DIS08 – Data Modeling

03 – Introduction to git and GitHub

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Version: WS 2021

Technology
Arts Sciences
TH Köln

git != GitHub

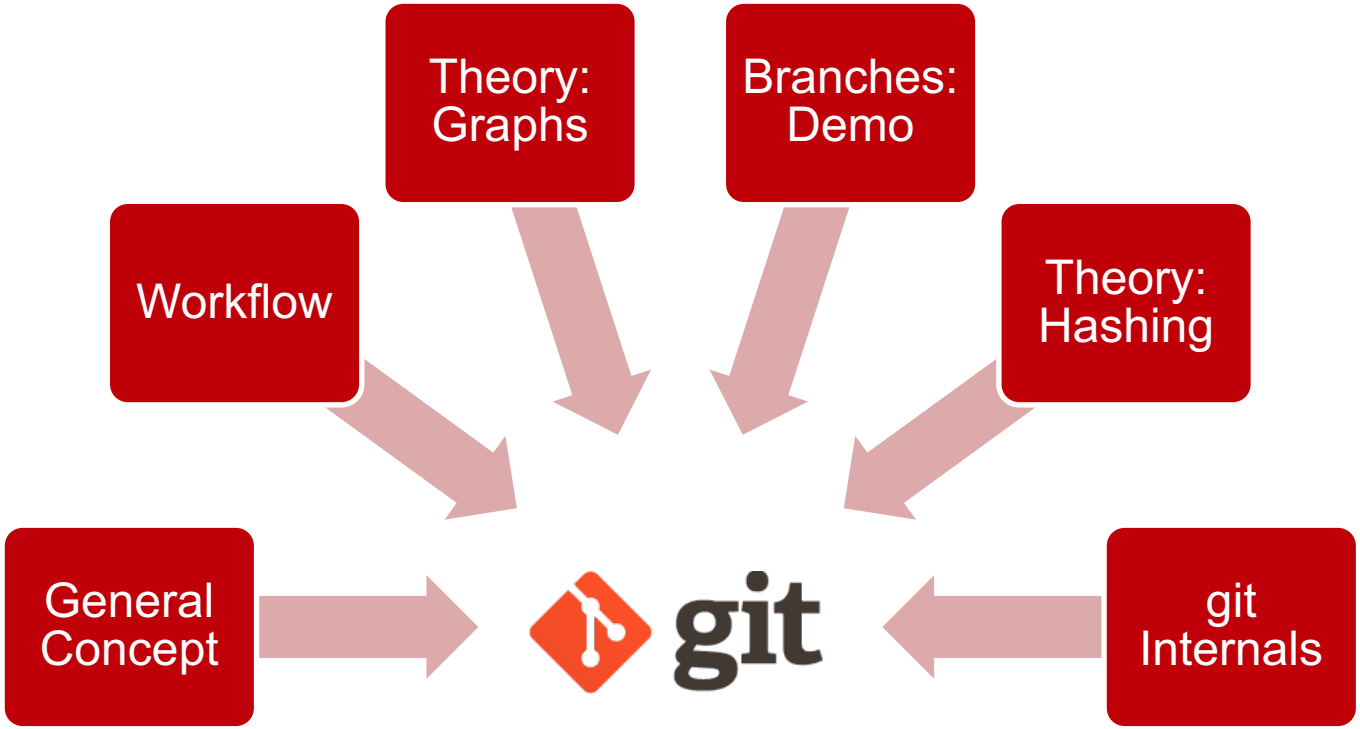
git

- Version control system (VCS)
- Created by Linus Torvalds (2005)
- Other VCS include CVS, SVN, Mercurial

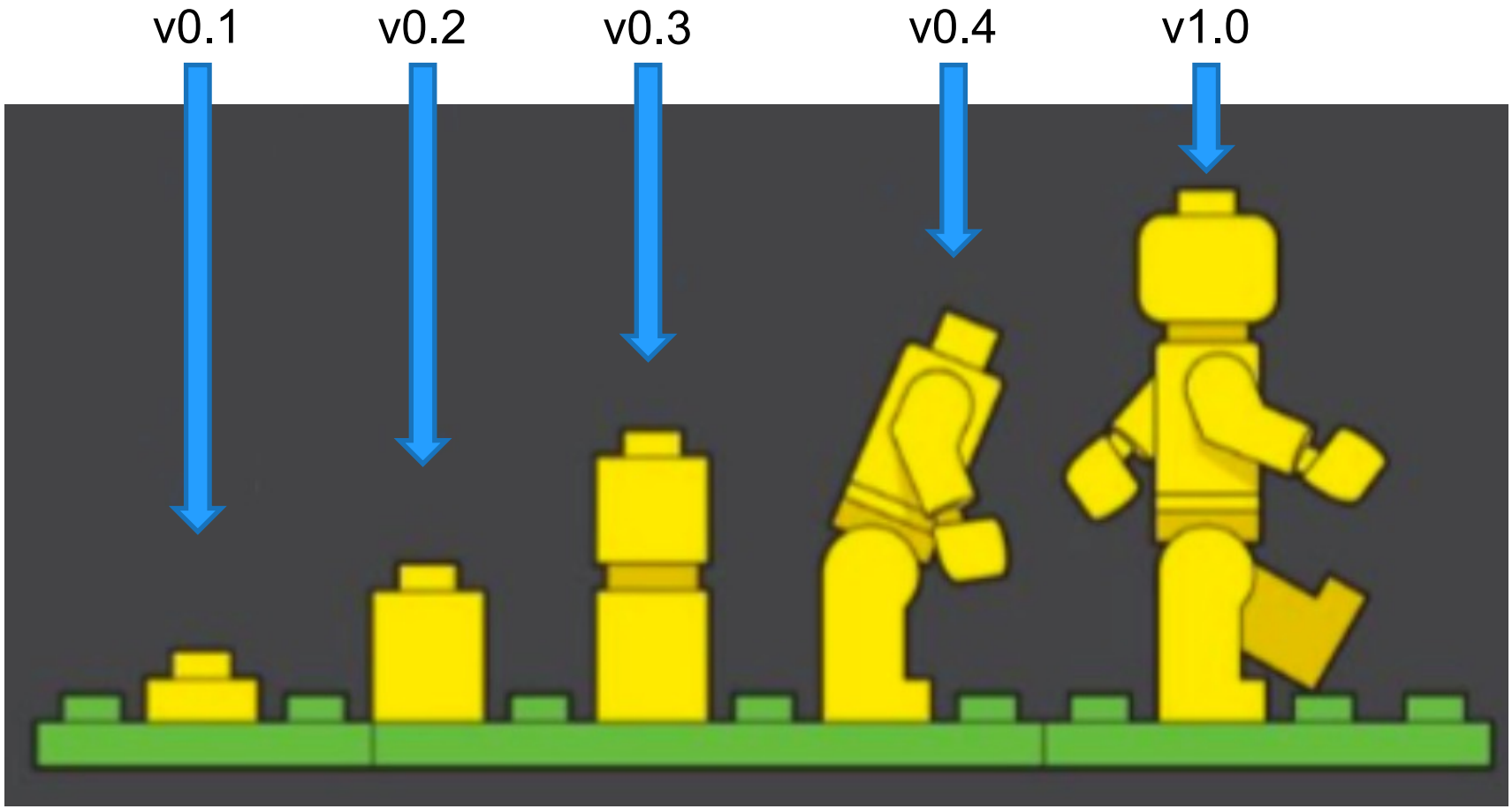
GitHub

- Website for hosting projects that use git
- Launched in 2008
- Others include BitBucket, GitLab

Outline

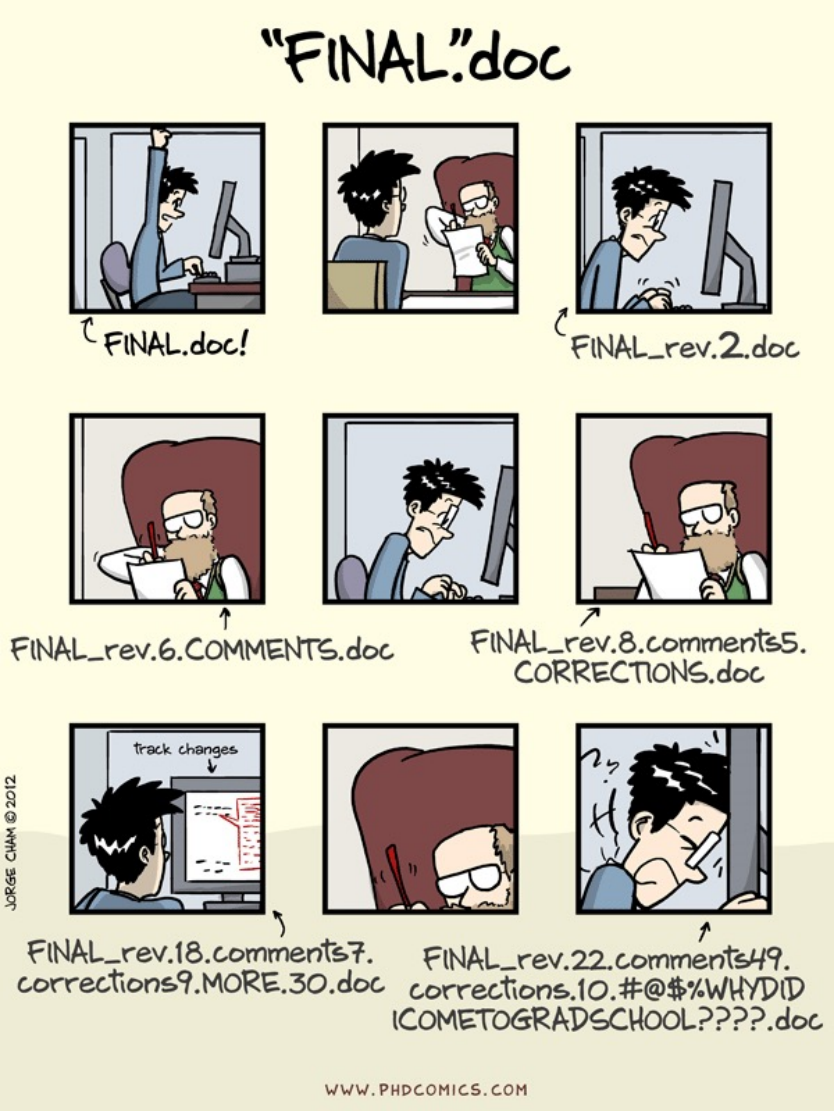

Theory: Graphs
Branches: Demo
Workflow
Theory: Hashing
General Concept
git
git Internals

git is a *Version Control System* (VCS)



