

Git & friends

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UNIMORE
UNIVERSITÀ DEGLI STUDI DI
MODENA E REGGIO EMILIA

High Performance
Real Time **Lab**



They call me 007

0 LINES ADDED

0 LINES MODIFIED

7 MERGE CONFLICTS



What is a version control?

A system that keeps records of your changes

- › Allows you to revert any changes and go back to a previous state

Enables collaborative development

- › Allows you to know who made what changes and when (with a bug...)

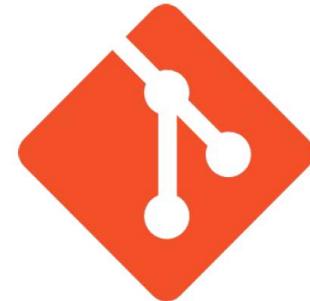
...but not only this!!

- › Forces you to follow well-known development flows
 - (Ever heard of DevOps?)
- › Provides a set of tools to automate testing, integration and deployment
 - (Ever heard of CI/CD?)
- › Provides an easy way to write documentation

Ultimately, let you focus on coding, coding, coding, removing all of (what programmers think is) clutter!



Git



- › "Widestly" adopted version control
- › Based on distributed repositories
- › Created by Linus Torvalds to support Linux kernel development, in 2005

git LISTEN: US ▾

UK: * /'git/ | US: (git)

[definizione](#) | [Sinonimi inglesi](#) | [in spagnolo](#) | [in francese](#) | [Coniugatore \[IT\]](#) | [Conjugator \[EN\]](#) | [nel contesto](#) | [immagini](#)

WordReference English-Italiano Dictionary © 2022:

Principal Translations/Traduzioni principali

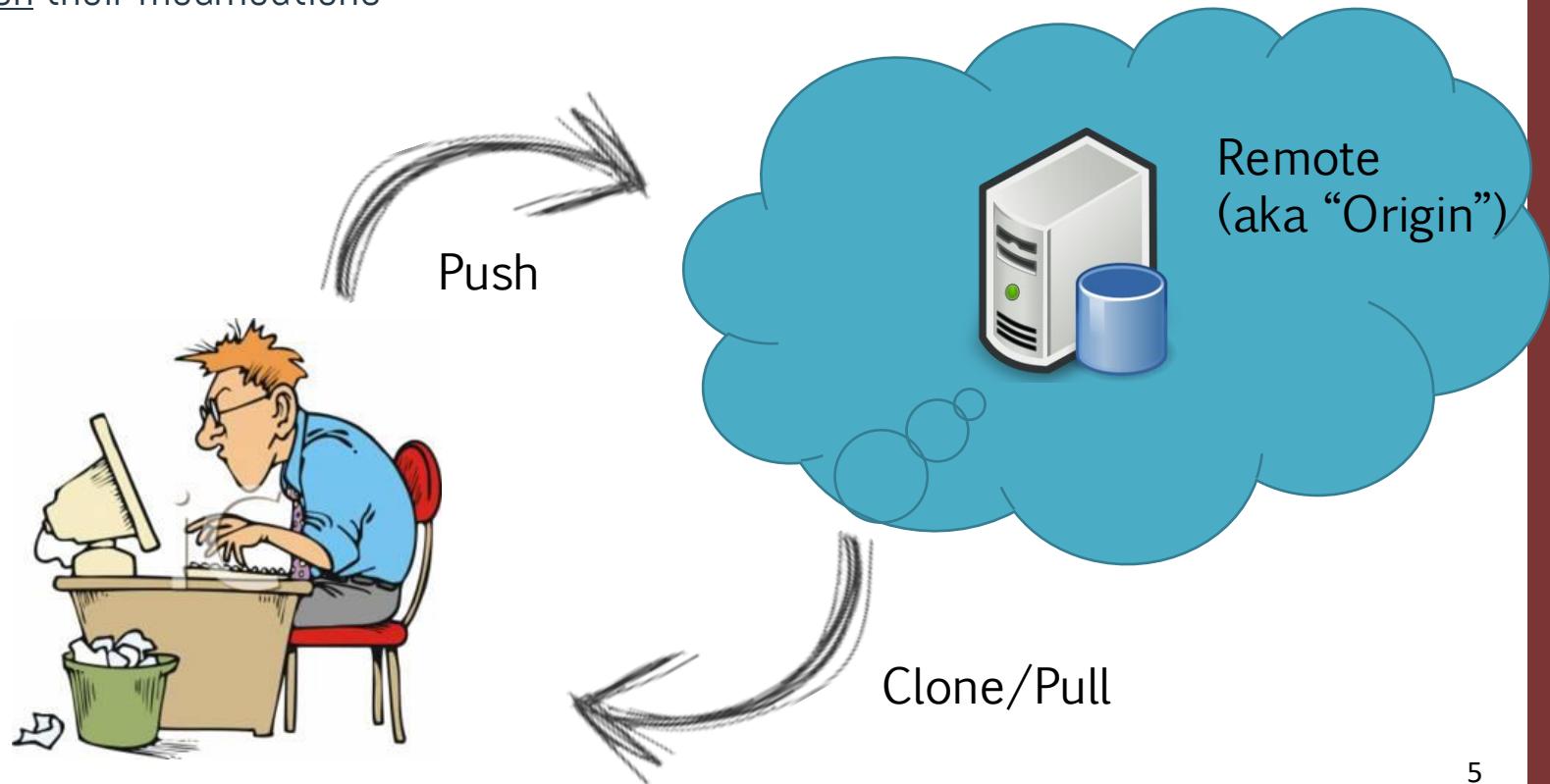
Inglese	Italiano
git <i>n</i> UK, pejorative, slang (contemptible man) George is such a git!	cretino, idiota, scemo <i>nm</i> (colloquiale, offensivo)



Step 1: let's start simple

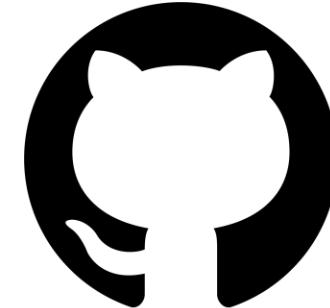
"Somewhere"/"on cloud" there is a remote repository with your codebase (called "origin")

- › Users clone this repo on their local machine
- › ...keep their local copy updated by pulling recent changes from the remote
- › And push their modifications





<https://github.com>



The most famous public git repo service

- › Free version + payment version
- › Acquired by BigM in 2016 (tbc)
- › Web console to access

Why do we use this?

