Git

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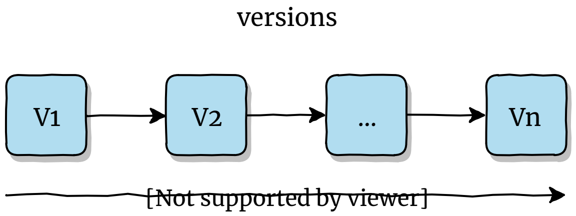
Introduction

Version Control Systems (VCS)

A system that records changes to a file or set of files over time.



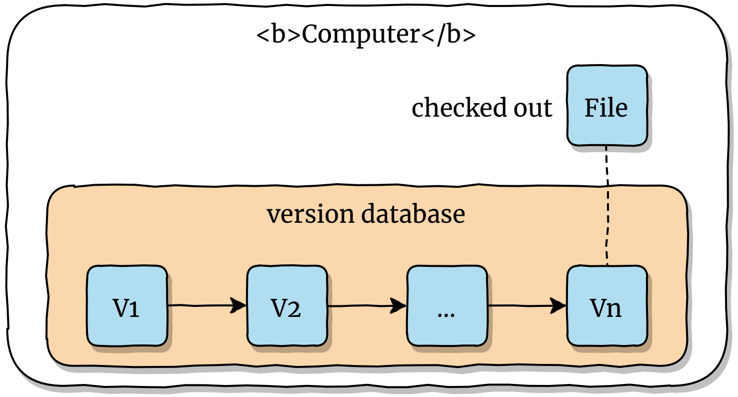
It allows you to:

- **revert** selected files, or a project, back to a previous state
- **compare** changes over time
- see **who modified** something
- ...

AKA Source Control Management (**SCM**)

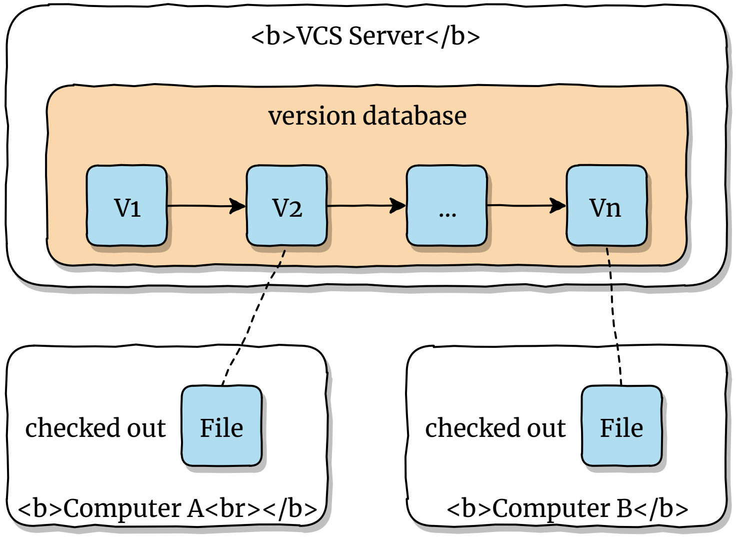
Local VCS

- Local VCS use a simple database that keeps all changes to files under revision control.
- Most store only the differences between files instead of copies of each version.
- Examples: RCS



Centralized VCS

- A **single server** that contains all the versioned files.
- Computers can **checkout** a particular file version.
- Examples: CVS, Subversion



Centralized VCS

Advantages:

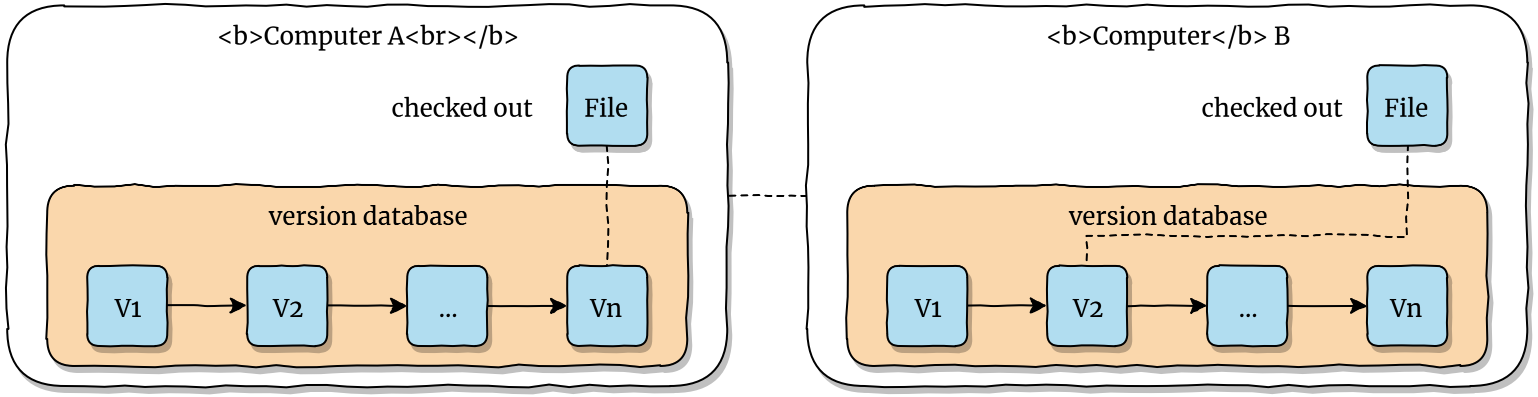
- Everyone knows what everyone is doing.
- **Fine grained control** over who can do what.

Disadvantages:

- Single point of **failure**.
- Needs constant **connectivity**.
- Backups are **mandatory**.

Distributed VCS

- All clients **fully mirror** the repository, including its **full history**.
- There is **no difference** between a server and a client.
- But one, or more, computers can be used as a **central point** of synchronization.
- Allows lots of different **workflows**.



Examples: Git, Mercurial, Bazaar, Darcs

Git Basics

Basics

Snapshots:

- Does **not** store only the differences between versions of a file.
- Instead, it saves them as a series of **snapshots**.
- But, if files have not changed, it does not store them again (**link**).

