CS 241: Systems Programming Lecture 5. Version Control/Git (+ Wrapup of Environment/Expansion)

Fall 2025

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Mon Review - Expansion/Environment

- Environment variables and bash variables
- Bash expansion
- Word splitting

Expansion summary

Braces form separate words [{a,b,c}] → [a] [b] [c]

Tildes give you home directories ~ → /home/mhogan

Variables expand to their values `"${class}"` → `"CS 241"`

Commands expand to their output `"$(ls *.txt | wc -l)"` → `"3"`

Wildcards expand to matching file names `*.txt` → `a.txt b.txt c.txt`

Put literal strings in `'single quotes'`

Put strings with variables/commands in `"${double} $(quotes)"`

If we have set a variable
`books='Good books'`
and we want to create a directory with that name, which command should we use?

```
A. $ mkdir "${books}"

B. $ mkdir "$(books)"

C. $ mkdir ${books}

D. $ mkdir $(books)

E. $ mkdir $books
```

Version control system (VCS)

A way to track changes to your files

- What you changed
- Why you changed it

A way to keep “backups” of older versions

A way to keep track of different versions (branches) of a project

- Development
- Release

A way to organize and collaborate on a project

VCS history (abridged)

SCCS → RCS → CVS → SVN → {Git, Mercurial, …}

1972 — Source Code Control System (SCCS)
1985 — Revision Control System (RCS)

- All users on the same system, each with their own checkout of the files

1986 — Concurrent Versioning System (CVS)

- Client/server model

2000 — Subversion (SVN)

- Essentially a better CVS

2005 — Git and Mercurial

- Distributed model: each user has their own copy of the whole repository

VCS history (abridged)

SCCS → RCS → CVS → SVN → {Git, Mercurial, …}

SCCS/RCS

- Shared, authoritative repository with all history stored somewhere, e.g., `/source/program`
- Individual users checkout the current version somewhere else, e.g., `~/program`
- Modifications can be checked in to the shared repo
- Other users' modifications can be checked out again
- The history of files and their differences can be shown

VCS history (abridged)

SCCS → RCS → CVS → SVN → {Git, Mercurial, …}

CVS/SVN

- Authoritative repo stored on some server, e.g.,
  `vcs.oberlin.edu:/vcs/program`
- Users on many different machines can checkout copies, e.g.,
  `mcnulty.cs.oberlin.edu:~/program`
- Changes to files are committed to the server which maintains the authoritative copy of the repository history
- Local copies can be updated with other users' changes from the server
- Multiple branches, but each with a linear commit history (r1, r2, r3, …)

VCS history (abridged)

SCCS → RCS → CVS → SVN → {Git, Mercurial, …}

Git/Mercurial

- Decentralized
  - Each user has a full copy of the repo
  - No authoritative version
- Users can push changes to other users or pull changes from others
- Multiple, lightweight branches
- History is not linear, it's a DAG (we'll see what this means shortly)
- Decentralization is hard to deal with: use Github (or similar)

Git

A distributed version control system

- Everyone can act as a “server”
- Everyone mirrors the entire repository

Many local operations

- Quick to add files, commit, create new branches, etc.
- Can have local changes w/o pushing to others

Collaborate with other developers

- “Push” and “pull” code from hosted repositories such as Github

Initial setup

```
$ git config --global user.name 'Mary Hogan'
$ git config --global user.email 'mhogan1@oberlin.edu’
$ git config --global core.editor vim
```

Global config values are stored in `~/.gitconfig`

Can also have local config settings in `${repo}/.git/config`

To see your settings: `$ git config —list`

Environment variables are inherited

Environment variables are inherited by default by child processes

1. Bash starts up and sets some environment variables (from .bash_profile)

2. User runs git commit with no commit message

3. Git uses the EDITOR environment variable to open an editor for the user to enter the commit message

No need pass options to Git to select the editor, it can use the standard environment variable

Creating a repository

```
$ mkdir project
$ cd project
$ git init
```

Creates a `.git` folder in `project`

No files are currently being tracked or managed (you need to add and commit them to the repository - we'll get to this soon)

