Git & Github

Introdução Engenharia Informática

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A Practical Guide to Version Control and Collaboration

The Chaos Before Version Control

Imagine you're writing a large essay or coding project. Your folder probably looks like this:

- `Project_v1.c`
- `Project_v2_fixed.c`
- `Project_final.c`
- `Project_final_REALLY.c`
- `Project_final_APPROVED_v3.c`

This is confusing, error-prone, and impossible to scale. You have no clear record of *what* changed, *why* it changed, or *when*.

The Collaboration Problem

1. **Method 1: Shared Folders (e.g., Dropbox, Google Drive)**
   - These are **file synchronization** tools, not version control tools.
   - **Problem:** *File locking.* If two people edit the same file, you get `MyFile (Conflict Copy).doc`. The last person to save *wins,* and work is lost. It only syncs the *latest* version.
2. **Method 2: Emailing Files**
   - `Project_v5_Marios_changes.zip`
   - `Project_v5_Anas_feedback.zip`
   - **Problem:** How do you merge these changes? This is a manual, chaotic process that guarantees failure.

The Solution: A Version Control System (VCS)

A VCS is a system that records changes to a file or set of files over time. It's a **time machine** for your project.

It allows you to:

- See who changed what, and when.
- Revert to any previous version.
- Compare changes over time.
- Safely merge work from multiple people.

Types of VCS: Centralized vs. Distributed

1. **Centralized (CVCS) - e.g., Subversion (SVN)**
   - There is **one single central server** that holds the entire project history.
   - Developers “check out” the latest version, work, and “check in” their changes.
   - **Weakness:** It’s a single point of failure. If the server goes down, no one can collaborate or save their history.

2. **Distributed (DVCS) - e.g., Git, Mercurial**

- **Every developer** has a full, local copy (a “clone”) of the **entire repository**, including its full history.
- The “server” is just another repository that everyone agrees to sync with.
- **Strength:** You can work offline, and the history is safe on dozens of machines.

The Origin of Git

- **Who:** Linus Torvalds (the creator of the Linux Kernel).
- **When:** 2005.
- **Why:** The Linux Kernel team was using a proprietary DVCS called BitKeeper. A licensing change forced them to stop.
- **The Problem:** No other VCS could handle the sheer scale (speed, size, and number of contributors) of the Linux Kernel project.
- **The Solution:** Linus created **Git** in about a week. It was designed from the ground up to be distributed, fast, and to ensure data integrity.

How Git “Thinks”: Snapshots, Not Diffs

Many older VCS tools (like SVN) store changes as *deltas* or *diffs* (a list of what changed, line by line).

Git does not. Git “thinks” of its history as a **stream of snapshots**.

When you **commit** (save a version), Git takes a “picture” of what all your files look like at that moment and stores a reference to that snapshot. If a file hasn’t changed, Git just links to the previous version of that file.

The Core Concept: The 3 States

This is the most crucial, and sometimes confusing, part of Git. Your files exist in one of three states:

1. **Working Directory:** All your files and folders on your computer's filesystem. This is your "messy desk."
2. **Staging Area (Index):** A "drafting" area. This is where you assemble your snapshot. You use `git add` to move files *from* the Working Directory *to* here.
3. **Repository (.git):** The permanent, immutable database of all your project's snapshots (commits). This is the "file cabinet."

Creating a Repository: `git init`

There are two ways to start a project with Git:

1. `git clone`: (We'll see this later) Copy an *existing* repository from a server.
2. `git init`: Create a *new* repository from scratch.

`git init` is the command you run inside a project folder to turn it into a Git repository.

```
$ mkdir my-new-project
$ cd my-new-project
$ git init
Initialized empty Git repository in /path/to/my-new-project/.git/
```

This command creates a hidden sub-directory named `.git`. This `.git` folder is the "brain" of your repository—it contains all the snapshots, branches, and history.

The Core Workflow: `add` & `commit`

1. You modify files in your **Working Directory**.
2. You run `git status` to see what has changed.
3. You use `git add <filename>` to move your desired changes from the Working Directory to the **Staging Area**.
4. You use `git commit -m "My message"` to take everything in the Staging Area, create a permanent **snapshot** (a commit), and save it to your **Repository**.

The commit message is vital. It should explain *why* you made the change, not *what* you changed (the code shows what).

What Makes a *Good* Commit Message?

A commit message is a log for your future self and your teammates. A good message provides context and answers *why* a change was made. The community standard follows a *50/72* rule:

- **Subject:** A short summary, 50 characters or less.
- (Leave one blank line)
- **Body:** A detailed explanation, wrapping lines at 72 characters.

The 7 Rules of a Great Commit Message

1. **Use the imperative mood in the subject.**
   - **Good:** `Add login page`
   - **Bad:** `Added login page` or `Adding login page`
     (Think of it as a command: “This commit will…”)
2. **Separate the subject from the body with a blank line.**
3. **Limit the subject line to 50 characters.**
4. **Do not end the subject line with a period.**
5. **Capitalize the subject line.**
6. **Wrap the body at 72 characters.**
7. **Use the body to explain *what* and *why* vs. *how*.** The code shows *how*.

Example: Good vs. Bad

Bad Commit: `git commit -m "fix stuff"`

Good Commit:

```
git commit -m "Fix: Correct user authentication logic" -m "

The previous login function failed to hash the password before
comparing it to the database, resulting in a critical security
vulnerability.

This commit applies the SHA-256 hashing function to the user's
input before the database query. This resolves the security flaw."
```

The Power of Git: `branch`

A **branch** is simply a lightweight, movable pointer to one of your commits. The main branch is typically called `main` or `master` (depracated as of late).

Why use branches? To work on new features or fix bugs in **isolation** without breaking the stable code on the `main` branch.