Source: GitHub Campus Advisors

Files and Revisions – The Problem



Source: http://phdcomics.com/comics/archive.php?comicid=1531

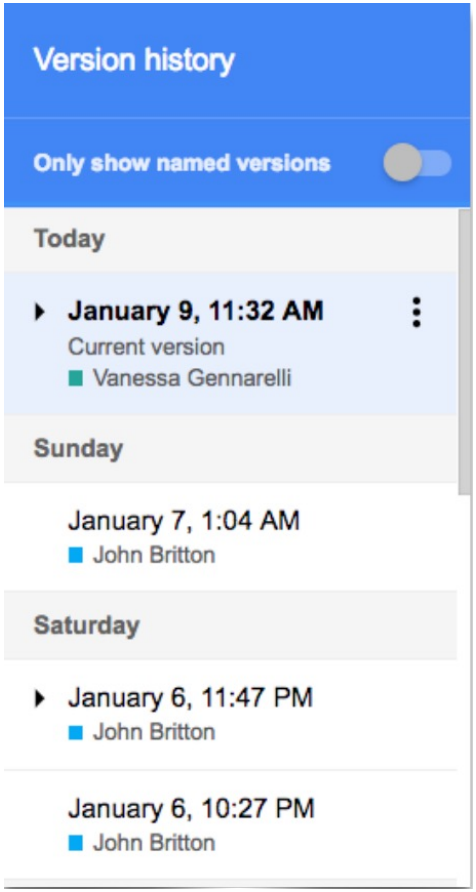
Version Control – The Solution

Version Control Systems

- **Track progress** over time
- Save **snapshots** to your history to **retrace your steps**
- ***What*** changed, ***who*** changed it, and ***why***

Order with coordination

- In a **centralized system**, you can objectively call versions a numerical progression: version 1, version 2, version 3...
- Since John made a new version before Vanessa, his is n+1, and Vanessa is n+2.

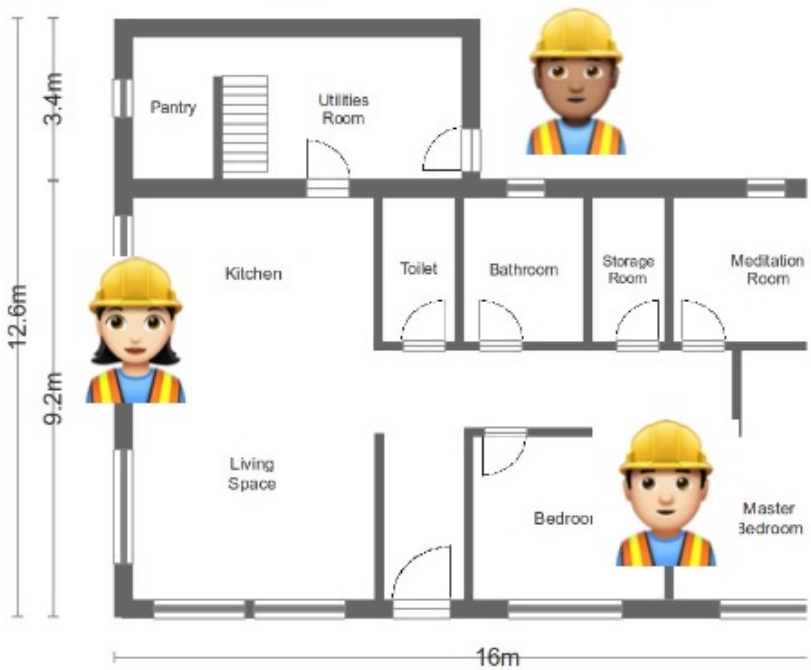


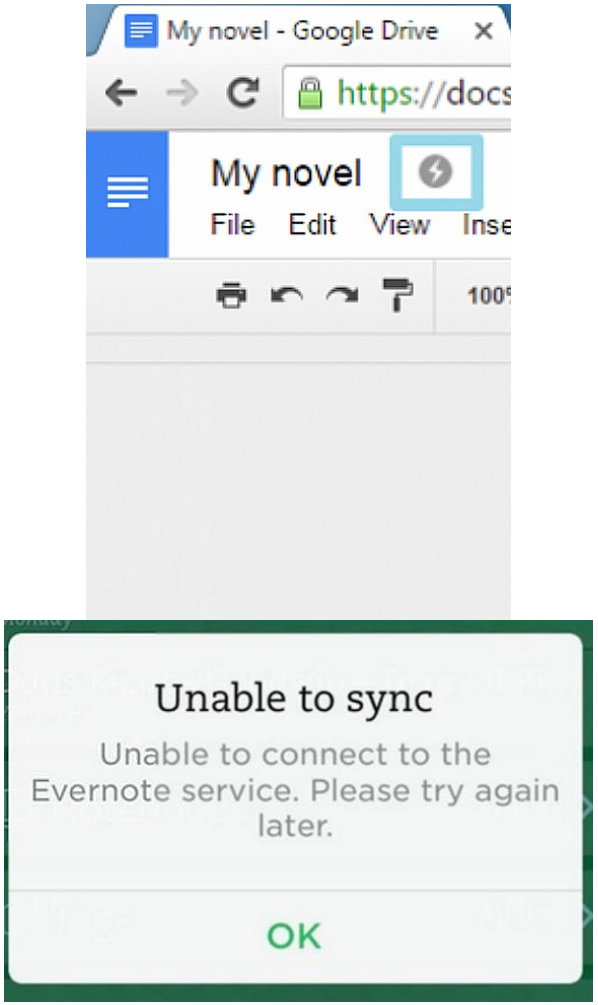
Source: GitHub Campus Advisors

Centralized systems require coordination

In reality we are working in **parallel**

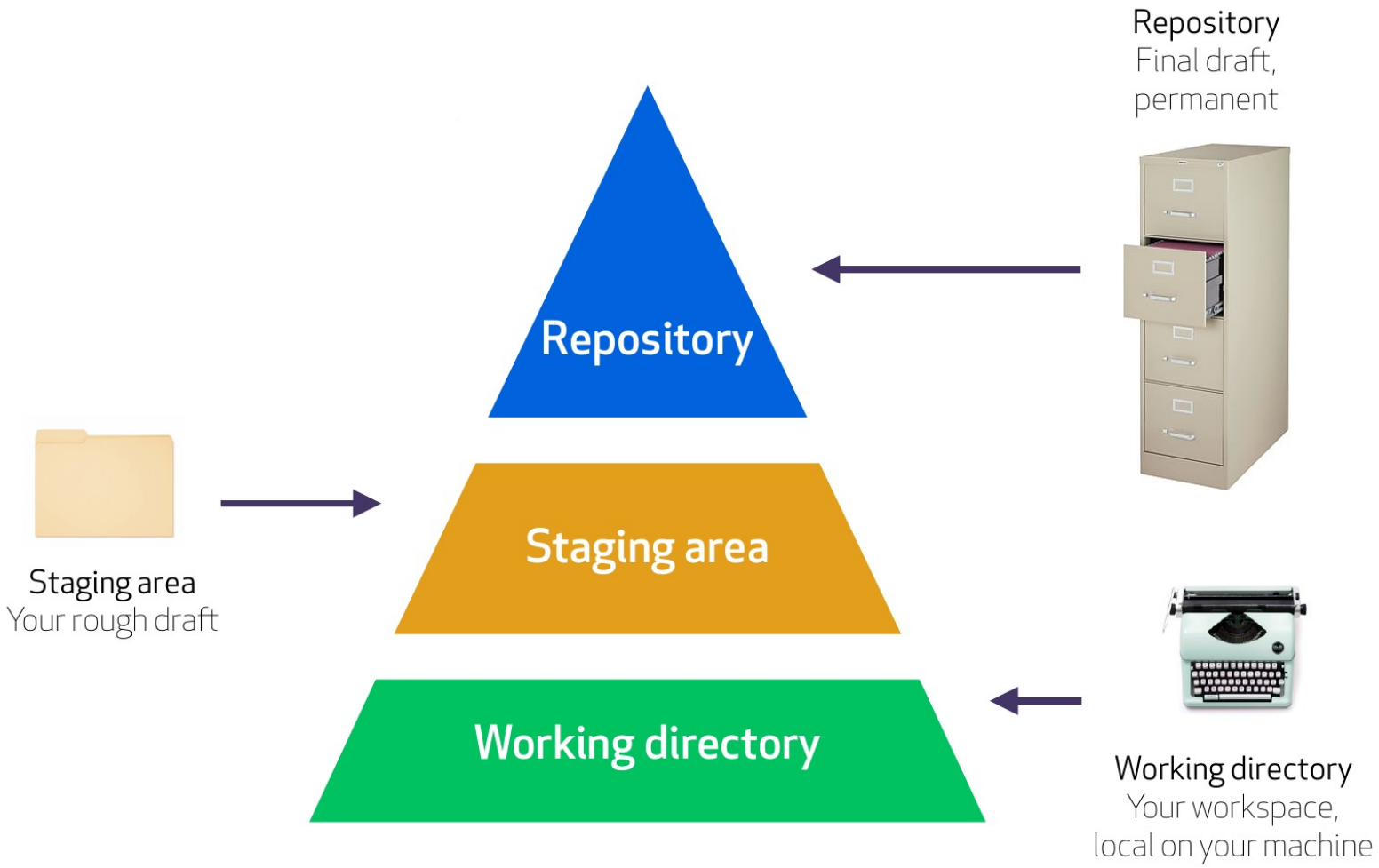
- This leads to **conflicts**
- So, we need **order without coordination**