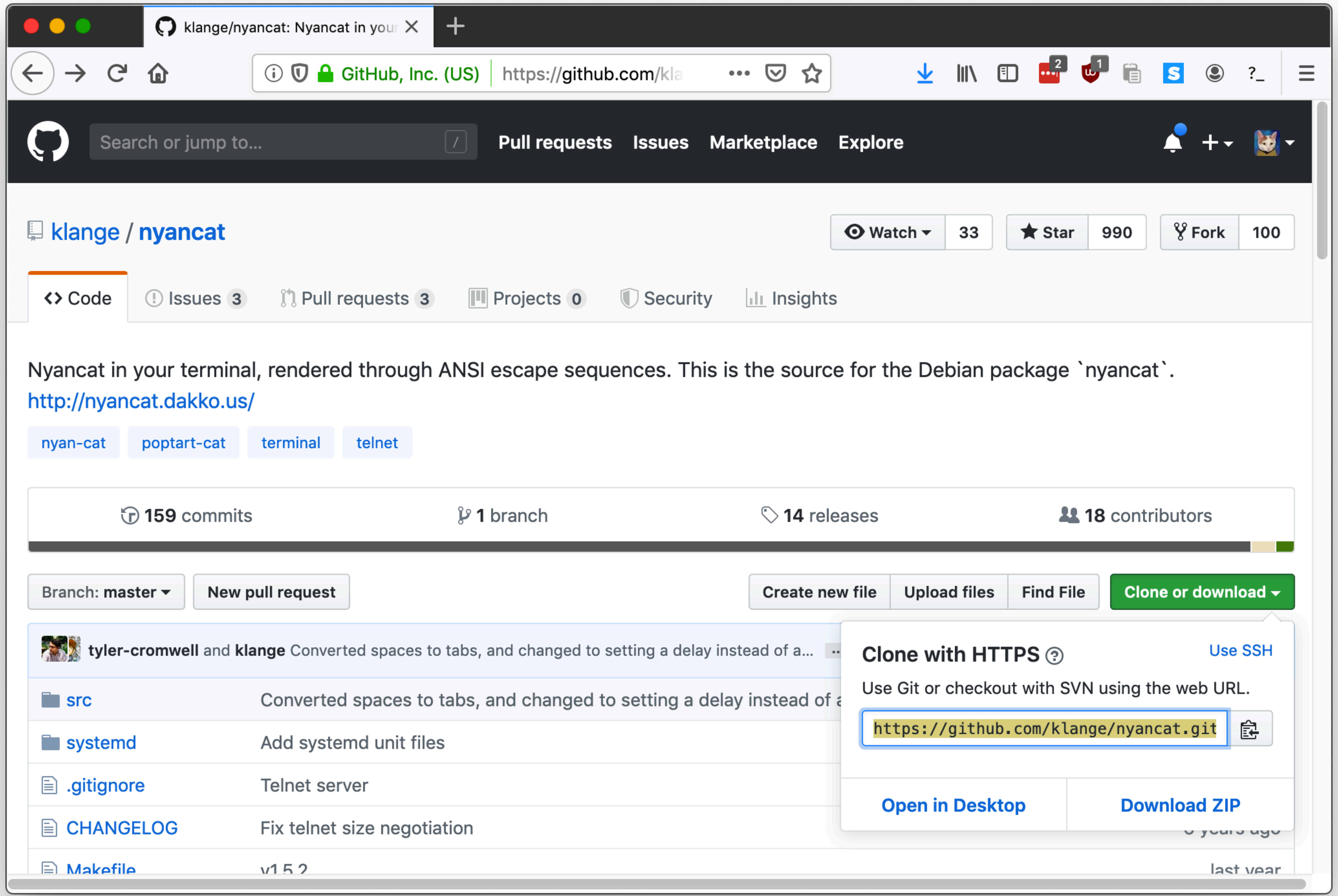
No remote server

Cloning a (remote) repository

```
$ git clone https://github.com/klange/nyancat.git
```

Creates a local copy of the repo including the whole history

Associated with a remote server



Nyancat in your terminal, rendered through ANSI escape sequences. This is the source for the Debian package `nyancat`.
http://nyancat.dakko.us/

Use Git or checkout with SVN using the web URL.

```
https://github.com/klange/nyancat.git
```

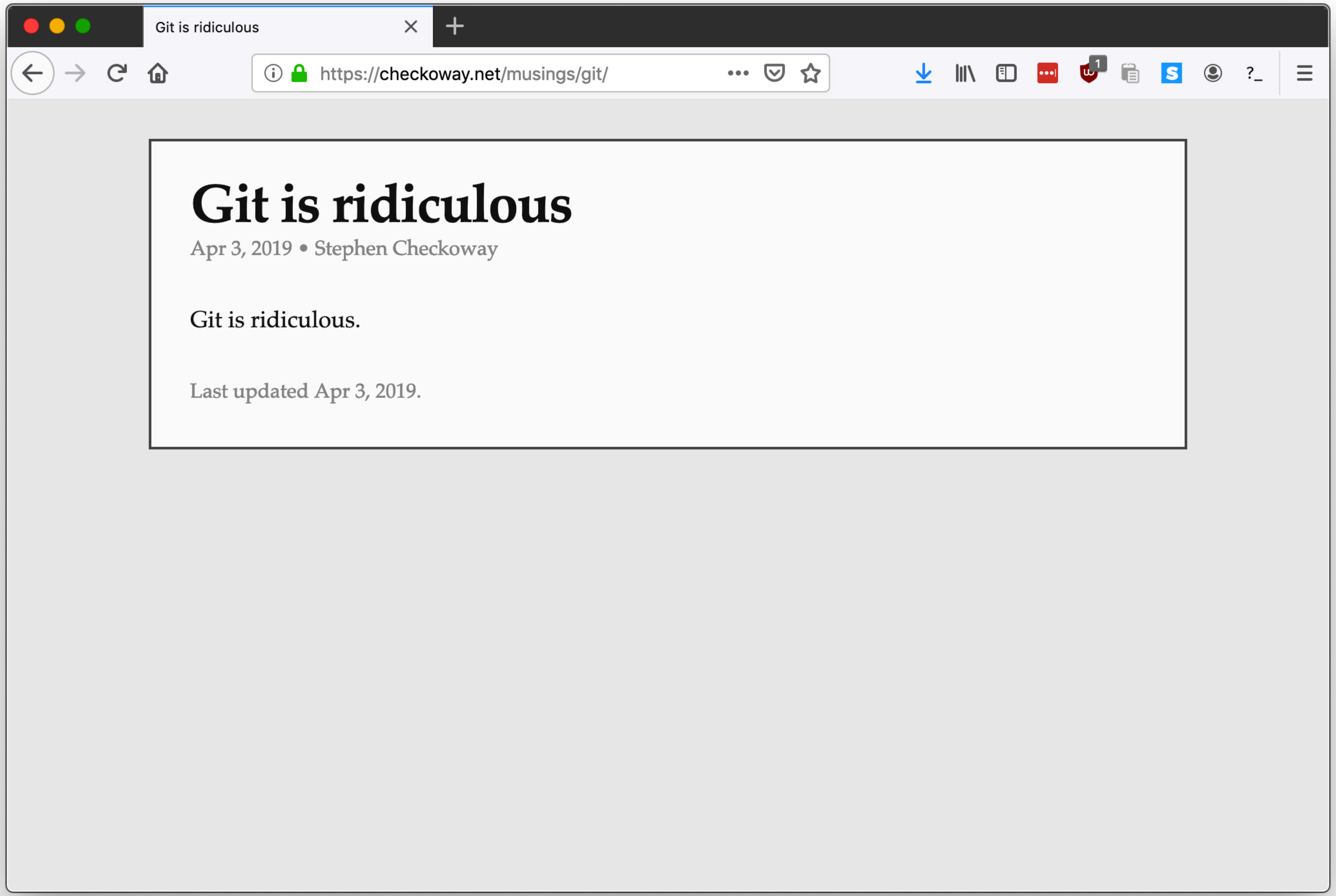
tyler-cromwell and klange Converted spaces to tabs, and changed to setting a delay instead of a...

