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

+ loads of other options (see `git log --help`)

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

```
$ git log
commit f6ceaac2cc74bd8c152e11b9c12ada725e06c8b9 (HEAD -> master, origin/master)
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 -> master, origin/master) peak_sorter: add 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
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 -> master, origin/master) peak_sorter: add 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, 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!
But Git developers have you covered, allowing you to set **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
```



exercise 1

Your first commit



This exercise has helper slides

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

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

Git concepts

commits, the **HEAD** pointer and the **git index**

Git commits

Git's immutable, atomic, units of change

Introducing SHA-1

- SHA-1 stands for **Secure Hashing Algorithm 1**.
- 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

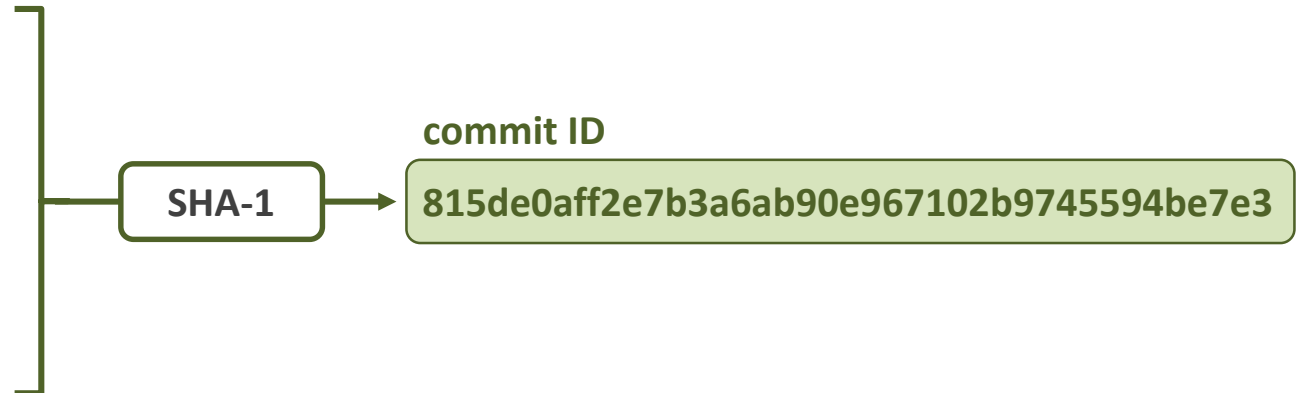
* as of Jan 2020, SHA-1 collisions can be created for 45'000 USD worth of CPU time.

Commits: Git's atomic, immutable, units of change

- A commit is the **smallest unit of change** in a Git repository.
- A commit is **the only way to enter a change** into a Git repository.
(enforces accountability as you cannot have untraceable modifications)
- Each commit has an associated author, committer, commit message and date.
(enforces documentation)

Content of a commit

Author: Mad Hatter
Committer: Alice
Commit msg: Fix bug in class CheshireCat()
Date: 24.02.2020 10:43
Parent: `e5d56fa`
Tree: `57dc232`



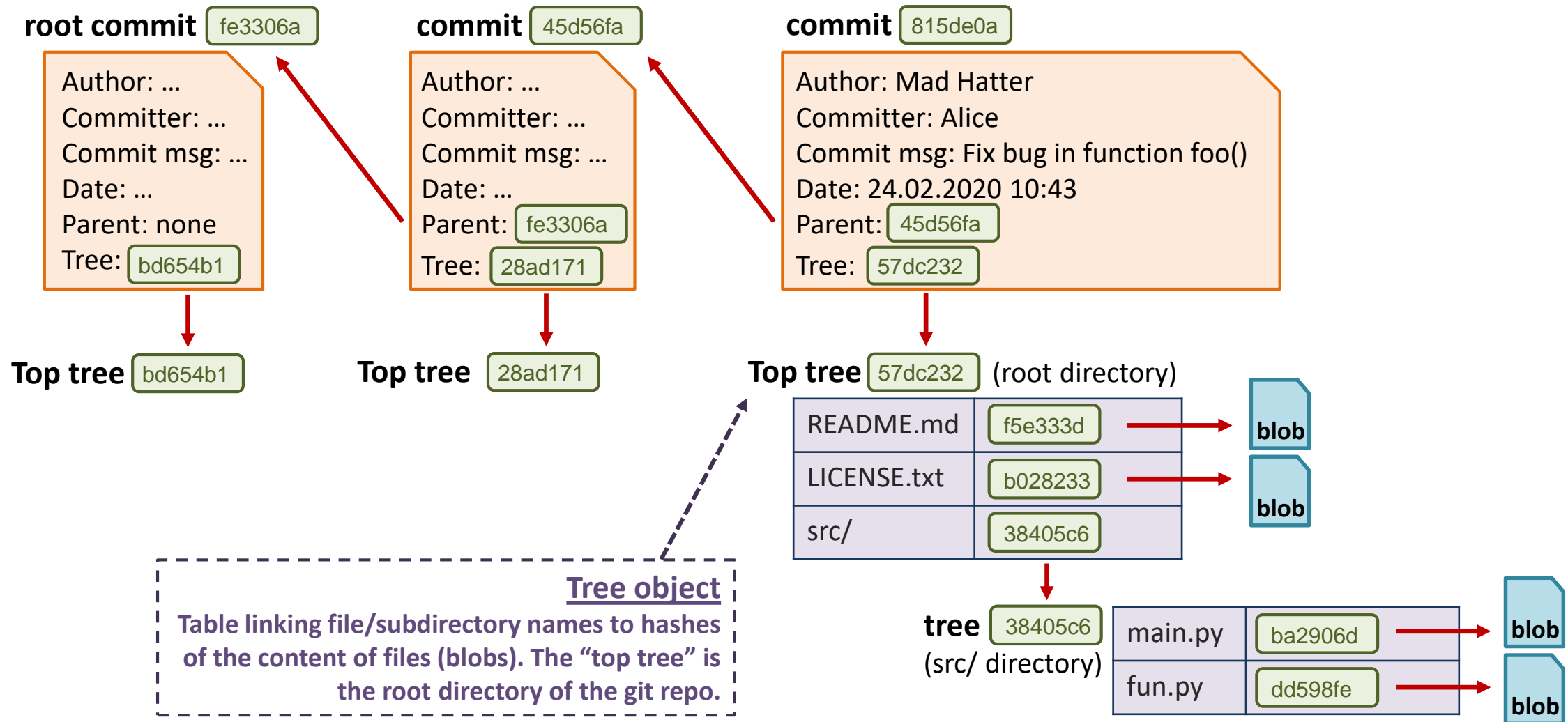
- Commits are lightweight: they do not contain the tracked files' data, only a **reference to the data**.
(a tree* object that represents the content of the Git index at the time the commit was made).
- Commits contain a **reference to their parent** commit.
- Each commit is uniquely identified by a **commit ID**: a SHA-1 hash/checksum computed on its metadata

* Tree = reference to the content of all files at a given time point.

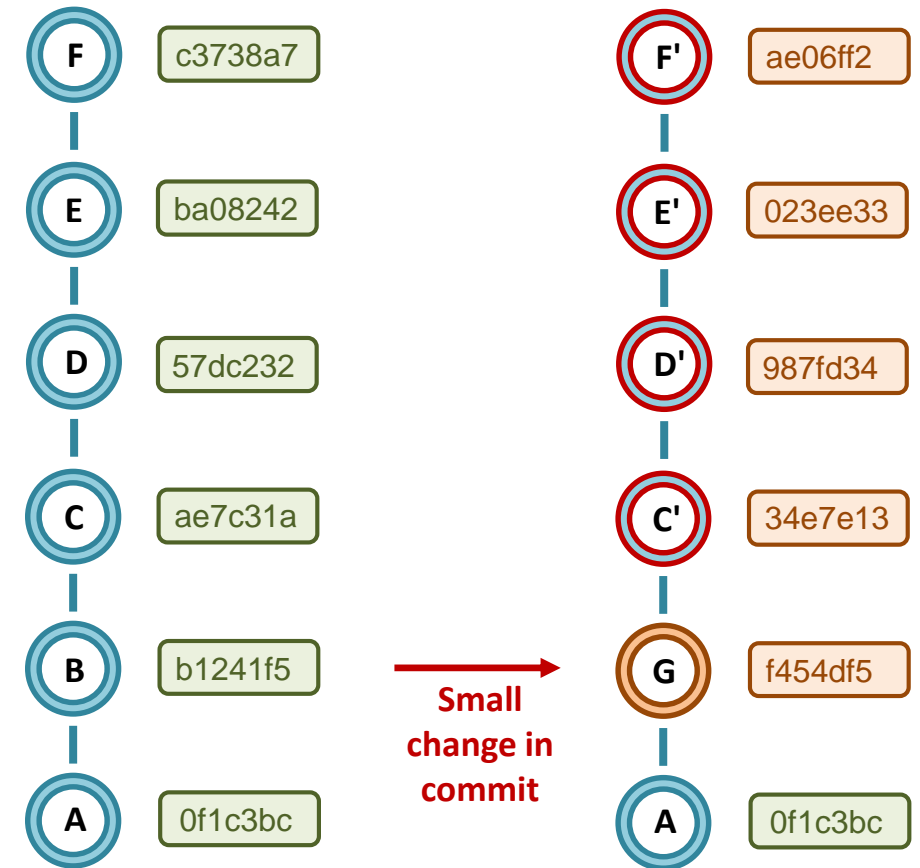
- **Commits contain a reference to the top “Tree object”** – a table linking file names and hashes of the Git index at the time the commit was made. This is how Git can retrieve the state of every file at a given commit.
- **Commits point to their direct parent** – forming a DAG (directed acyclic graph) 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 their commit ID (SHA-1 hash) 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.



Git versioning

- Git stores a complete version 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 :-)

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

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...



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

The tip of your current branch

HEAD: a pointer to the most recent commit on the current branch.

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

```
[rengler@pc-robin exercise_1]$ git log
commit 30e657bc31de70de260fdcfa3d90f350db69942e (HEAD -> master)
Author: Robin Engler <robin.engler@sib.swiss>
Date: Tue Oct 5 11:22:39 2021 +0200

    Update DESCRIPTION and README
```

Commit ID (SHA1 hash)

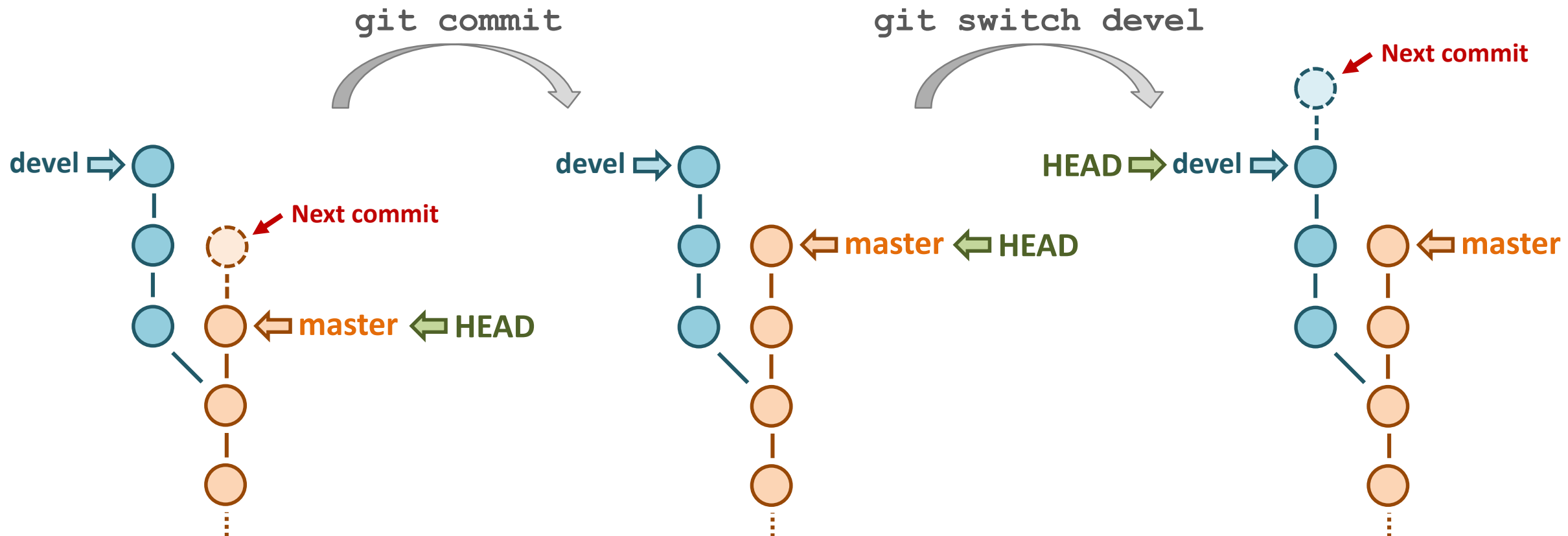
HEAD pointer

branch name

```
[rengler@pc-robin exercise_1]$ git log --all --decorate --oneline --graph
* 30e657b (HEAD -> master) Update DESCRIPTION and README
* b6d778e README: add author and URL
* fd570c5 Add .gitignore file
* e50b5cc Initial commit for fake stringr package
```


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's also described as a pointer to the current branch – which is itself a pointer to the latest commit on the branch.
- When a new commit is added, **HEAD** is automatically moved by Git to point to that new commit.



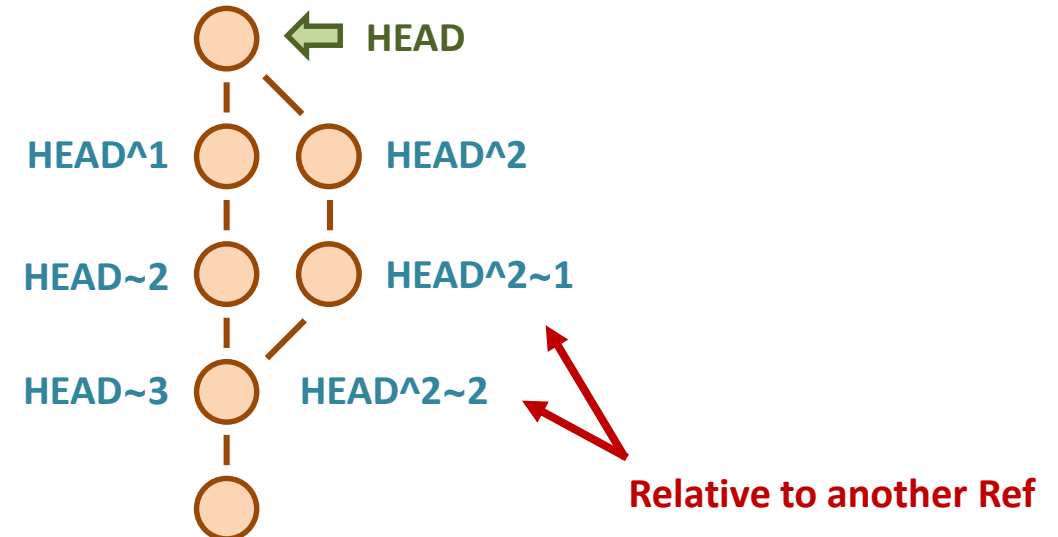
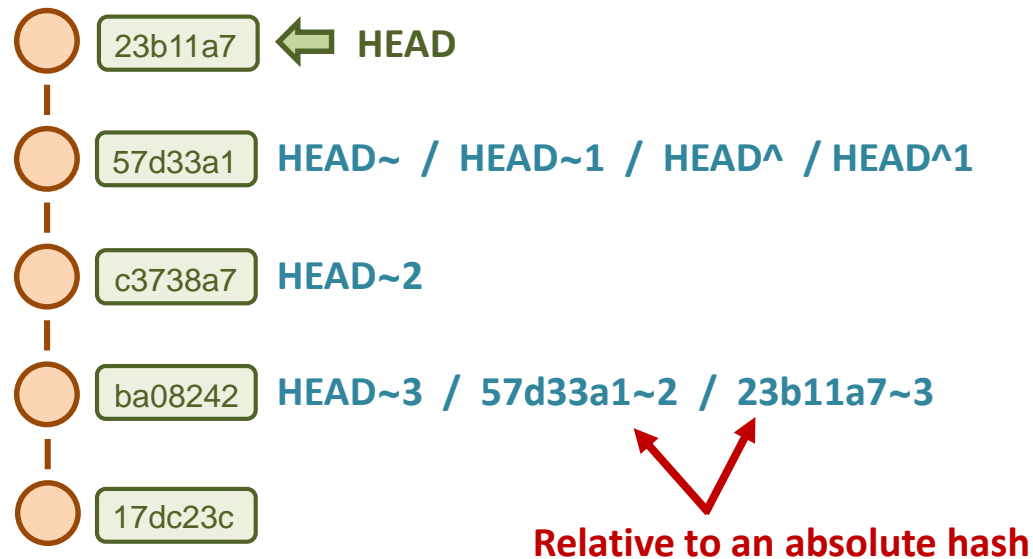
Another way to look at it, is that **HEAD** always points to the parent of your next commit.

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**



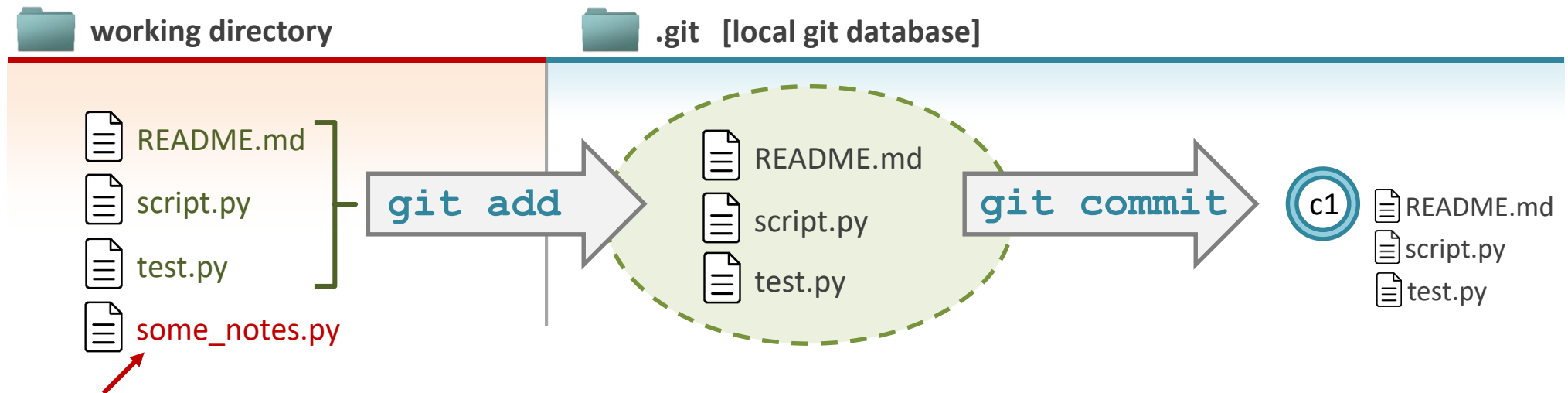
the **Git** index

(staging area)

A preview of your next commit

Committing new content: a two-step process...

- Any new content to be committed must first be added to the **git index**, or **staging area**. This process is referred to as **staging**. The objective of this 2-step procedure is to help create “well defined” commits
- New commit = snapshot of the Git index**. The Git index can be thought of as a sort of “virtual stage” where the content of the next commit is prepared.
- Staged files remain staged**, unless removed or overwritten by a newer version.
- When files are added to the git index (staged), their content is already copied to the git database.