Source: GitHub Campus Advisors

git - General Concept



Source: GitHub Campus Advisors

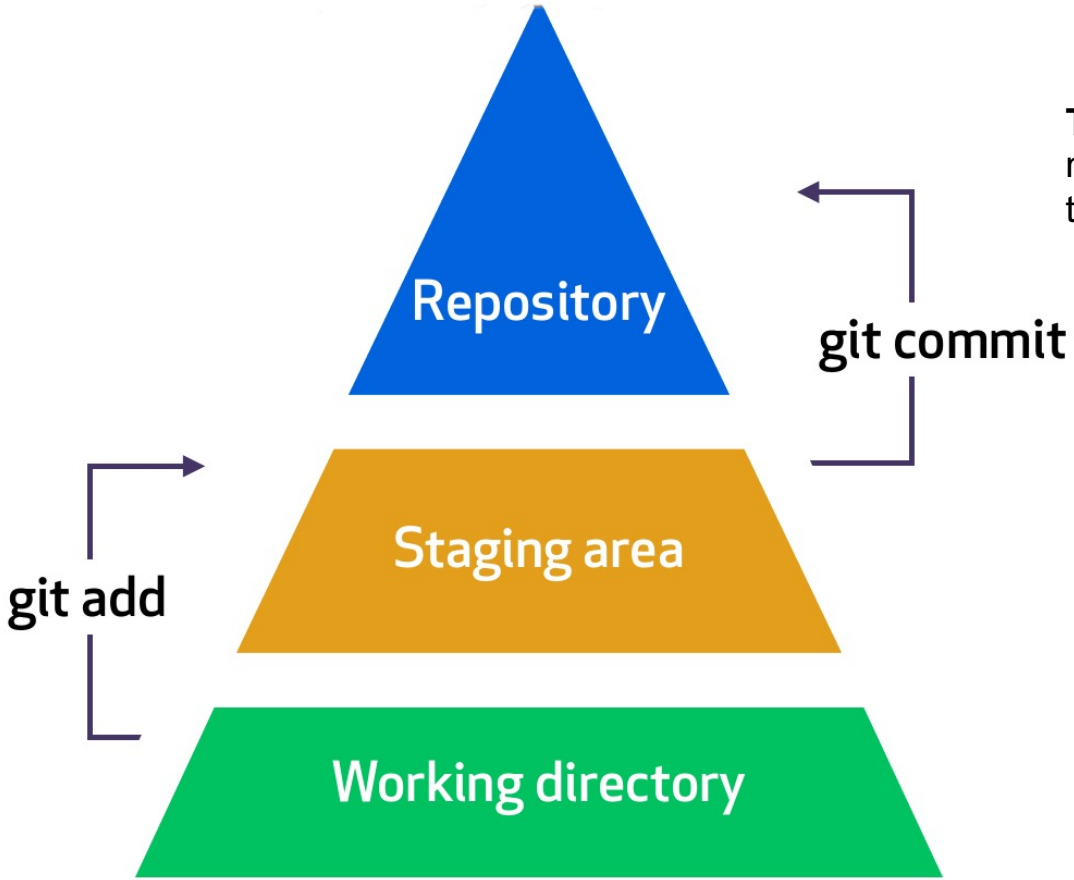
git - General Concept

- All the internal „tracking data“ is stored inside of a **repository**.
- Logically, a repository holds all files belonging to one project.
- The repository lives in a special folder called `.git`

```
$ git init example
Initialized empty Git repository in /[…]/example/.git/
```

- The newly-created directory `example` is now the **working directory** for a project.
- You can also perform `git init` inside of an existing directory to put it under version control.

git Workflow



Then, *commit* the modifications to the repository

First, *stage* the modifications made

Source: GitHub Campus Advisors

git add

Ask git for the status of this repository

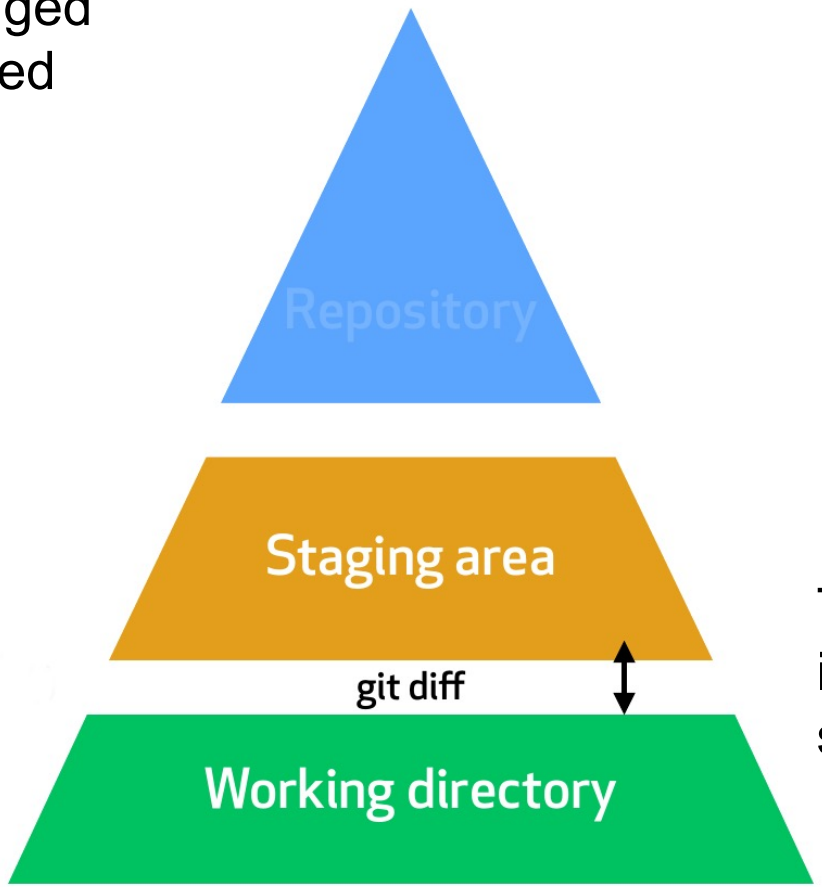
```
$ git status
On branch master

No commits yet

nothing to commit (create/copy files and use "git add" to track)
```

git gives some hints what can be done next

```
$ echo 'Hello, World!' > hello.txt
$ git add hello.txt
$ git status
On branch master

No commits yet

Changes to be committed:
  (use "git rm --cached <file>..." to unstage)

        new file:   hello.txt
```

git diff

See what has changed that is not yet tracked with `git diff`.