Local: Most Git operations are **local**.

Integrity:

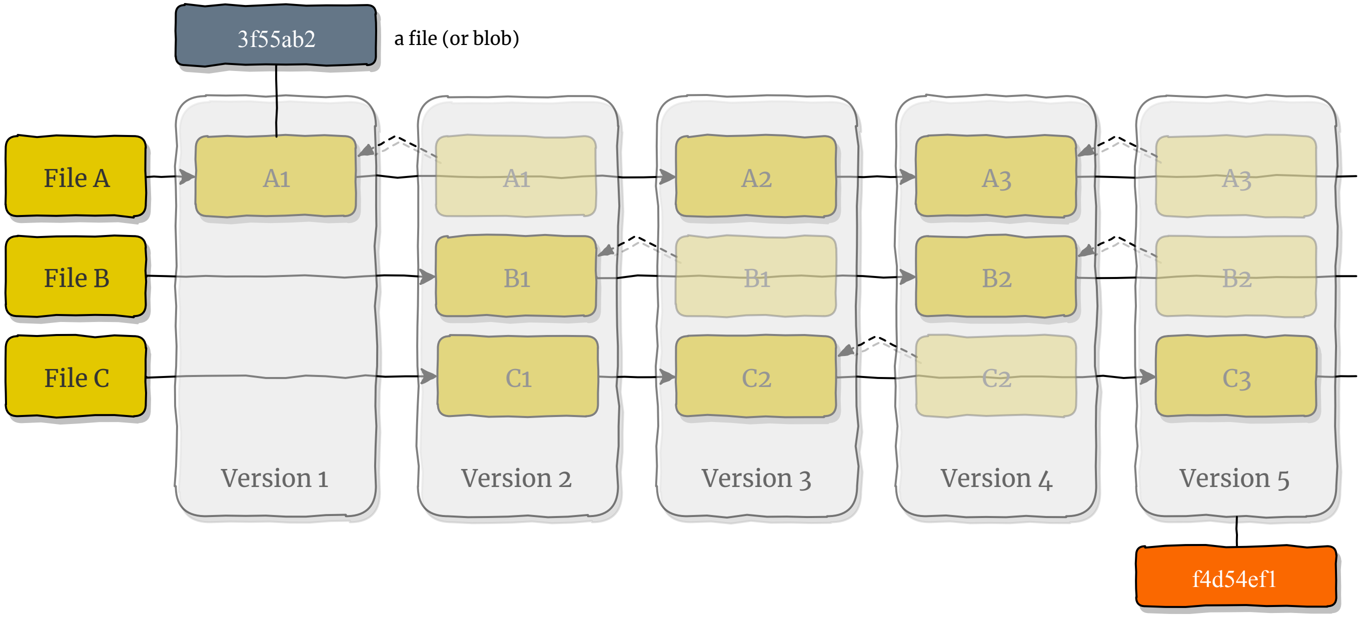
- Everything in Git is *checksummed* (SHA-1) before it is stored.
- Everything is then **referred** to by that **checksum**.
- Checksum example: `7e16b5527c77ea58bac36dddda6f5b444f32e81b`

Versions

Each version (aka a **commit**) is a snapshot of that version files.

If not changed, files are just **links** to a previous version.

All objects (files, commits, ...) have an **hash** identifier.

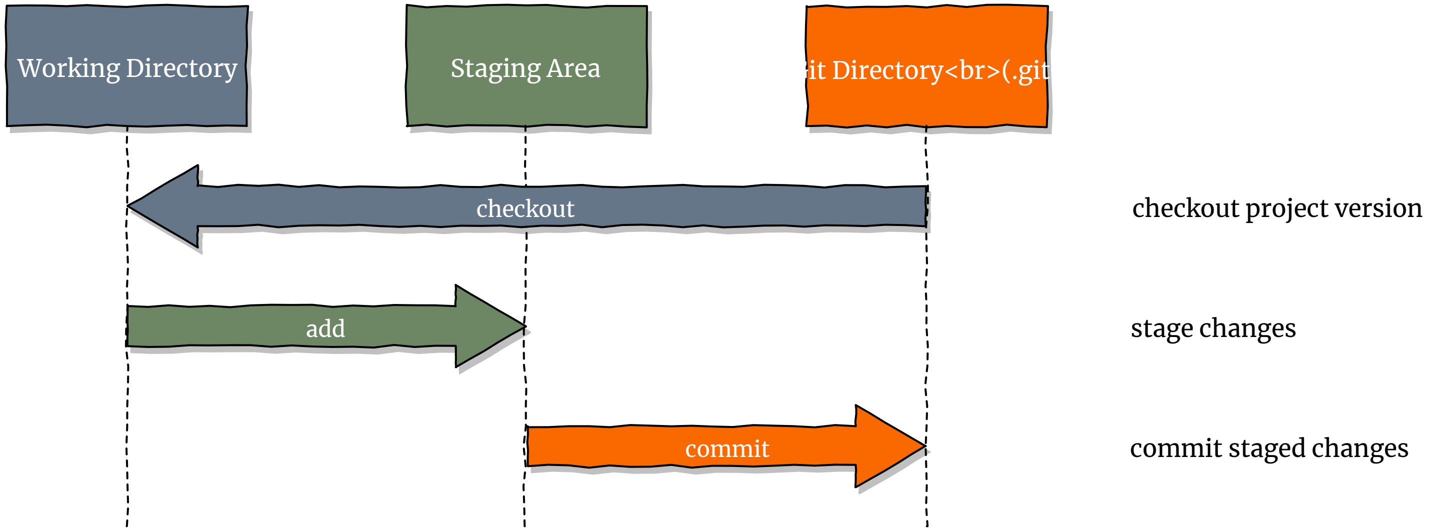


Git Areas

The **Git directory** is where Git stores the metadata and object database for your project.

The **working tree** is a single **checkout** of one version of the project.

The **staging area** (or **index**) is a file in your Git directory that stores information about what will go into your next commit.