This file is not added (untracked),
because we don't want it in our commit.

git index = content of your next commit.
commit = snapshot of the git index at a given time.

working directory

.git, local git database

working tree
actual files on disk

README.md

git index
"staging area"

README.md

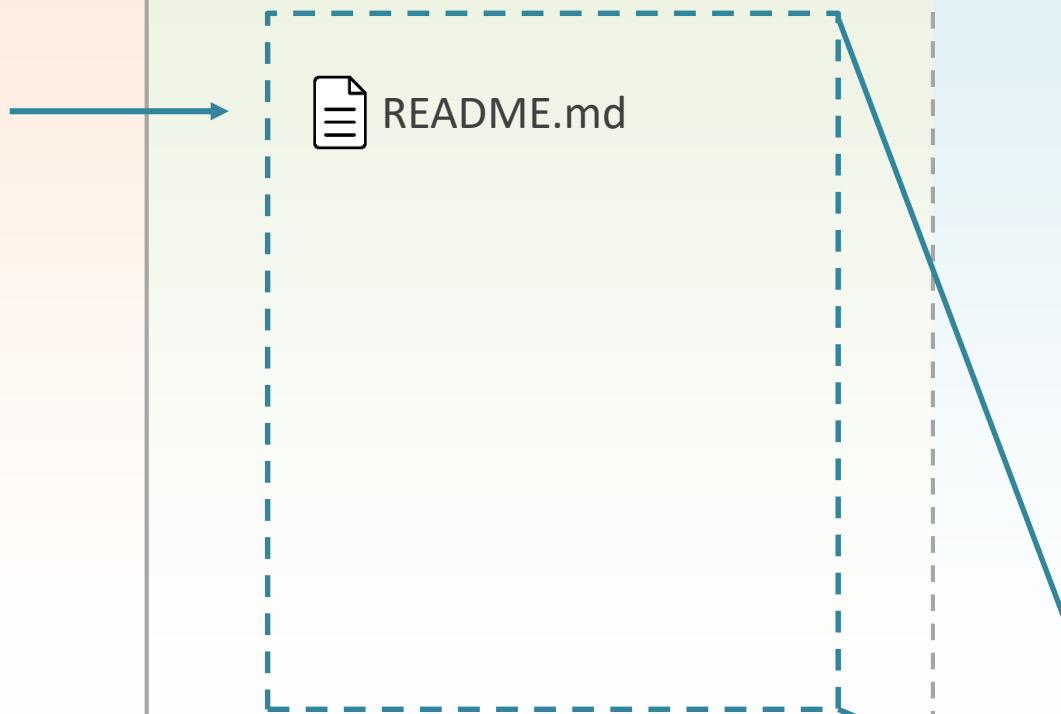
Committed content

Command lines

```
$ git add README.md
$ git commit --message "c1"
```

c1

README.md



working directory

.git, local git database

working tree
actual files on disk

README.md

script.py

git index
"staging area"

README.md

script.py

Committed content

Command lines

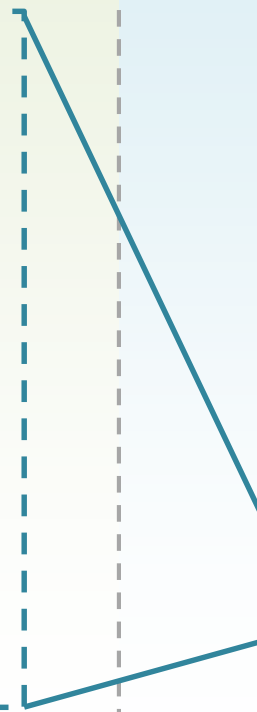
```
$ git add script.py
$ git commit --message "c2"
```

c2

README.md
script.py

c1

README.md



working directory

.git, local git database

working tree
actual files on disk

README.md

script.py [version 2]

private_tests.py

output.txt

Command lines

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

git index
"staging area"

README.md

script.py [version 2]

private_tests.py

output.txt

Committed content

c3

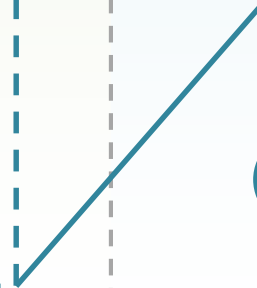
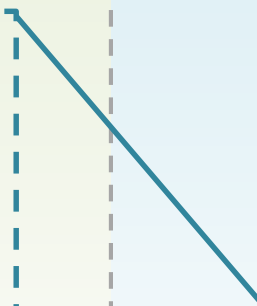
README.md
script.py [version 2]
private_tests.py
output.txt

c2

README.md
script.py

c1

README.md



working directory

.git, local git database

working tree
actual files on disk

README.md
script.py [version 2]
private_tests.py
output.txt

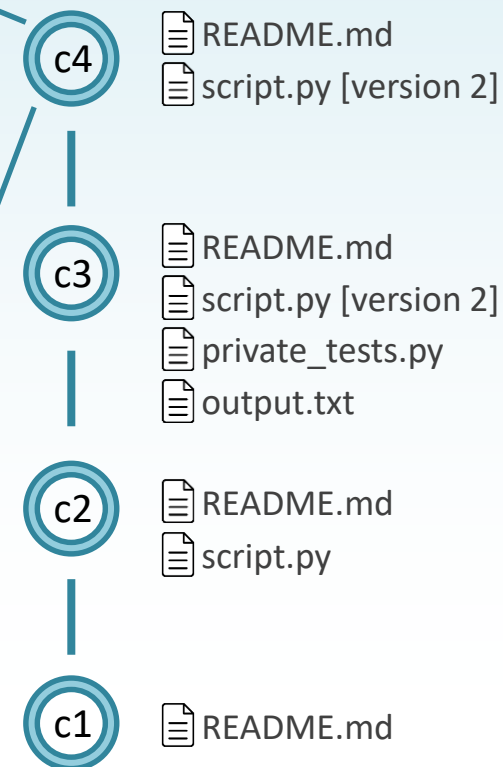
Command lines

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

git index
"staging area"

README.md
script.py [version 2]
~~private_tests.py~~
~~output.txt~~

Committed content





working directory

.git, local git database

working tree
actual files on disk

README.md
script.py [version 2]
private_tests.py
output.txt ✓

git index
"staging area"

README.md
script.py [version 2]
output.txt ✓

Committed content

c4
README.md
script.py [version 2]
c3
README.md
script.py [version 2]
private_tests.py
output.txt ← **File remains available in the Git database**
c2
README.md
script.py
c1
README.md

Command lines

```
$ git checkout c3 output.txt
```


Adding content to the index (staging content)

```
git add <file/directory> # add the selected file/directory to the git index.
```

- Adds the file content to the Git index (“stages” a file).
- By default, the entire content of a file is added.
(adding only part of a file is possible with --edit or --patch options)
- **Each time a file is modified, it must be added again** so that the new version of the file gets added to the git index.

- Useful `git add` options

```
git add <file(s) or directory(ies)> # Stages selected files/directories.
git add -u/--update                  # Stages all already tracked files, but ignore untracked files.
git add -A/--all                     # Stages all files/directories in the working directory (except
                                     # ignored files). Also stages file deletions.
git add .                            # Stages entire content of working directory, except file deletions.
```


Removing content from the index

- **git restore --staged / git reset HEAD:** remove newly staged content from the index.

```
git restore --staged <file> # remove newly staged content of specific file.
```

Note: this is a specific use of the reset command, which has a wider scope.

```
git reset HEAD <file> # remove newly staged content of specific file.
git reset HEAD         # remove all newly staged content.
```

- **git rm:** remove entire files from the index and the working tree.

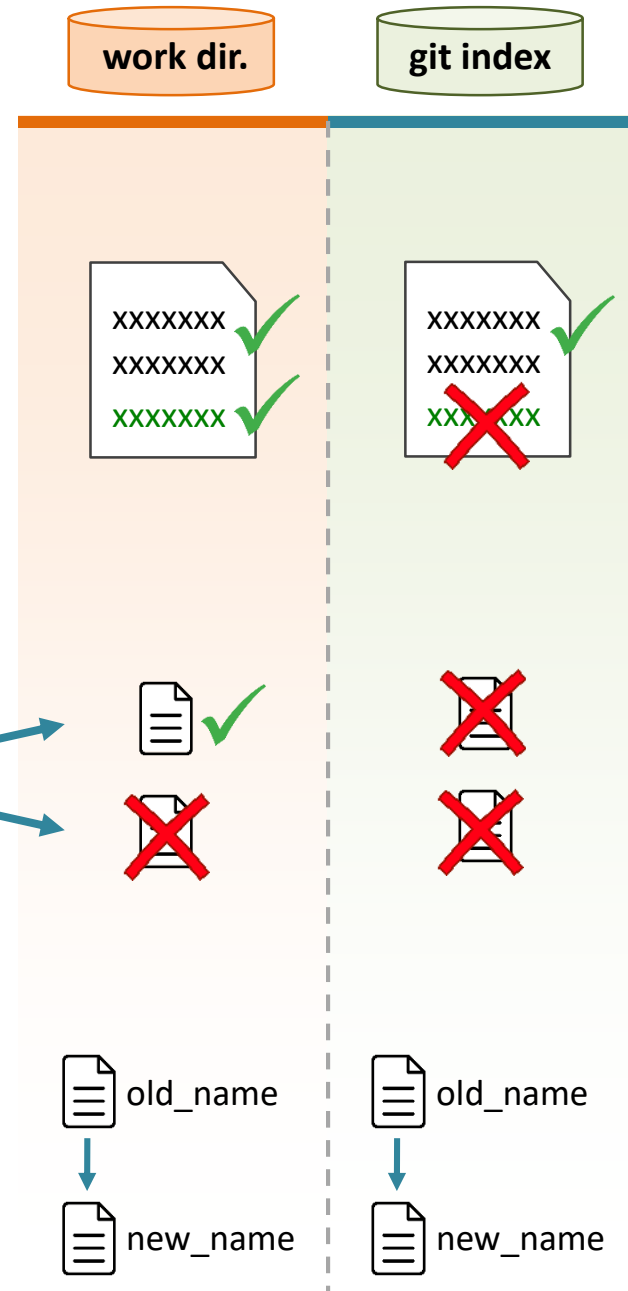
```
git rm --cached <file> # remove file from index only.
git rm <file>           # remove file from both index and working tree.
```



With no `--cached` option => deletes file on disk !

- **git mv:** rename and/or move files both in the working tree and the index.

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



How do I know which files are staged? use **git status**!

git status

```
$ git status
```

```
On branch master
```

Changes to be committed:

```
(use "git reset HEAD <file>..." to unstage)
```

```
modified:    LICENSE.txt
```

```
modified:    README.md
```

Changes not staged for commit:

```
(use "git add <file>..." to update what will be committed)
```

```
(use "git checkout -- <file>..." to discard changes in working directory)
```

```
modified:    README.md
```

Untracked files:

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

```
untracked_file.txt
```

Green = new content in this file
has been staged and will be part
of the next commit.

Red = this file contains new content,
but it is not staged and will not be
part of the next commit.

tracked
files.

untracked
files.

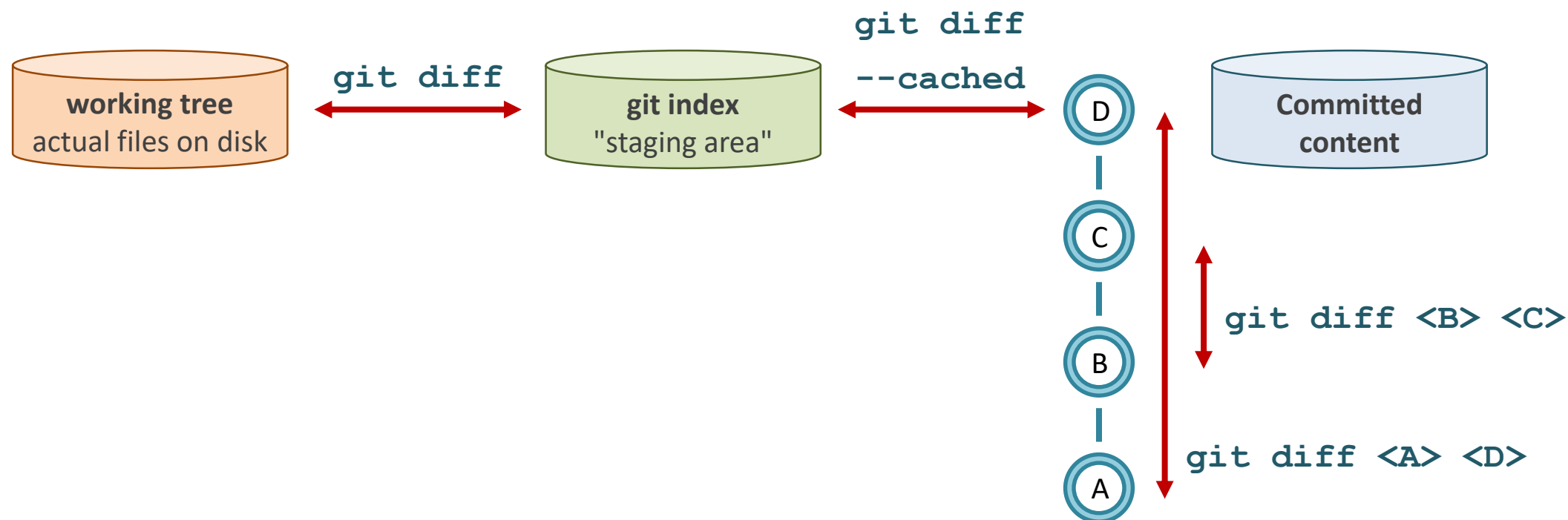
How do I know which changes are staged? use **git diff**!

- Show differences between two states of the git repo.

```
git diff
git diff <file>           # show diff only for a specific file
git diff --cached
git diff <commit 1 (older)> <commit 2 (newer)>
```

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
```



Shortcuts: add + commit in a single command

- Stage all changes in *tracked* files (does not add untracked files).

```
git add -u
```

- Stage all changes in *tracked* files and commit them.

This will not commit untracked files (unlike `git add --all` that also adds untracked files).

```
git commit --all --message "log message"
git commit -am "log message"           # short options version.
```

- Stage + commit all changes in the specified files:

```
git commit -m "log message" <file to commit>
```

This only works for files
that are already tracked.



Example

```
$ git commit -m "README: updates project description" README.md
```

Is the same as:

```
$ git add README.md
```

```
$ git commit -m "README: updates project description"
```

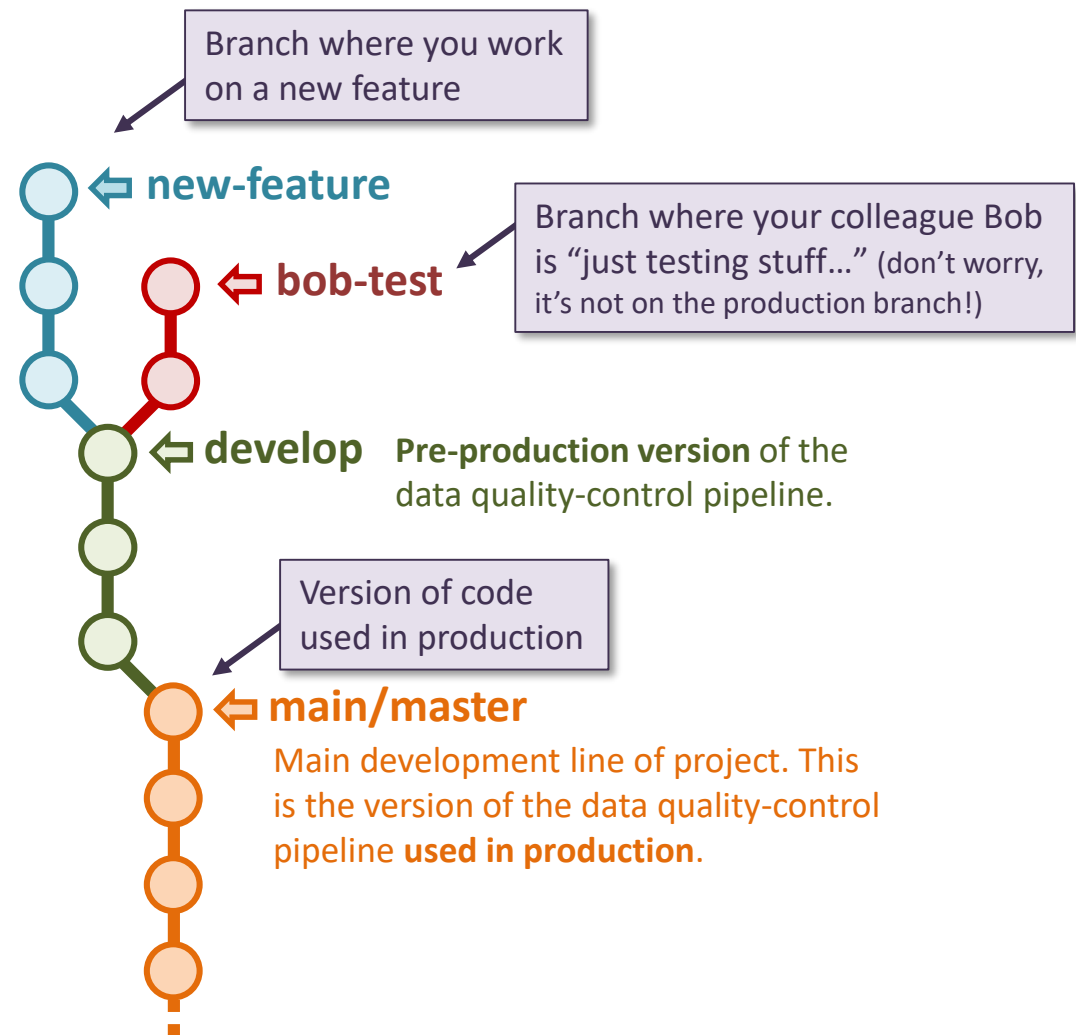

Git branches

run multiple lines of development

Why branches?

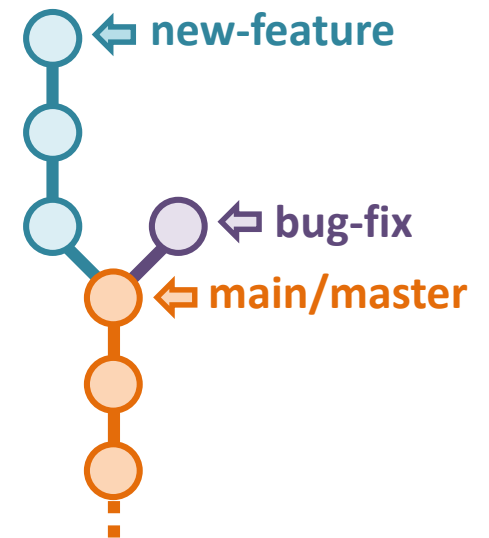
An example of a data quality-control pipeline project

- Branches are **a great way to isolate new changes you are working on** from the main line of development.



What are branches?

- A branch is just a pointer (to a commit).
- A branch is **very lightweight** (41 bytes).
- By convention, the **master/main branch** is the branch representing the stable version of your work.
- Git is **designed to encourage branching**: branches are “cheap” to create (use little disk space), and switching between them is fast.



The master/main branch

The **master/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.



main or master ?

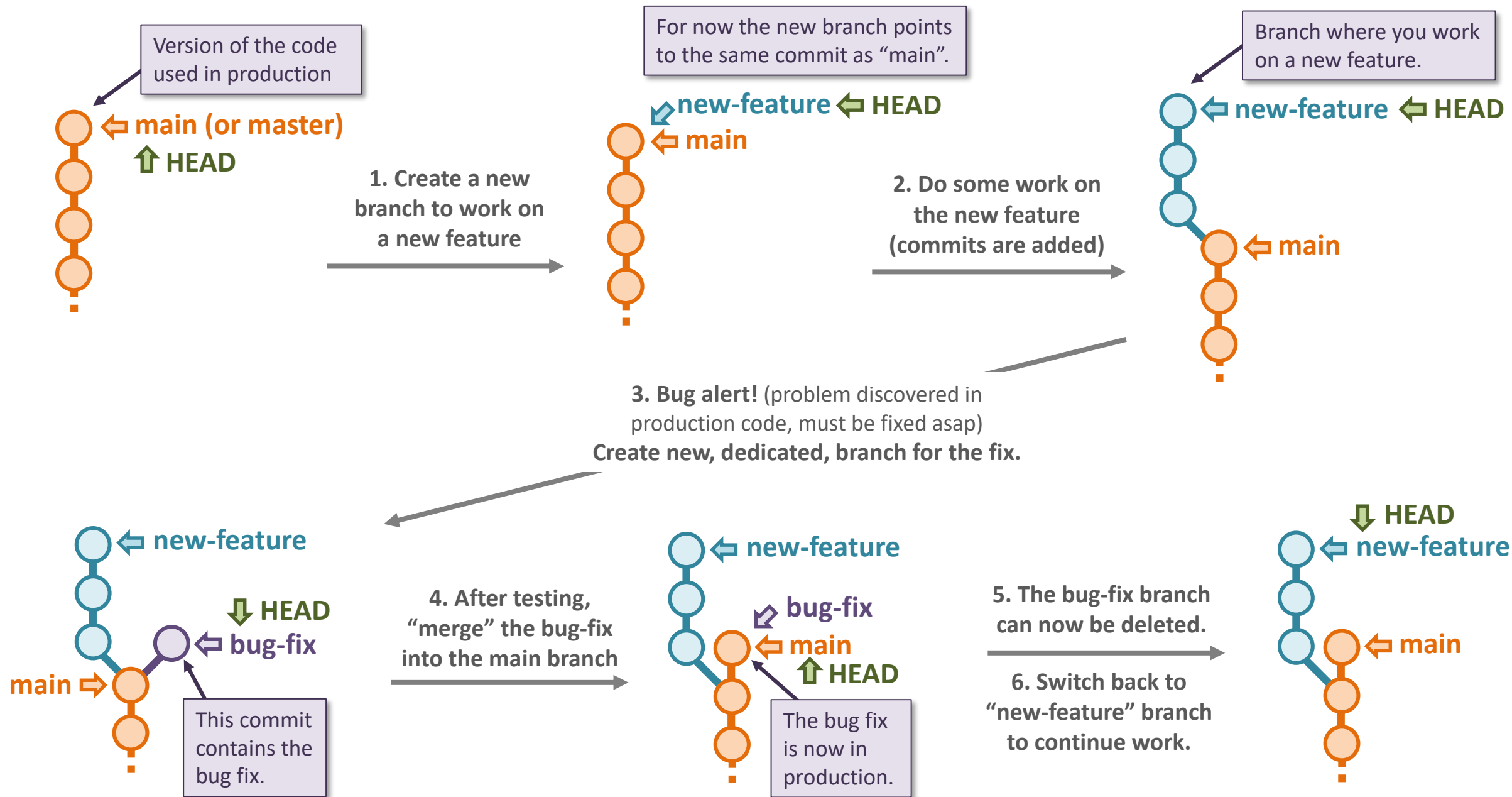
Since October 2020, repositories created on GitHub use **main** instead of **master** as their default branch (because “master” carries a references to slavery). It is likely that at some point Git will also adopt this convention.

Illegal characters within 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 [`-`].

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

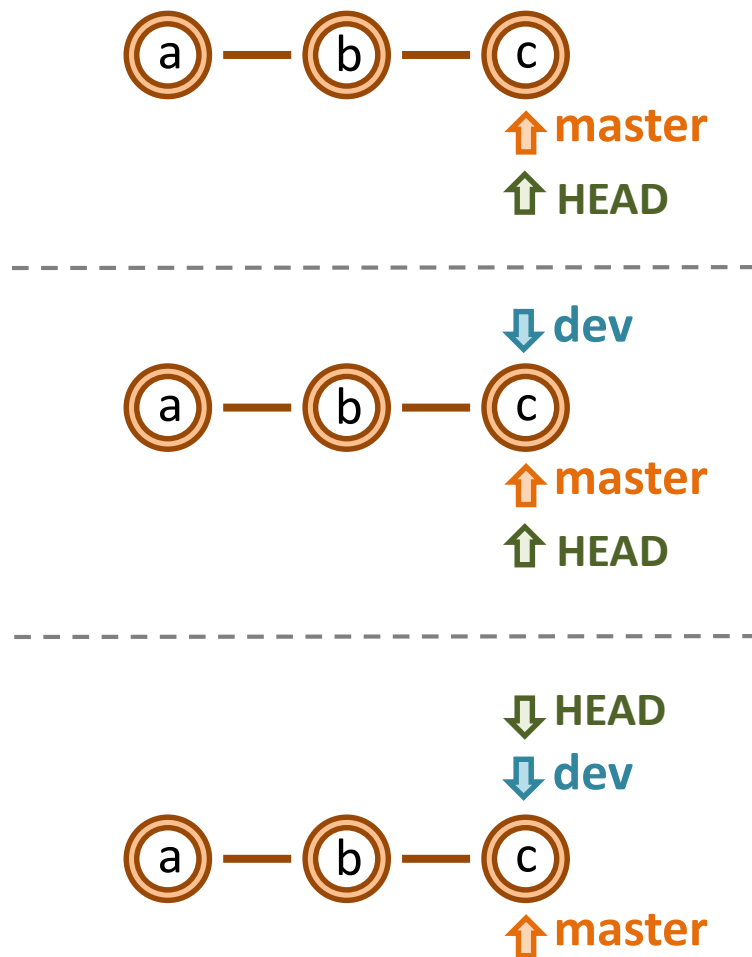


Creating new branches

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

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

Same as above, for older Git versions: `git checkout -b <branch name>`



`git branch dev`

`git switch dev`
or
`git checkout dev`

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

`git switch -c dev`

checkout vs. switch



The `git switch` command was introduced in Git version 2.23 as an alternative/replacement to `git checkout` when switching branches. This is because the `checkout` command already has other uses (e.g. to revert files to a given version), and it was deemed confusing that a same command would have multiple usages.

List branches and identify the currently checkout-out 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 checkout-out (active) branch. Generally it is also 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, you can also run the “git adog” command (`git log --all --decorate --oneline --graph`) that will show all branches. The currently active branch as the **HEAD** pointing to it.