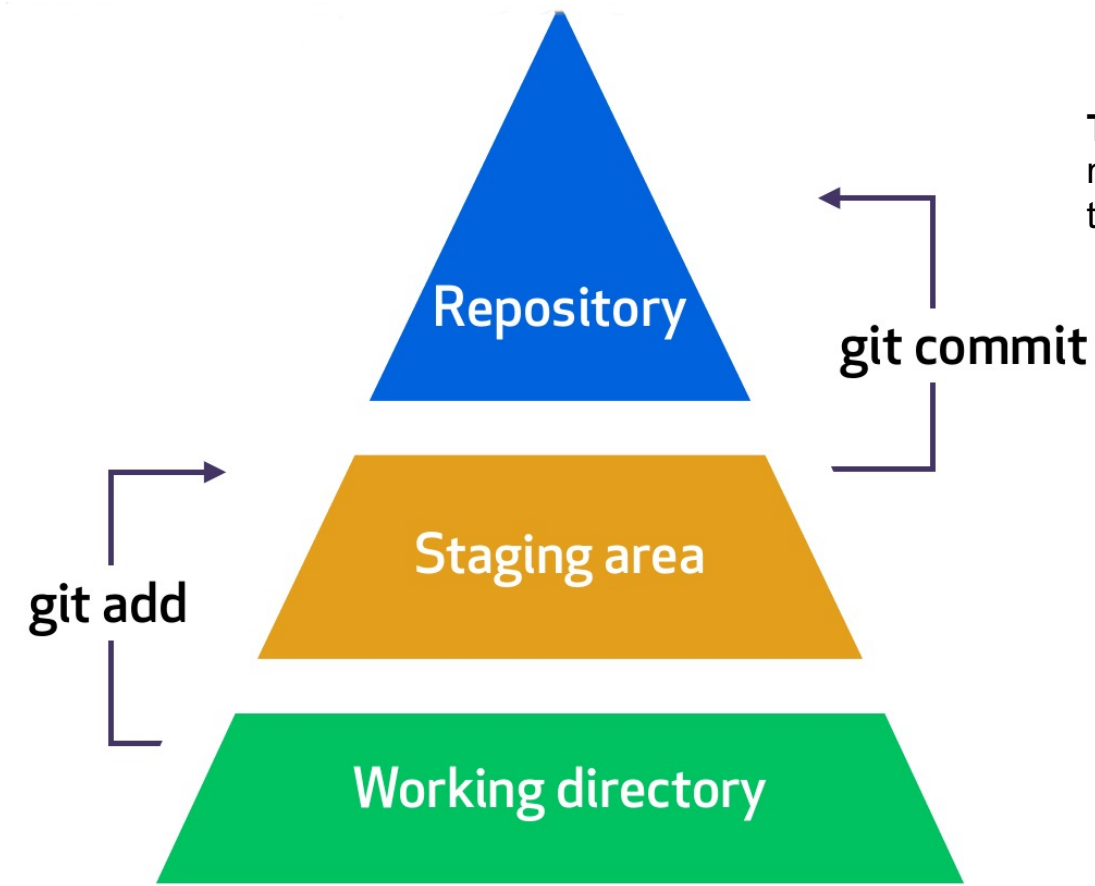


There‘s no output if they are the same.

Compares staging area to working directory.

Source: GitHub Campus Advisors

git Workflow



Then, *commit* the modifications to the repository

First, *stage* the modifications made

Source: GitHub Campus Advisors

git commit

- After we have done some work, we want to create a snapshot of the project.

```
$ git status -s
A  README.md
A  hello.txt
```

Short version of status – one file per line with status code

- All modifications to the staging area since the last commit will be part of this snapshot. This includes new files, changed files and deleted files.

-m option: no external editor needed, provide message as argument

```
$ git commit
```

or

```
$ git commit –m 'Initial commit'
```

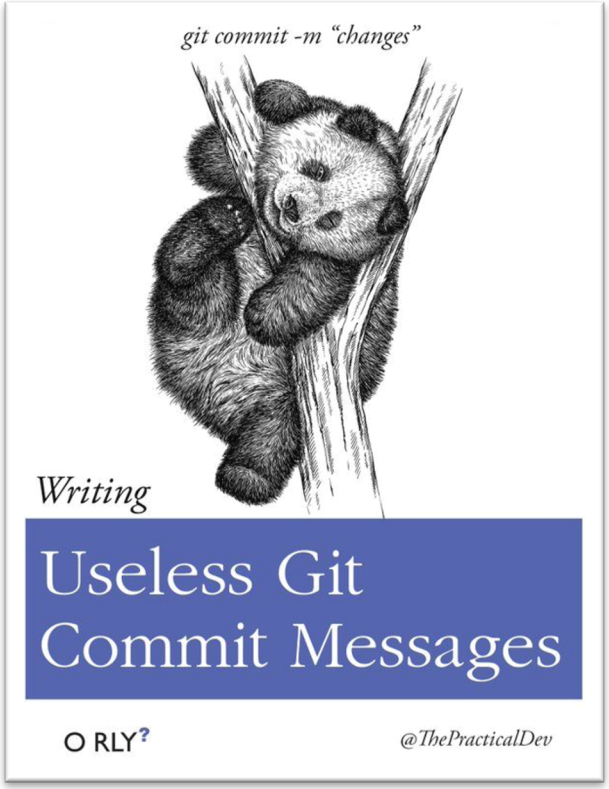
- The commit stores the **who**, **when** and **why** to a snapshot: author information, commit message, and current timestamp.

git commit

- Pro-Tip: Write **meaningful commit messages** to make **clear for everyone** (including future-you) **what** changes were introduced in this commit.

- The first line should be a short summary. Additional lines can be used to elaborate.

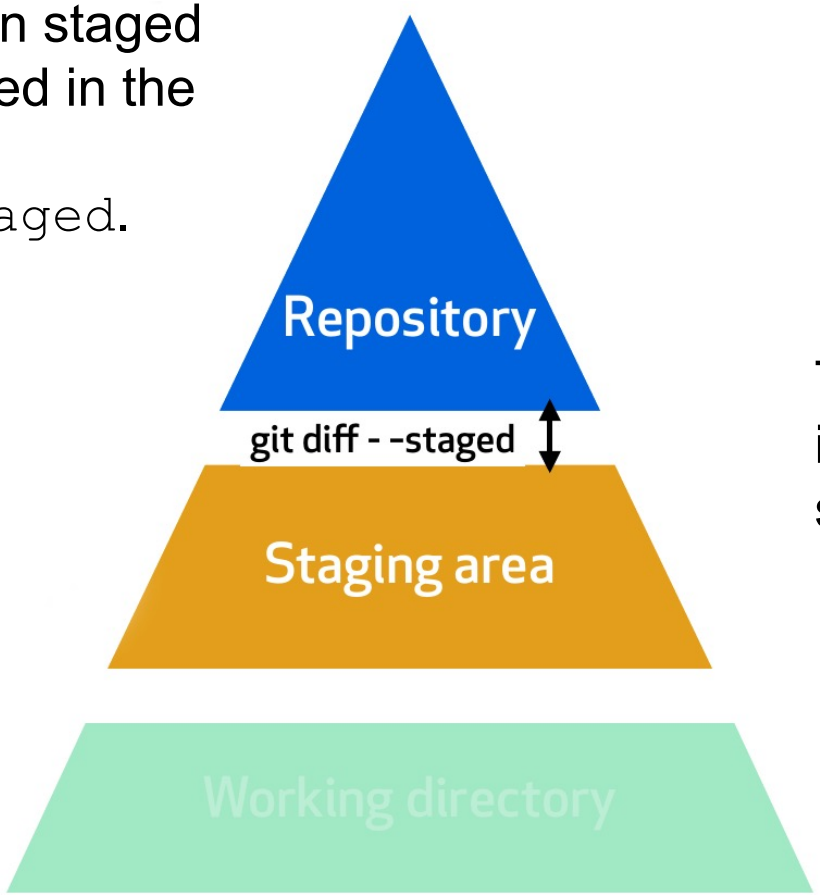
- Best practice: group commits logically, e.g. one commit for a new feature, another one for fixing typos.



git diff --staged

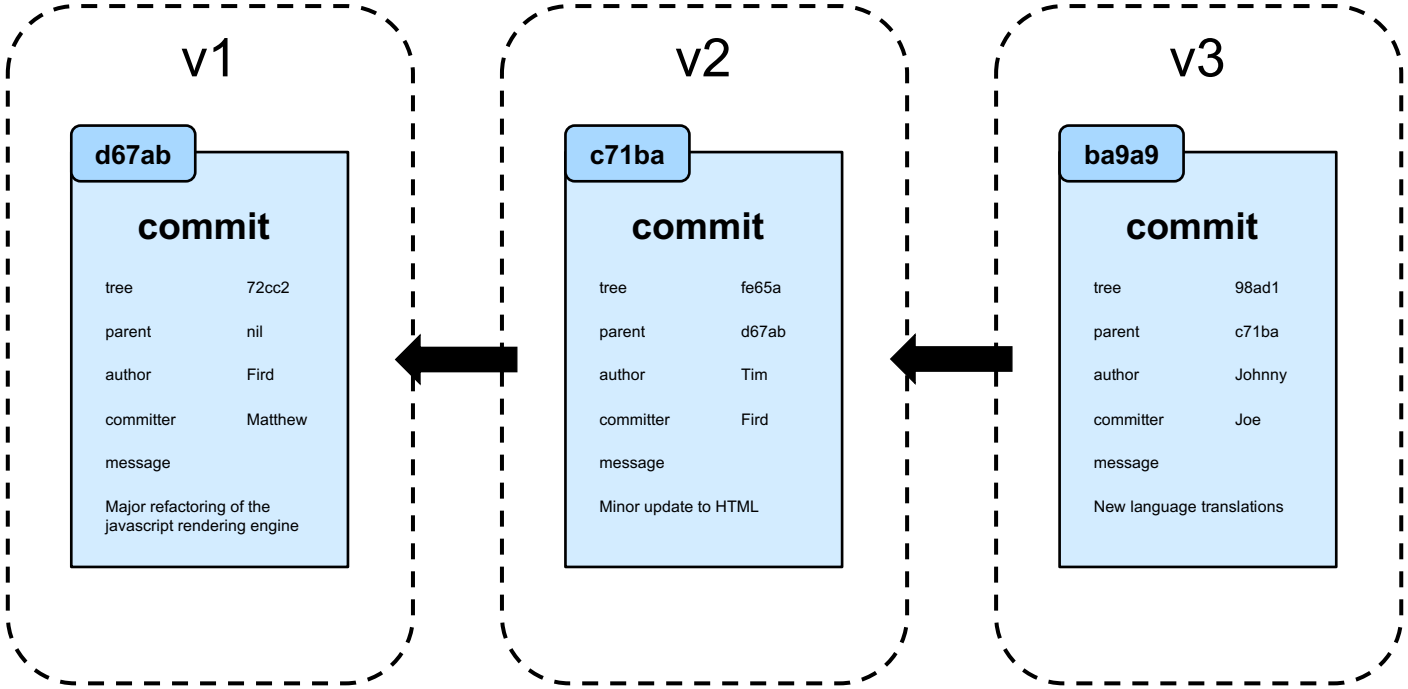
See what has been staged that is not yet stored in the repository with `git diff --staged`.