src	Converted spaces to tabs, and changed to setting a delay instead of a	
systemd	Add systemd unit files	
.gitignore	Telnet server	
CHANGELOG	Fix telnet size negotiation	6 years ago
Makefile	v1.5.2	last year

Cloning a (remote) repository

```
steve@clyde:~$ 
```

Warning: Git is ridiculous


Git is ridiculous

https://checkoway.net/musings/git/

Git is ridiculous

Apr 3, 2019 • Stephen Checkoway

Git is ridiculous.

Last updated Apr 3, 2019.

Working dir vs staging vs .git

After `git init` or `git clone`, you have a working directory on the file system

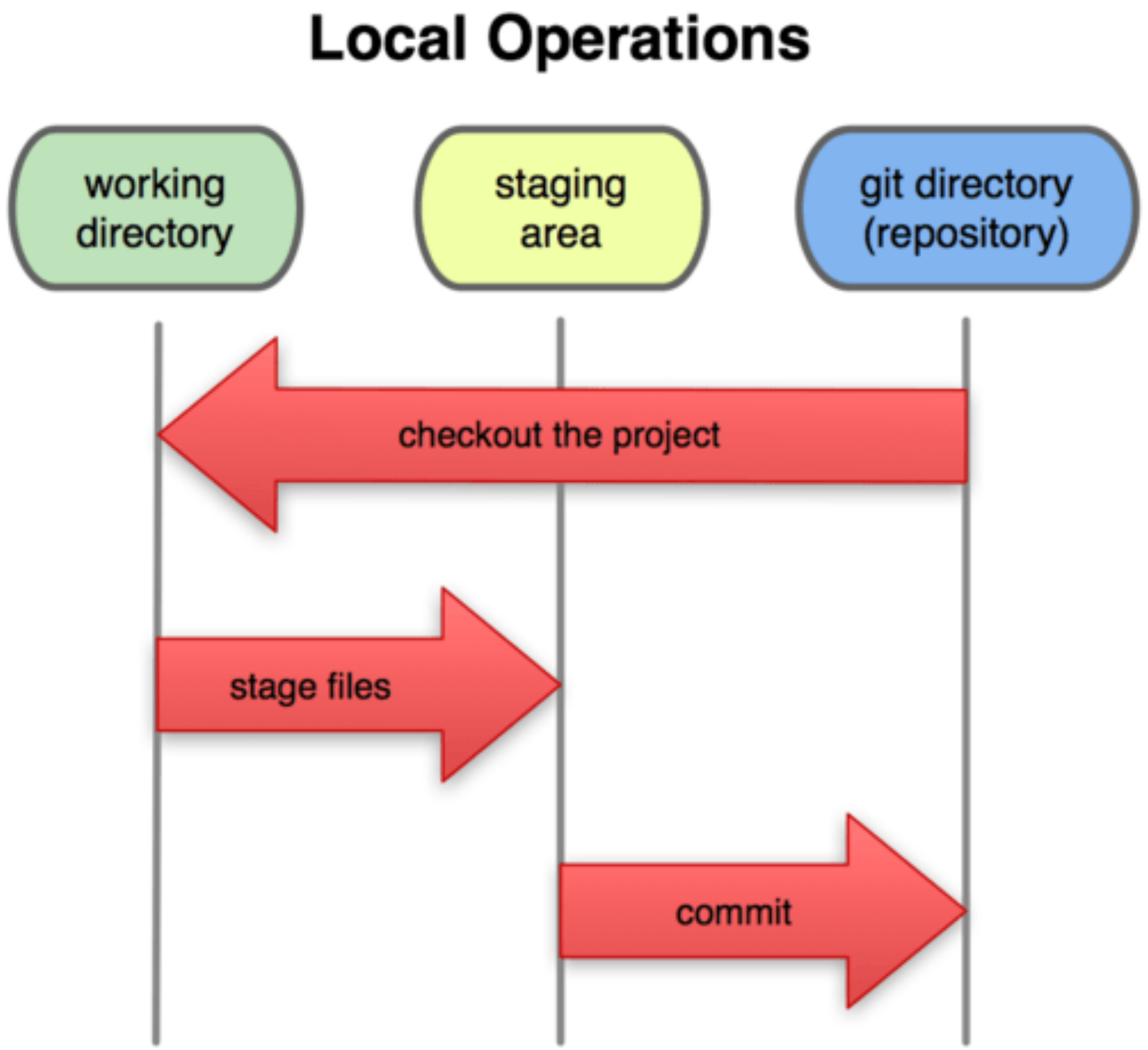
- Holds one version of the files in the repo