Working Directory

Staging Area

it Directory<br>(.git

checkout

checkout project version

add

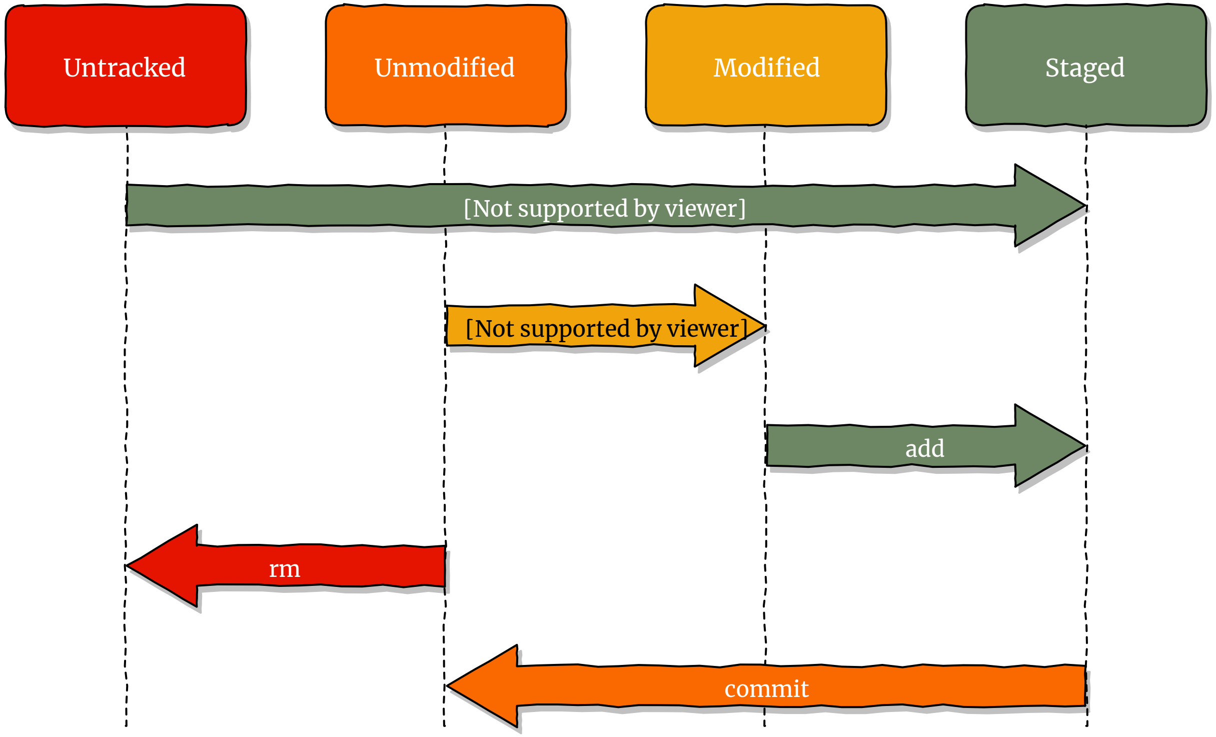
stage changes

commit

commit staged changes

File States

Files in the working directory can be in different states:



tracking a new file

edit / modify a file

staging a modified file

untracking a file

Local Git

Git as a local VCS

Create a Repository

Enter a local directory, currently not under version control:

```
cd project
```

And turn it into a Git repository:

```
git init
```

This will create an hidden *.git* subdirectory containing all of your necessary repository files.

Add

The add command can be used to:

1. **Track** and **stage** a file that is currently **not tracked** by Git.
2. Stage a file that has been **modified**.

```
$ echo "hello git" > README    # File is created
$ git add README               # File is now tracked and staged
```

You can use the **--all** or **-A** flag to stage all untracked **or** modified files.

```
$ echo "hello git" > README    # File is created
$ git add --all                # File is now tracked and staged
```

Commit

The commit command records a new snapshot to the repository:

```
$ echo "hello git" > README    # File is created
$ git add README               # File is now tracked and staged
$ git commit                   # Commits the file
```

After running commit, Git will open your predefined text editor so that you can write a small commit message (or use the --**message** or -**m** flag).

The --**all** or -**a** flag automatically stages any **modified** (tracked) files:

```
$ echo "goodbye git" > README      # Already tracked file is modified
$ git commit -a -m "Edited README" # Stages and commits the file
```

Status

The status command can be used to determine which files are in which state:

```
$ echo "hello git" > README     # File is created
$ git status                    # Asking for file status
On branch master

No commits yet

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


        README

nothing added to commit but untracked files present (use "git add" to track)
```

The --short (or -s) flag can be used to get a more concise output:

```
$ git status --short            # Asking for file status
?? README
$ git add README                # File is now tracked and staged
$ git status --short            # Asking for file status
A  README
```

Status

Notice that the **git status -s** command consists of two columns for each file.

```
$ echo "hello git" > README      # File is created
$ git status -s
?? README                        # File is untracked
```

The first column has information about the **staging area** and the second one about the **working directory**. In this case the file is untracked on both.

```
$ git add README                 # Modifications are staged
$ git status -s
A  README                        # File added to staging area
```

Now the file has been added in the staging area.

```
$ git commit -m "Added README"   # Commiting changes
$ git status -s
```

Now the file has been commited and is unmodified.