```
* 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
```


git merge

get branches back together

Branch merging

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

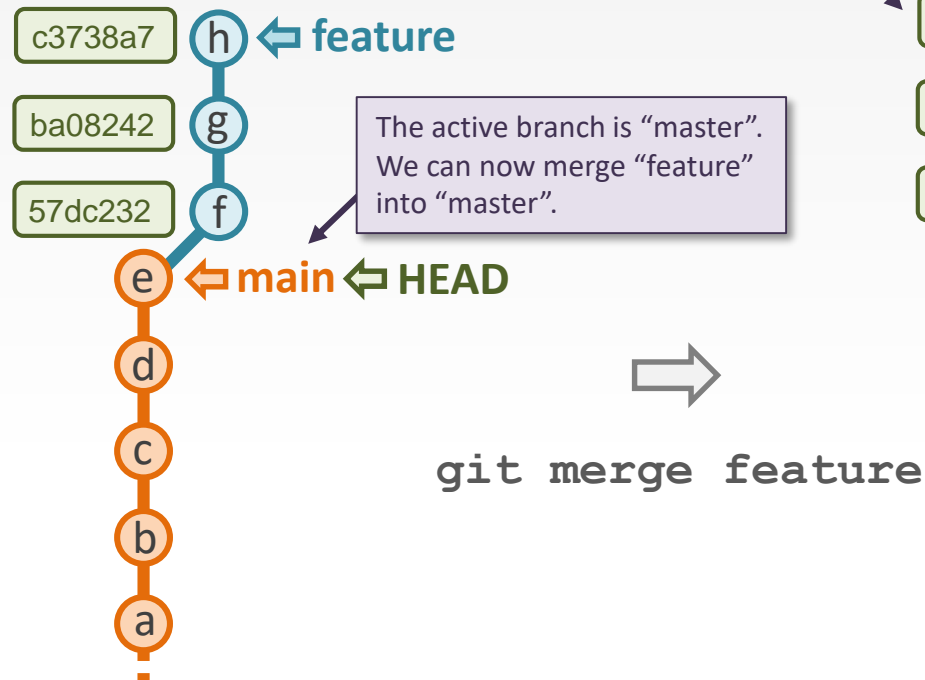
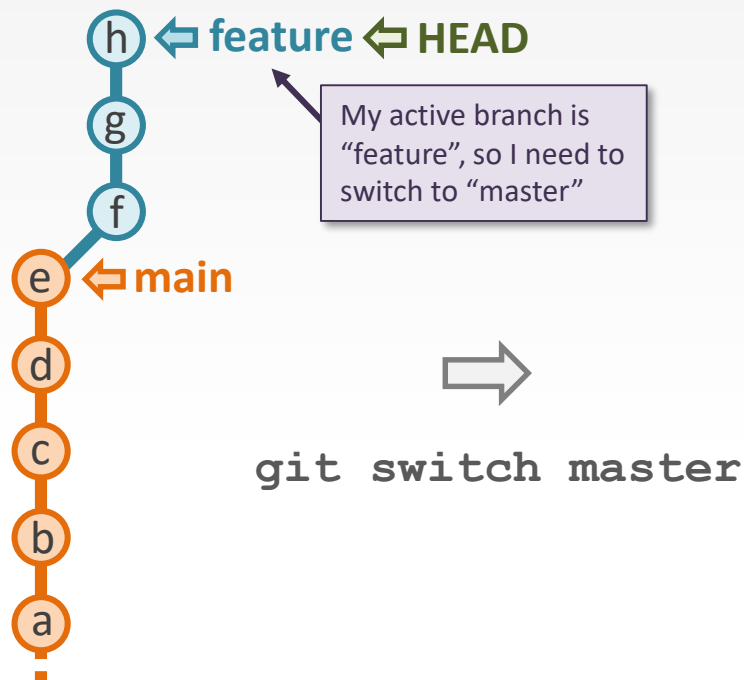
```
git merge <branch to merge into the current branch>
```



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

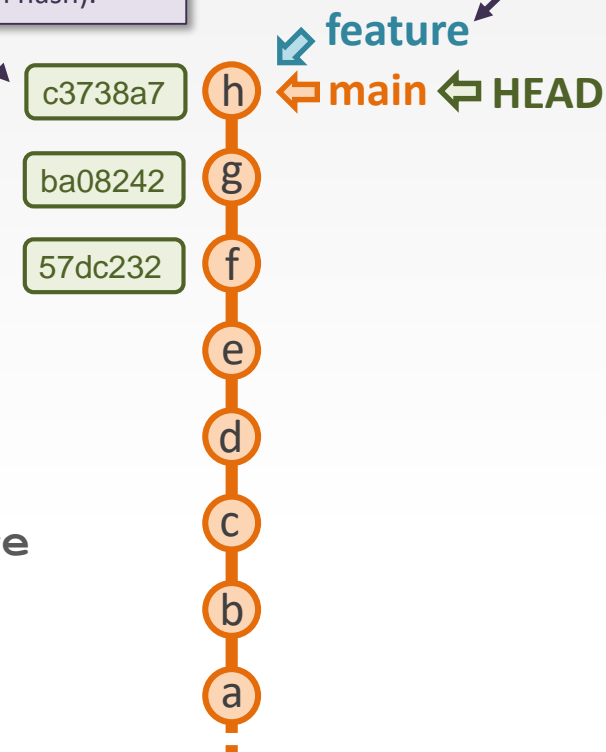
If not, use `git switch <branch>` to checkout the correct branch.

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



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 could be deleted.
`git branch -d feature`



Two types of merges

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

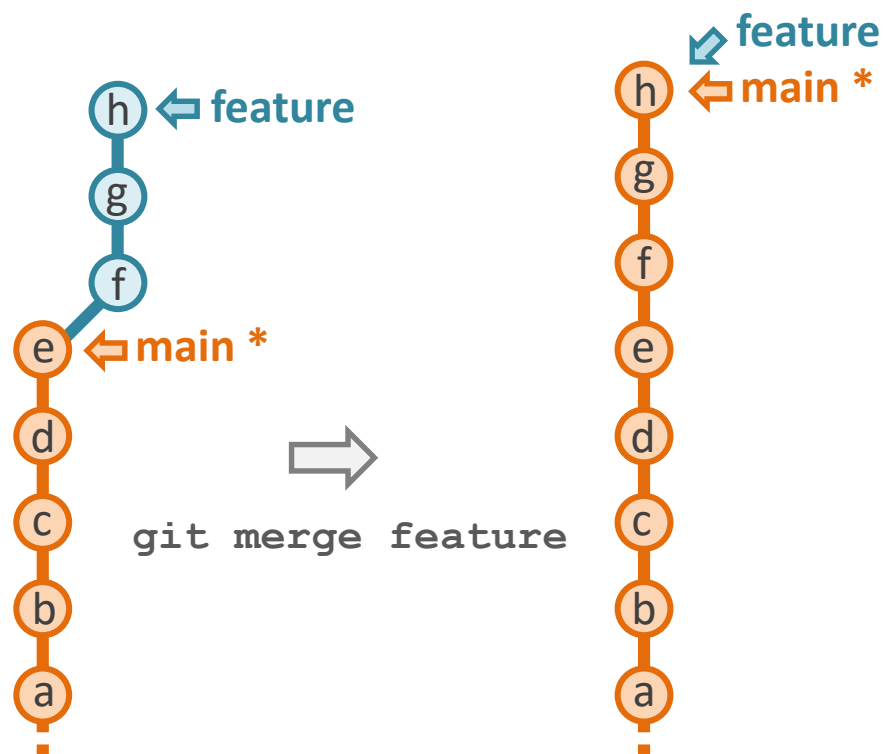
The branch that is being merged (here **feature**) is rooted on the latest commit of the branch that it is being merged into (here **main**).

- **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**).

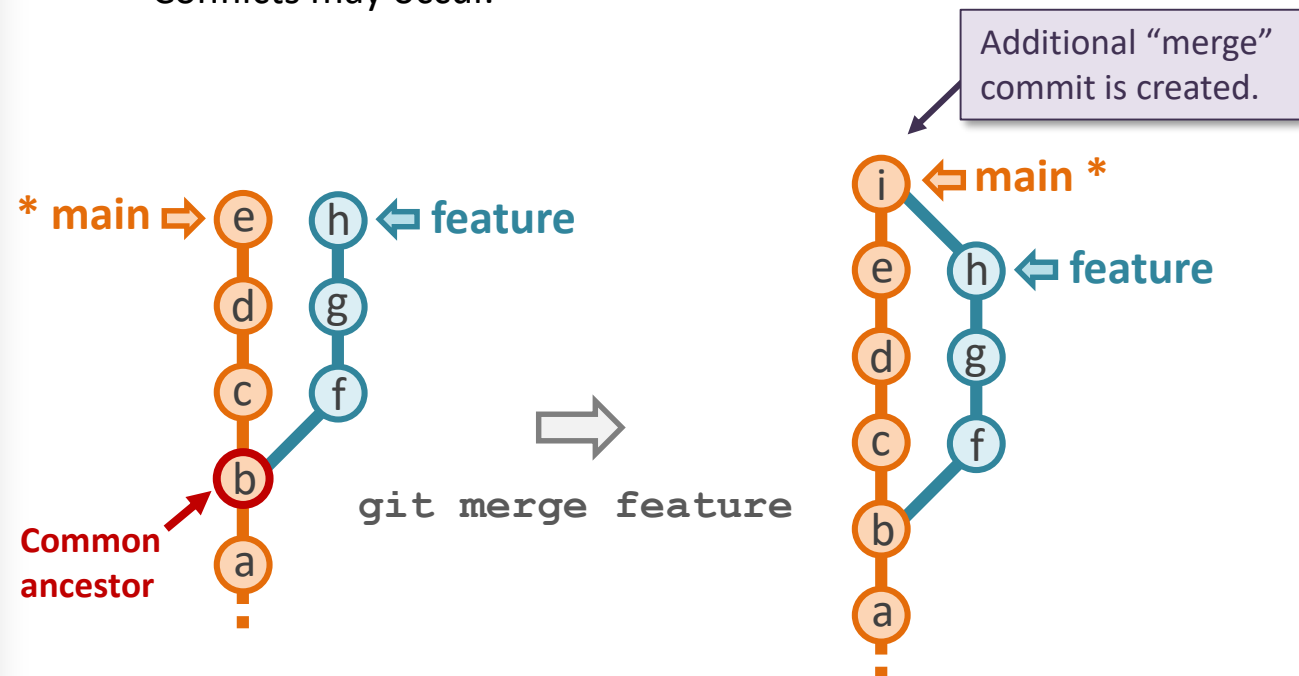
Fast-forward merge

- Guaranteed to be conflict free.



3-way merge (non-fast-forward)

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



* 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".

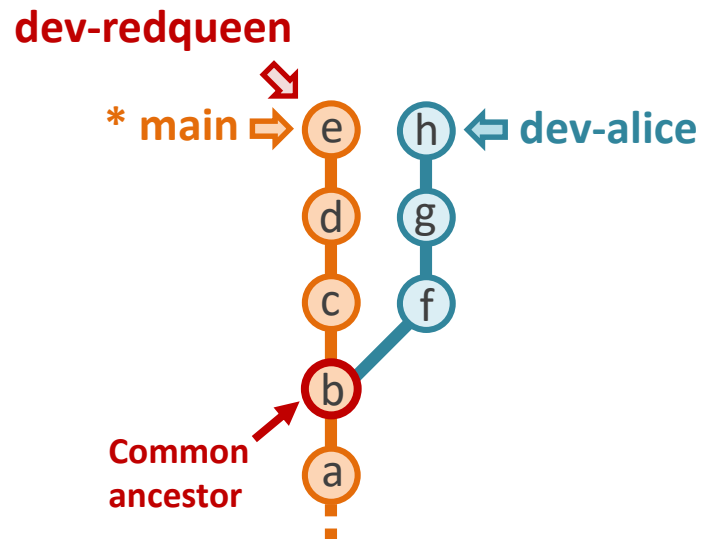
README.md version of **dev-alice** branch.

```
# 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.
```



Let's merge feature 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.
```

← File with conflicts that need to be manually solved.



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 ===== corresponds to the version of the current branch (branch into which you merge).
- The text between ===== and >>>>>> corresponds to the version from the branch you from which you insert changes.

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

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

← File with conflicts



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, you can 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
```

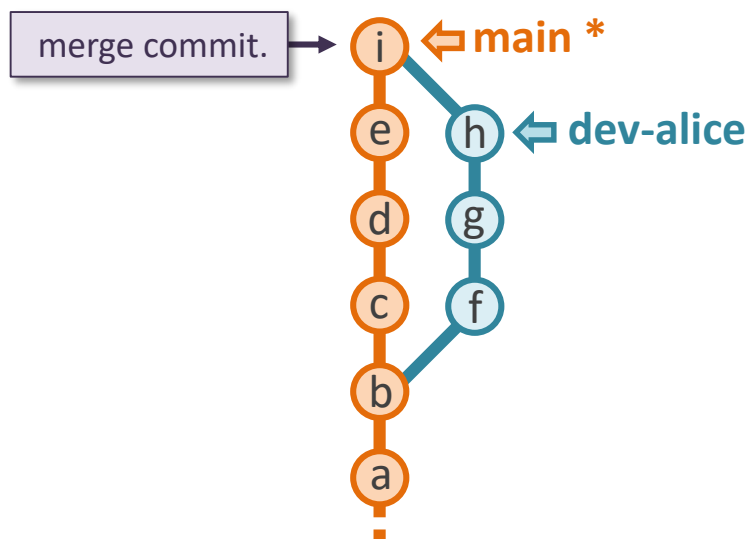
Git tells you what to do and reminds you of commands.

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).

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



```
$ 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'
```

```
$ git show HEAD
commit a317d38448dae4e6bd9b4862dcacccf4e416cc46c (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: branch merging

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

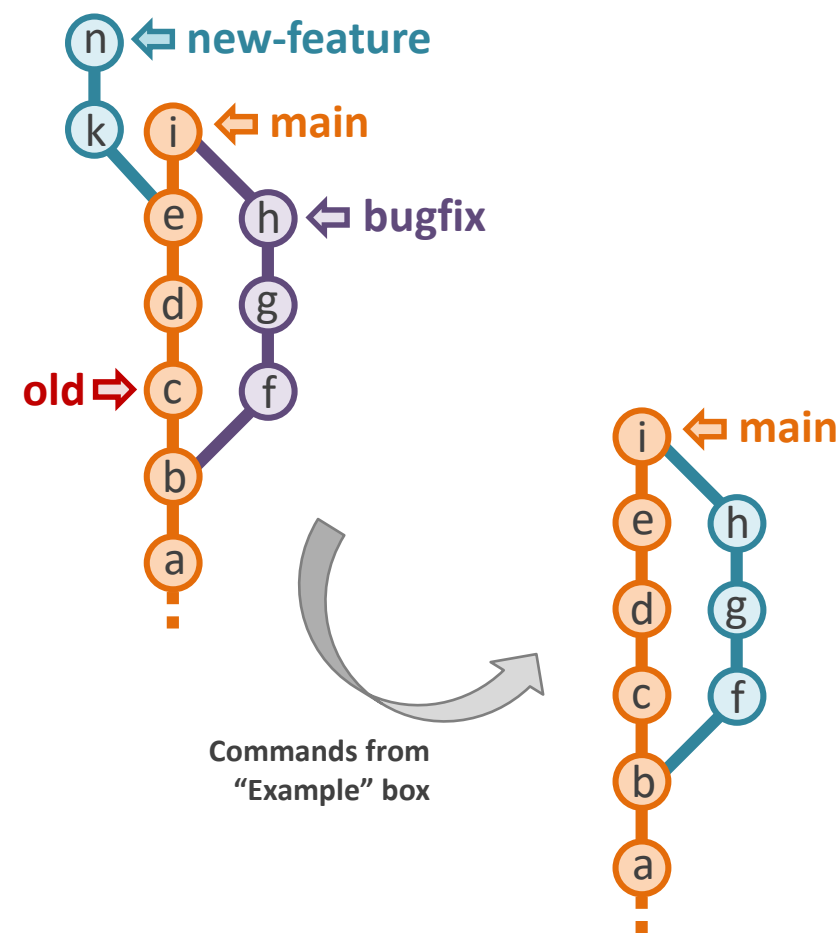
```
# The 'bugfix' and 'old' branches are fully merged.
$ git branch -d bugfix
Deleted branch bugfix (was bd898dc)
$ git branch -d old
Deleted branch old (was 75d3fed)

# 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'.

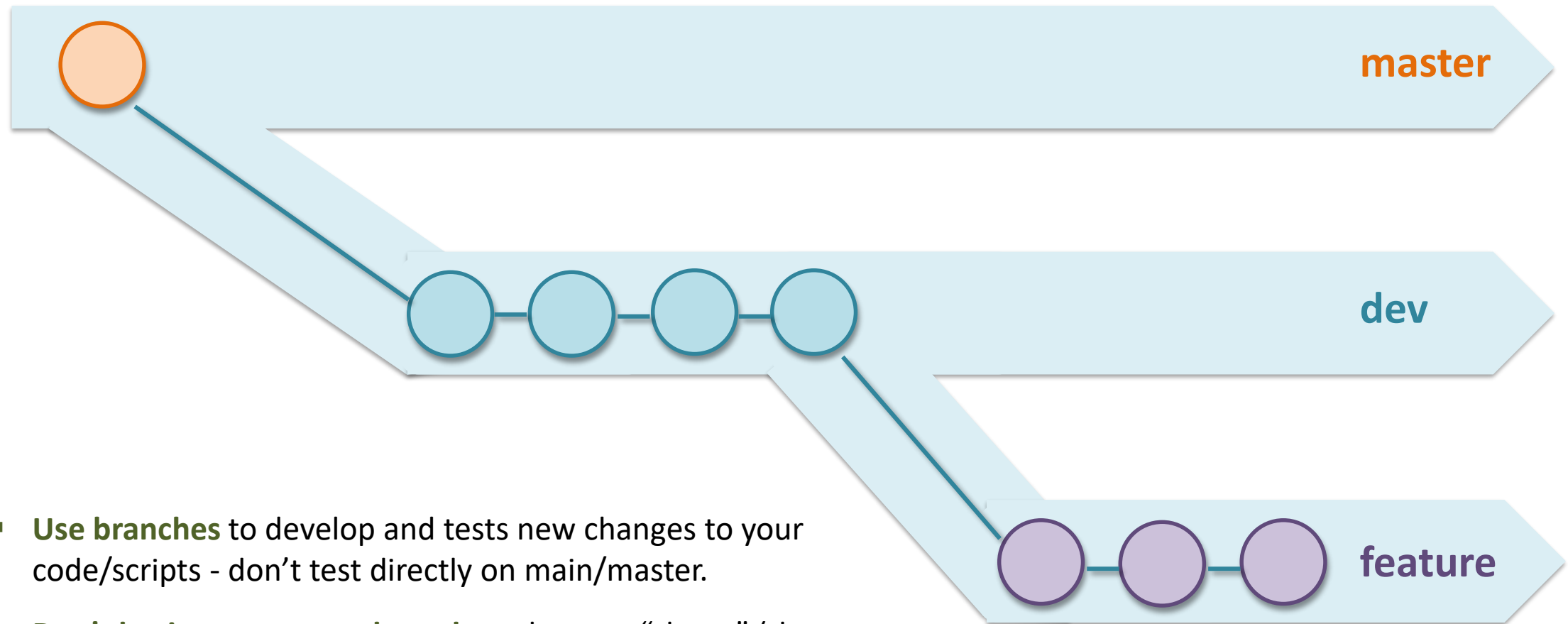
# Using -D will allow deletion of a non-merged branch:
$ git branch -D new-feature
Deleted branch new-feature (was f2a898b)
```

Deleted a branch by mistake ?

