

## COMP(2041|9044) 25T2 — GIT

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COMP(2041|9044) 25T2 — GIT

1 / 22

### Things developers want

- Tell me what changes were recently made to this file?
- Tell me who added this line of code? When? Why?
- Take all files back to the way they were 2 weeks ago
- 2 coders have been working independently on the system - combine their work safely
- Develop new system features in parallel but still incorporate bug fixes being made to the main release
- Allow me to propose this bug fix and get comments from other developers
- Record that these code changes fix this bug report.

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COMP(2041|9044) 25T2 — GIT

2 / 22

### Git

- Git is a Version Control System (VCS)
  - Track changes to a file or set of files over time so that you can recall specific versions later
- Git is open source under the GPLv2 licence
  - Git git repo
  - Created for and still used by Linus Torvalds for the linux kernel

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COMP(2041|9044) 25T2 — GIT

3 / 22

- SCCS
- RCS
- CVS
- Subversion
- Mercurial
- Fossil
- etc.

## VCS terminology

- Repository (repo)
- Branches
  - Default Branch (master/main/trunk)
- Tags
- Commits
- Index
  - Staging
- Working Directory

## Repository

Many VCSs use the notion of a *repository*

- store all versions of all objects (files) managed by VCS
- may be single file, directory tree, database,...
- possibly accessed by filesystem, http, ssh or custom protocol
- possibly structured as a collection of *projects*

# Git Repository

Git uses the sub-directory `.git` to store the repository.

Inside `.git` there are (among other things):

- **Objects**

- **Blobs** are file contents
  - no file names, permissions, links, etc.
- **Trees** are directory listings
  - model the file system
  - this is where: file names, permissions, links, etc. live
  - trees can also point to other trees to store subdirectories
- **Commits** are snapshots
  - represents the state of the working directory at a particular time
  - has a list of parent commits
  - stores meta info: author, committer, message, etc.
  - points to a tree that represents the file structure at the time of the commit

- **Refs** are pointers

- **Branches**
  - branches provide dynamic pointers to the commits we care about
  - contain hex strings referencing the Object ID of a commit
- **Tags**
  - tags provide static pointers to historic commits
  - contain hex strings referencing the Object ID of a commit

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COMP(2041|9044) 25T2 — GIT

7 / 22

## Inside a Git Repository

A new git repository is created with `git init` will have the following structure:

```
$ tree .git
.git/
├── config
├── HEAD
├── objects
└── refs
    ├── heads
    └── tags
```

Some files are not shown as they are not relevant for us.

- `branches/` is a deprecated implementation of `heads/`
- `description` is only used by the `gitweb` program
- `hooks/` is used for git hooks (very useful, but not relevant for us)
- `info/` is used for git logs and metadata (not relevant for us)

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COMP(2041|9044) 25T2 — GIT

8 / 22

## Inside a Git Repository

Once we have added some files and made some commits the structure may look like this:

```
$ tree .git
.git/
├── config
├── HEAD
├── objects
│   ├── 63
│   │   ├── 438577f200a1323959c79c6bcbdb98b52f95c
│   │   ├── 8bd101ad9ff2a7f224fa89062a693d2afa4964
│   │   └── <more objects>
│   ├── 8d
│   │   └── <more objects>
│   ├── c2
│   │   └── <more objects>
│   ├── ff
│   │   └── <more objects>
│   └── <more objects>
└── refs
    ├── heads
    │   ├── master
    │   ├── develop
    │   ├── feature
    │   │   ├── feature1
    │   │   ├── feature2
    │   │   └── <more branches>
    │   └── <more branches>
    ├── remotes
    │   └── origin
    │       ├── HEAD
    │       └── master
    └── tags
        ├── v1.0
        ├── v1.1
        ├── v1.2
        ├── v2.0
        ├── v2.1
        └── v3.0
```

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COMP(2041|9044) 25T2 — GIT

9 / 22

HEAD is a special file that points to the current ref

- This is usually a branch
- But it can also be a tag or a specific commit

refs/heads/ contains all the branches refs/tags/ contains all the tags refs/remotes/ contains all the remote branches

- refs are simply pointers to commits

## Inside a Git Repository

objects/ contains all the objects

each object is a 20 byte SHA1 hash of the object contents  
stored as a 40 character hex string.

the first two characters of the hash are used as a directory name  
with the remaining 38 characters as the file name.