Partially Staged Files

A file can be partially staged:

```
$ echo "some text" > README     # File is modified
$ git add README                # Modifications are staged
$ echo "another text" >> README # File is modified again
$ git status -s
AM README                       # Added to staging area and modified
```

1) Commiting again would only commit the initial staged edits:

```
$ git commit -m "Added some text"      # Commiting initial edit
$ git status -s
 M README                              # File now still has changes
$ git add README                       # Staging those changes
M  README
$ git commit -m "Added another text"   # Commiting following edits
```

2) We can also only commit once:

```
$ git add README                               # Staging following changes
$ git status -s
A  README                                      # All changes staged
$ git commit -m "Added some and another text"  # Commiting both changes at once
```

Remove

If you delete a file from your working area, it will appear as a change that needs to be staged in order to be reflected in the repository:

```
$ rm README                      # File is removed from working directory
$ git status -s
 D README                        # File removed in working tree
$ git add README                 # File removal is staged
$ git status -s
D  README                        # File removed in staging area
$ git commit -m "Removed README"  # File removal is committed
```

The **git rm** command simplifies this operation by removing the file from the working directory and staging that change at the same time.

```
$ git rm README                  # Removed from working directory and staged
$ git status -s
D  README                        # File removed in staging area
$ git commit -m "Removed README"  # File removal is committed
```

History

The **log** command allows you to see the **commit history** of a repository.

```
$ git log
commit 41138ac70c5b32239c0000824d8d64315cb50d84 (HEAD -> master)
Author: User <user@email.com>
Date:   Thu Feb 7 09:55:36 2019 +0000

    Modified README

commit 5621668b7f21c4a06385e123d6ee20d1beb6fa1d
Author: User <user@email.com>
Date:   Thu Feb 7 09:55:15 2019 +0000

    Added README
```

- We can see by **whom** and **when** each commit was made.
- We can see the commit **message**.
- And also the **hash** of each commit.

Simplified History

The **--oneline** flag produces a simplified version of the log.

```
$ git log --oneline
41138ac (HEAD -> master) Modified README
5621668 Added README
```

We can also limit the number of entries to be shown.

```
$ git log --oneline -1
41138ac (HEAD -> master) Modified README
```

Patches

The **--patch** (or -p) flag shows the difference (the patch output) introduced in each commit.

```
$ git log -1 -p
commit 41138ac70c5b32239c0000824d8d64315cb50d84 (HEAD -> master)
Author: User <user@email.com>
Date:   Thu Feb 7 09:55:36 2019 +0000

    Modified README

diff --git a/README b/README
index 7b57bd2..2e24352 100644
--- a/README
+++ b/README
@@ -1 +1,2 @@
 some text
+another text
```

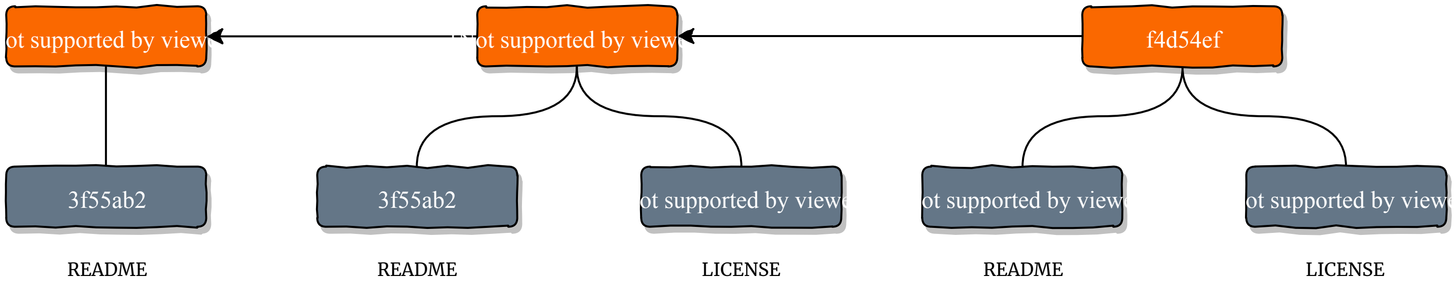
The output is rather intimidating but it allows you to see what changed in each commit.

Branches

Commits

As we have seen before, files are stored as **blobs** and identified by an **hash**.

Versions (or commits) are just a **snapshot**, also identified by an **hash**, pointing to a series of blobs.

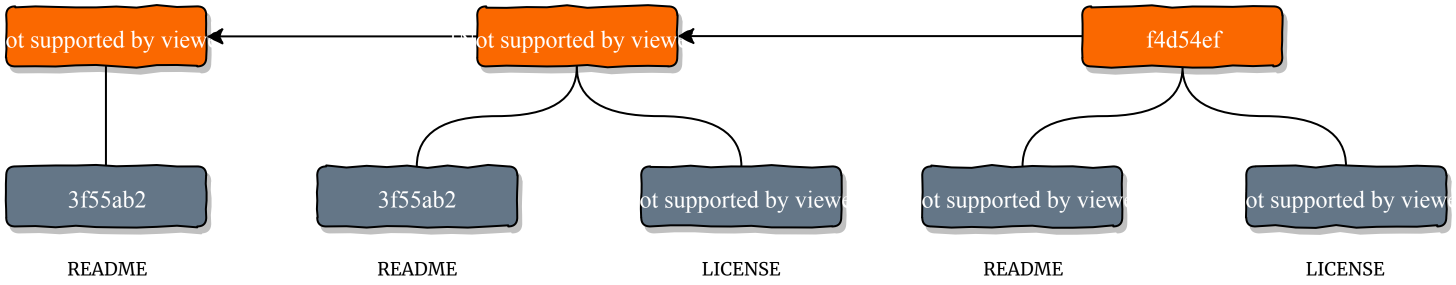


Each commit contains the author's **name** and **email** address, the **message** that was typed, and pointers to the commit (or commits) that directly came before this commit (its **parent** or parents).

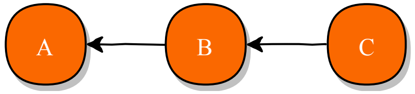
Commits

In this specific example we have 3 commits:

1. 3523e920 – The initial commit where a README file was added.
2. 70aca513 – A second commit where a LICENSE file was added.
3. f4d54ef1 – A third commit where the README file was modified.



From now on, we will use a simplified version of this commit tree:

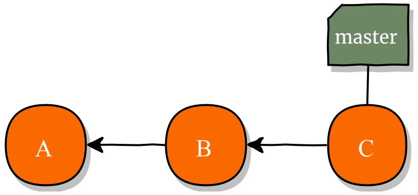


Branches

A **branch** in Git is simply a lightweight movable **pointer** to one of these commits.