Inside it (usually) is a `.git` directory with

- The whole history of the repo (all commits)
- config options, branches, etc.

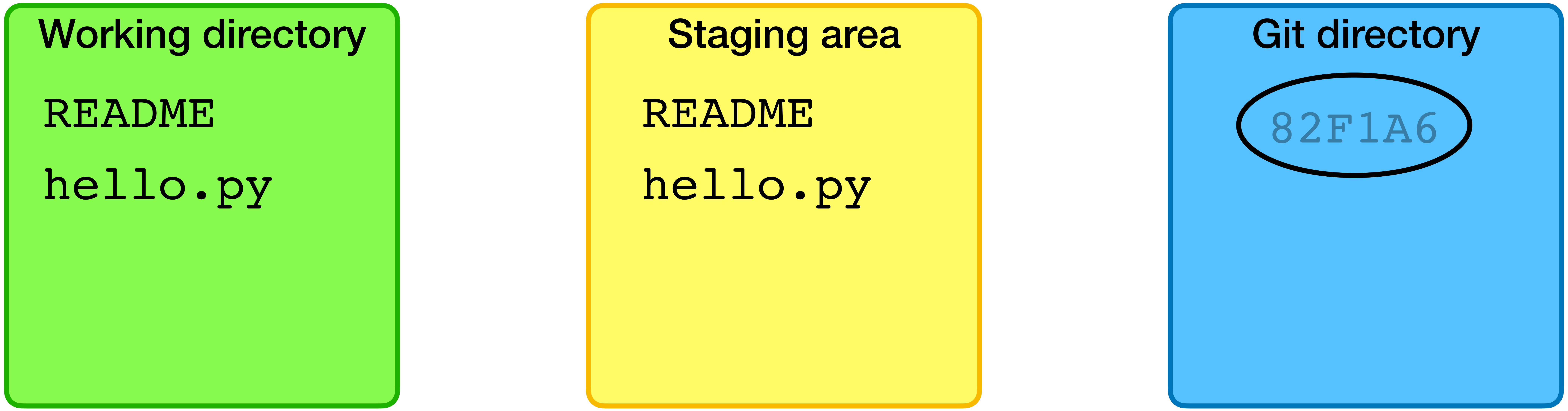
Conceptional staging area

- Holds files to be committed



Adding and committing

```
$ vim README         # Create a readme describing the project
$ git add README     # Add README to the staging area
$ vim hello.py       # Create some code
$ git add hello.py # Add the hello.py to the staging area
$ git commit         # Commit the files to the repo
```



Commits

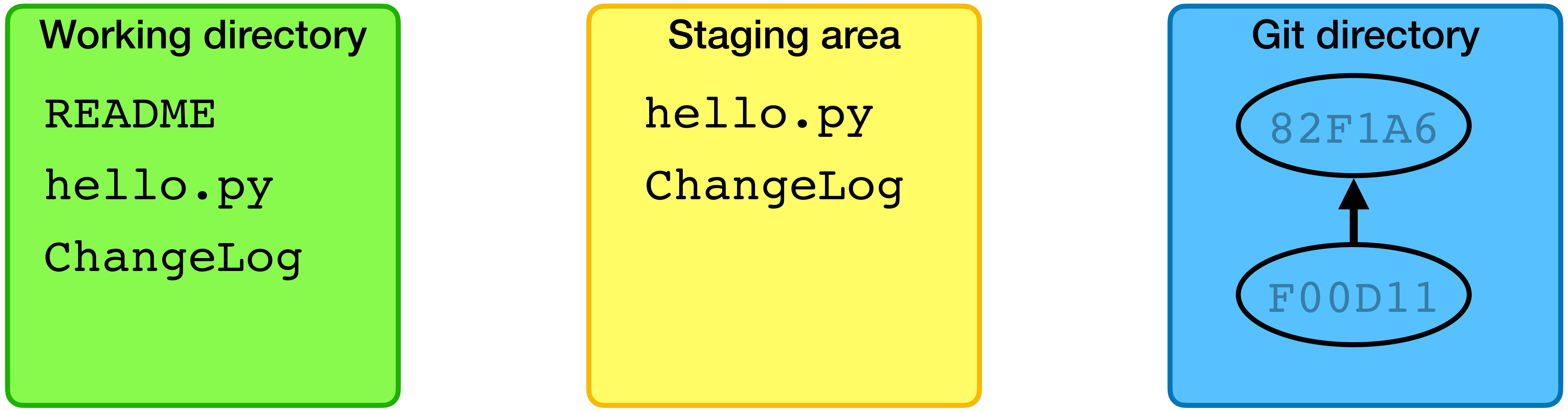
Each commit is (in essence) a snapshot of the repository