This hash can be used to re-create it *: **git branch f2a898b**



Branch management: best practices



- **Use branches** to develop and tests new changes to your code/scripts - don't test directly on main/master.
- **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/master branch** if your project is used by others.



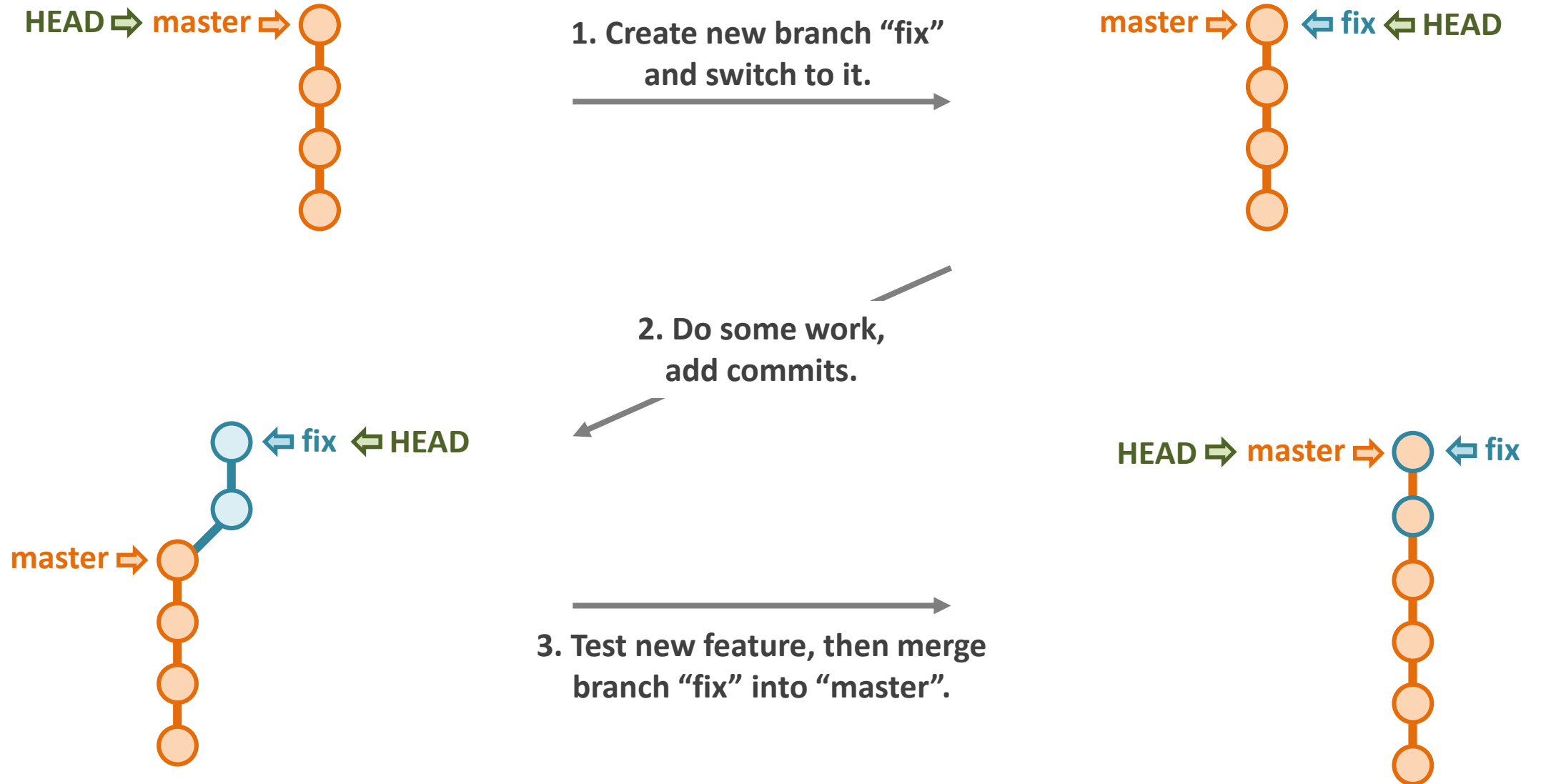
exercise 2

The Git reference webpage



This exercise has helper slides

Exercise 2 help: workflow example



git rebase

make a linear history

git rebase: replay commits onto a different base

- `git rebase` allows to "move"/"re-root" a branch to a different base commit.
- **Important:** it 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
```

```
master
```



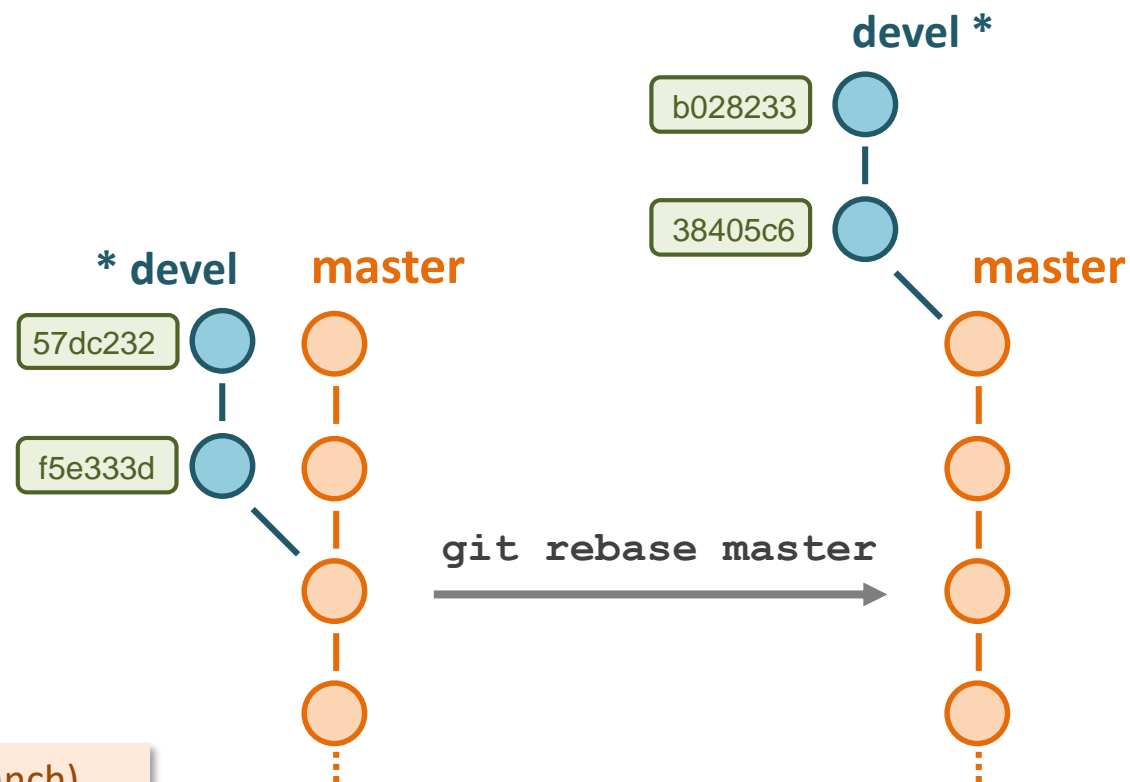
Make sure you are on the
branch you want to rebase !

```
$ git rebase master
```

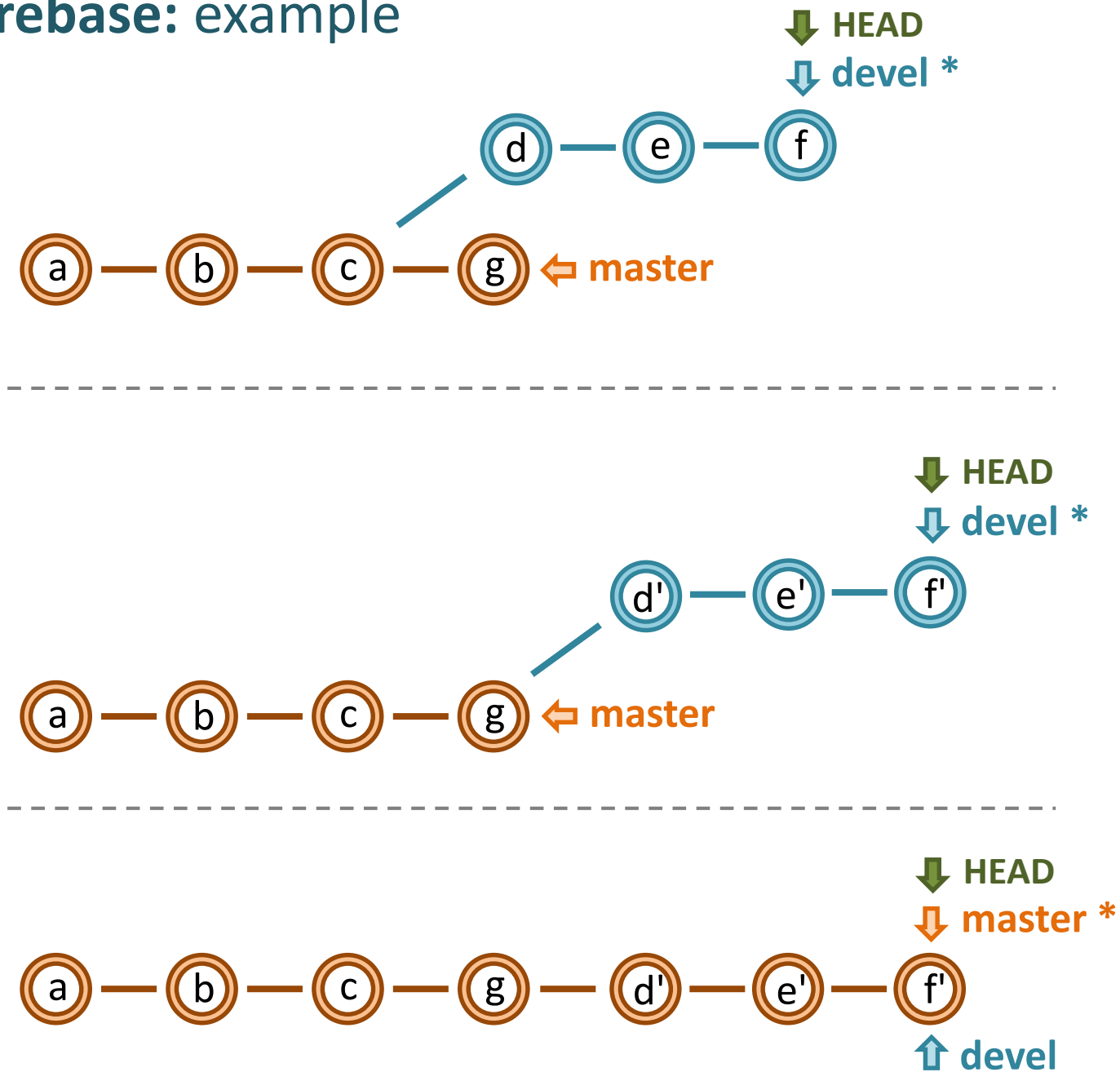
The branch you want to
rebase on.



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: make sure you are on the branch to rebase!

`git branch`

If not on `devel`: `git switch devel`

`git rebase master`

We can now fast-forward merge !
Guaranteed to be conflict free :-)

`git switch master`
`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:

1. **Edit the conflicting files**, choose the parts you want and 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 master
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

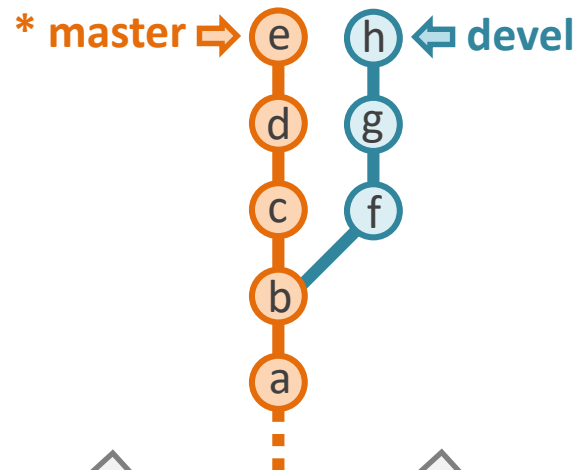
1. → Resolve all conflicts manually,
2. → mark them as resolved with "git add/rm <conflicted_files>"
3. → , then run "git rebase --continue".

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

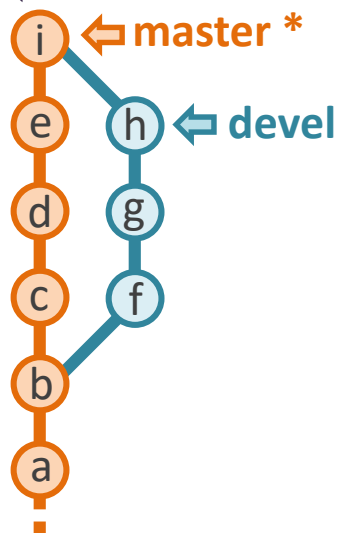


rebase + fast-forward merge

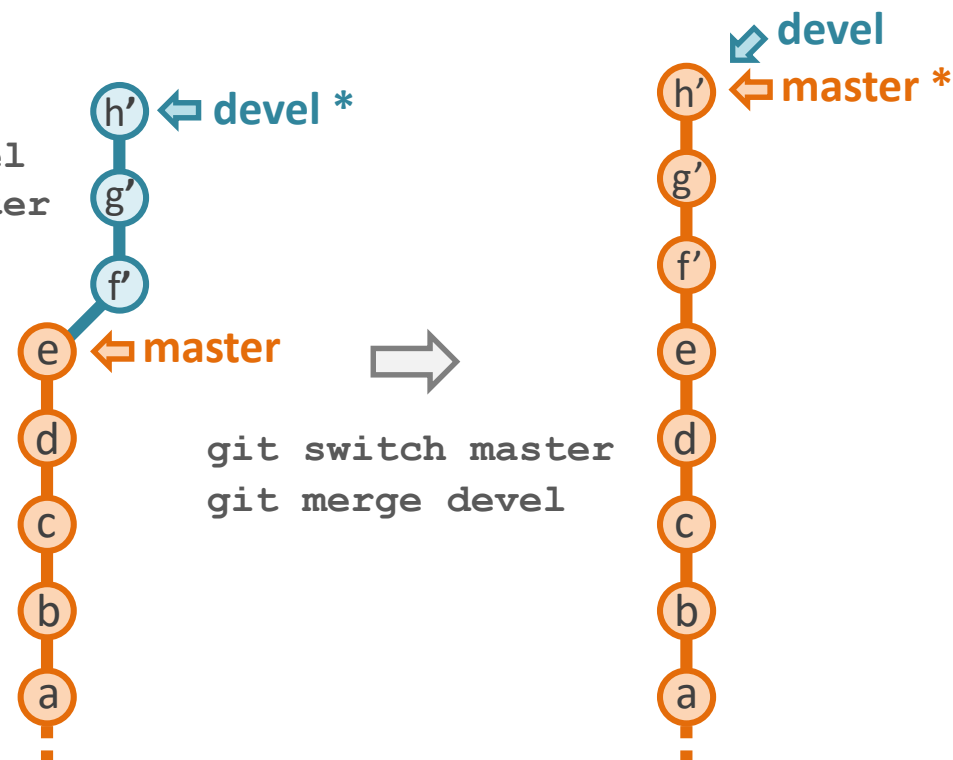
- + Cleaner history = easier to read and navigate.
 - Conflicts may have to be solved multiple times.
 - Loss of branching history.
- History of rebased branch is rewritten, not a problem in general.

Additional "merge branch devel" commit.

git merge devel



git switch devel
git rebase master



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`

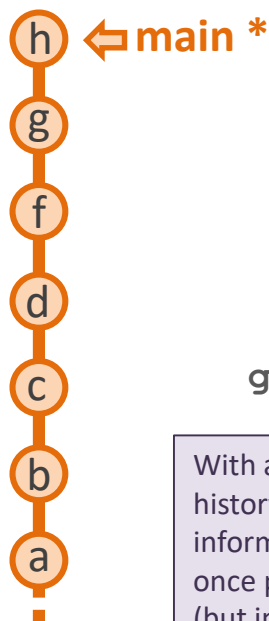
If keeping an **exact record** of how the history of a Git repo came into existence is of prime importance, some people like to **add a merge commit even if a fast-forward merge is possible**.

This is possible by adding the `--no-ff` option (“no fast-forward”) to git merge.

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

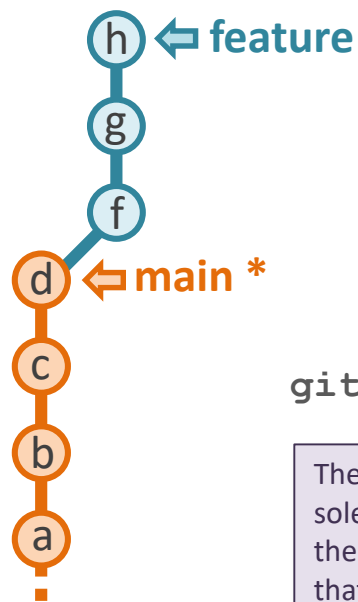
```
$ git show 10fa3ad
commit 10fa3ad505821b0ea628b8
Merge: 7446b3e b4fb462
Author: Alice <alice@redqueen.org>
Date: Tue Oct 11 15:16:39 2022 +0200
```

Merge branch 'feature'



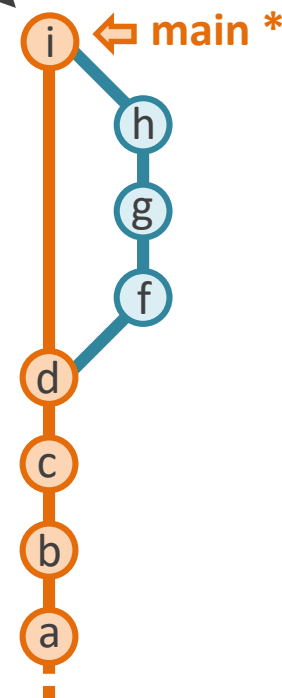
`git merge feature`

With a regular fast-forward merge, the history is cleaner. However, the information that “f”, “g” and “h” were once part of a branch “feature” 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”.



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
```




```
/*
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
* 925cfc73a7 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
* 1c52b44bf3 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: branch rebase

feat. manual conflict resolution

git cherry-pick

the "copy/paste" for commits

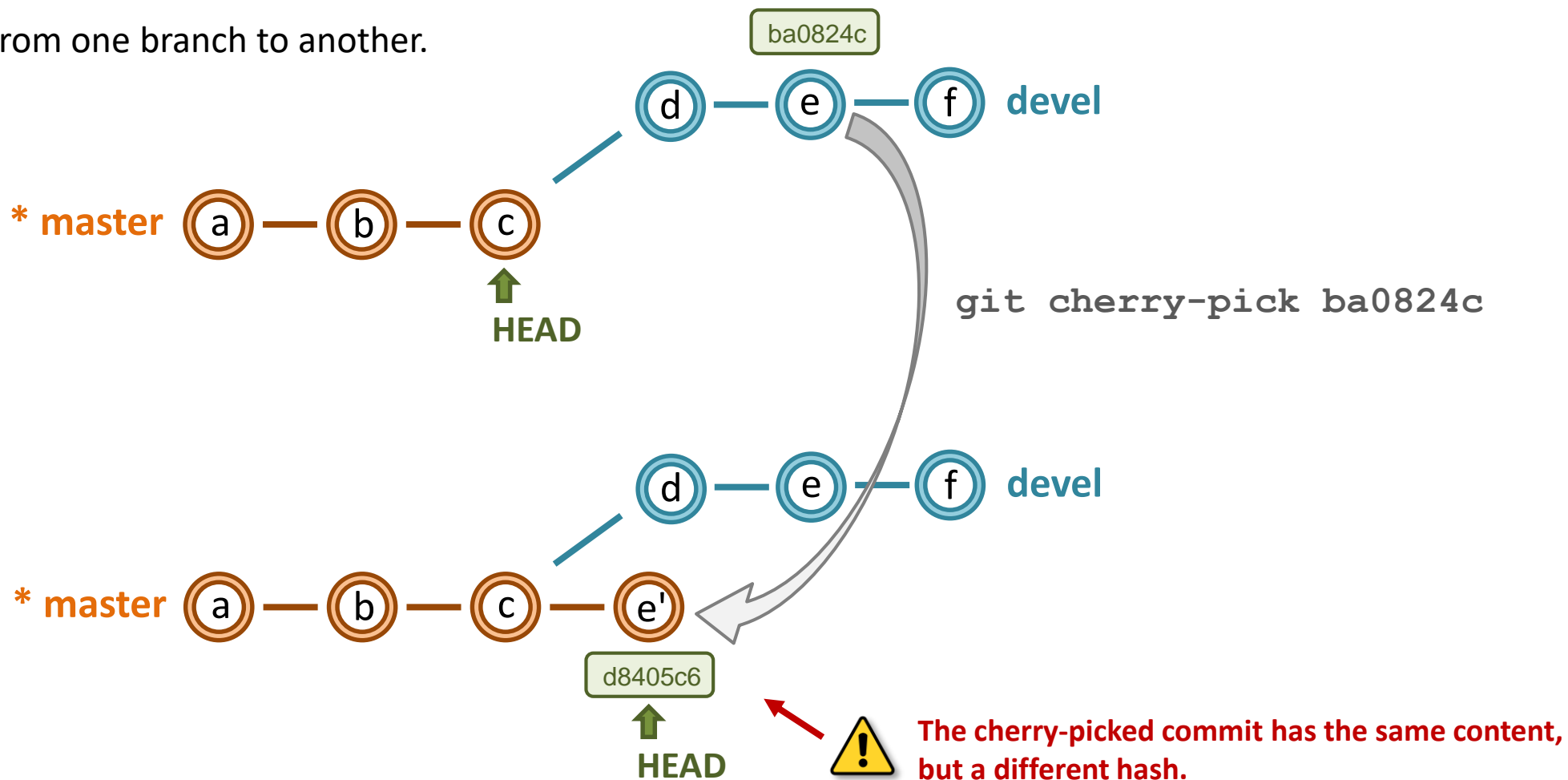
Cherry-pick: merge a single commit into the current branch

- `git cherry-pick` allows to "copy" a single commit to the current branch.

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

Example:

"copy" a fix from one branch to another.



git restore / checkout

retrieving data from earlier commits

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 directory.

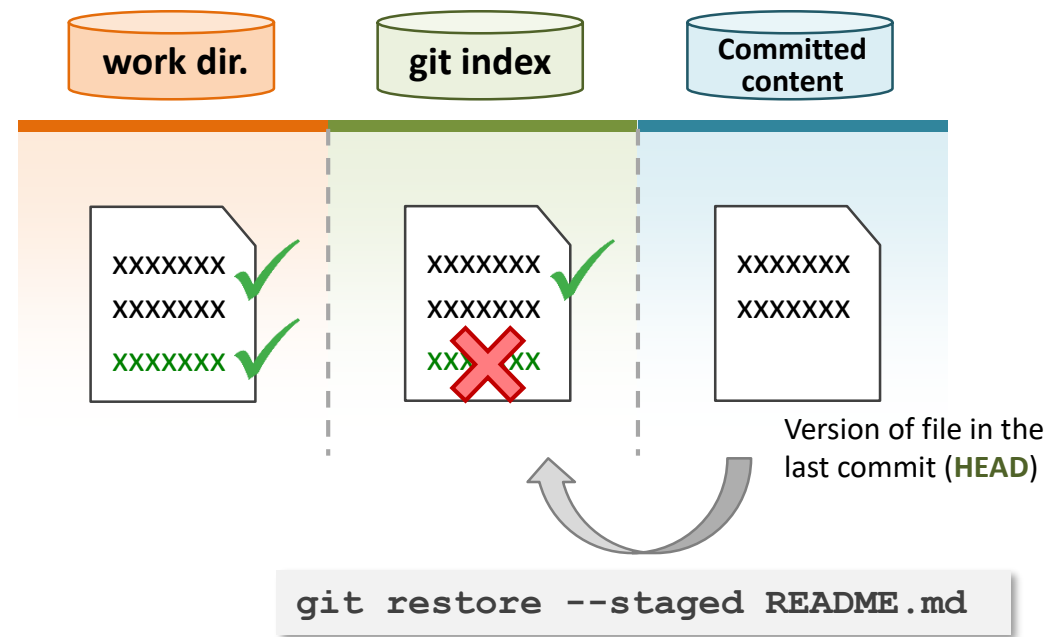
Example: un-stage changes to README.md file.