- › Preview for slides, past exams, code...
- › Issues!! You now are a team!
- › Let's set up an account



Why GitHub?

- › And not, for instance, GitLab.com?
- › ...or HiPeRT's on-premise GitLab?



Local tools

Baseline: command line tool

- › Comes with most of the GNU/Linux distros
- › (You can always “apt” it)

Under Win, multiple options

- › <https://git-scm.com/> - also, with (very ugly) UI
- › Use WSL
- › Powershell?

Integrated in most commonly used IDEs

- › .but, soon, we'll only work on web tools



Let's start!

Do the following

- › Create a GitHub account
- › Navigate to HiPeRT Lab's page
 - <https://github.com/HiPeRT>
 - <https://github.com/pburgio> for older stuff
- › Clone the repo
 - We will use git over https, but there are also other protocols

```
$ git clone https://<URL>
```

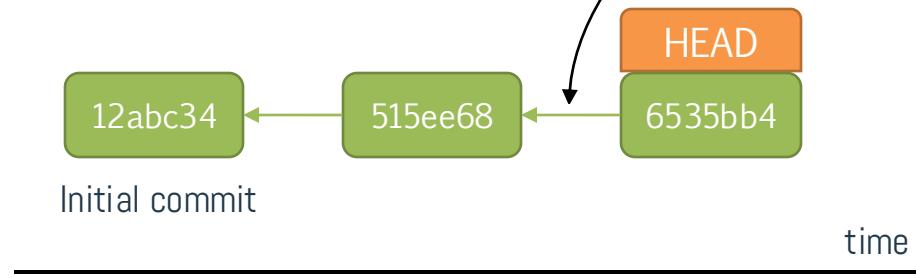


Basic workflow

A project is a sequence of commits

- › They are snapshots of your code in a given moment of time
- › Create with `git commit` (...or some "sugar" tool)
- › The granularity of a commit is on you
 - Typically, small changes of code that at least compiles..

Every commit
refers to its
parent



Commits track incremental changes! (`git diff`)

- › Every commit is identified by a hashcode, and has a parent
- › Most recent (...) comit is also called HEAD
- › It is **mandatory** to add a comment to every commit

\$ `git log` to see all information





The git flow

Working with commits

- › Before committing, files must be added to the staging area

```
$ git add <file> <file> && git commit
```

..or...

```
$ git commit -a
```

To check the status of your staging area and commits

```
$ git status
```

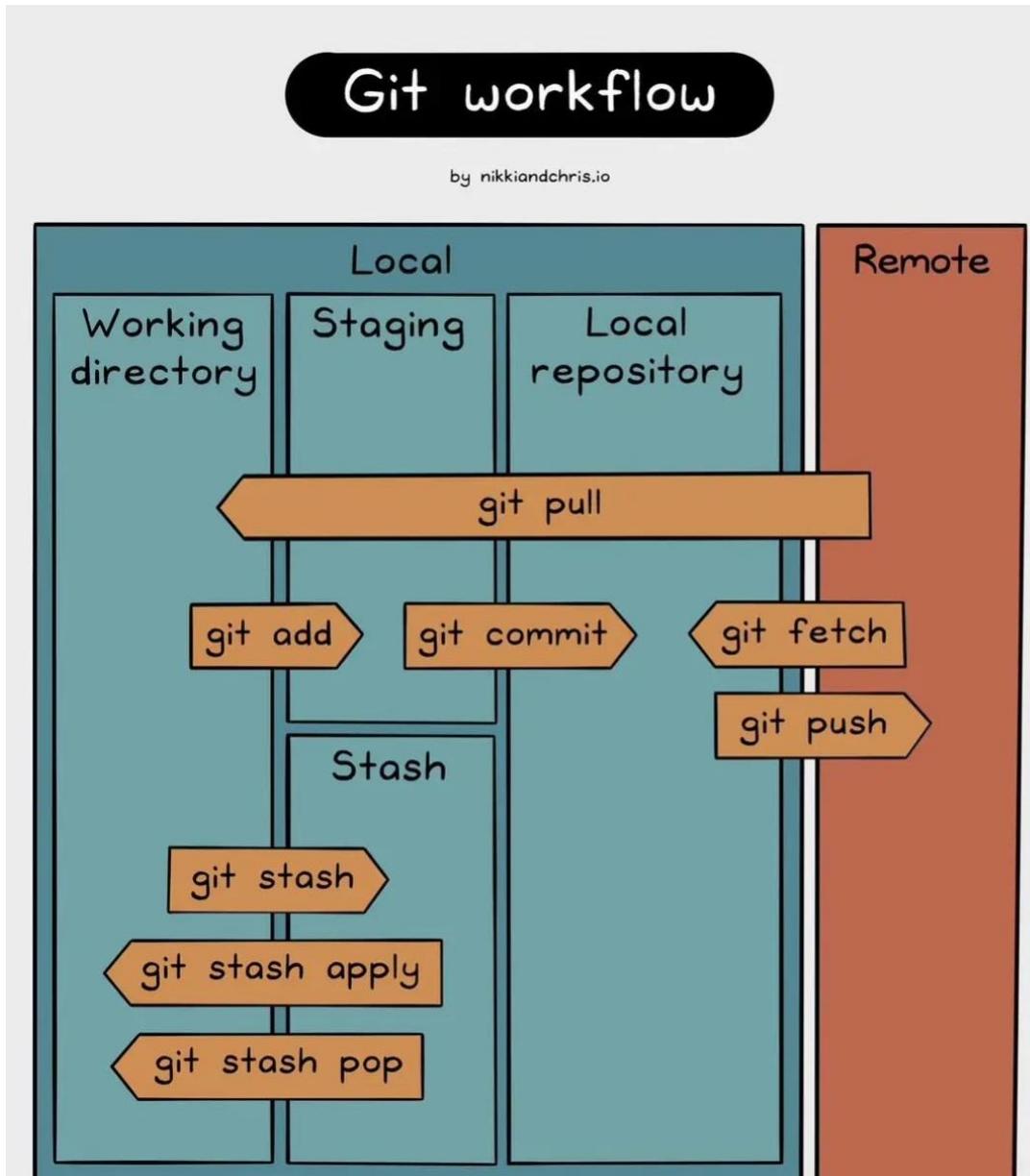
Watch out

- › -a option does not apply to new files
- › Empty folders are never added by git
- › You can always amend a previous commit, if you forgot to add something

```
$ git commit --amend
```