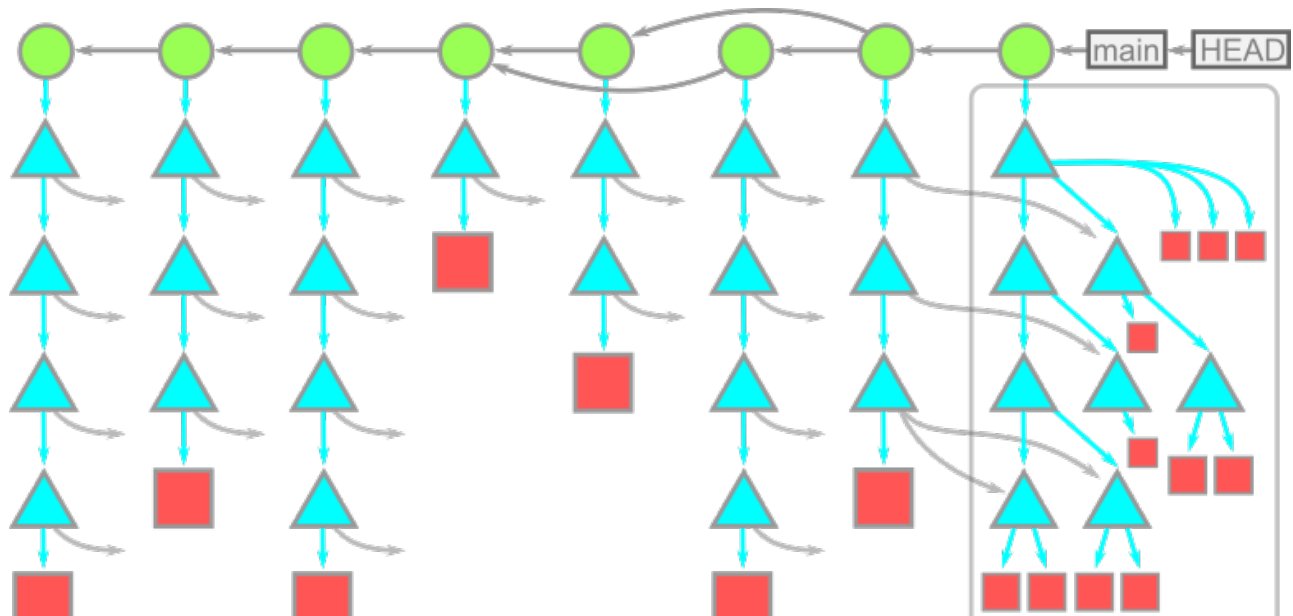
- objects are stored compressed, so can't be read directly

## Inside a Git Repository

- `git ls-files -s`
  - lists all objects in the index
- `git cat-file -t <object>`
  - prints the type of the object
- `git cat-file -p <object>`
  - prints the contents of the object
- `git cat-file --batch-check --batch-all-objects`
  - list all objects, their type and size
- `git rev-list --objects --all`
  - list all objects and their name (if they have one)

# Git Repository Overview

Boxes are blobs, Triangles are trees, Circles are commits



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13 / 22

## Git Repo Hosting

Some of the best known Git repo hosting services

- GitHub
- GitLab
  - UNSW CSE GitLab
- BitBucket
- SourceForge
- etc.

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14 / 22

## Why Git?

- distributed VCS - multiple repositories, no oracle
- every user has their own repository
- created by Linus Torvalds for Linux kernel
- external revisions imported as new branches
- flexible handling of branching
- various auto-merging algorithms
- not better than competitors but better supported/more widely used (e.g. github/gitlab/bitbucket)
- at first stick with a small subset of commands
- substantial (exponential) time investment to learn to use Git's full power

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15 / 22

# git commands

The **80/20 rule**:

80% of the time you run the same 20% of the available commands.