```
$ 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
```

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:

Warning: these commands will overwrite existing versions of the retrieved file in your working directory. Make sure you don't have uncommitted changes you want to keep.



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

or



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

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

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.

exercise 3

The crazy peak sorter script



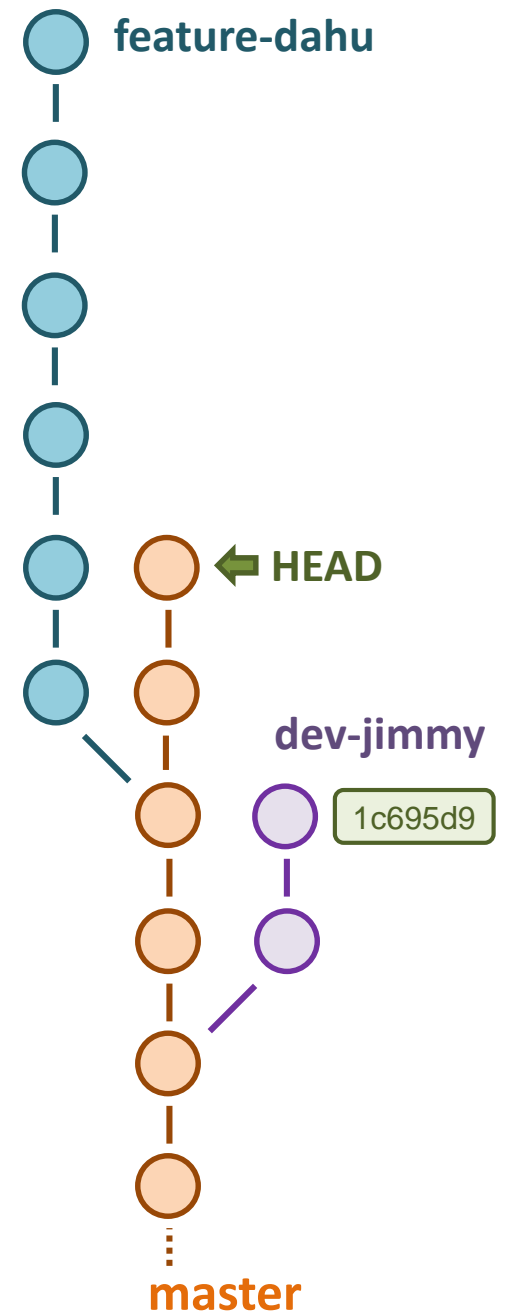
This exercise has helper slides

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
```



Working with **remotes**

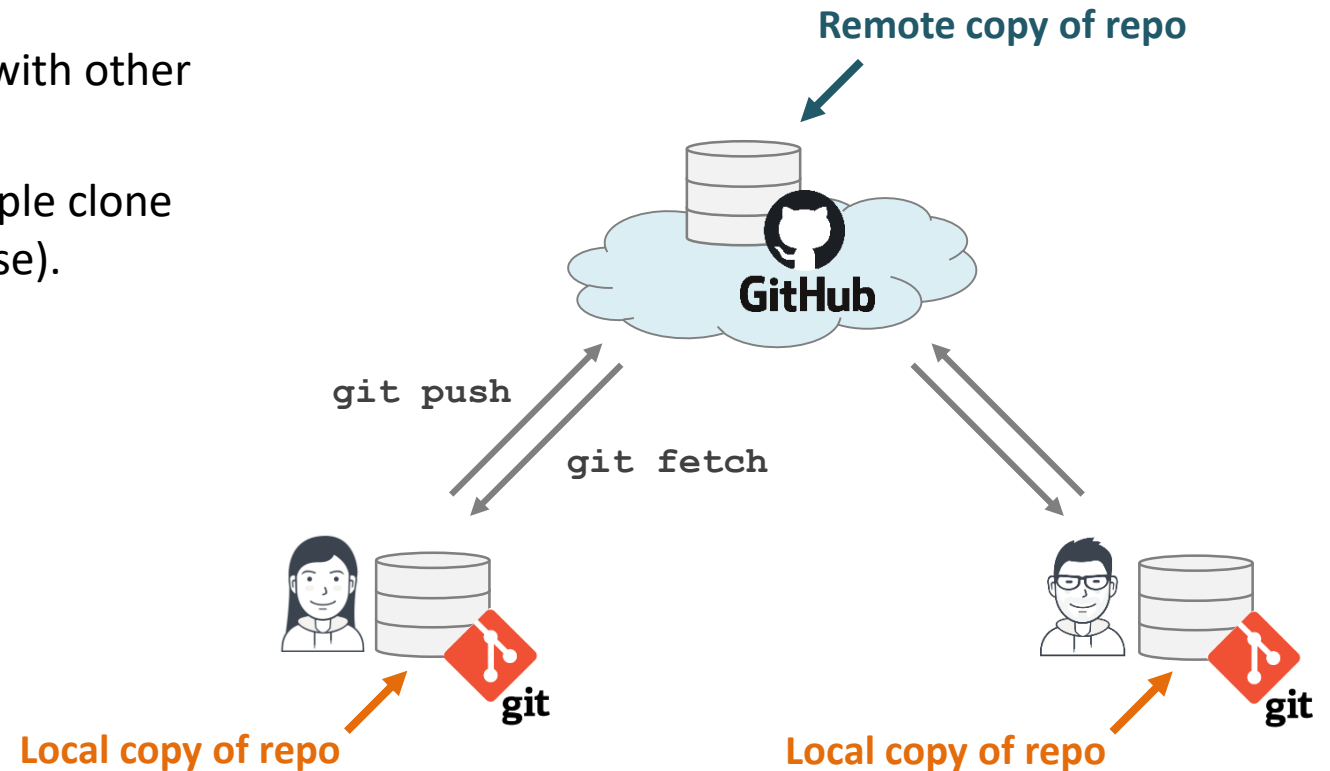
Linking your local repo with an online server

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**/copy of 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).



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:
```

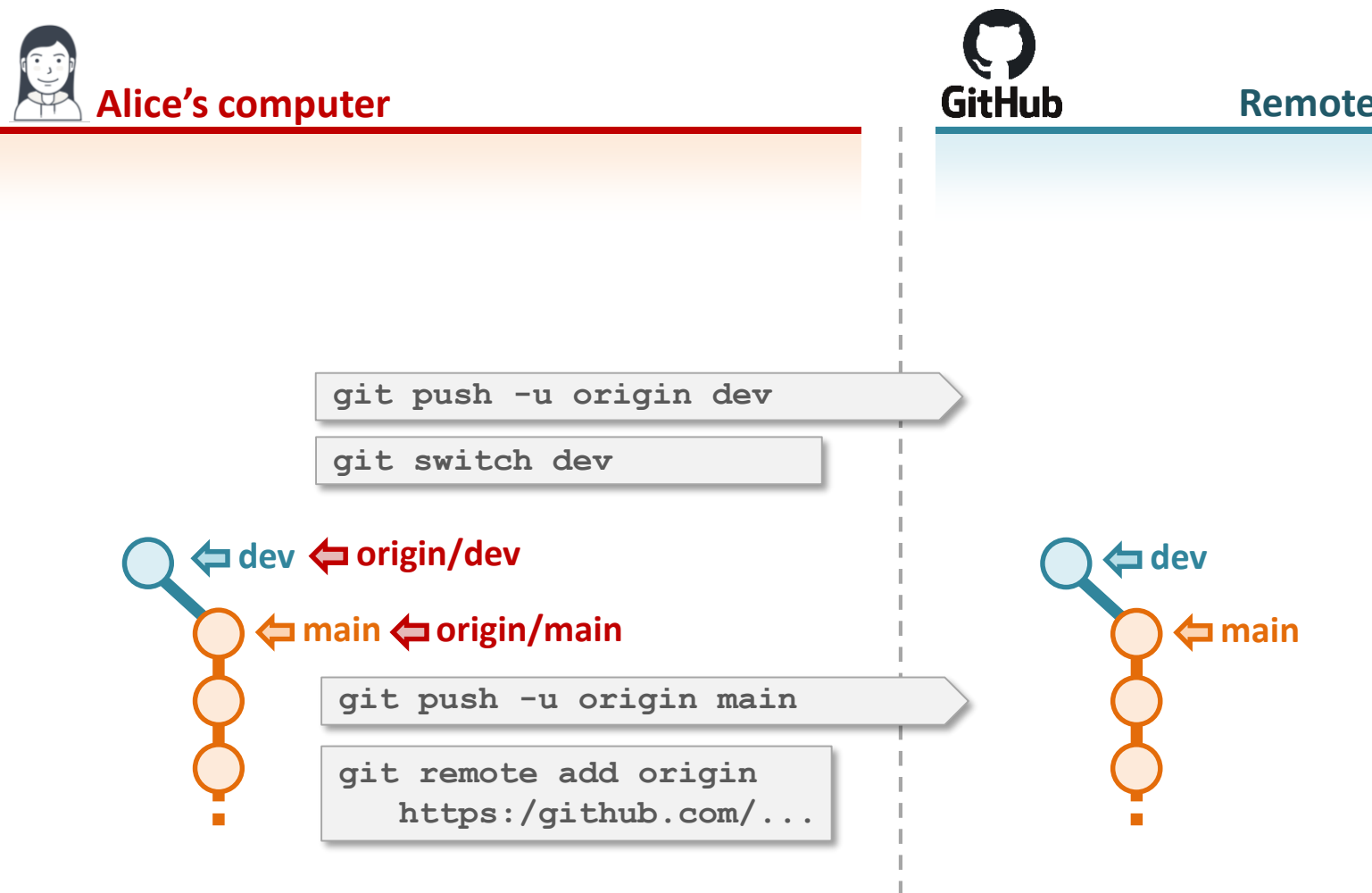
```
$ git remote add origin https://github.com/sibgit/test.git
```