The git flow (cont'd)





The git flow (cont'd)

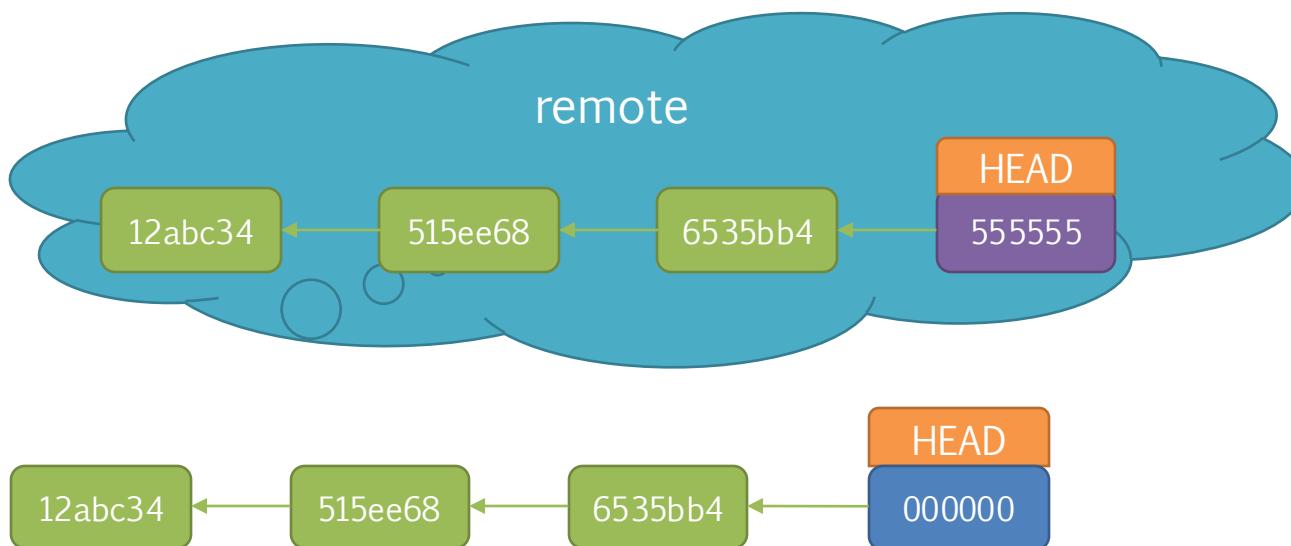
- › You can remove/delete files
- › Renaming files means deleting + adding

When you're done, transfer files to the remote repo by

```
$ git push [origin] [master]
```

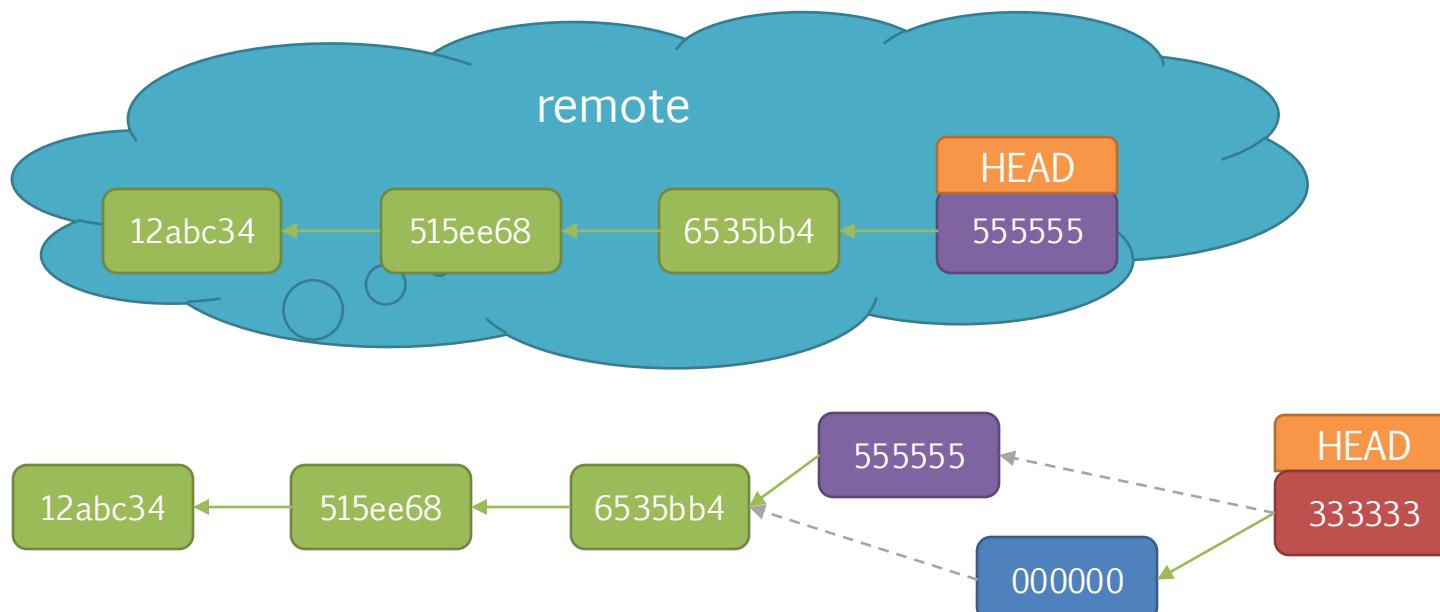
Always make sure you have the latest version!

```
$ git pull [origin] [master]
```



Pulling and auto-merging

- › Based on the actual time of commit, local history is updated
- › The local codebase is automatically updated (aka: files are merged), including modifications both from local and remote
- › A new commit is created





Merge...and conflicts



- › It is extremely easy to mess things up, if codebases are significantly different!!!
- › Git works at the code line level
 - What if we modify the same code line?
 - Some modern systems track also single words

If there are merge conflicts, the local repo stays in conflicting state

- › Until you solve the conflicts locally, and manually merge them
 - Easier if you do it on IDEs
 - Using appropriate flags in the checkout command

Tips & tricks

- › Frequently pull changes
- › Always make sure your code works by re-running the testing automation
- › Create small commits, “packed” by “working area” (ex: one for the code, one for the makefiles, one for the scripts...)
 - This also forces you to keep the workspace clean and well structured!!