The **BIG 7**:

- `git init [<name>]` or `git clone <URI>`
- `git status`
- `git add <file>...`
- `git commit [-m "<message>"]`
- `git pull`
- `git push`

The others:

- `git branch <branch>`
- `git checkout <branch>`
- `git fetch`
- `git log`
- `git stash`
- `git cherry-pick`
- `git bisect`

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COMP(2041|9044) 25T2 — GIT

16 / 22

## git init

*git-init - Create an empty Git repository*

How every repository starts.

```
git init [options]          # turn the current directory into a git repo
git init [options] <dir>    # create a new directory `dir` that is a git repo
```

Has some very rarely used options:

- `--bare` repo without a working directory, can't commit to the repo.
- `--template` files to copy into `.git` upon creation.
- `--separate-git-dir` create a working directory for a repo located elsewhere
- `--shared` share the repo amongst several users

Reads some very rarely used environment variables:

- `$GIT_DIR` if set use `$GIT_DIR` not `.git` as the name of the base of the repository
- `$GIT_OBJECT_DIRECTORY` store object files here instead of `$GIT_DIR/objects`

99% of the time you will use `git init` without options.

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COMP(2041|9044) 25T2 — GIT

17 / 22

## git clone

*git-clone - Clone a repository into a new directory*

How repositories are shared.

```
git clone [options] <repoURL>          # clone the git repo from `repoURL` into a
↪ directory named after itself
git clone [options] <repoURL> <dir>    # clone the git repo from `repoURL` into a
↪ directory named `dir`
```

Has many (rarely used) options:

- `--bare` similar to `git init --bare`
- `--sparse` start with only the files in the root of the repository
- `-o/--origin <name>` use `<name>` instead of `origin` for the upstream repository
- `-b/--branch <name>` checkout the `<name>` branch instead of `master/main`
- `--recurse-submodules` initialize and clone submodules
- `-j/--jobs` the number of fetches to do at the same time

85% of the time you will use `git clone` without options.

Another 10% will just use the `--recurse-submodules` option.

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COMP(2041|9044) 25T2 — GIT

18 / 22

*git-status - Show the working tree status*

How you know the state of a repository.

```
git status [options]
git status [options] <path> ...
```

Has many options.

The most used options being:

- `-s/--short` output in “short-format”
- `--long` output in “long-format” (default)
- `--porcelain [<version>]` easy-to-parse format for scripts, with the API `<version>`
- `-v/--verbose` show the textual changes that are staged to be committed

## Tracking a Project with Git

- Project must be in single directory tree.
- Usually don't want to track all files in directory tree
- Don't track binaries, derived files, temporary files, large static files, secrets, etc.
- Use **.gitignore** files to indicate files never want to track
- Use `git add <file>` to indicate you want to track *file*
- Careful: `git add <directory>` will recursively add **every** file in **directory**

## git add

*git-add - Add file contents to the index*

```
git add [options] <path> ...
```

- `-n/--dry-run` don't actually add anything, just show what would be added
- `-f/--force` add ignored files
- `-i/--interactive` add interactively
- `-A/--all` add all files already in the index
- `-N/--intent-to-add` mark files as tracked but don't save their contents

*git-commit - Record changes to the repository*

```
git commit [options] [-m <message>] [--] <path> ...
```

- `-m/--message <message>` use <message> as the commit message (almost always used)
- `-a/--all` automatically stage all tracked files before committing
- `-C/--reuse-message <commit>` use the commit message from <commit>
- `--amend` replace the previous commit with a new one
- `--author <author>` use <author> instead of the current user
- `--date <date>` use <date> instead of the current date
- `--allow-empty` allow empty commits (useful for CI/CD pipelines)

if `--message` is not used, `git commit` will open an editor for you to write the commit message. This allows you to write a longer, multi-line, commit message.