Compares staging area to the repository.



There‘s no output if they are the same.

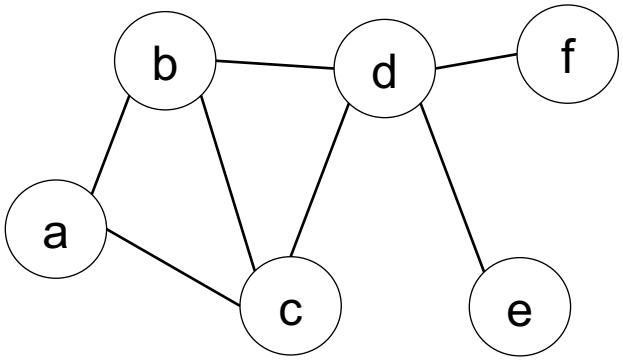
Several commits build up a history



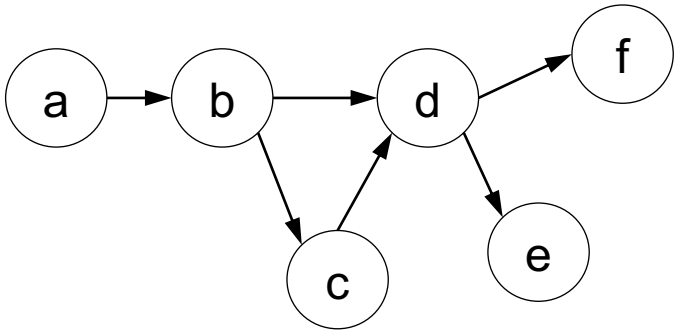
Source: GitHub Campus Advisors

Theory: Graphs

- A graph is a collection of **nodes** and **edges** that connect pairs of nodes.
- Graphs can be *undirected* or *directed*, which has consequences for possible modes of traversal.



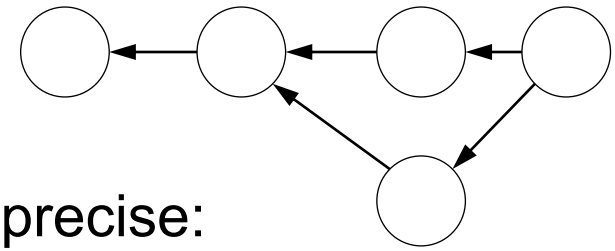
Undirected graph



Directed graph

Theory: Graphs

- A git repository is in fact a giant **graph**.



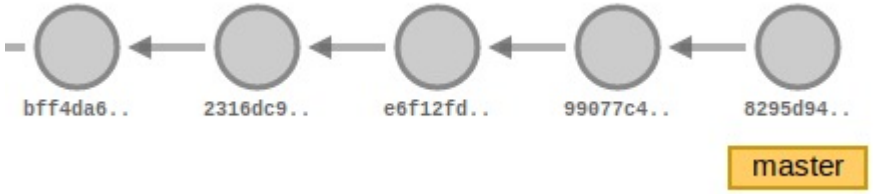
- A **directed acyclic graph** (DAG) to be precise:
  - **Directed**: edges have a direction
  - **Acyclic**: no path starting from one node will ever lead back to that node
- Each commit creates a new node in the graph. The **parent** of each new commit is then the previous commit.
- git commands are used to navigate this graph, add new nodes, get back to previous ones etc.

Branches and the Ominous „Master“

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

Branches are named references to commits and are continuously updated

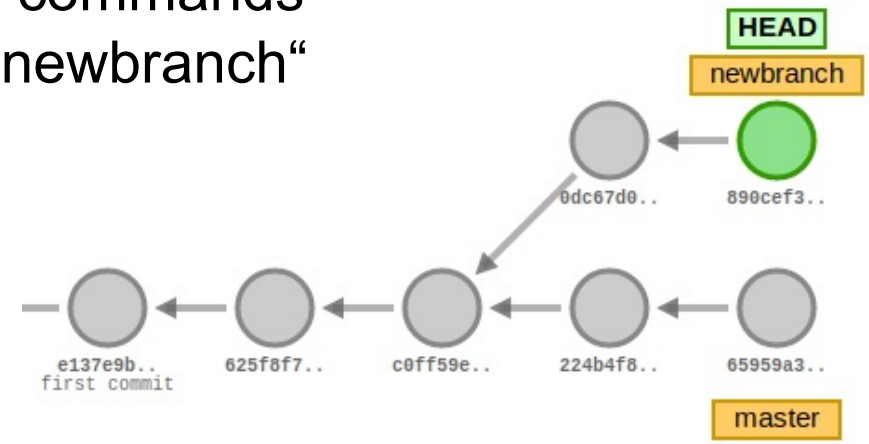
- e.g. to separate work on bugfixes or new features from the main development
- The default/main branch is always called „**master**“ or „**main**“ as a convention.



Think of branches as **bookmarks or pointers** to commits.

Commands related to branches

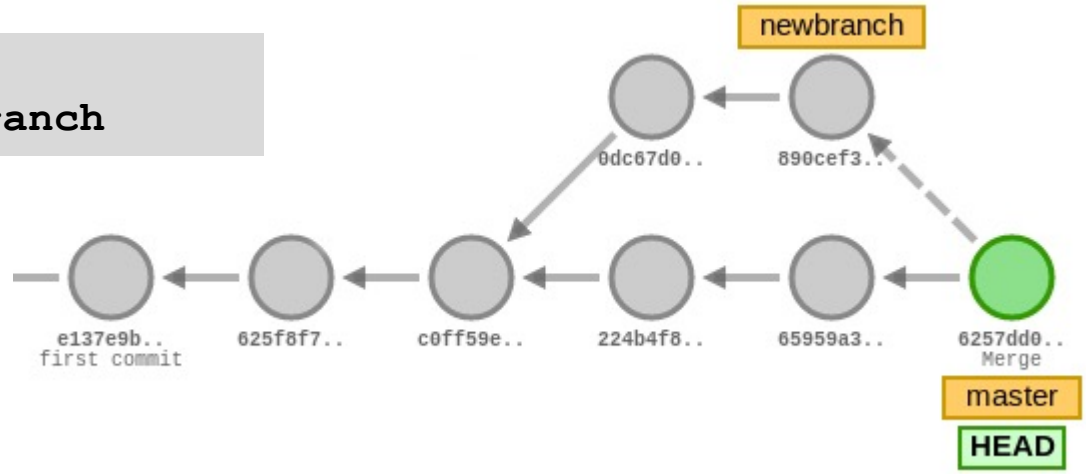
- `git branch`
  list all existing branches
- `git branch newbranch`
  create a new branch called „newbranch“
- `git checkout newbranch`
  switch to the new branch
- `git checkout -b newbranch`
  shortcut for the previous two commands - create a new branch called „newbranch“ and immediately switch to it



Integrating lines of history: Merging

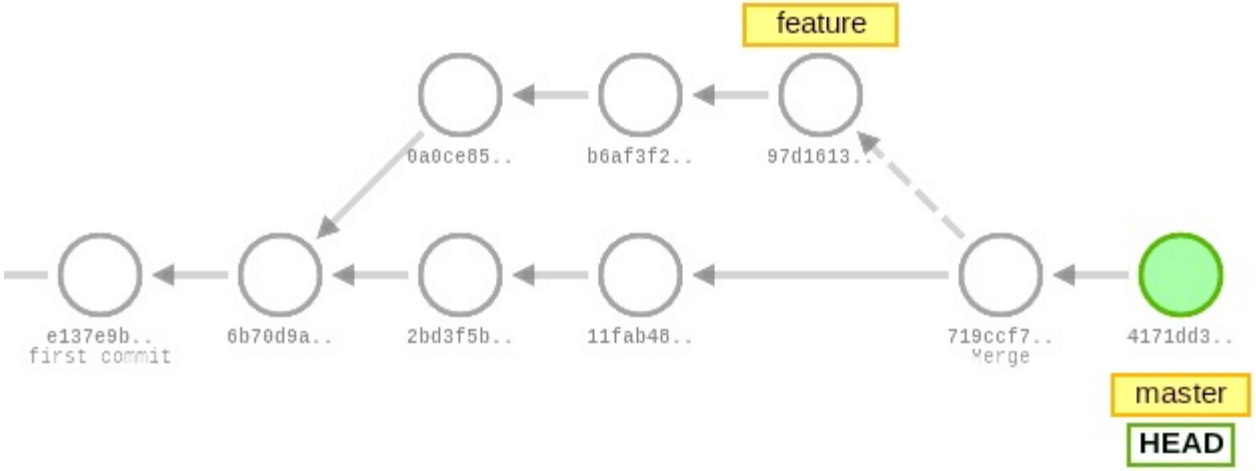
- To integrate changes made on one branch into another, use `git merge`.
- When merging branches, a new commit (a so-called *merge commit*) is created that combines the most recent commit from each branch and the common anchestor.

```
On branch master:
$ git merge newbranch
```



- To avoid conflicts, work on two branches should not affect the same files.