Useful commands

Checkout and (hard or soft) reset

- › To unstage/delete local modifications and/or commits

Revert

- › To switch back to a specific commit

Cherry-pick

- › Commits are incremental. They simply trace the difference against parent commit
- › You can apply a commit/difference also to any other commit (not only parent)
- › By cherry-picking



The history of my project

A typical sw project is structured in quite a rigid way

- › A main branch ("master"), containing the latest released version (with full commit history)
- › Multiple branches that correspond to specific works/subprojects
- › You have total freedom on branches. Company-specific rules apply here
 - "develop", "bugfix/", "hotfix/", "features/", "pb_<SOMETHING>" (initials of the developer)

Once a project is started, you might **never** push onto the master branch

- › You typically fork the master, or the "Development" branch, and then issue a pull request
- › Which is served by the repo Maintainer
 - Typically a sadist, with very limited empathy and sense of humour
 - Sysadmins are good candidates for this role
- › There are access rules and user roles, both at the org and repo level, and also at the branch level, etc



Torvalds is a nice person....

```
On Sun, Sep 18, 2011 at 1:35 PM, Eric Dumazet <eric.dumazet@gmail.com> wrote:  
> [PATCH] tcp: fix build error if !CONFIG SYN_COOKIE  
> commit 946cedccbd7387 (tcp: Change possible_SYN flooding  
> messages) added a build error if CONFIG_SYN_COOKIE=n
```

Christ Eric, you clearly didn't even compile-test this one either.

Which is pretty bad, considering that the whole and only *point* of the patch is to make it compile.

The config option is CONFIG SYN COOKIES (with an 'S' at the end), but your patch has 'CONFIG SYN COOKIE' (without the S).

Which means that now it doesn't compile when syncookies are *enabled*. I really wanted to release -rc7 today. But no way am I applying these kinds of totally untested patches. Can you guys please get your act Together?

PLEASE?

Stop with the "this might just work" crap. Because -rc7 is just too late to dick around like that.

Linus





...sometimes he really is

```
On Thu, Aug 25, 2011 at 1:21 PM, Arnaud Lacombe  
<lacombar@gmail.com> wrote:  
> On Thu, Aug 25, 2011 at 4:10 PM, Andy Lutomirski  
<luto@mit.edu> wrote:  
>>  
>> Arnaud, can you test this?  
>>  
> All good.  
>  
> Tested-by: Arnaud Lacombe <lacombar@gmail.com>
```

Thanks guys. Applied and pushed out,

Linus





What typically happens...

- › Developers clone a branch from an updated repo
 - Typically, you clone Master, or Develop
- › Anyway: your starting point

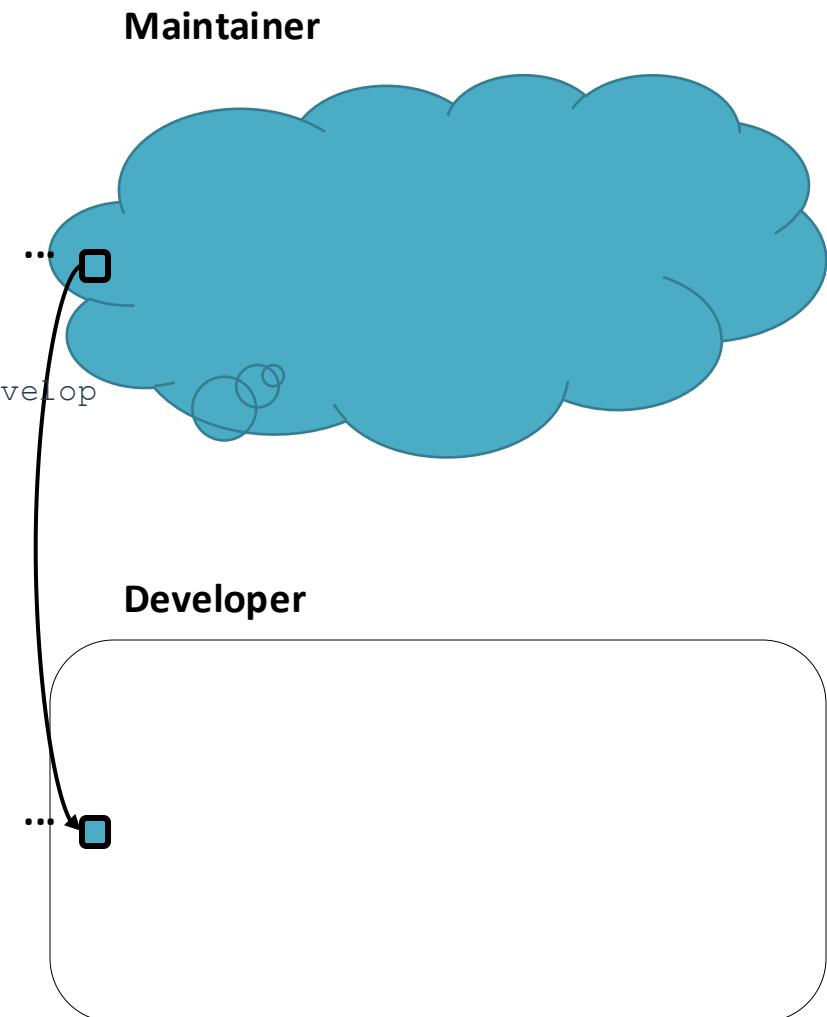
```
$ git clone <SOME_URL>  
$ git checkout Develop # Assume it exists  
$ git branch MY_LOCAL # Create from the Develop  
branch
```

```
$ git branch -l # To check  
$ git checkout MY_LOCAL # Switch to it
```