```
# 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
```

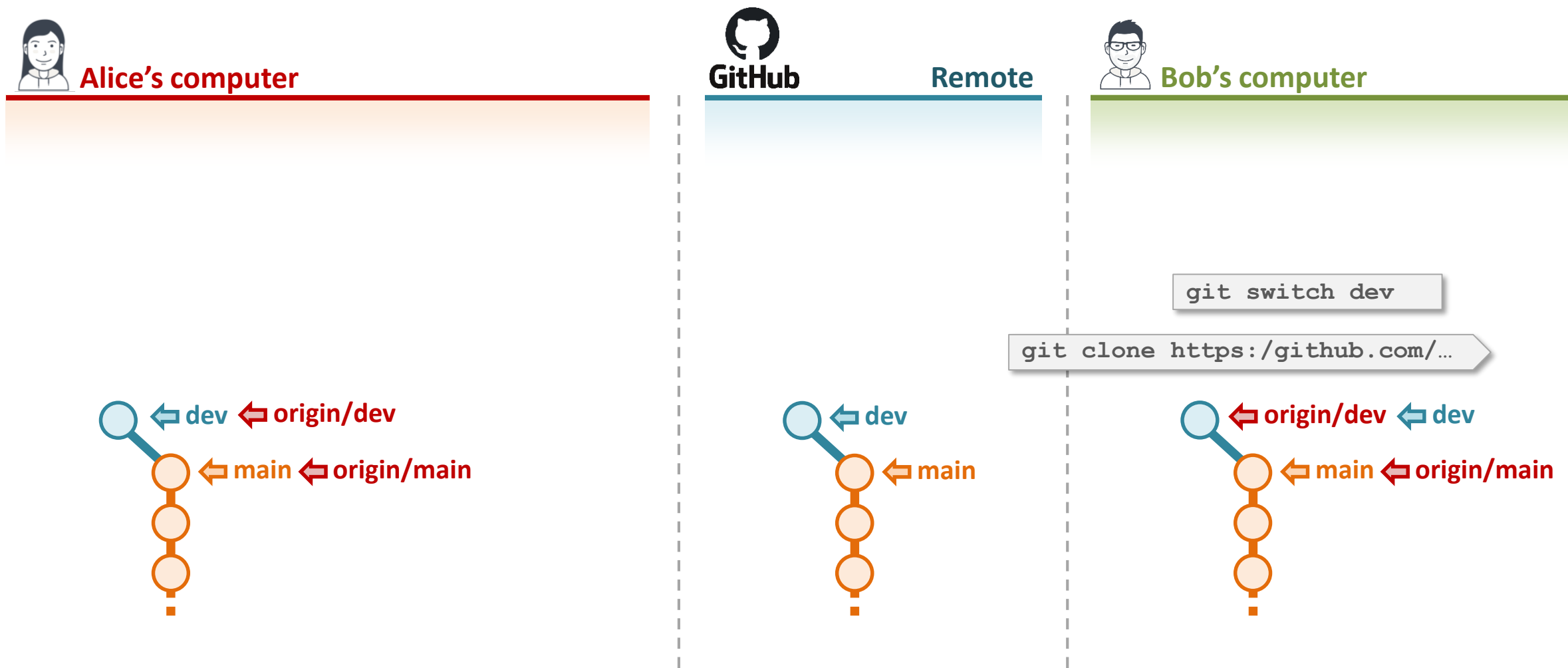

Example – part 1: creating a new remote and pushing new branches



Alice 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`.
2. She pushes her branch **main** to the remote using `git push -u origin main` (the branch has no upstream, so the `-u/--set-upstream` option must be used).
3. She pushes her branch **dev** to the remote (**important:** you must switch-to/checkout the branch before pushing).

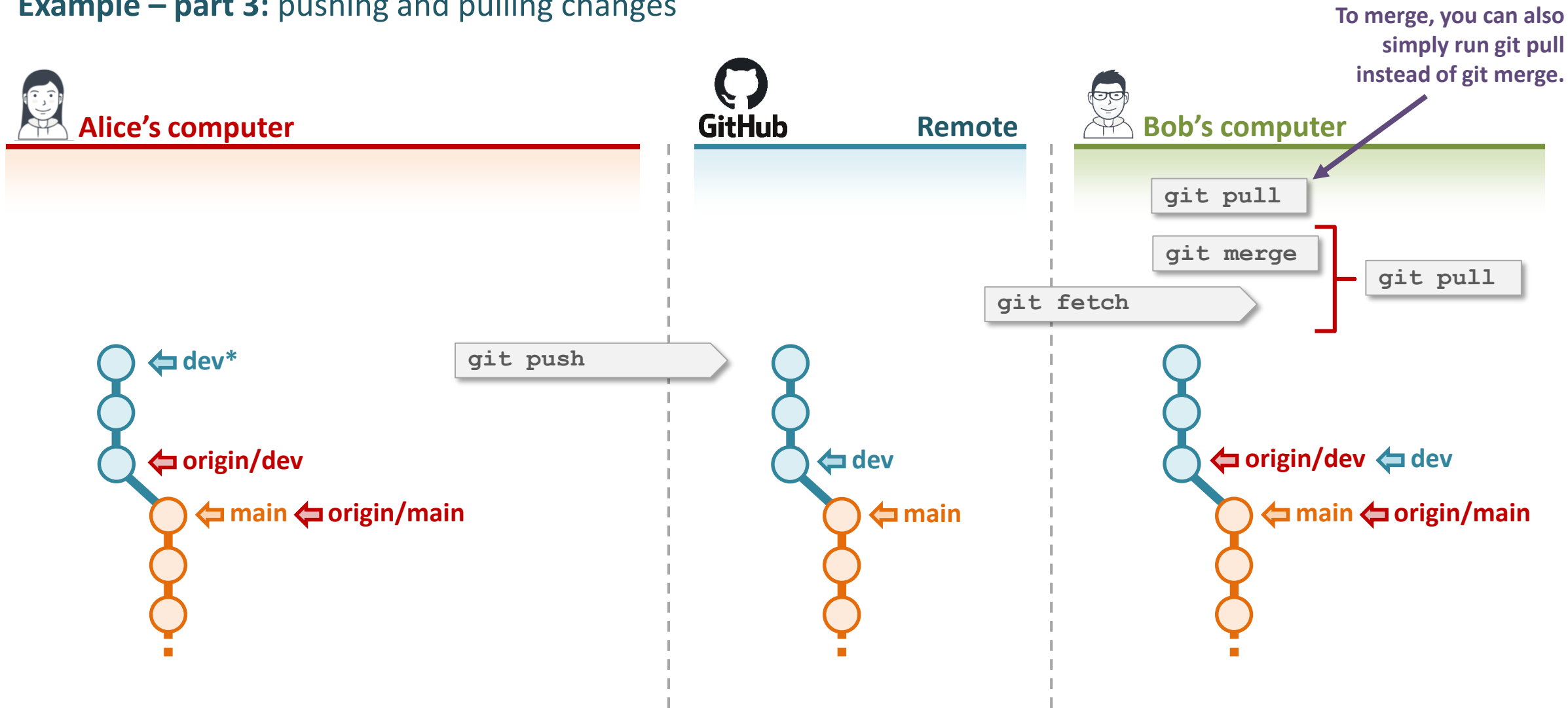
Example – part 2: cloning a remote and checking-out branches



Bob has now joined the team to work with Alice.

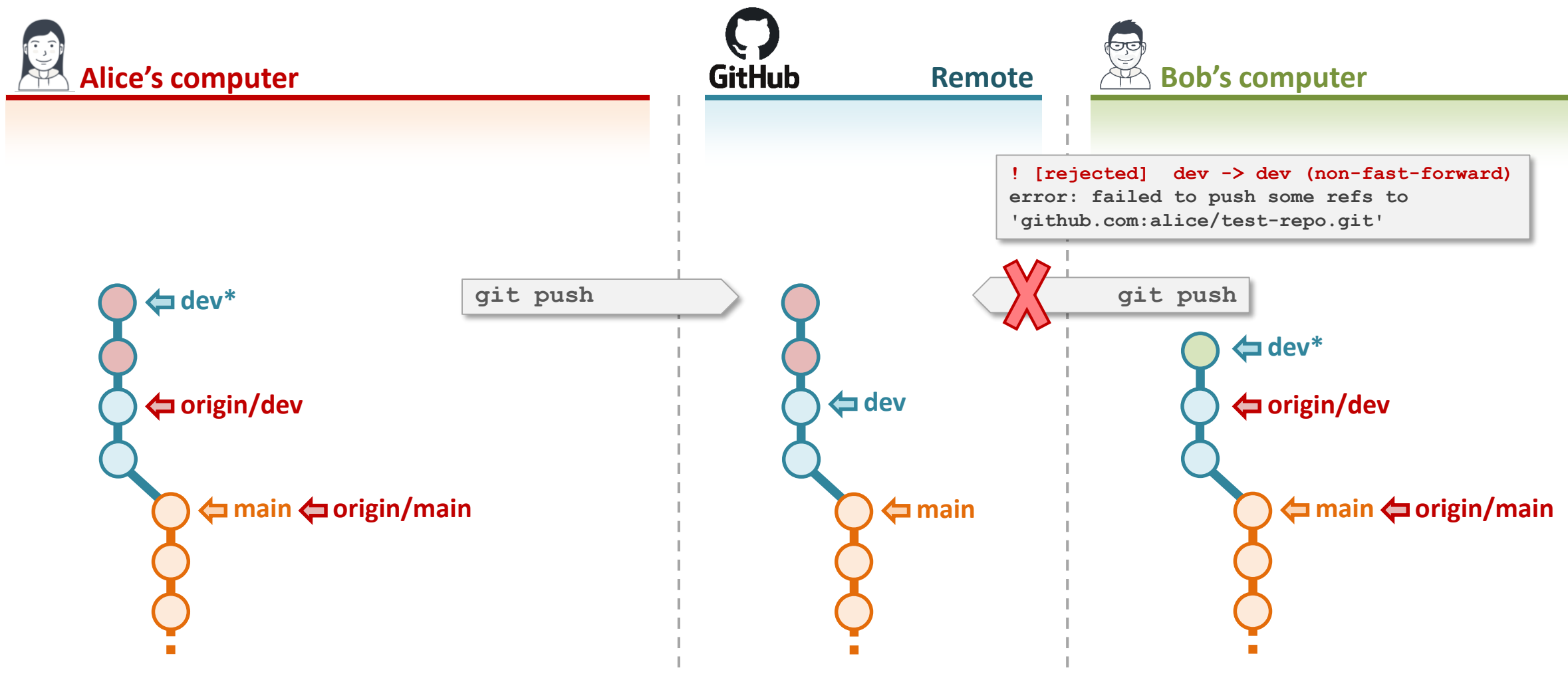
1. He **clones** the repo from GitHub (note: at this point, Bob has no local **dev** branch - but he has a pointer to **origin/dev**).
2. Bob checks-out the **dev** branch to work on it. Because there is already a remote branch **origin/dev** present, Git automatically creates a new local branch **dev**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

Example – part 3: pushing and pulling changes



1. Alice added 2 new commits to `dev`. She then 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).
2. To get Alice's updates from the remote, Bob runs `git pull` - which is a combination of `git fetch` + `git merge`.
Important: `git fetch` download all new changes/updates from the remote, but does not modify your local branches.

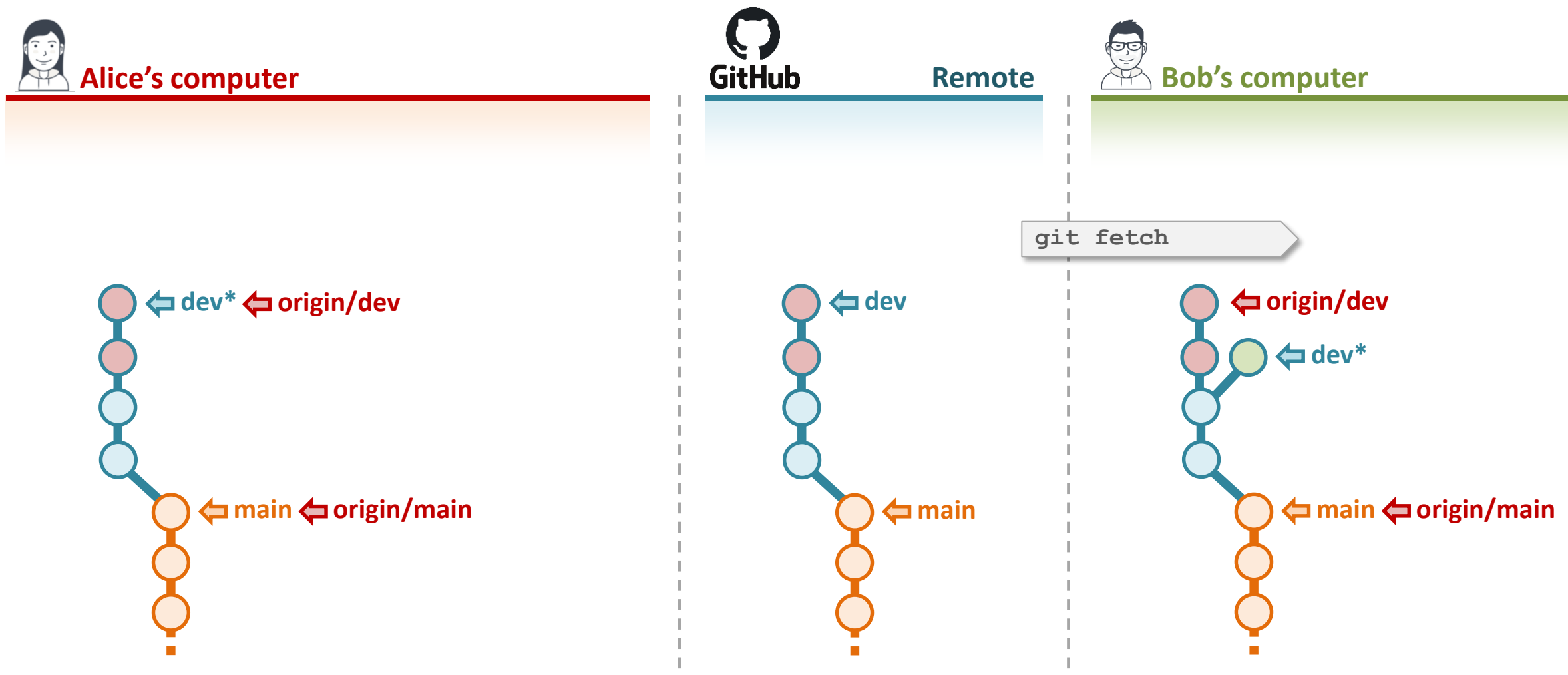
Example – part 4: reconciliation of a diverging history



Both Alice and Bob have now 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)

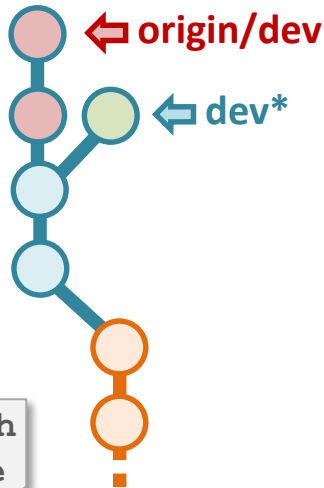


In order to be able to push his changes to the remote, Bob must first reconcile his local `dev` branch with the remote...

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).

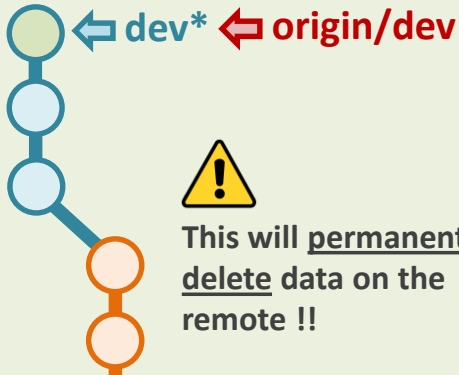
Example – part 4: reconciliation of a diverging history (continued)

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



`git push --force`

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



This will permanently delete data on the remote !!

Option 1 - reconciliation using **merge**.

This is equivalent to:

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

`git pull --no-rebase`

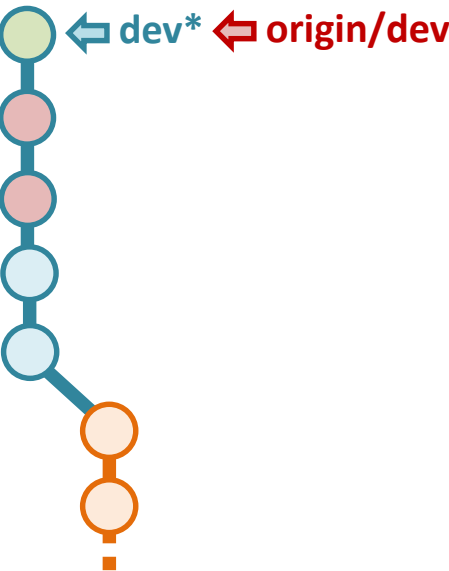
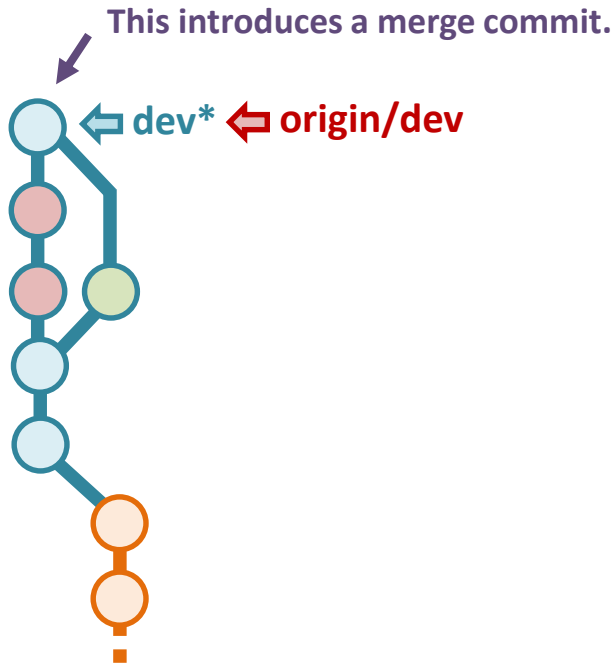
`git pull --rebase`

Option 2 - reconciliation using **rebase**.

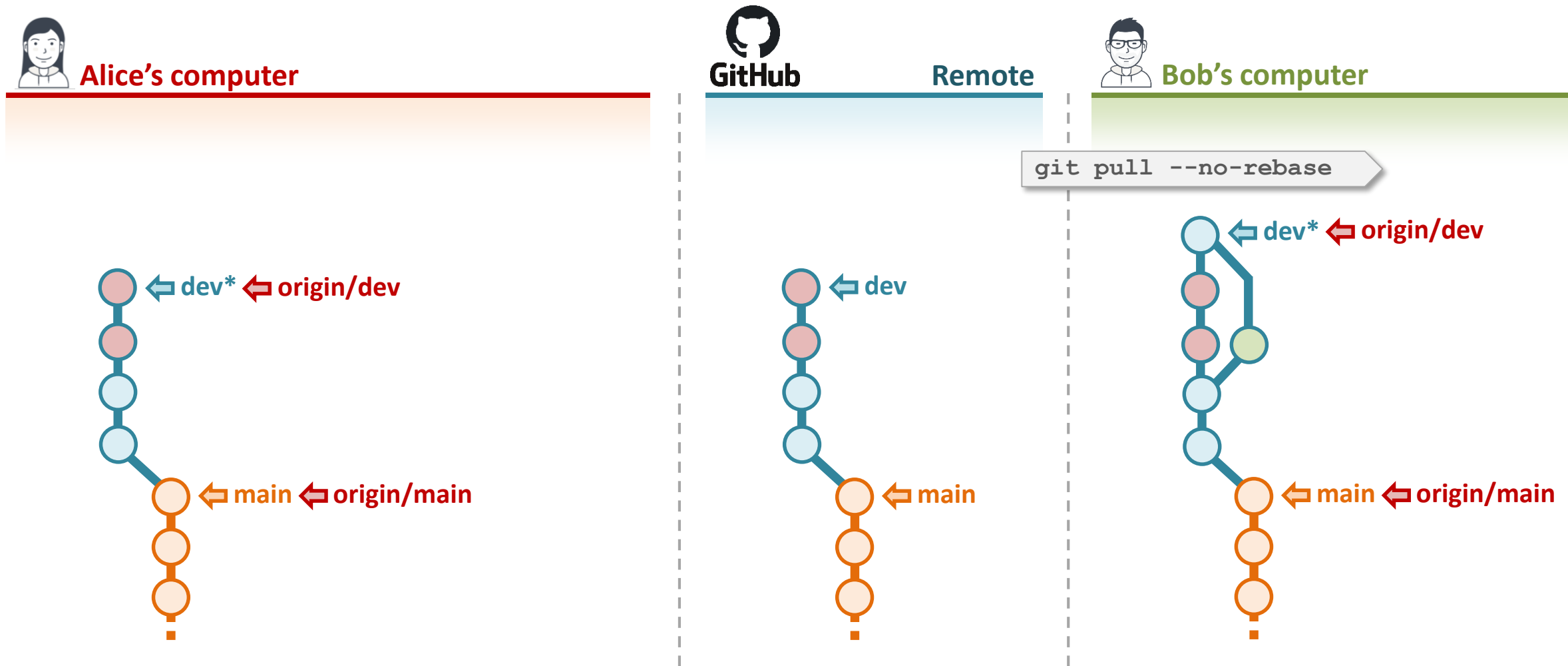
This is equivalent to:

```
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** from/on **origin/dev**.



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



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

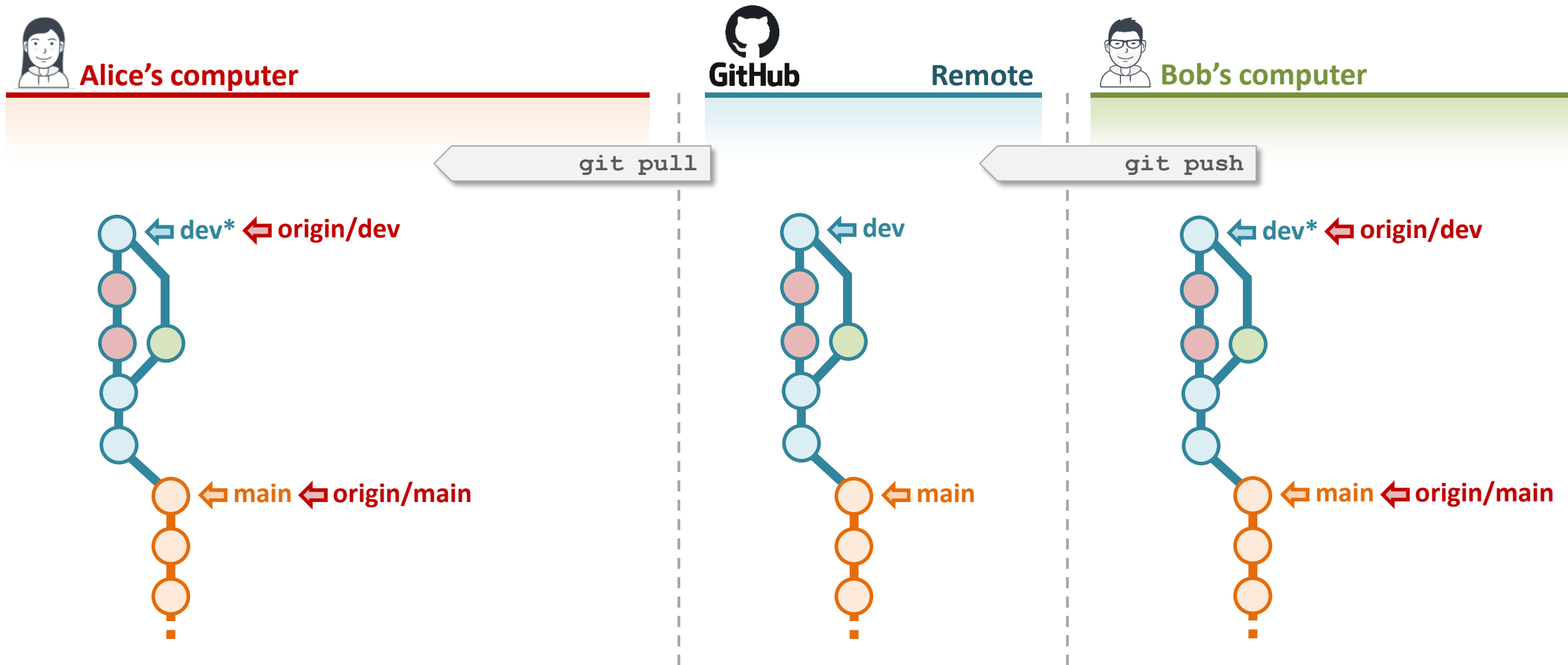
Note: depending on the version of Git, the default behavior of `git pull` is different:

- 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
```

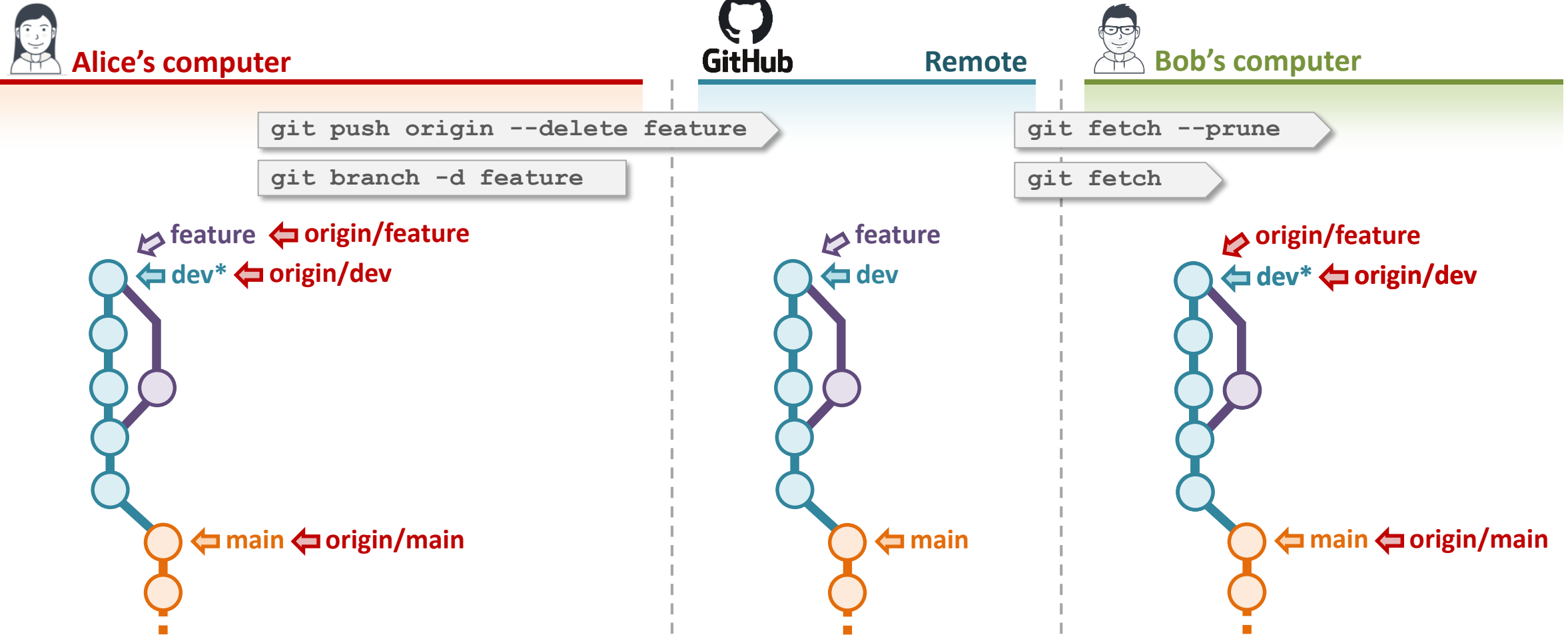

Example – part 4: reconciliation of a diverging history (the end!)



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

Alice can then `git pull` them.

Example – part 5: deleting branches on the remote



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 feature`.
2. Alice deletes the feature branch on the remote with `git push origin --delete feature`.
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`.

GitHub

collaborate and share your work

GitHub – an online home for your Git repos

- GitHub [github.com] is a hosting platform for Git repositories.
- 73+ million users, 200+ million repositories (as of 2022).
- 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:
 - **GitLab** [gitlab.com], which can also be installed as a local instance: e.g. gitlab.sib.swiss.
 - **BitBucket** [bitbucket.org].

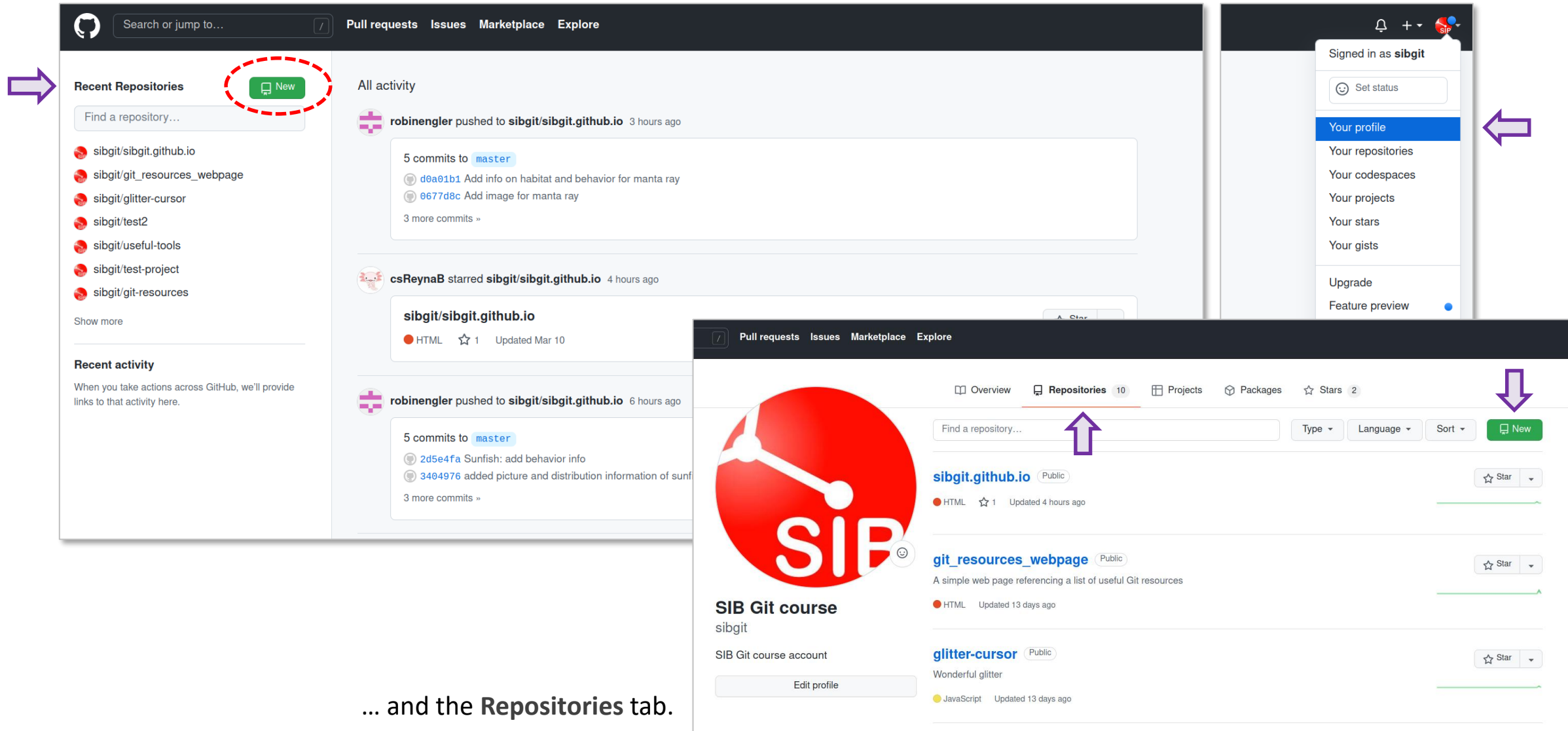


Creating a new project on GitHub

To create a new repo, click on 

... or click on your user icon (top right), then **Your profile** ...

Either on the welcome screen at <https://github.com> (after signing-in)...



The image shows two screenshots of the GitHub interface. The left screenshot shows the GitHub homepage with the 'New' button highlighted in the 'Recent Repositories' section. The right screenshot shows the user profile dropdown menu with 'Your profile' selected. Below these, a third screenshot shows the 'Repositories' tab of a user profile, with the 'New' button highlighted in the top right corner.

Recent Repositories

- [sibgit/sibgit.github.io](#)
- [sibgit/git_resources_webpage](#)
- [sibgit/glitter-cursor](#)
- [sibgit/test2](#)
- [sibgit/useful-tools](#)
- [sibgit/test-project](#)
- [sibgit/git-resources](#)

Recent activity

When you take actions across GitHub, we'll provide links to that activity here.

All activity

- [robinengler](#) pushed to [sibgit/sibgit.github.io](#) 3 hours ago
- 5 commits to [master](#)
- [d0a01b1](#) Add info on habitat and behavior for manta ray
- [0677d8c](#) Add image for manta ray
- 3 more commits »

- [csReynaB](#) starred [sibgit/sibgit.github.io](#) 4 hours ago
- [sibgit/sibgit.github.io](#)
- HTML ☆ 1 Updated Mar 10
- [robinengler](#) pushed to [sibgit/sibgit.github.io](#) 6 hours ago
- 5 commits to [master](#)
- [2d5e4fa](#) Sunfish: add behavior info
- [3404976](#) added picture and distribution information of sunfish
- 3 more commits »

SIB Git course

sibgit

SIB Git course account

Edit profile

Overview Repositories 10 Projects Packages Stars 2

Find a repository...

Type Language Sort New

- [sibgit.github.io](#) (Public)
- HTML ☆ 1 Updated 4 hours ago

- [git_resources_webpage](#) (Public)
- A simple web page referencing a list of useful Git resources
- HTML Updated 13 days ago

- [glitter-cursor](#) (Public)
- Wonderful glitter
- JavaScript Updated 13 days ago


... and the **Repositories** tab.

Create a new repository

A repository contains all project files, including the revision history. Already have a project repository elsewhere?
[Import a repository.](#)

Owner *



Repository name *

 sibgit / my-new-project ✓

Great repository names are short and memorable. Need inspiration? How about **super-duper-guacamole**?

Description (optional)

A first test project on GitHub

- ☒  **Public**
Anyone on the internet can see this repository. You choose who can commit.
- ☐  **Private**
You choose who can see and commit to this repository.

Initialize this repository with:

Skip this step if you're importing an existing repository.

- ☐ **Add a README file**
This is where you can write a long description for your project. [Learn more.](#)
- ☐ **Add .gitignore**
Choose which files not to track from a list of templates. [Learn more.](#)
- ☐ **Choose a license**
A license tells others what they can and can't do with your code. [Learn more.](#)

Create repository

← Enter a **name** for your new repository.

← Project **description**.

← Select whether your repo should be:

- **Public** - anyone can access it (read from it).
- **Private** - only people you authorize.

Note: even if a repo is public, only authorized members can push changes to it.

← Pre-fill the repository with some files (don't do this if you already have a local repo you want to push):

- **README** – A text file that is displayed on the homepage of your repo (with markdown rendering).
- A **.gitignore** file selected from a list of templates.
- A **license** file selected from a set of standard licenses (e.g. GPL, MIT, ...).

← Click **Create repository**.

The **home page** of an empty repository provides instructions to get started...

<> Code Issues Pull requests Actions Projects Wiki Security Insights Settings

Quick setup — if you've done this kind of thing before

Set up in Desktop or HTTPS SSH

Get started by [creating a new file](#) or [uploading an existing file](#). We recommend every repository include a [README](#), [LICENSE](#), and [.gitignore](#).

...or create a new repository on the command line

```
echo "# test-project" >> README.md
git init
git add README.md
git commit -m "first commit"
git branch -M main
git remote add origin https://github.com/sibgit/test-project.git
git push -u origin main
```

← Add remote to your local repo.

← Push a branch (here "main") to the remote.

...or push an existing repository from the command line

```
git remote add origin https://github.com/sibgit/test-project.git
git branch -M main
git push -u origin main
```

← Same commands as above...



When at least 1 file is present in the repo, the **home page** of your Git repo looks like this:

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).

The screenshot shows the GitHub interface for a repository named 'sibgit/test'. The 'Code' tab is selected, which is the 'home' page of the repository. The current branch is 'master', and there are 2 branches and 0 tags. A list of files is shown, including 'README.md'. The 'README.md' file is displayed with its content, which includes a heading 'Test' and two paragraphs. A callout box highlights the 'Code' button and the 'Clone' section, which contains the repository's URL: 'https://github.com/sibgit/test.git'. A note indicates that this URL can be copied to clone the repository.

Search or jump to... Pull requests Issues Marketplace Explore

sibgit / test Public

Pin Unwatch 2 Fork 0 Star 0

<> Code Issues 1 Pull requests 1 Actions Projects 1 Wiki Security Insights Settings

master 2 branches 0 tags

sibgit Update README.md 08b5c87 on Feb 26, 2020 3 commits 2 years ago

README.md Update README.md

README.md

Test

Here you can see the content of your README.md file.

This is a good place to put a description of your project.

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

Go to file Add file Code

Clone HTTPS SSH GitHub CLI To copy the repo's URL. https://github.com/sibgit/test.git Use Git or checkout with SVN using the web URL. Download ZIP

Cloning a repo: HTTPS vs. SSH

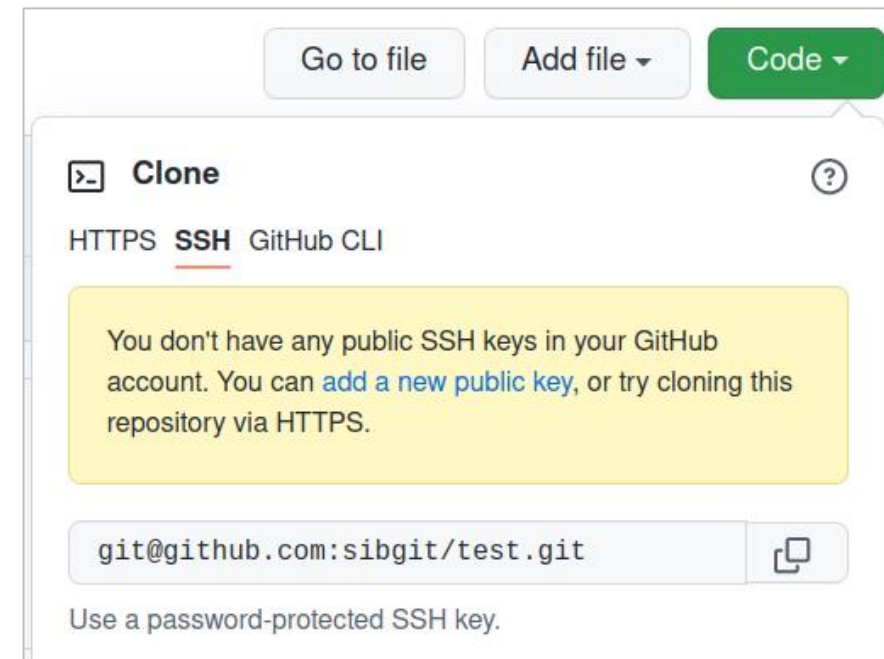
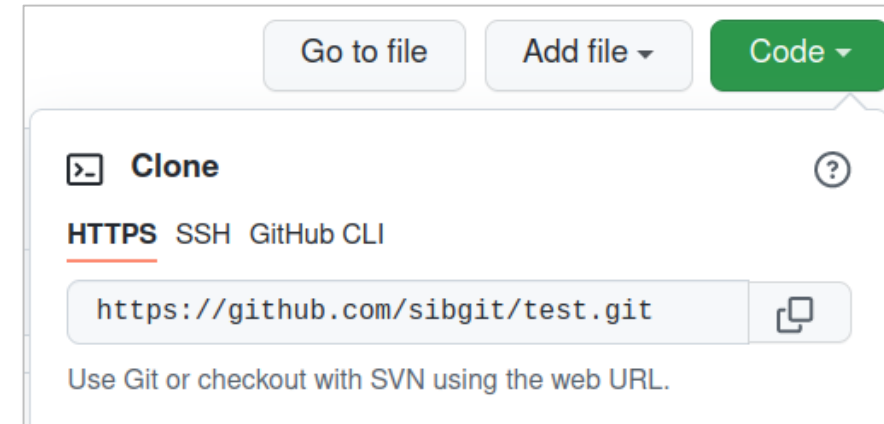
HTTPS and SSH are two different network protocols that machines can use to communicate.

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.
 - Instructions on **how to generate a PAT** can be found in the [helper slides of exercise 4](#).
- **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
```



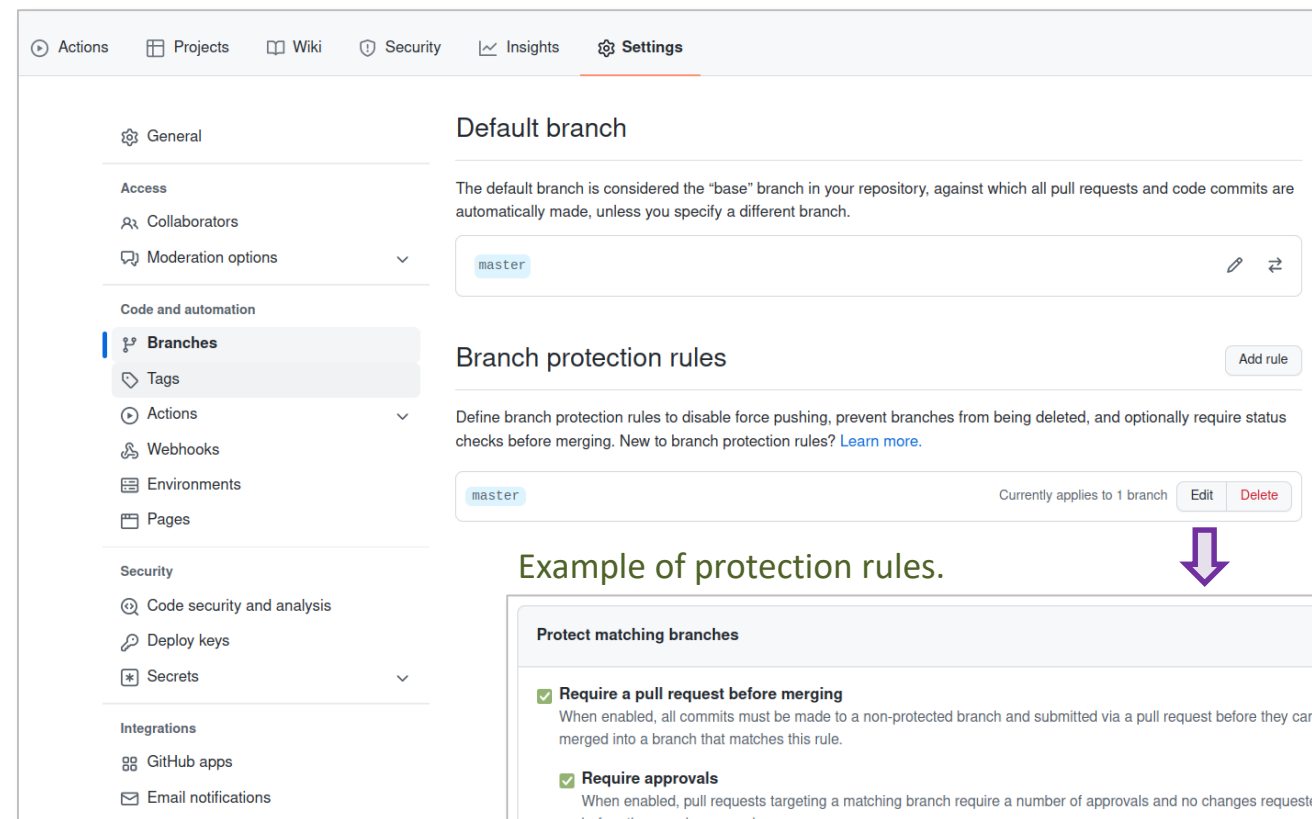
GitHub Pull Requests (PR)

Pull Requests * (PR) are a way to ask someone to integrate your changes (i.e. merge your branch) into another branch.

- PRs perform a branch merge operation on the GitHub remote (rather than on your local copy).
- Typically, a PR is created to merge a feature branch into the main/master branch on the remote.

Why use PRs instead of a local merge (and push)?

- The branch you want to merge into (e.g. main/master) 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.



Example of protection rules.

* On **GitLab**, pull requests are called **Merge Requests** (MR), but it's the exact same thing.

** **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.

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.

The screenshot shows the GitHub interface for the repository `sibgit / sibgit.github.io`. The **Pull requests** tab is selected in the top navigation bar. A purple arrow points to this tab with a callout box that says "Pull requests tab". Below the navigation bar, there is a message from GitHub about labeling issues and pull requests for new contributors, with a "Dismiss" link. A yellow banner indicates that `manta-dev` had recent pushes 8 minutes ago, with a "Compare & pull request" button. Below this, there are filters for "is:pr is:open" and a "New pull request" button. A purple arrow points to this button with a callout box that says "2. Click on New pull request.". The main content area shows "0 Open" pull requests and "25 Closed" pull requests. A purple arrow points to the "0 Open" section with a callout box that says "Pending pull requests will be listed here...". At the bottom, there is a message that says "There aren't any open pull requests." and a link to search all of GitHub or try an advanced search.



3. Select the branches to merge:

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**.

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

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▾

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 ▾



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

Reviewers



sibgit



Assignees



No one—assign yourself

Labels



None yet

Projects



None yet

Milestone



No milestone

Development



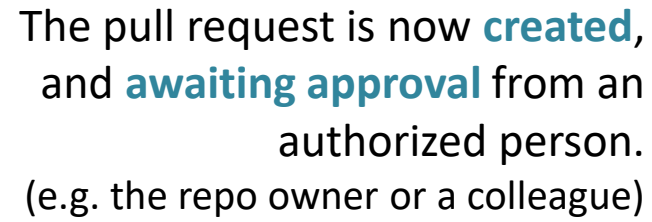
Use [Closing keywords](#) in the description to automatically close issues

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



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





Merging is **blocked**, because someone has to approve your PR. ➡

Pull requests

ActionsProjectsWikiSecurityInsights

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

Collaborator

😊 ...