Demo


feature
0a0ce85..
b6af3f2..
97d1613..
e137e9b..
first commit
6b70d9a..
2bd3f5b..
11fab48..
719ccf7..
Merge
4171dd3..
master
HEAD

Viewing History: git log

- `git log` provides an overview on your repository's history

```
[…]/example/$ git log
    commit 8dffdeb3570dd63612f420fe432401498e0 (HEAD -> master)
    Author: Mandy Neumann <mandy.neumann@th-koeln.de>
    Date:   Mon Mar 11 11:21:44 2019 +0100
        Initial commit
```

So, what are these strange strings of letters and digits?

- Useful options to `git log`:
  - `-p / --patch: view changes introduced in each commit`
  - `--oneline: one commit per line (short info only)`
  - `--stat: show statistics on modified files`
  - `--graph: display an ASCII graph of branch/merge history`

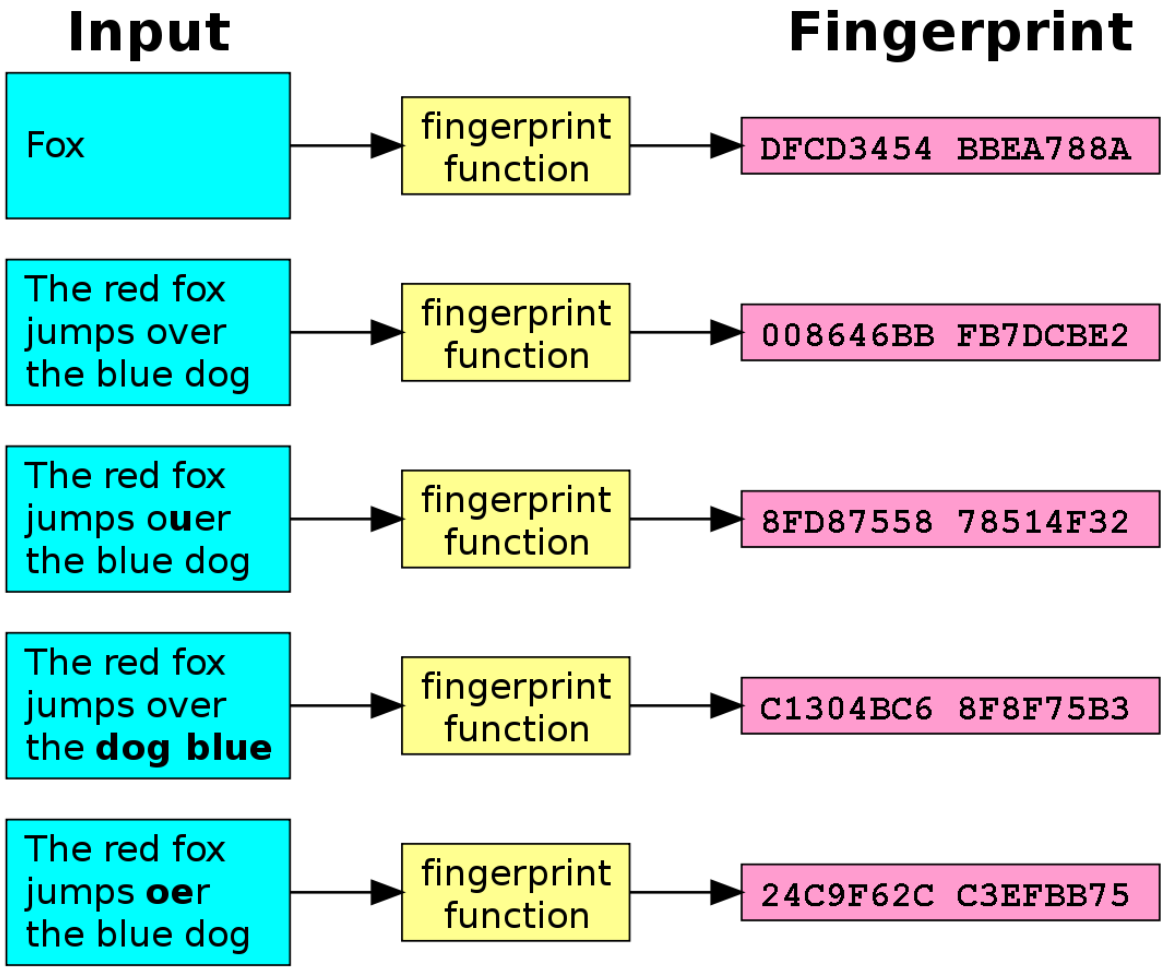
Theory: Hashes

- Every object in git is identified by a unique **hash**. You can think of a hash as a *fingerprint*.

- A hashing algorithm is a **mathematical function** that condenses *variable-length* input to a bit string of *fixed size*.

- It is meant to produce **irreversible** and **unique** hashes.

Even the slightest change results in a completely new hash:

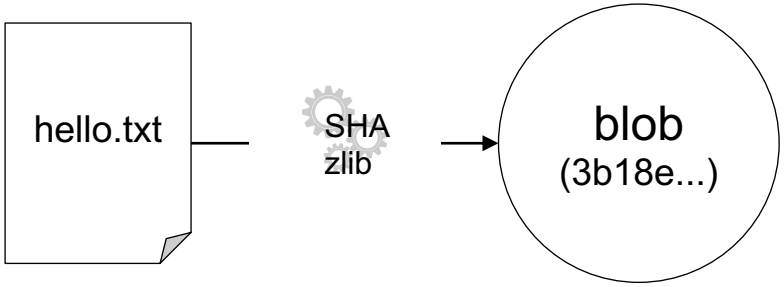


Source: https://en.wikipedia.org/wiki/Fingerprint_(computing)

SHA – Secure Hash Algorithm

- Group of standardized **cryptographic** hash functions
  - SHA-1 – 160 bit hash
  - SHA-2 – family of hashes (224, 256, 384 or 512 bit hashes)
  - SHA-3 – same lengths as SHA-2, but completely new structure

- Git computes the *SHA-1* hash of a file with a hash value of 160 bits (which is 20 8-bit bytes or 40 4-bit hex digits) that *uniquely identifies the contents of the file*. The content itself is stored in compressed form in a **blob file**.



git Internals: The git File System

- git is basically a special file system. File contents are stored in objects called **blobs** (binary large objects), which are grouped together in **trees**.

A … in a file system	is a ... in git
Directory	Tree
File	Blob

- Every single object in the file system is referenced by ist hash value.

git Objects

```
$ echo 'hello world' | git hash-object --stdin
3b18e512dba79e4c8300dd08aeb37f8e728b8dad
```

40 hex digits

Compute the object hash from input

```
$ git init
$ echo 'hello world' > hello.txt
$ git hash-object -w hello.txt
3b18e512dba79e4c8300dd08aeb37f8e728b8dad
$ tree .git/objects/
.git/objects/
├── 3b
│   └── 18e512dba79e4c8300dd08aeb37f8e728b8dad
├── info
└── pack

3 directories, 1 file
```

git Objects

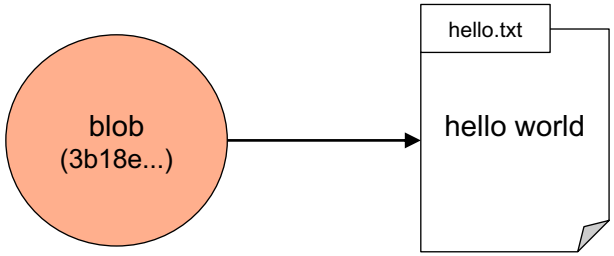
```
$ echo 'Hello, World!' > hello.txt
$ git hash-object -w hello.txt
8ab686eafeb1f44702738c8b0f24f2567c36da6d
$ tree .git/objects/
.git/objects/
├── 3b
│   └── 18e512dba79e4c8300dd08aeb37f8e728b8dad
├── 8a
│   └── b686eafeb1f44702738c8b0f24f2567c36da6d
├── info
└── pack

4 directories, 2 files

$ ls
hello.txt
$ cat hello.txt
Hello, World!
```