You can also do all of these together

```
$ git checkout -b MY_LOCAL
```

- Master, or Develop branch
- MY_LOCAL branch





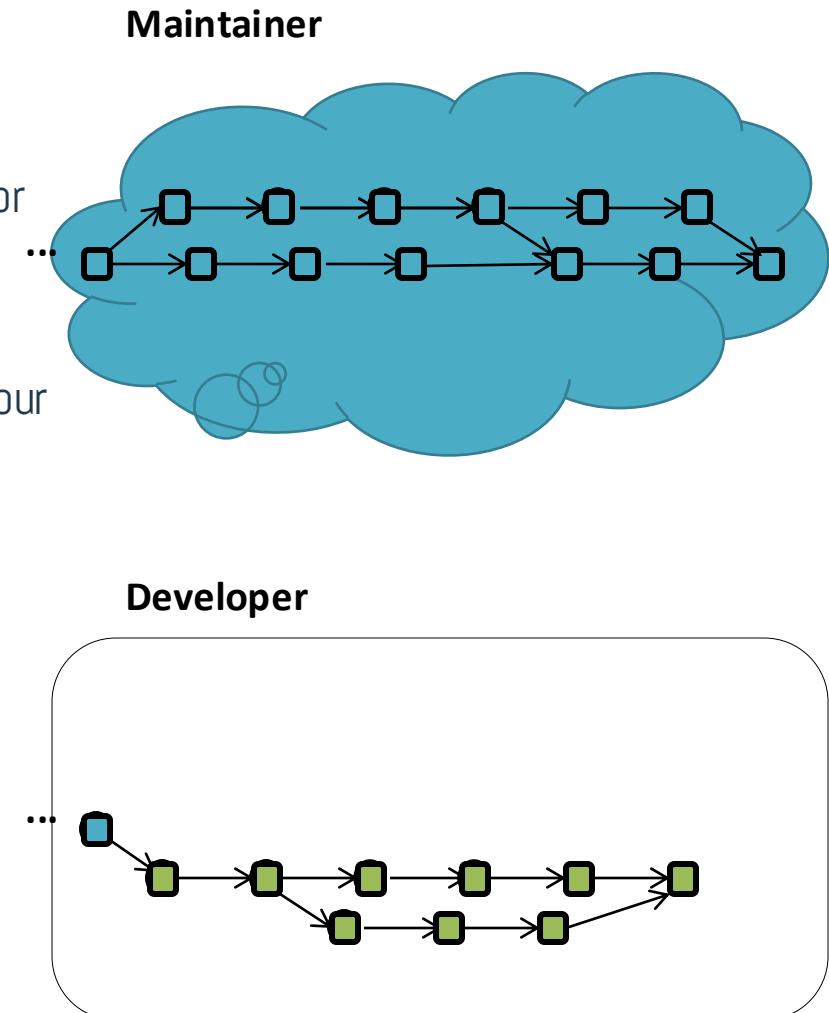
What typically happens...

- › Developer starts his work, producing new commits
- › In a local branch
- › Similarly, remote repo gets some updates for some reason

(You can push your local branch to back up your work on the cloud)

```
$ git push origin MY_LOCAL
```

- Develop branch
- MY_LOCAL branch





What typically happens...

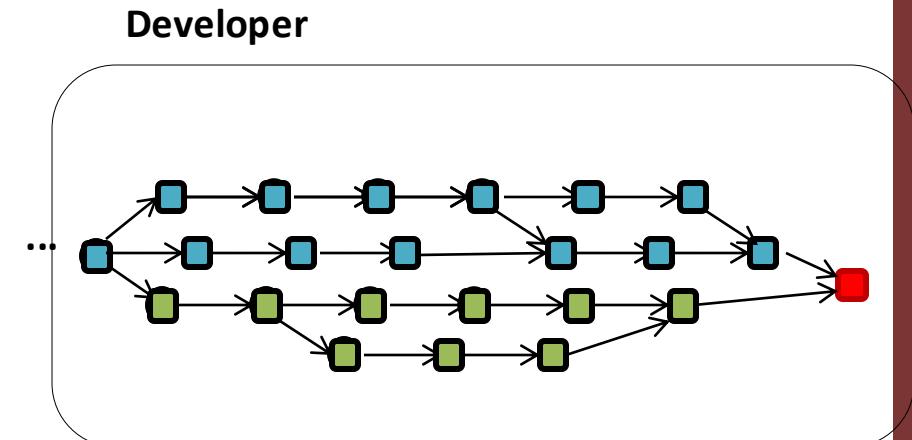
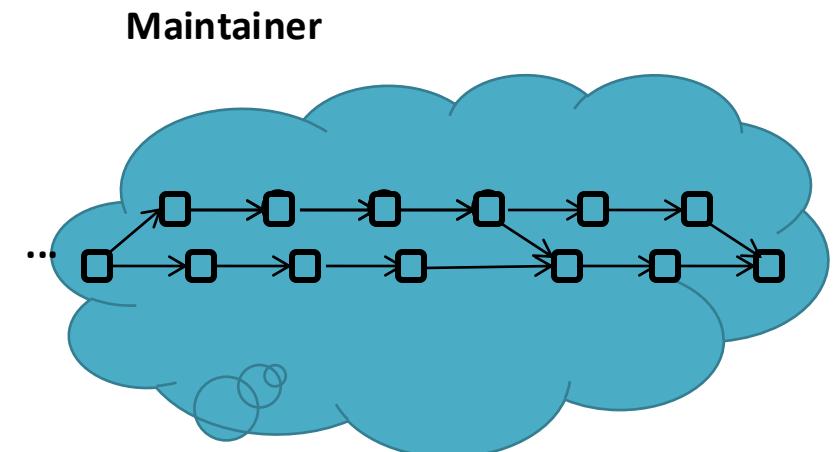
- › When developer is ready, he pulls to update with whatever is in the cloud
- › He's in charge of "making his commits consistent" with the whole story
- › This implies re-testing the whole thing!!

```
$ git pull origin Develop
```

```
$ git merge Develop
```