Commits are named by a hash of their contents, e.g.,
`c37ce054c766b79a3577aba898b296d3557c3d24`,
often just the first 7 digits: `c37ce05`

Each commit links to its parent commit(s)

Adding and committing

```
$ vim hello.py         # Modify the code
$ vim ChangeLog        # Write a change log with changes
$ git add hello.py     # Add the hello.py to the staging area
$ git add ChangeLog    # Add ChangeLog
$ git commit           # Commit the files to the repo
```



You've just cloned a repository from github, cd'd into the repo's directory, and created a new file.

```
$ git clone git@github.com:username/example-project.git
$ cd example-project
$ vim foo.sh
```

What command(s) should you run to commit this new file to the repo?

```
A. $ git add foo.sh

B. $ git commit foo.sh

C. $ git add foo.sh
   $ git commit

D. $ git add foo.sh
   $ git push

E. $ git add --commit foo.sh
```

After adding and committing initially, you've been working on `foo.sh` for a while and want to commit again.

What command(s) should you run to commit your changes repo?

```
A. $ git add foo.sh

B. $ git commit foo.sh

C. $ git add foo.sh
   $ git commit

D. $ git commit foo.sh
   $ git push

E. $ git add --commit foo.sh
```

Commit Message

When doing a commit, your editor will be opened so you can enter a commit message

- Short summary line
- Blank line
- Longer description

Try to provide enough detail that you can read the message to understand what changes were made (and why)

- Might be easy to remember now, but in 6 months?

Commit Message

If you’re using a short line, you can write the message on the command line:

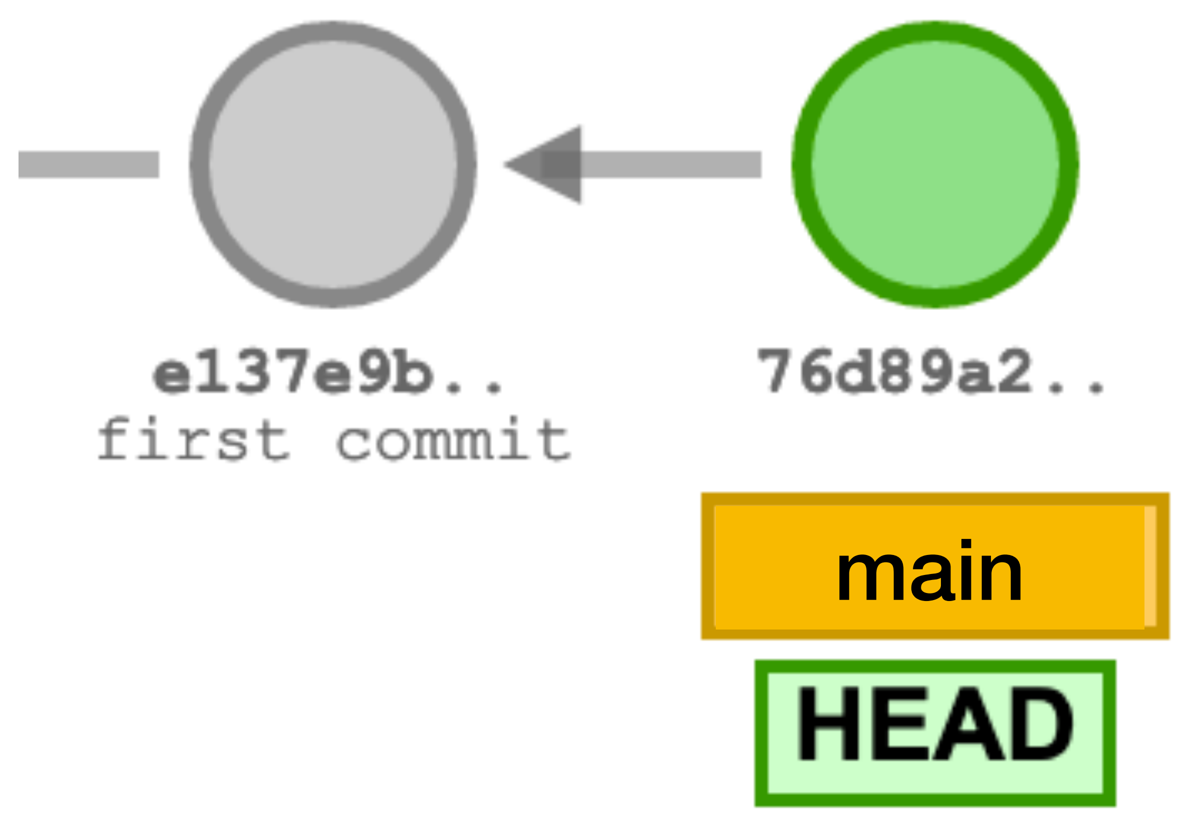
- `$ git commit -m “your message here”`

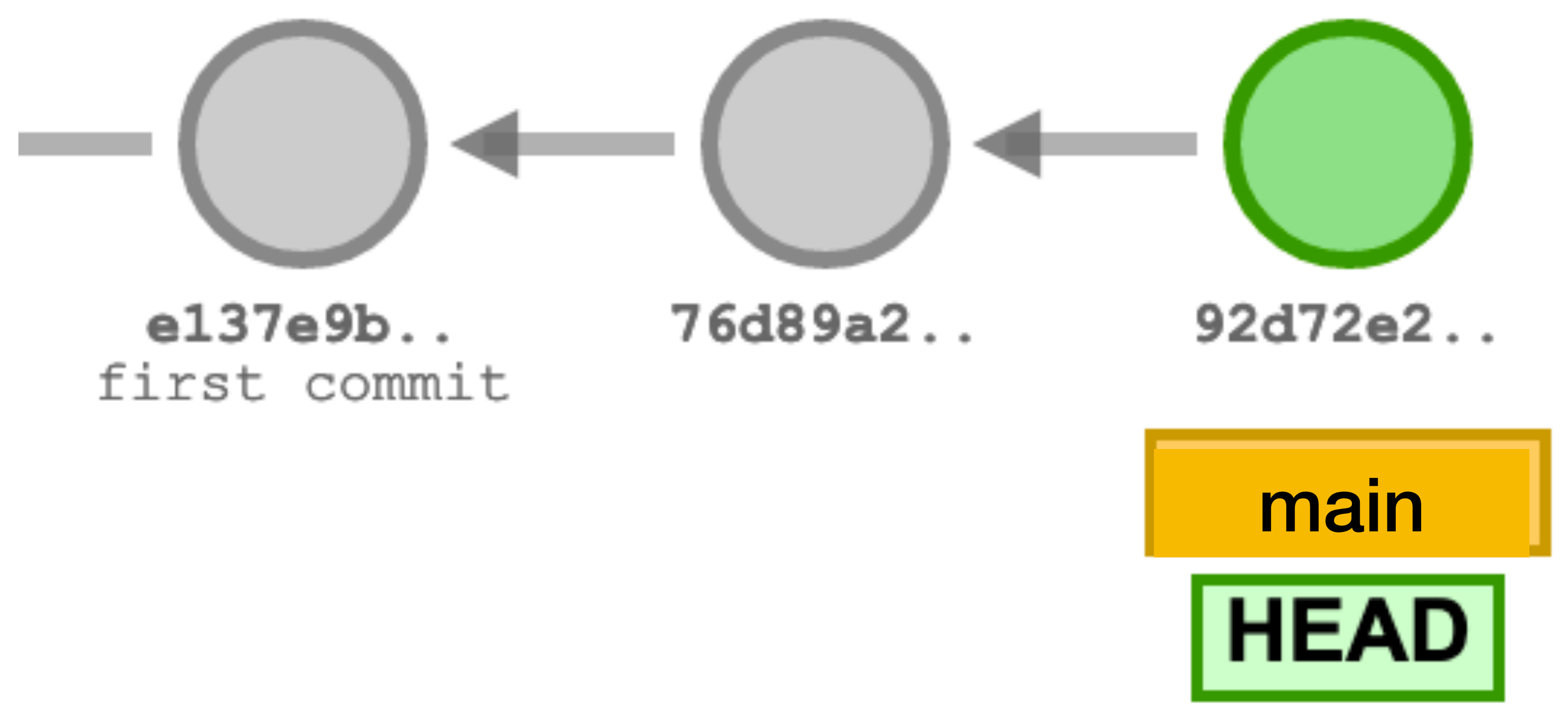
Naming commits

Individual commits can have human-readable names (instead of hash strings)

- `HEAD` is the currently checked out commit
- `main` is most recent commit on the default **branch** (which is itself named `main`)
- `main` used to be named `master`, lots of documentation still refers to `master`
- tags and branches give names to commits
  - Tags used to identify specific versions (e.g., can tag a commit as v1.0)
  - Branches diverge from the `main` branch