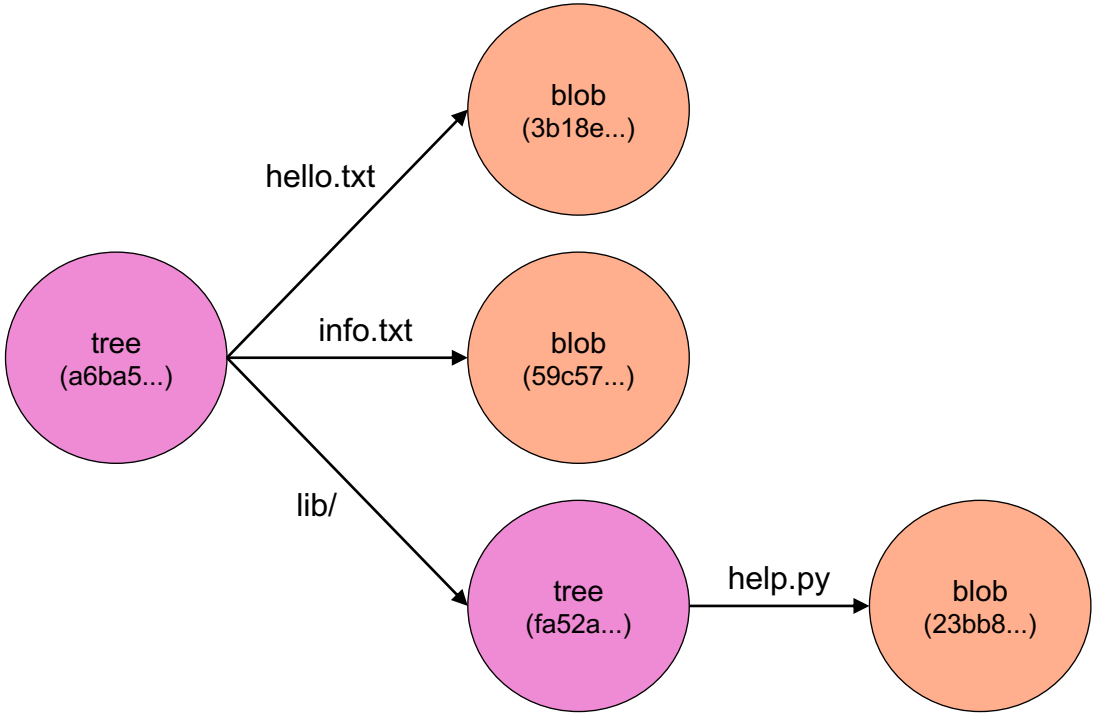
For each new version of a file, a new git object with different hash is created.

Notice that the old version is still there.

But there‘s only one actual file in the directory.

A Tree Stores Blobs and Other Trees





Some Notes

- Note that only the content of a file is hashed.

Print the content of this object

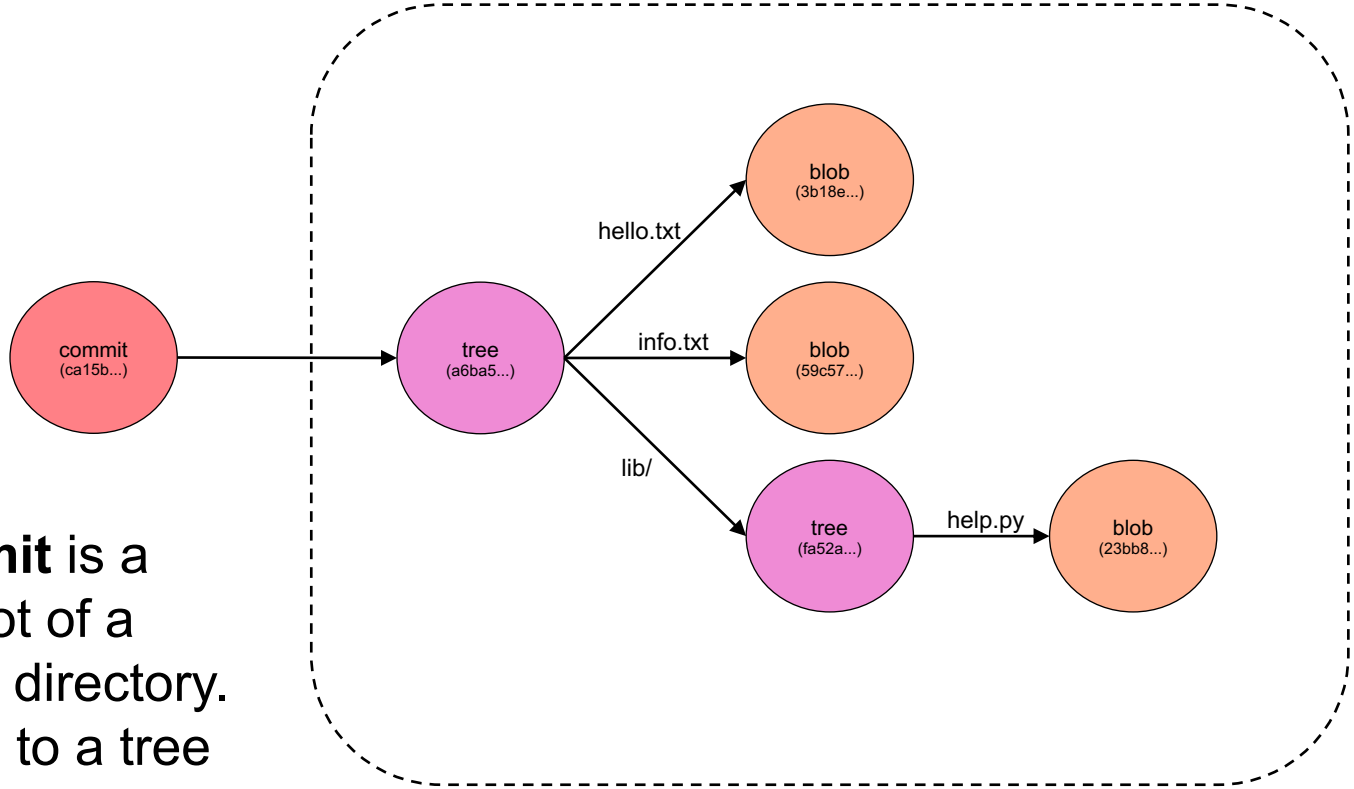
```
$ git cat-file -p 8ab686eafeb1f44702738c8b0f24f2567c36da6d
Hello, World!
```

- To also store info about the file like file name, type and mode, **tree** objects are used.
- A tree in git represents directories for blobs and more trees.

```
$ git cat-file -p 8250974359066f3218053315be483201bd7d37e2
100644 blob 861dbb4fd2cb99053a9b4ef8450aa4f6351b7484 README.md
100644 blob 8ab686eafeb1f44702738c8b0f24f2567c36da6d hello.txt
```

mode | type | hash of the object | file name

Commits Point to Trees and Have Their Own Hashes



A **commit** is a snapshot of a working directory. It points to a tree and stores metadata on the snapshot.

Commits under the hood

the tree object referencing the two committed files

```
$ git cat-file -p 8dffdeb3570dd63612f420fe43240149c15708e0
tree 8250974359066f3218053315be483201bd7d37e2
author Mandy Neumann <neumann@th-koeln.de> 1552299704 +0100
committer Mandy Neumann <neumann@th-koeln.de> 1552299704 +0100

Initial commit
```

timestamp

commit message

```
$ git cat-file -p bd5c4ef8aacfc24a660a736659c647f52006af04
tree 9d960d1b6141ad4e1cb07d80a20b5eb3289de09c
parent 8dffdeb3570dd63612f420fe43240149c15708e0
author Mandy Neumann <neumann@th-koeln.de> 1552307124 +0100
committer Mandy Neumann <neumann@th-koeln.de> 1552307124 +0100

Extend hello.txt
```

Don‘t worry

- You neither have to interact with git‘s internal file system, nor would you normally deal with commit hashes.
- In case you really need to get back to a specific commit, you can use the abbreviated hash with `git checkout`:

```
[…]/example$ git checkout bd5c4ef8
Note: checking out 'bd5c4ef8'.

You are in 'detached HEAD' state. [...]

If you want to create a new branch to retain commits you create,
you may do so (now or later) by using -b with the checkout
command again. Example:

  git checkout -b <new-branch-name>

HEAD is now at bd5c4ef Extend hello.txt
```

Only use this if you really know what you‘re doing!

Summary

git command	Action
`git init`	Initialize new repository
`git add`	Add file(s) to staging area
`git status`	Check status
`git commit`	Create a snapshot of staging area
`git diff`	Show differences
`git branch`	Show available branches
`git branch <newBranch>`	Create new branch
`git checkout <newBranch>`	Switch to another branch
`git checkout -b <newBranch>`	Create new branch and switch to it
`git merge`	Combine changes from several branches
`git log`	Show commit history
`git show [<branch>]`	Show the commit where HEAD (or some branch) points to