■ Develop branch

■ MY_LOCAL branch





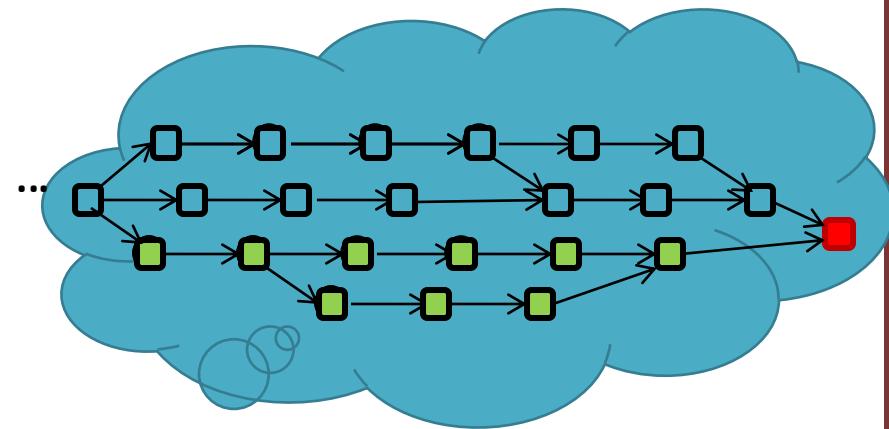
What typically happens...

- › After the merge is done, the “final commit” is created
- › And then we can push on the cloud
- › And issue a pull request
 - By email, or by automated tools

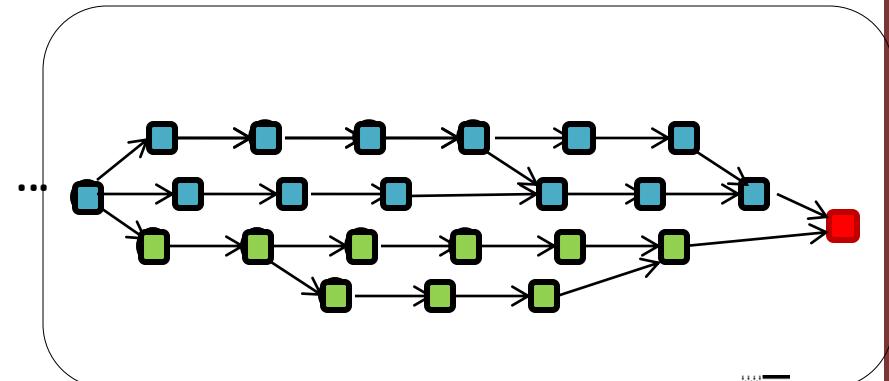
```
$ git push origin MY_LOCAL
```

(Remember, you cannot push Master)

Maintainer



Developer



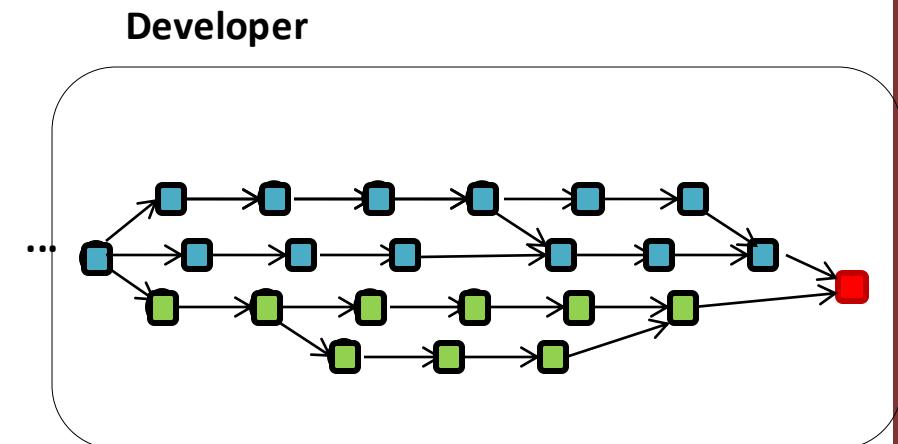
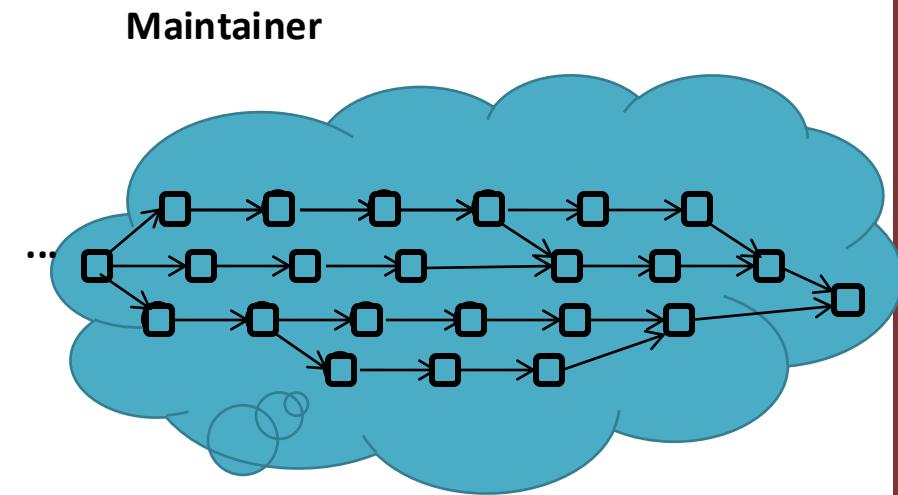
■ Develop branch

■ MY_LOCAL branch



What typically happens...

- › Request is accepted, and modifications apply to the Develop branch
- › Hopefully