Example

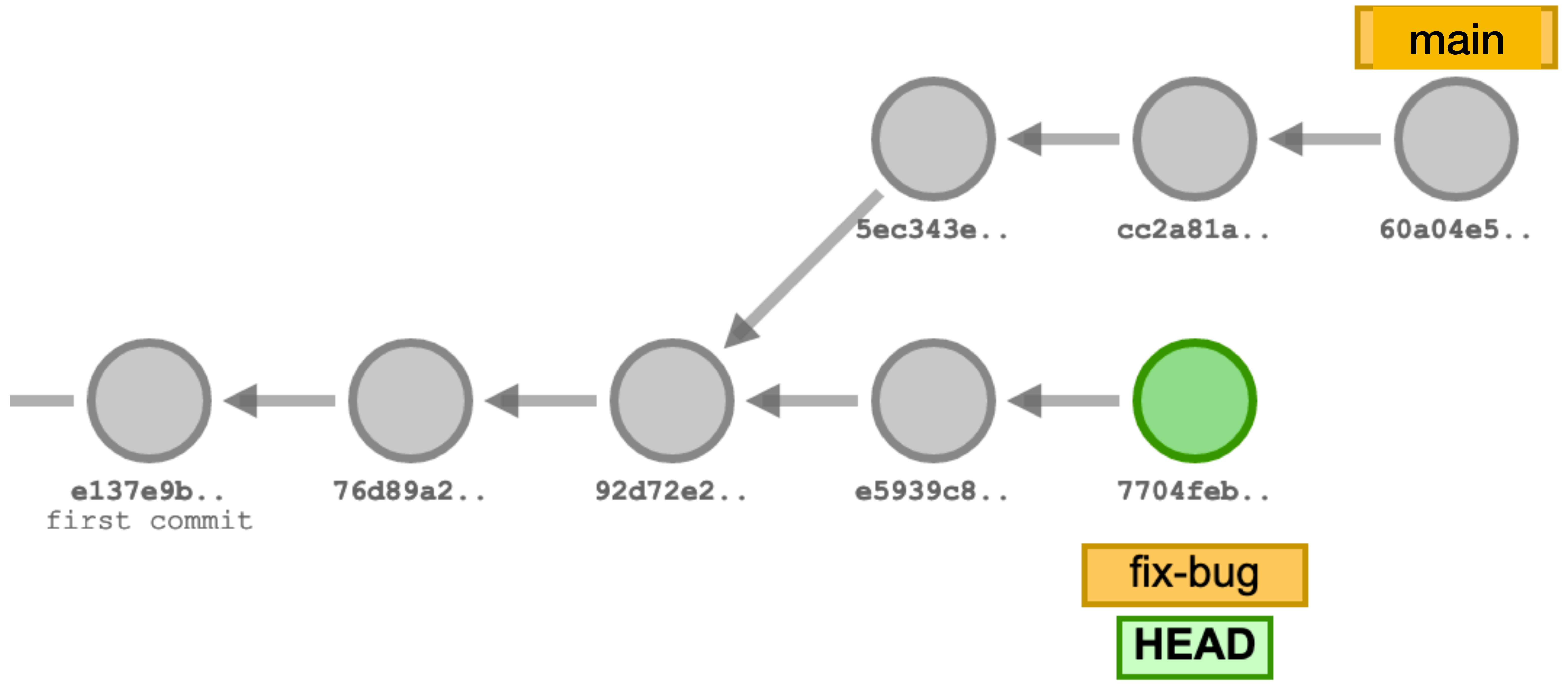




After two commits, `HEAD` and `main` point to the second commit

After a third commit, `HEAD` and `main` point to the third commit

HEAD != main



We can create a new branch `fix-bug` and commit to that branch

We can also keep committing to `main`

`HEAD` points to the branch we have checked out

Pushing to the remote server

```
$ git push
```

Sends to the remote server all of your committed data (it doesn't already have)

Remote servers are called remotes

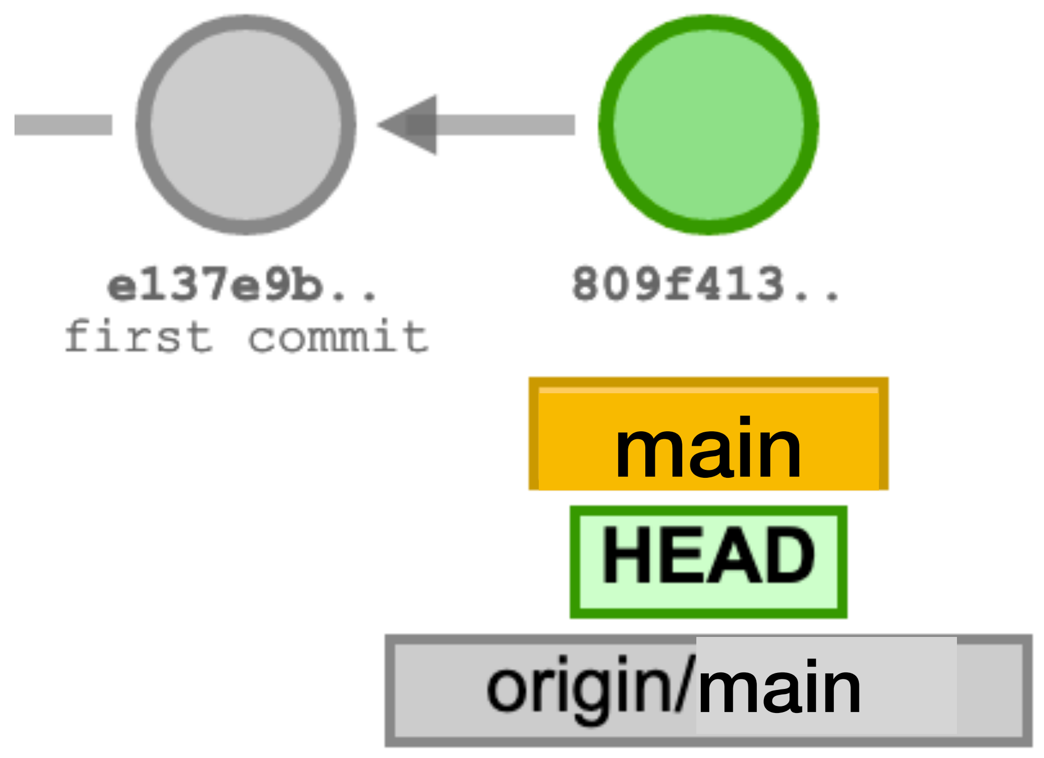
- When cloning, the remote is named `origin` by default
- Remotes have their own branches `origin/main` is `origin`'s `main` branch
- It's possible to have multiple remotes (but we probably won't in this class)