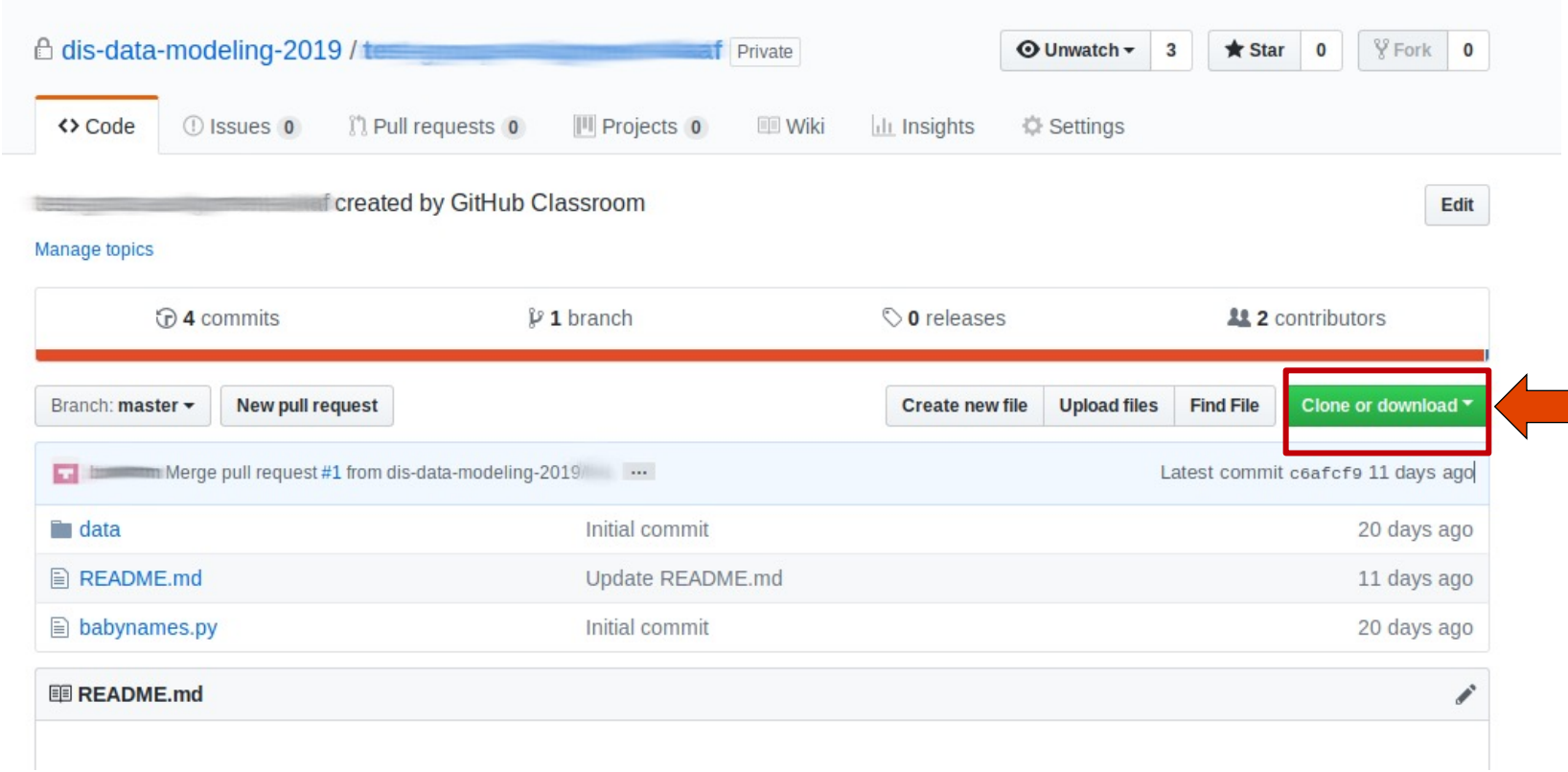
GitHub

Why GitHub?

- While git can be used completely offline, GitHub or similar services make it possible to
  - **Sync** the local repository with a remote one
    → like a cloud backup, and to be able to work on the same project from multiple machines
  - **Share** and **collaborate** with others

- In this class, we will also use GitHub to **manage the assignments**.

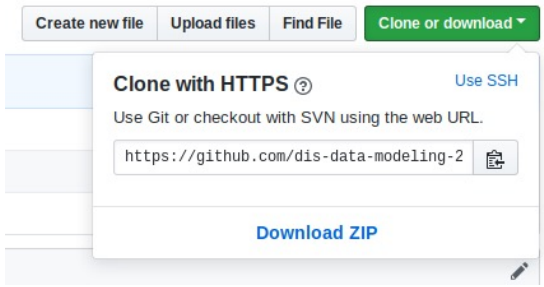
Remote Repositories



- Existing repositories are **cloned** to a local machine.

Remote Repositories

- Copy the URL (use HTTPS method)…

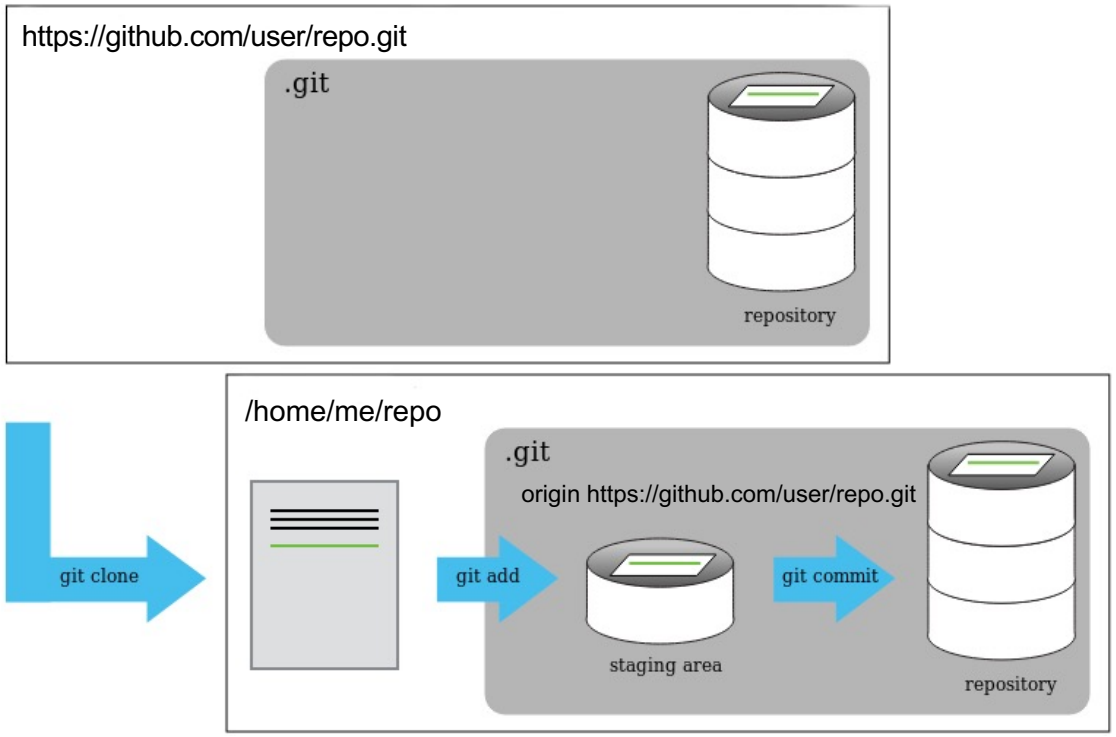


- … and clone to your local machine:

```
$ git clone https://github.com/dis-data-modeling-
2019/<repository>.git
Cloning into '<repository>'...
remote: Enumerating objects: 22, done.
remote: Counting objects: 100% (22/22), done.
remote: Compressing objects: 100% (12/12), done.
remote: Total 22 (delta 8), reused 15 (delta 8), pack-reused 0
Unpacking objects: 100% (22/22), done.
```

Remote Repositories

- Now you‘ve got a local copy of the remote repository in a directory with the repository‘s name.



You can now go on and work with it – add and change files, tell git to track them (`git add`), snapshot your work (`git commit`), check the status of your working directory (`git status`) and the history of commits (`git log`).

Syncing with Remotes

- Check available „bookmarks“ to remote repositories:

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

name URL

- Send your recent commits to the remote repository:

```
$ git push
Username for 'https://github.com': neumannm
Password for 'https://neumannm@github.com':
Counting objects: 7, done.
Delta compression using up to 8 threads.
Compressing objects: 100% (5/5), done.
Writing objects: 100% (7/7), 605 bytes | 605.00 KiB/s, done.
Total 7 (delta 0), reused 0 (delta 0)
To https://github.com/neumannm/example.git
 * [new branch]      master -> master
Branch 'master' set up to track remote branch 'master' from
'origin'.
```

Syncing with Remotes

- Update your local copy by **pulling** remote changes:

```
$ git pull
Username for 'https://github.com': neumannm
Password for 'https://neumannm@github.com':
[…]
Unpacking objects: 100% (3/3), done.
From https://github.com/neumannm/example
   bd5c4ef..5e7d3f8  master     -> origin/master
Updating bd5c4ef..5e7d3f8
Fast-forward
 README.md | 2 ++
 1 file changed, 2 insertions(+)
```

Summary

Git command	Action
`git remote -v`	List info on remotes
`git remote add <bookmark> <url>`	Add a new remote named „bookmark“ at given url
`git fetch`	Fetch latest changes from remote
`git pull`	Fetch and integrate latest changes from remote
`git push`	Push latest changes to remote

`git push --set-upstream <bookmark> <branch>`
or
`git push -u <bookmark> <branch>`
	Tell git to always use the remote “bookmark“ when pushing „branch (only needed once)

Resources

- Official reference, free eBook, videos and more: https://git-scm.com/doc
- Cheat sheet by GitHub: https://github.github.com/training-kit/downloads/github-git-cheat-sheet.pdf
- Visual git cheat sheet: http://ndpsoftware.com/git-cheatsheet.html
- Visual git reference: https://marklodato.github.io/visual-git-guide/index-de.html (German) https://marklodato.github.io/visual-git-guide/index-en.html (English)
- Interactive online course to learn git (paid-only): https://www.codecademy.com/learn/learn-git