■ Develop branch

■ MY_LOCAL branch



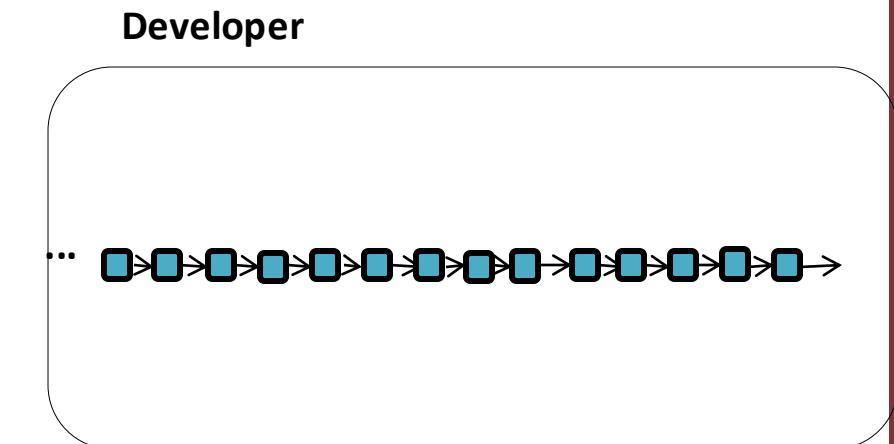
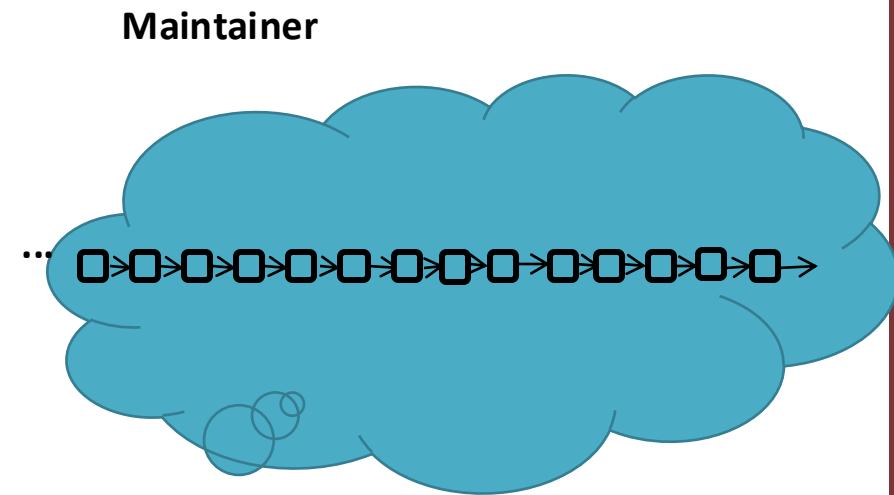
What typically happens...

- › Typically, the “other” branch is then deleted remotely by maintainer
- › The story is now consistent, and a “unique” timeline exist
- › We need to pull the Develop branch one more time, to make my local copy consistent (and delete local branch)

```
$ git pull origin Develop  
$ git branch -d[D] MY_LOCAL
```

■ Develop branch

■ MY_LOCAL branch



Advanced features



Ignore files

Some folders and files are not useful for your projects!

- › .vscode
- › ROS2: install/ build/ log/ ...

So, why adding them to the repo?

Add `.gitignore` file in your repo (or in some subfolder)..

- › Specify files to ignore
- › Can use wildcards
- › Comments start with #

```
# Ignore VSCode local configurations
.vscode/*

# Ignore ROS2 temp folders
install/*
logs/*
build/*

# Ignore specific file
i_love_maneskin.txt
```

Remember to commit your
`.gitignore` file!



Submodules

You can include a git repo as part of another git repo!

- › Maintainability, scalability, etc...

Syntax

- › ..from the folder where you want to include...
- › \$ git submodule add <REPO-URL>
- › It will create a `.gitmodules` file in the root folder

```
[submodule "my_module"]
  path = src/my_module
  url = https://github.com/something/my_module.git
```

Where:

- › url can also be relative
- › You will also need to commit the `.gitmodules` file
- › Update with \$ `git submodule update --init --recursive`



Verifying your identity

You might have noticed that on first commit, Git requested you to set your identity, locally

- › By "simply" setting a global, **unchecked**, name/email tuple

```
$ git commit -m "my first commit"
Author identity unknown

*** Please tell me who you are.

Run

git config --global user.email "you@example.com"
git config --global user.name "Your Name"

to set your account's default identity.
Omit --global to set the identity only in this repository.
```

- › **PROBLEM:** you can not guarantee the identity of the committer!!

```
pol@polso:/media/pol/DATA/Unimore/Workspace/ProgSW$ git log
commit 76944a4a8516ab6aba1eafc8b8ed594a7b112127 (HEAD -> master, origin/master, origin/HEAD)
Author: Paolo Burgio <paolo.burgio@gmail.com>
Date:   Mon Feb 23 13:02:54 2026 +0100

    Added 00 and 01

commit 5c85984b70972af134a26cd0f6f7cf9278e0b54b
Author: Paolo Burgio <paolo.burgio@gmail.com>
Date:   Mon Feb 23 13:02:45 2026 +0100

    Updated README.md; fix in FAQ.md
```





Digital signature



Use the GNU Privacy Guard (GPG) - <https://www.gnupg.org/>

Step 1: Generate a signing key



```
$ gpg --gen-key
```

...and check

```
$ gpg --list-keys
```

```
/home/pol/.gnupg/pubring.kbx
```

```
-----  
pub ed25519 2026-02-25 [SC] [expires: 2029-02-24]
```

0123456789ABCDEF

```
uid [ultimate] Paolo Burgio <paolo.burgio@gmail.com>
```

```
sub cv25519 2026-02-25 [E] [expires: 2029-02-24]
```

Step 2: Let Git know that you want to sign it with this key

```
$ git config --global user.signingkey 0123456789ABCDEF
```



Digital signature (cont'd)

Step 3: Sign your commits (use the -s flag)

```
$ git commit -S -m 'Modified 01 to add slides on commit signatures'
```

Then you will see a validated commit with --show-signature flag to git log command

```
pol@polso:/media/pol/DATA/Unimore/Workspace/ProgSW$ git log --show-signature
commit 760b8f793882f21fc3a37f47f15bcba2efd341c5 (HEAD -> master)
gpg: Signature made Wed 25 Feb 2026 10:12:36 AM CET
gpg:                               using EDDSA key BFC0E4C47D0CF20DAF25299DE75EC7494789458D
gpg: Good signature from "Paolo Burgio <paolo.burgio@gmail.com>" [ultimate]
Author: Paolo Burgio <paolo.burgio@gmail.com>
Date:   Wed Feb 25 10:12:36 2026 +0100

Modified 01 to add slides on commit signatures
```



NOTE: GitHub double checks your identity using your email

...but I haven't registered your GPG key in your GitHub account (which matches your email)

The screenshot shows a GitHub commit page for a repository named 'ProgSW'. The commit hash is 'ae57a1b'. The author is listed as 'Paolo Burgio committed 3 minutes ago'. A red circle highlights the word 'Unverified' next to the author's name. Below the commit details, the commit message 'Modified 01 to add slides on commit signatures' is visible. At the bottom of the commit card, it says 'master'.