The **default** branch name in Git is *master*.

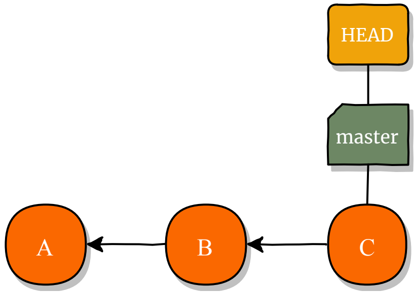
As you start making commits, you're given a *master* branch that points to the **last** commit you made.



Every time you commit, the *current* branch pointer moves **forward automatically**.

Head

Git uses a special pointer called HEAD that always points to your current branch.



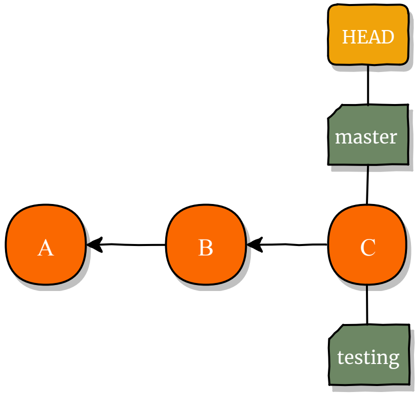
And now this makes a little bit more sense:

```
$ git log --oneline
f4d54ef (HEAD -> master) Modified README
70aca51 Added LICENSE
3523e92 Added README
```

Creating Branches

To create a branch we use the **branch** command. This only creates the branch, it does not move the HEAD:

```
$ git branch testing
```



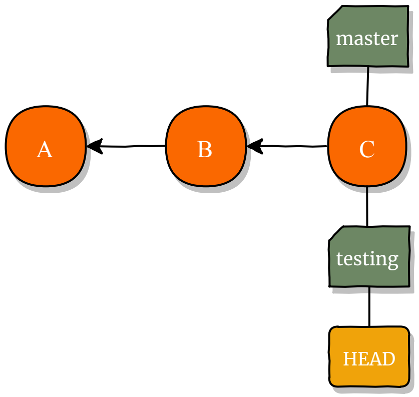
The **branch** command can also show the current local branches.

```
$ git branch
* master                  # The asterisk (*) represents the HEAD
  testing
```

Checkout

To change to another branch we can use the **checkout** command:

```
$ git checkout testing
  master
* testing
```



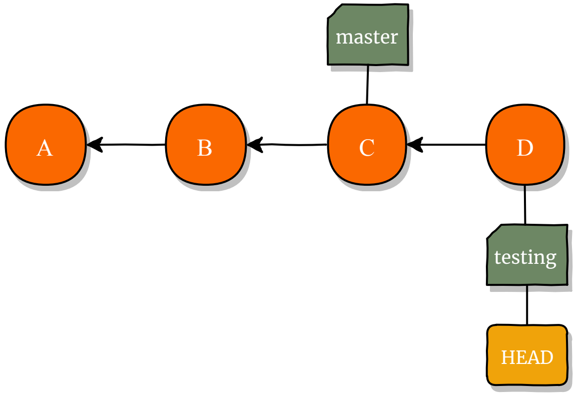
We can also create and checkout a new branch using the **-b** flag:

```
$ git checkout -b testing
```

Moving the HEAD

If we create a new commit now:

```
$ echo "more license info" >> LICENSE
git commit -a -m "Testing LICENSE"
```



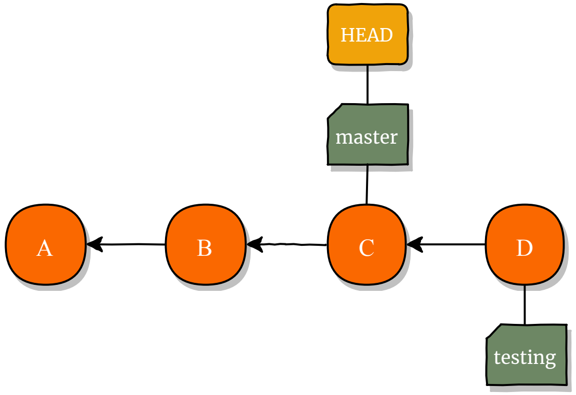
We can see that **only the current branch**, the one pointed by the HEAD, **moved**.

Checkout

If we **checkout** the *master* branch again, two things happen:

```
$ git checkout master
```

1. The HEAD moves to the commit pointed by the **master** branch.
2. Our files are reverted to the snapshot that **master** points to.

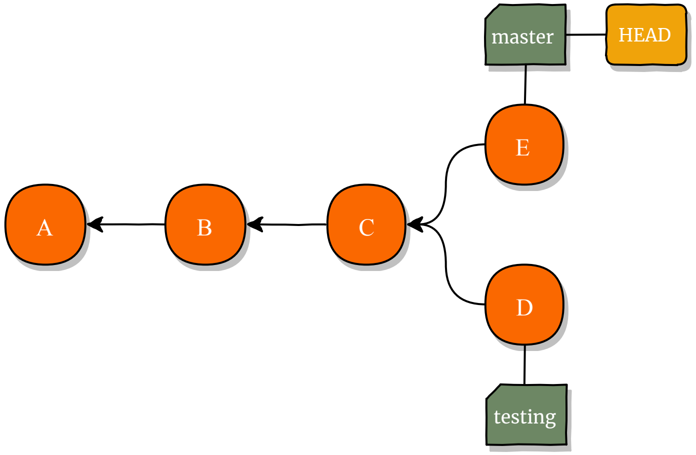


This means we are now working on top of a version that has **already been changed**. Any changes we make will create a **divergent history**.

Divergent Histories

Now that we are back to our master branch, let's do some more changes:

```
$ git checkout master
$ echo "license looks better this way" >> LICENSE
git commit -a -m "Better LICENSE"
```



Now we have two divergent histories that have to be **merged** together.

Merging

Merging is done by using the merge command:

```
$ git checkout master
$ git merge testing
```

Git merges the **identified** branch **into** the **current** branch.