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 rayd0a01b1

Add image for manta ray0677d8c

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

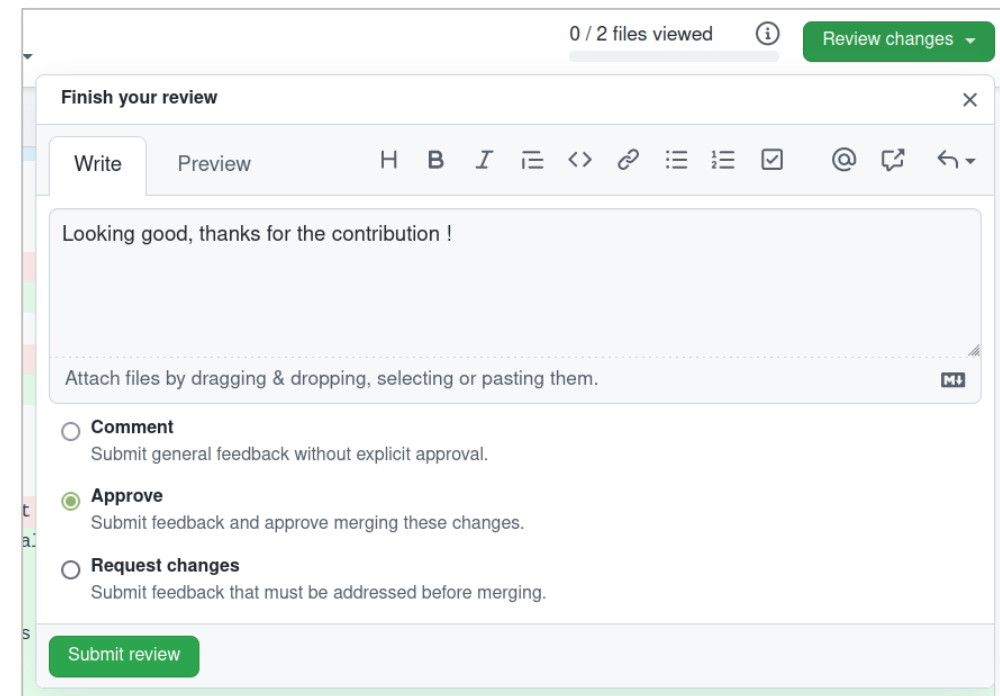
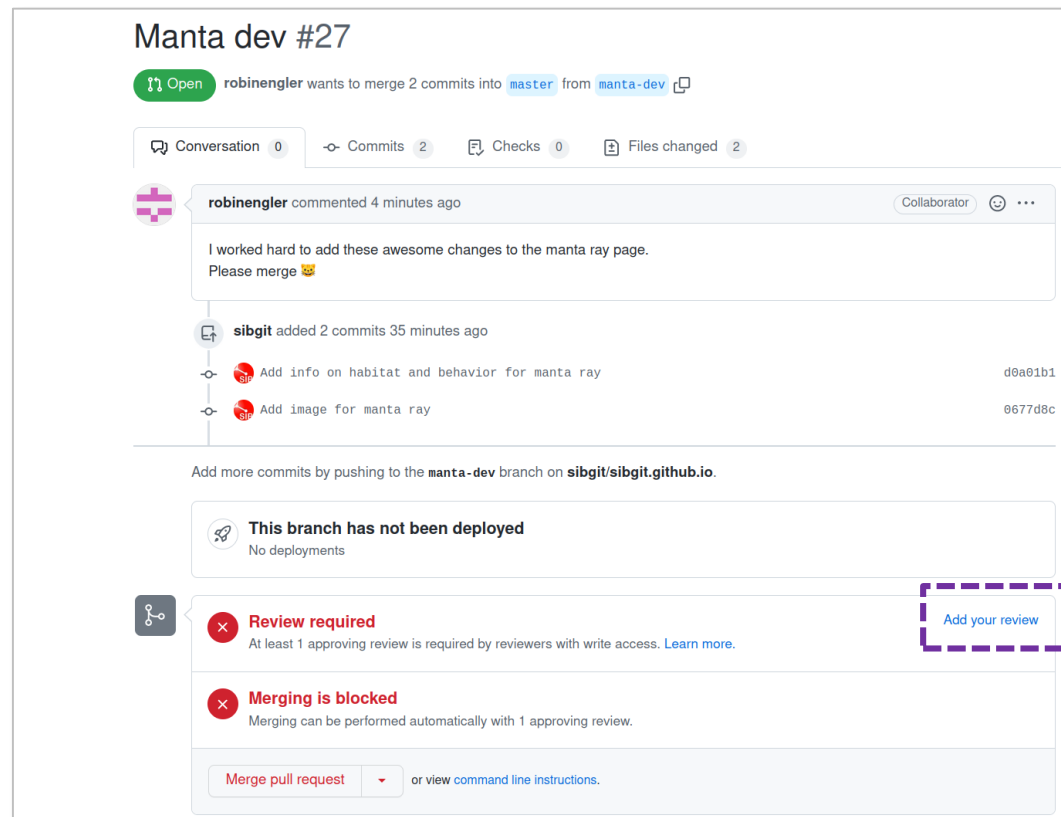
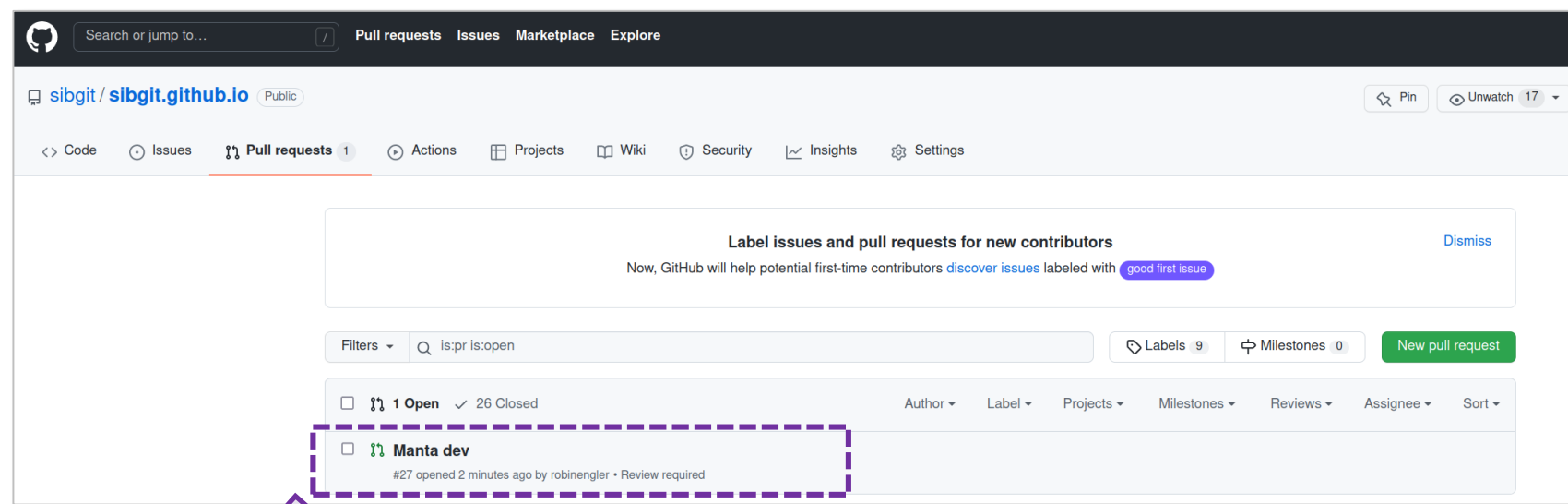
Merging can be performed automatically with 1 approving review.

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**.





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 Collaborator

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 View changes

sibgit left a comment Owner

Looking good, thanks for the contribution !

Add more commits by pushing to the `manta-dev` branch on [sibgit/sibgit.github.io](https://github.com/sibgit/sibgit.io).

This branch has not been deployed
No deployments

Changes approved Show all reviewers
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 Collaborator

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 View changes

sibgit left a comment Owner

Looking good, thanks for the contribution !

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

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



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

Repository settings (only available if you are the owner).

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

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

The screenshot shows the GitHub repository settings for `sibgit / sibgit.github.io`. The **Settings** tab is active. The left sidebar lists various settings categories: General, Access, Code and automation, Security, and Integrations. The **Collaborators** option under the **Access** section is highlighted with a purple arrow. The main content area displays 'Who has access' information, stating the repository is public and visible to anyone, with 26 collaborators and 9 invitations. Below this, the 'Manage access' section shows a list of collaborators with checkboxes to manage their access. A red arrow points to the 'Add people' button in the 'Manage access' section, with the text 'Click here to add a collaborator' next to it.

Who has access

PUBLIC REPOSITORY
This repository is public and visible to anyone.
[Manage](#)

DIRECT ACCESS
26 have access to this repository.
[17 collaborators](#), [9 invitations](#).

Manage access

☐ **Select all** Type ▾

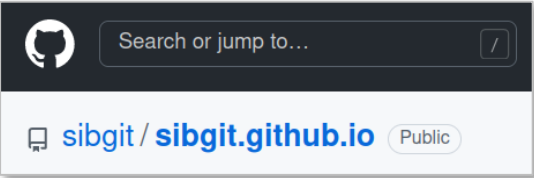
Find a collaborator...

<input type="checkbox"/>	alinefuchs Awaiting alinefuchs's response	Pending Invite	
<input type="checkbox"/>	AmirKH Awaiting AmirKhalilzadeh's response	Pending Invite	
<input type="checkbox"/>	AurelieLen Awaiting AurelieLen's response	Pending Invite	
<input type="checkbox"/>	Burulca burulca • Collaborator		
<input type="checkbox"/>	christec5 Awaiting christec5's response	Pending Invite	

Click here to add a collaborator

[Add people](#)

Other GitHub features (some of them)



“Home” of
your repo
(repo content)

Issue tracker

Continuous integration
(automated testing)

Group issues and
PR by topics.

Add a wiki for
your project.

Setup automated security scanning
for your code (vulnerability check).

Statistics about your
repo’s activity.

<> Code

Issues

Pull requests

Actions

Projects

Wiki

Security

Insights

Settings

Pulse

Contributors

Community

Community Standards

Traffic

Commits

Code frequency

Dependency graph

Network

Forks

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

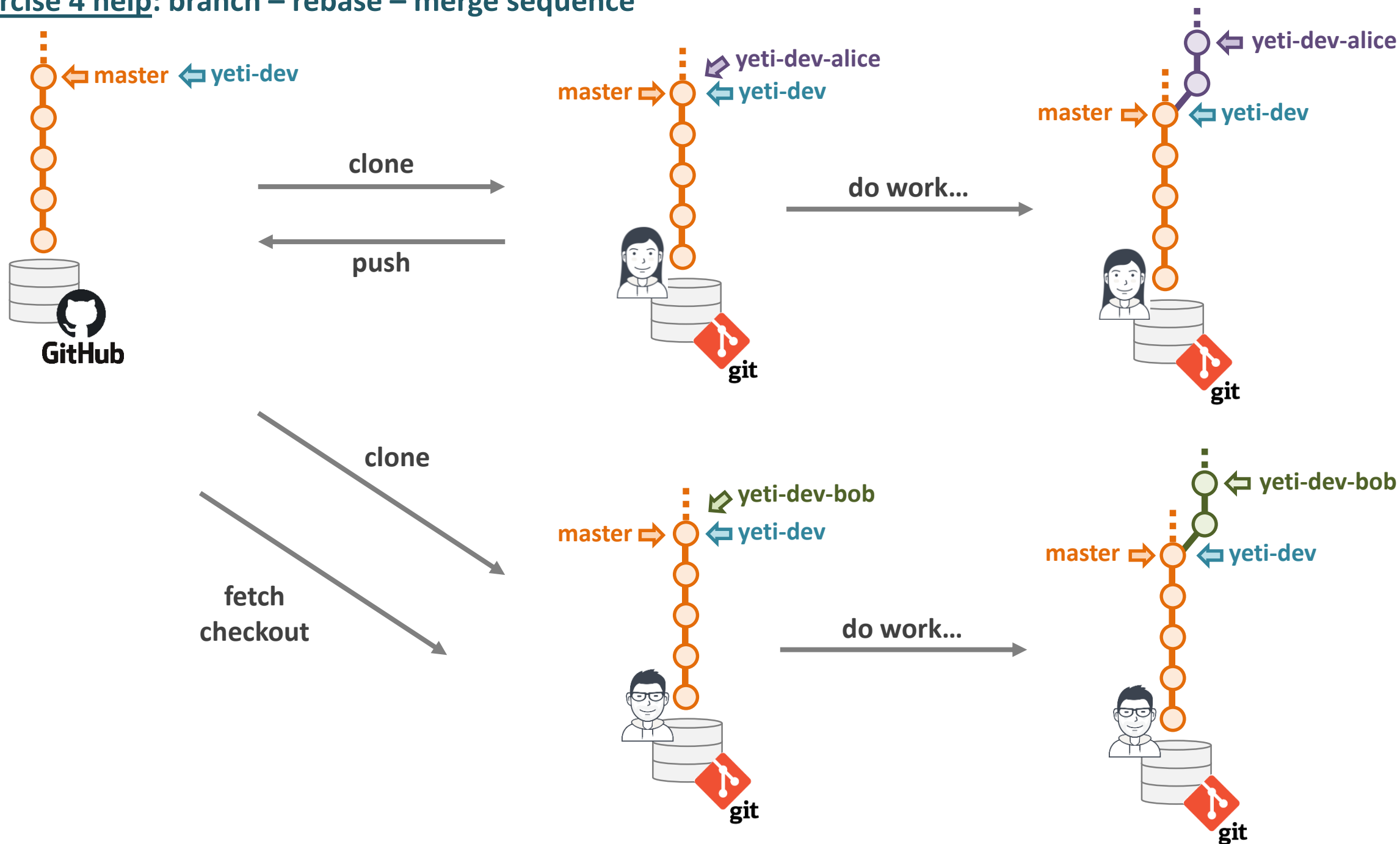
exercise 4

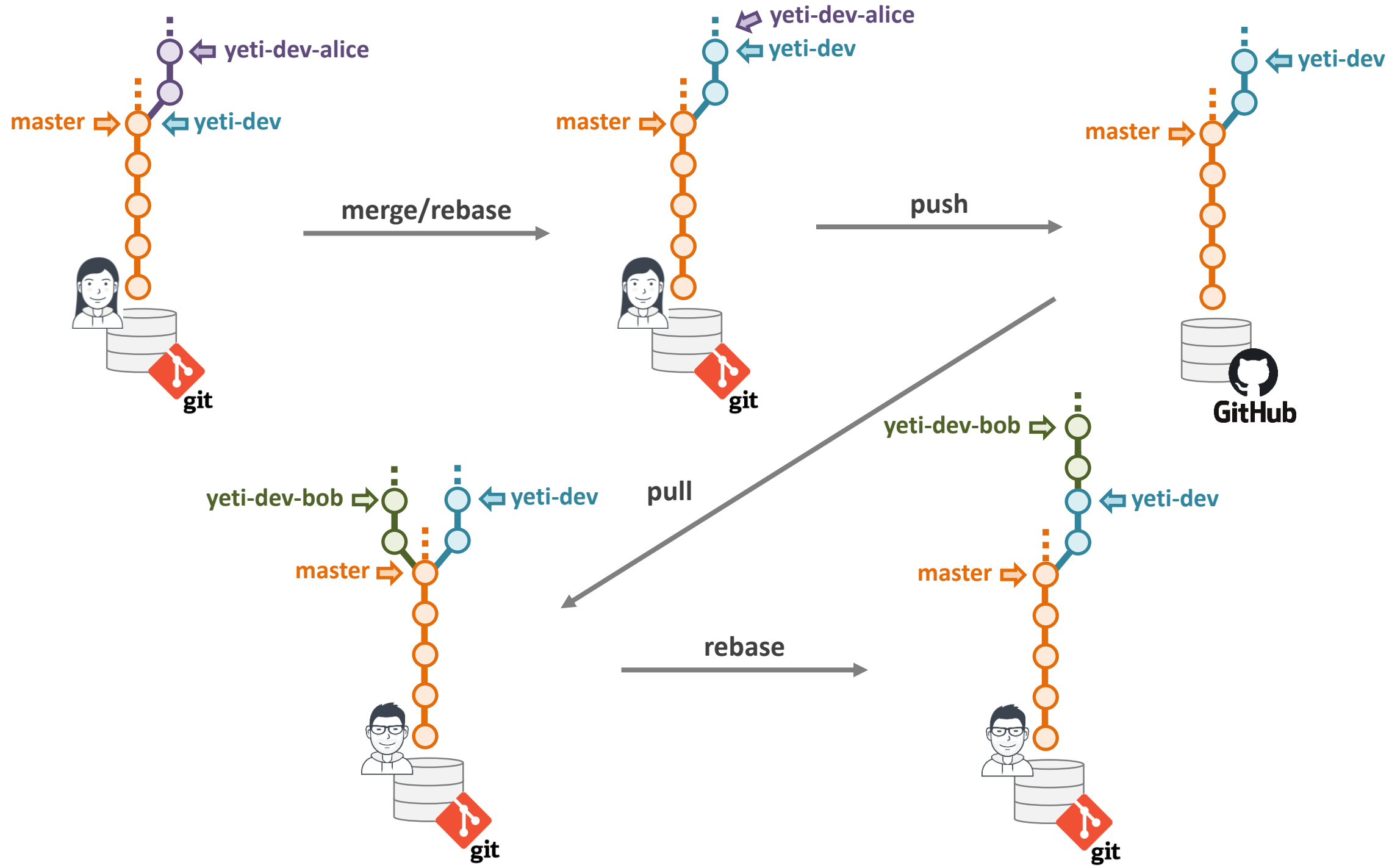
The Awesome Animal Awareness Project



This exercise has helper slides

Exercise 4 help: branch – rebase – merge sequence

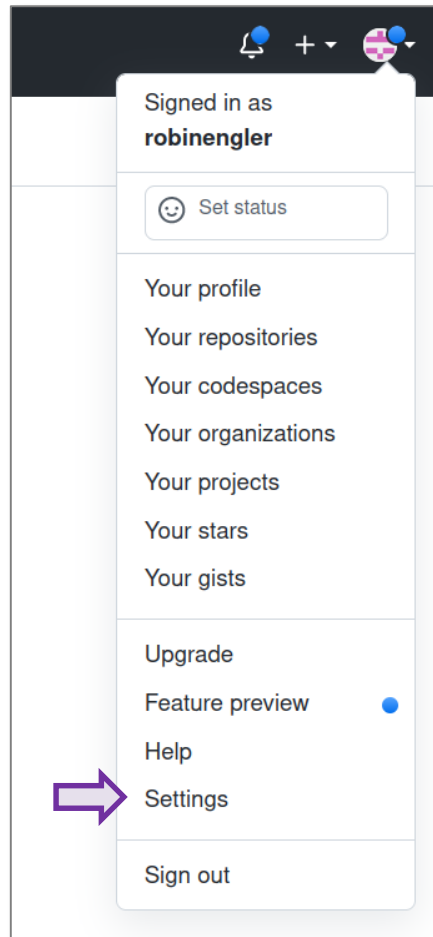




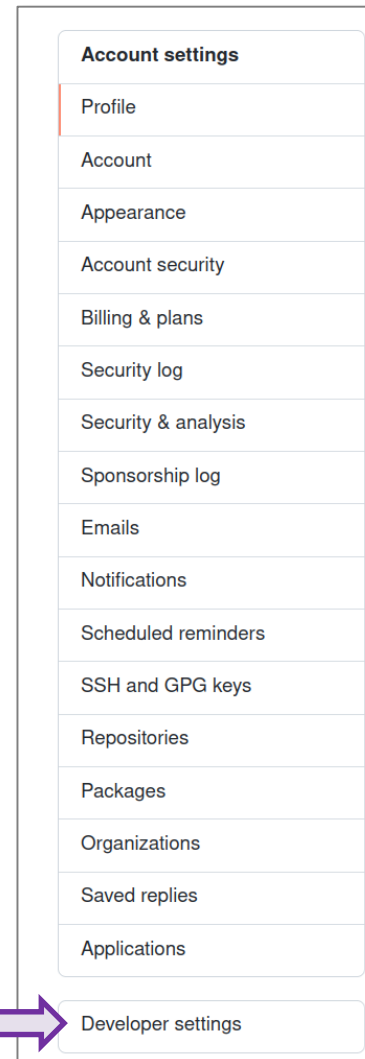
Exercise 4 help: generating a “personal access token” on GitHub

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

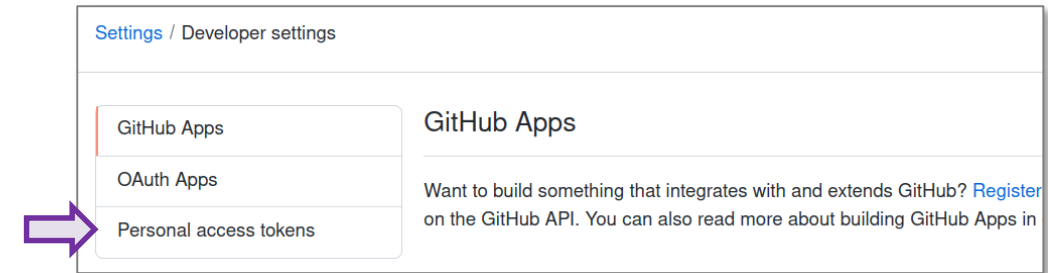
1. In your user profile (top right), click on **Settings**.



2. In your Account settings, click on **Developer settings**.



3. In **Developer settings**, click on **Personal access tokens**.



Go to next page 

Exercise 4 help: generating a “personal access token” on GitHub

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

New personal access token

Personal access tokens function like ordinary OAuth access tokens. They can be used 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 Fri, Nov 5 2021

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 checked="" type="checkbox"/> repo:status	Access commit status
<input checked="" type="checkbox"/> repo_deployment	Access deployment status
<input checked="" type="checkbox"/> public_repo	Access public repositories
<input checked="" type="checkbox"/> repo:invite	Access repository invitations
<input checked="" type="checkbox"/> security_events	Read and write security events

Generate token Cancel

5. **Copy the personal access token** to a safe locations (for now maybe in a text file, but ideally in a password manager). You will not be able to access it again later.

Personal access tokens

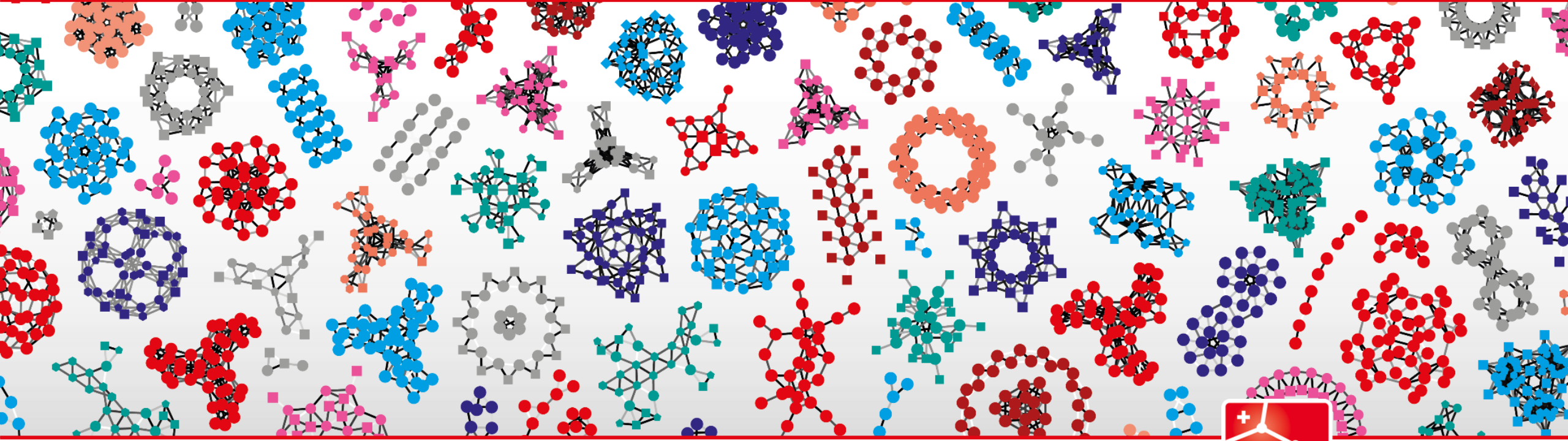
Generate new token Revoke all

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

6. 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.



Thank you for attending this course



Swiss Institute of
Bioinformatics