Setting up GPG in GitHub

 ✓

- ## 1. First, you need to dump it

```
$ gpg --export --armor paoletto.burgio@gmail.com
```

-----BEGIN PGP PUBLIC KEY BLOCK-----

-----END PGP PUBLIC KEY BLOCK-----



Setting up GPG in GitHub (cont'd)

2. Import it in the GitHub setting page

The screenshot shows the GitHub settings interface. A red circle highlights the 'Settings' button in the top left. A red arrow points from the 'SSH and GPG keys' link in the sidebar to the 'GPG keys' section. Another red circle highlights the 'New GPG key' button. The 'GPG keys' section lists a single key: 'POLSO' with Key ID E75EC74947894580, Subkeys: 013A6B2C2D266E21A, and was added on Feb 25, 2026.

The screenshot shows a GitHub commit details page. The commit message is 'Commit 760b8f7' made by 'pburgio' 1 minute ago. A red circle highlights the 'Verified' badge next to the commit time. The commit message itself reads 'Modified 01 to add slides on commit signatures'. The commit is shown against the 'master' branch.

...and now....

*NOTE: this is GitHub specific!



Multiple repos for release/nightly work

You can add as many remote repos you want

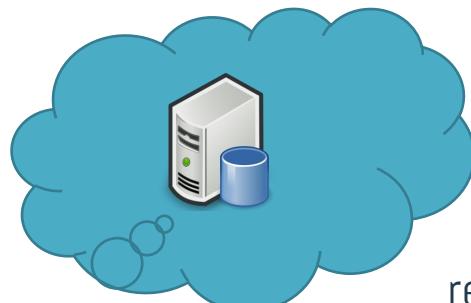
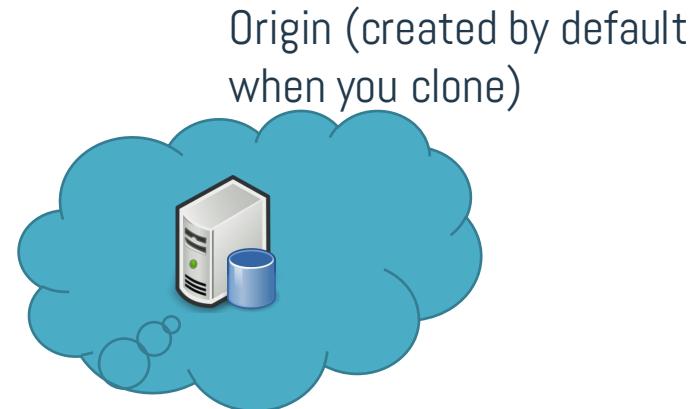
- › Origin is the one you cloned from
- › Typically a *private* one for nightly builds

In Git philosophy, all repos are equal!

- › Each of them has a maintainer

```
$ git remote -v # To list them
```

```
$ git remote add <name> <url>
```

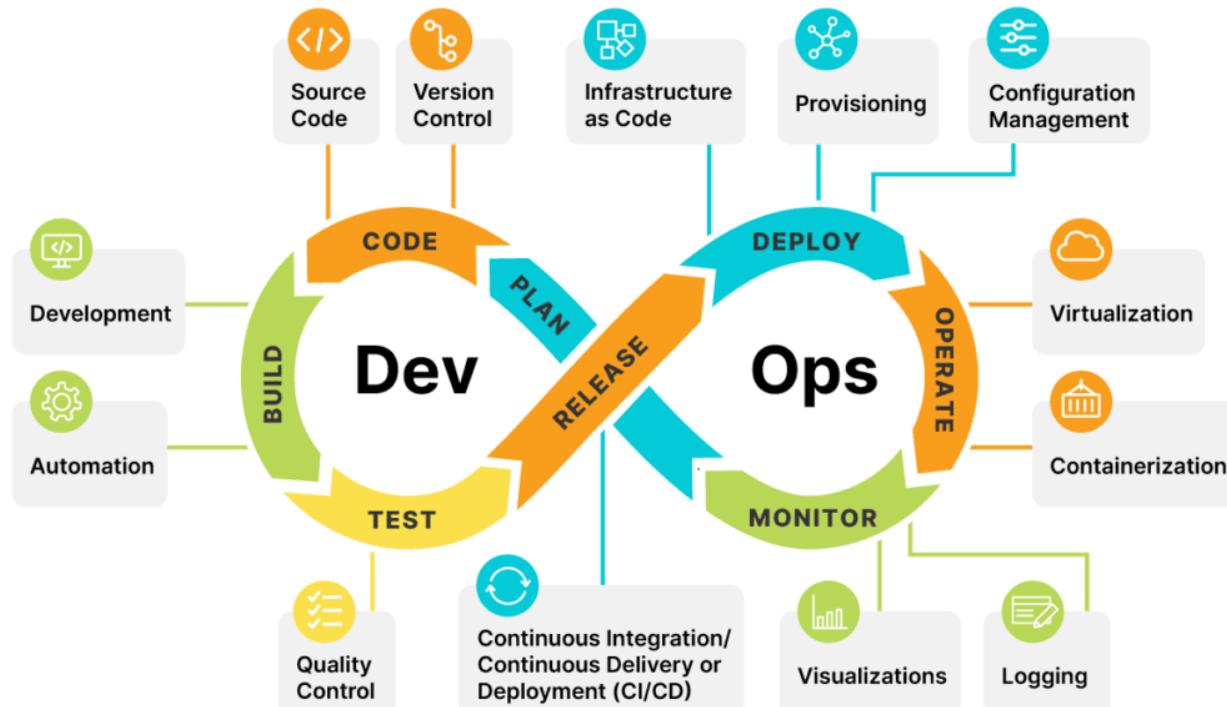


pburgio

Code like a pro: Continuous Integration, Continuous Deployment

Git enables workflows to automate build, testing, docs...

- › Not covered in the course
- › ...a seminar, maybe?





References



Course website

- › <http://hipert.unimore.it/people/paolob/pub/ProgSW/index.html>

My contacts

- › palo.burgio@unimore.it
- › <http://hipert.mat.unimore.it/people/paolob/>

Resources

- › <https://git-scm.com/>
- › <https://docs.github.com>