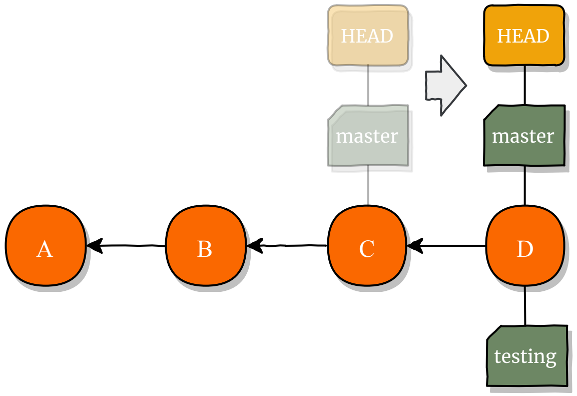
Git uses **two main strategies** to merge branches:

- Fast-forward merge: when there is **no divergent** work
- Three-way merge: when there is **divergent** work

Fast-forward Merge

When you merge one commit with a commit that can be reached by following the first commit’s history because there is **no divergent work** to merge together, Git just **moves the branch pointer forward**.

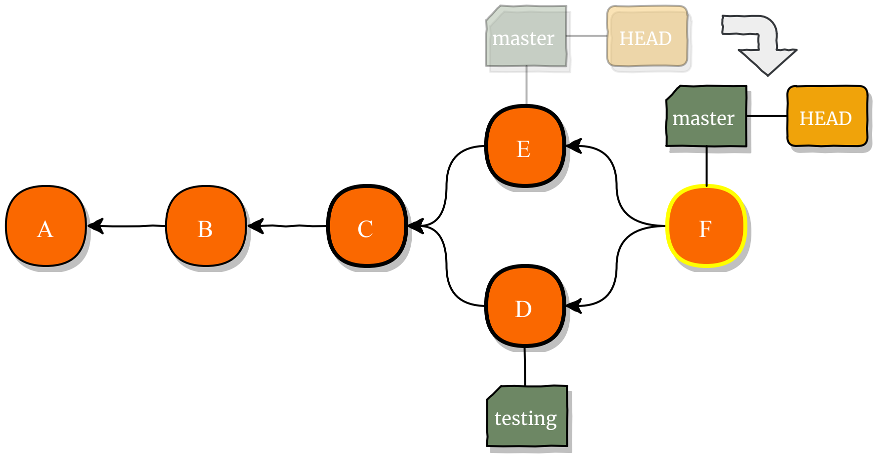
```
$ git checkout master
$ git merge testing
```



Three-way Merge

When the commit on the branch you're on **isn't a direct ancestor** of the branch you're merging in, Git uses the **two** snapshots pointed to by the **branch tips** and the **common ancestor** of the two to create a **new commit**.

```
$ git checkout master
$ git merge testing
```



Deleting Branches

If you do not need a branch any longer, you can just delete it.

Deleting a branch leaves all commits alone and only deletes the pointer.

```
$ git branch -d testing
```

Conflicts

If you changed the **same part** of the **same file** differently in the two branches you’re merging, Git **won’t be able** to merge them cleanly:

```
$ git merge testing
Auto-merging README
CONFLICT (content): Merge conflict in README
Automatic merge failed; fix conflicts and then commit the result.
```

You can use the **status** command to see which files have conflicts:

```
$ git status
On branch master
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

no changes added to commit (use "git add" and/or "git commit -a")
```

Resolving Conflicts

Editing the file with conflicts we can see the conflict:

```
This is a README file
<<<<<<< HEAD
This was added in the master branch
=======
This was added in the testing branch
>>>>>>> testing
```

To solve it we just have to edit the file:

```
This is a README file
This was added in the master branch
This was added in the testing branch
```

And commit the merge:

```
$ git commit
```

Git Ignore

- A *.gitignore* file specifies intentionally untracked files that **Git should ignore**. Files already tracked by Git are not affected.

- Each line in a *.gitignore* file specifies a pattern.

- Some examples:

```
# this is a comment
docs/          # everything inside root directory docs
**/docs/       # any docs directory
!docs/**/*.txt # don't ignore (!) any .txt files inside directory docs
```

What files to ignore: 1) not used by your project, 2) not used by anyone else and 3) generated by another process.

Remotes

Remotes

Remote repositories are **versions** of your project that are hosted **elsewhere** (another folder, the local network, the internet, ...).

You can push and pull data to and from remotes but first you need to learn how to configure them properly.

Cloning

The easiest way to end up with a remote, is to **clone** another repository.

```
$ git clone https://example.com/test-repository
Cloning into 'test-repository'...
remote: Enumerating objects: 129, done.
remote: Counting objects: 100% (129/129), done.
remote: Compressing objects: 100% (73/73), done.
remote: Total 129 (delta 54), reused 115 (delta 44), pack-reused 0
Receiving objects: 100% (129/129), 46.90 KiB | 565.00 KiB/s, done.
Resolving deltas: 100% (54/54), done.
```

To list our remotes (the verbose **-v** flag gives us some info about the URL):

```
$ git remote -v
origin  https://example.com/test-repository (fetch)
origin  https://example.com/test-repository (push)
```

We can see that git named our remote **origin** and set it up for both **fetching** and **pushing** data.

Protocols

Git can use **four** major network protocols to transfer data to and from **remotes**:

- **Local** - Useful if you have access to a shared mounted directory.
- **Git** - A special daemon that comes packaged with Git. SSH but without authentication or encryption.
- **SSH** - The most commonly used protocol.
- **HTTP** - Easiest to setup for read-only scenarios but very slow.