- `git branch <name>`: Creates a new branch.
- `git checkout <name>`: Switches your Working Directory to that branch.
- `git checkout -b <name>`: A shortcut that creates and switches in one step.

Viewing History: `git log`

Once you have commits, you need to see them.

- `git log`: Shows the full commit history, with authors, dates, and messages.
- `git log --oneline`: Shows a compact, one-line view of the history.
- `git log --graph --oneline`: Shows the history with ASCII art representing the branches and merges.

Combining Work: `merge`

After you finish your work on a feature branch (e.g., `feature/login`), you need to integrate it back into `main`.

A `merge` joins the histories of two branches.

1. Switch to the branch you want to update: `git checkout main`
2. Run the merge: `git merge feature/login`

Git will create a new “merge commit” that ties the two histories together.

The Inevitable: Merge Conflicts!

A merge conflict happens when you try to merge two branches that have **edited the same line in the same file**. Git doesn't know which change is correct, so it stops and asks you to fix it manually.

1. Git will mark the file with `<<<<<<<` and `>>>>>>>` to show you both conflicting versions.
2. You must open the file, delete the markers, and edit the code to be correct.
3. You then `git add` the fixed file and run `git commit` to finalize the merge.

Alternative to Merging: `rebase`

A `rebase` is a way of "rewriting history" to keep it clean and linear.

Instead of a "merge commit," `rebase` takes all the commits from your feature branch and **re-applies them, one by one,** on top of the latest version of the `main` branch.

- **Result:** A clean, single-file-line history.
- **Warning:** This is a powerful, history-altering command. **NEVER** rebase public branches that other people are using.

Collaboration - Git & GitHub: `remote` & `origin`

So far, everything has been local. How do you share?

- A `remote` is a named connection to a Git repository in another location (e.g., on a server).
- `origin` is the default, conventional name for your main `remote` (the server you cloned from or want to push to).

The Main Collaboration Commands

- `git clone [url]`: Downloads a full copy (a clone) of a remote repository to your machine and sets up the `origin` connection.
- `git pull`: (“Pulls”) Fetches changes from `origin` and merges them into your local branch. It’s `git fetch` + `git merge`.
- `git push`: (“Pushes”) Uploads your local commits (that the remote doesn’t have) to `origin`.

Git vs. GitHub

This is a critical distinction.

- **Git** is the **tool**. It's the distributed, command-line VCS you install on your computer.
- **GitHub** is a **service**. It's a web-based company (founded in 2008, now owned by Microsoft) that **hosts** Git repositories.

GitHub provides a "social layer" on top of Git, adding features like issue tracking, wikis, and Pull Requests.

The Open-Source Workflow: `fork`

You can't just `push` your changes to a project you don't own (like the official Python repository).

A `fork` is a **personal, server-side copy** of someone else's repository. It lives in your GitHub account, and you have full control over it. This is the first step to contributing.

The Heart of Collaboration: `pull request`

A **Pull Request (PR)** is a formal request for a project owner to “pull” (merge) your changes from your branch (or fork) into their main branch.

A PR is the start of a **conversation**. It is *not* just a command. It’s a web page on GitHub where: * You describe *why* you made the changes. * Your team can **review your code** line by line. * You can discuss improvements. * Automated tests can be run. * The project owner can approve and merge your code.

A Typical Git Workflow (Summary)

1. `git clone [url]`: Get the project from a remote server (like GitHub).
2. `git checkout -b new-feature`: Create a new branch to work in isolation.
3. ... *Write your code, make your changes* ...
4. `git add .` : Stage your changed files.
5. `git commit -m "Add login functionality"`: Save a snapshot of your work.

6. `git push origin new-feature`: Upload your branch to the remote server.
7. **Go to GitHub:** Open a **Pull Request** to propose your changes.
8. **Discuss / Review:** Your team reviews your code.
9. **Merge:** A project maintainer merges your PR into the `main` branch.
10. `git checkout main`: Switch back to your local `main` branch.
11. `git pull origin main`: Update your local `main` with the newly merged code.

Marking Versions: `tag` & `release`

When your project reaches a stable point (e.g., `v1.0.0`), you want to mark it.

- `git tag v1.0.0`: A "tag" is a permanent pointer that points to a specific commit. Unlike a branch, a tag is not meant to move. It's an anchor in your history.
- **GitHub Releases:** A "Release" is a feature on GitHub that is built on top of a tag. It's a formal web page for your release that lets you:
  - Write a "changelog" (what's new).
  - Attach binary files (like `.exe` or `.zip` installers).
  - Mark it as a "pre-release."

This is how you officially present a new version to your users.

Summary: Git vs. GitHub

- **Git** is the distributed **tool** on your computer for tracking changes (snapshots).
  - `init`, `add`, `commit`, `branch`, `merge`, `pull`, `push`
- **GitHub** is the social web **service** that hosts your repositories and facilitates collaboration.
  - `Fork`, `Pull Request`, `Issues`, `Releases`
- **Core Workflow:** `Branch` ➡️ `Add` ➡️ `Commit` ➡️ `Push` ➡️ `Pull Request` ➡️ `Merge`
- **Golden Rule:** Work in isolation on branches. Only merge clean, finished work into `main`.

Further Reading & Resources 📚

- **Pro Git Book:** The definitive guide to Git, available free online.
  - https://git-scm.com/book/
- **GitHub Hello World Guide:** A simple, 10-minute tutorial to get started.
  - https://docs.github.com/en/get-started/quickstart/hello-world
- **Learn Git Branching (Interactive):** An interactive game-like tutorial to learn branching.
  - https://learngitbranching.js.org/
- **Git Cheat Sheet (Atlassian):** A great one-page reference for common commands.
  - https://www.atlassian.com/git/tutorials/atlassian-git-cheatsheet