Adding Remotes

Besides the origin remote from where we cloned our project, we can add more remotes:

```
git remote add john http://john-laptop.org/test-repository
```

In this example, we added a new remote and gave it the alias *john*:

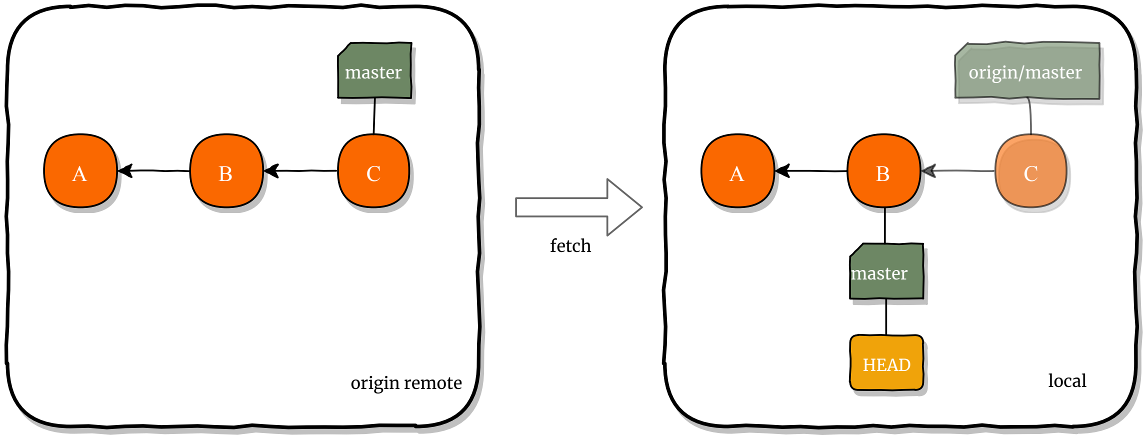
```
$ git remote -v
origin  https://example.com/test-repository (fetch)
origin  https://example.com/test-repository (push)
john  http://john-laptop.org/test-repository (fetch)
john  http://john-laptop.org/test-repository (push)
```

Fetching

Fetching pulls down all the data from a remote project that you don’t have yet.

After fetching, you will also have references to all the branches from that remote.

```
$ git fetch origin
```



Fetching **only downloads** the data to your local repository. It doesn’t automatically merge it with any of your work or modify what you’re currently working on.

Tracking Branches

Tracking branches are local branches that have a **direct relationship** to a remote branch.

When you clone a repository, it generally **automatically** creates a **master** branch that tracks **origin/master**.

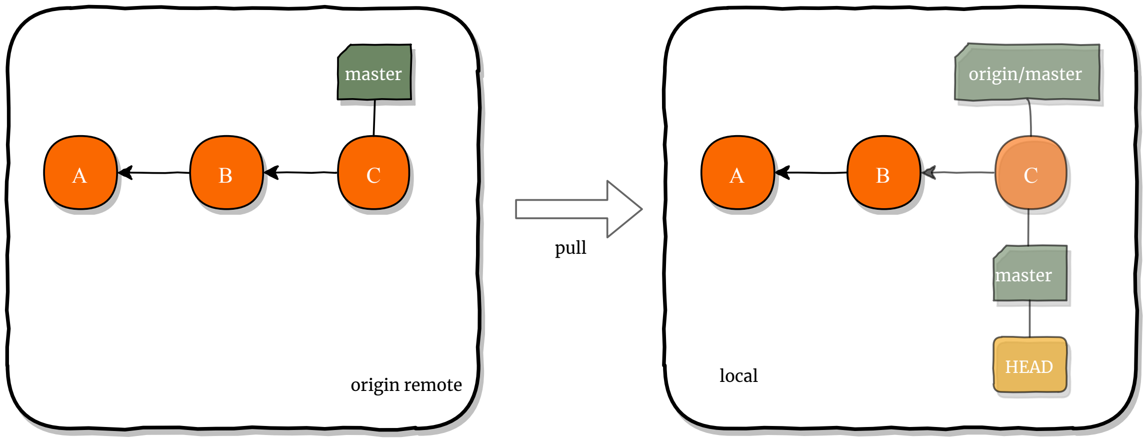
You can set up other tracking branches:

```
$ git checkout --track origin/feature # creates a local feature branch
                                    # that tracks origin/feature
```

Pulling

If your current branch is set up to **track** a remote branch, you can use the **git pull** command to automatically **fetch** and then **merge** that remote branch into your current branch.

```
$ git pull origin master # fetches and merges origin/master
```



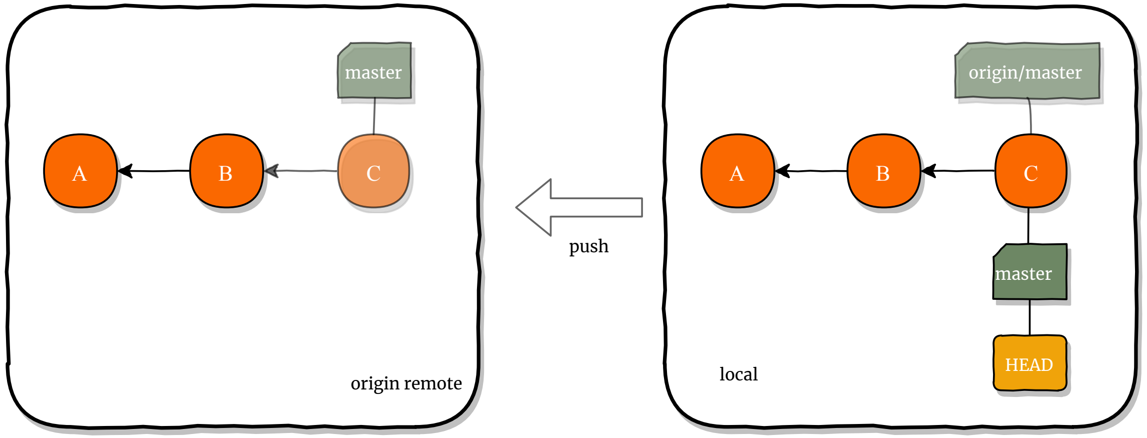
This fetches data from the server you originally cloned from and automatically tries to merge it into the code you are currently working on.

```
$ git pull # uses default values for current local branch
```

Pushing

Pushes local modifications to a remote. Only fast-forward merges are allowed so you might need to fetch and merge locally first.

```
$ git pull # or git pull origin master
$ echo "some changes" >> README
$ git commit -a -m "Made some changes"
$ git push # or git push origin master
```



With the -u flag, it also sets the local branch to track the remote branch.

Git Hosts

Some free (for **open** source, **education** and **small** projects) git hosts you can use:

- GitHub
- BitBucket
- GitLab
- SourceForge

Reverting

Reset

The **reset** command resets the current branch HEAD to a certain commit.

These are some of the many different modes it can operate under:

- --**soft** - Does not touch the index[1] file or the working tree at all.
- --**hard** - Resets the index and working tree.
- --**mixed** - Resets the index but not the working tree (**default mode**).

[1] The staging area.

Local unstaged changes

If you haven't staged or commited the changes you want to revert you can:

```
$ git checkout -- README # undo changes to a single file
```

```
$ git reset --hard       # discard all local changes
```

Staged but uncommited changes

If you have staged the changes you want to revert but haven't commited them yet, you can:

```
$ git reset HEAD <file>  # unstage changes to a single file
```

```
$ git reset # unstage all changes
```

Commited but not pushed

If you have already commited the changes you want to revert but haven't pushed them to a remote yet, you can find the *commit-id* you want to revert to and:

```
$ git reset --hard <commit-id>
```

Commited and already pushed

You should try, **really hard**, to never rewrite public history.

For that reason, if you want to revert a file that was already pushed, your best bet is to use revert:

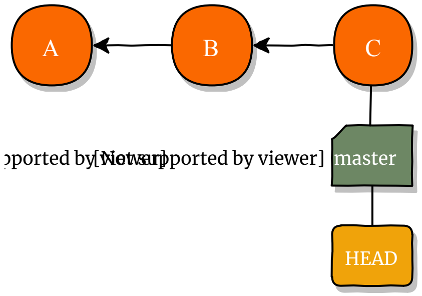
```
$ git revert <commit-id>
```

This will introduce the changes needed to revert the ones done by the commit without deleting the commit from history.

Relative commits

The ~(tilde) and ^(caret) symbols are used to point to a position relative to a specific commit.

- COMMIT^ refers to the previous commit to COMMIT.
- COMMIT^^ refers to the previous commit to COMMIT^.
- COMMIT~2 refers to two commit previous to COMMIT.
- And so on...



Workflows

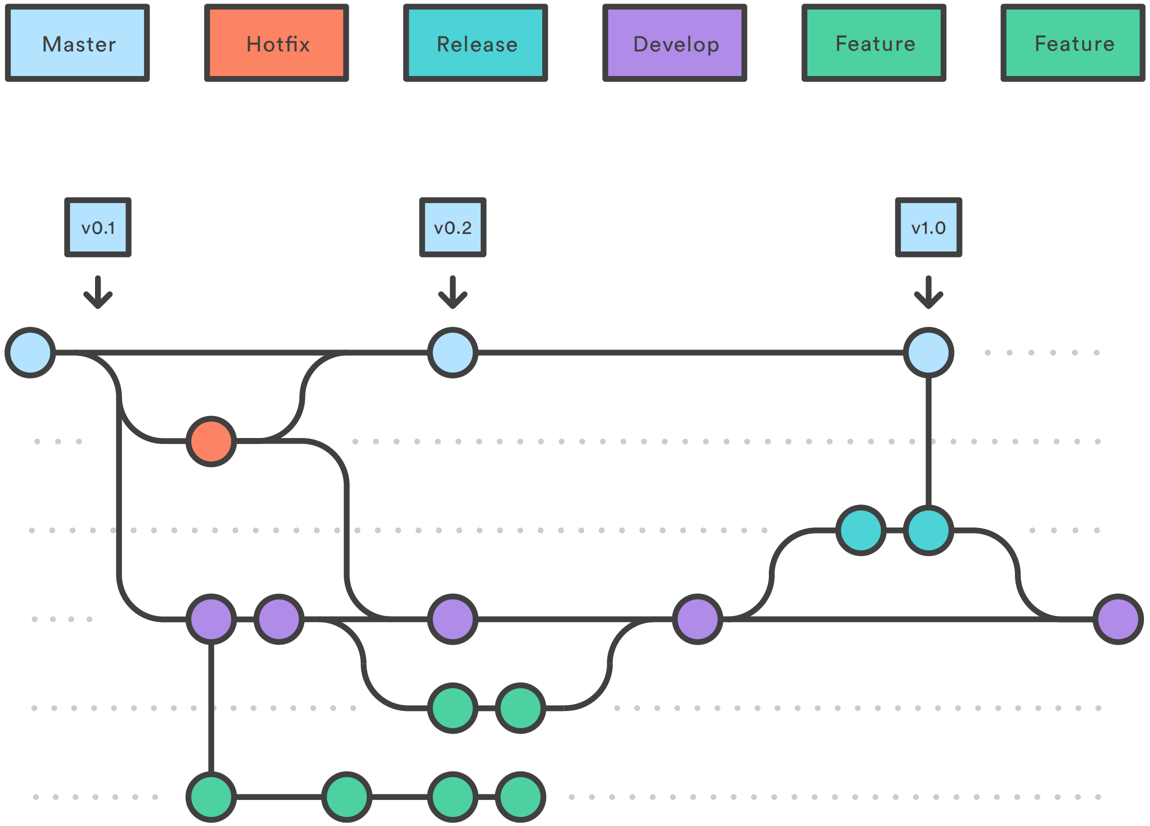
Workflows

There are endless different ways to use Git. For example:

- Having **feature branches** for each new feature.
- Having **release branches** where releases can be maintained.
- Hot fix branches to quickly patch production releases.

Git Flow

Git Flow is one way, but not the only one, of using git.



What's important is that you are consistent in the way you use Git.

More

More stuff

Things we haven't talked about:

- Tags - Really just unmovable branches. Useful for marking releases.
- Rebase - A different and cleaner way to merge.
- Hooks - IFTTT for Git.
- Blame - Who broke the code?
- Bisect - Finding a bad commit.
- Stash - Save these changes for later.
- Pull requests - Please take my code...
- And so much more...