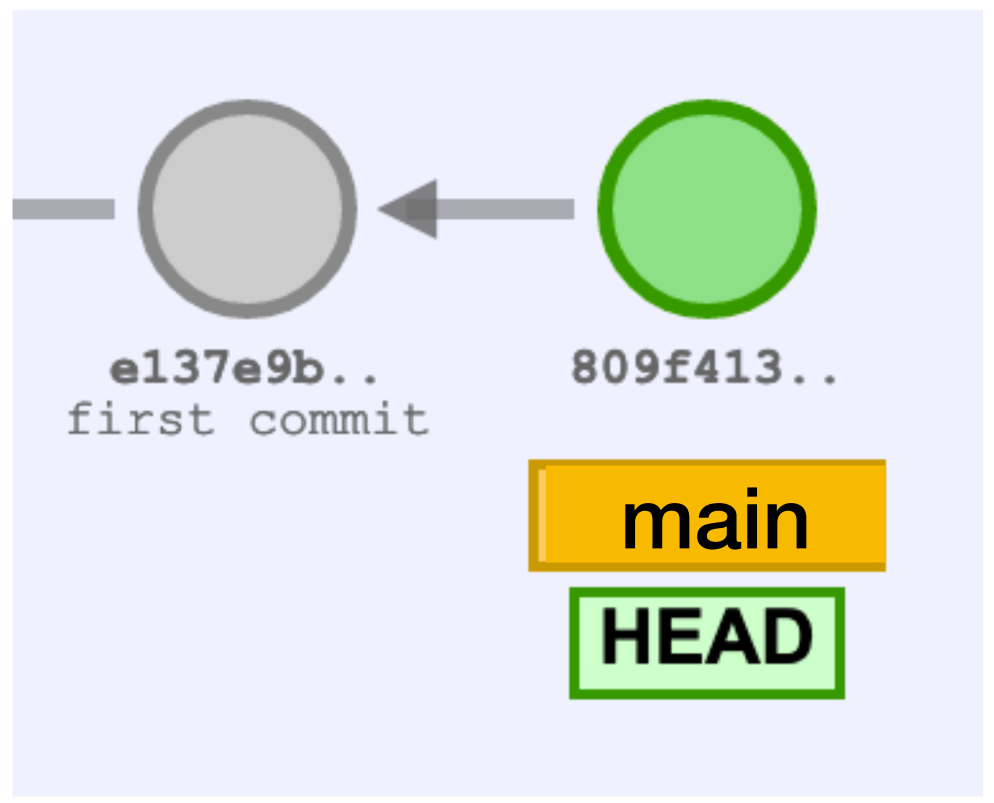
Example

Local repository

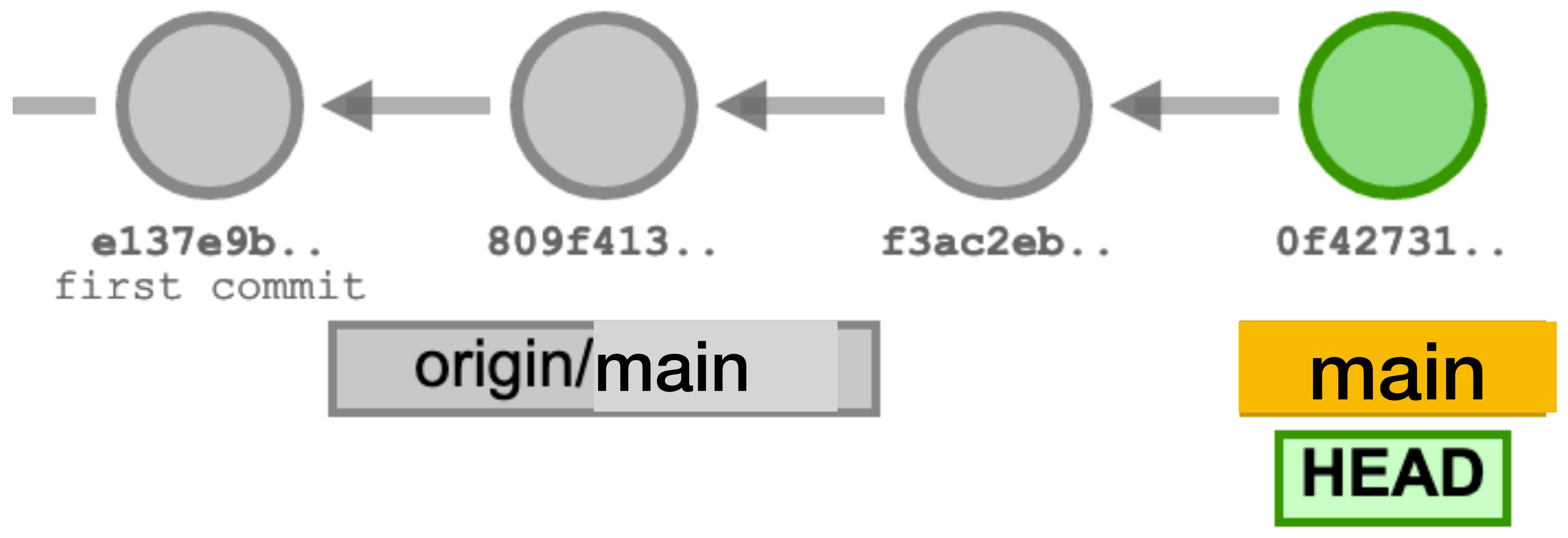
Origin

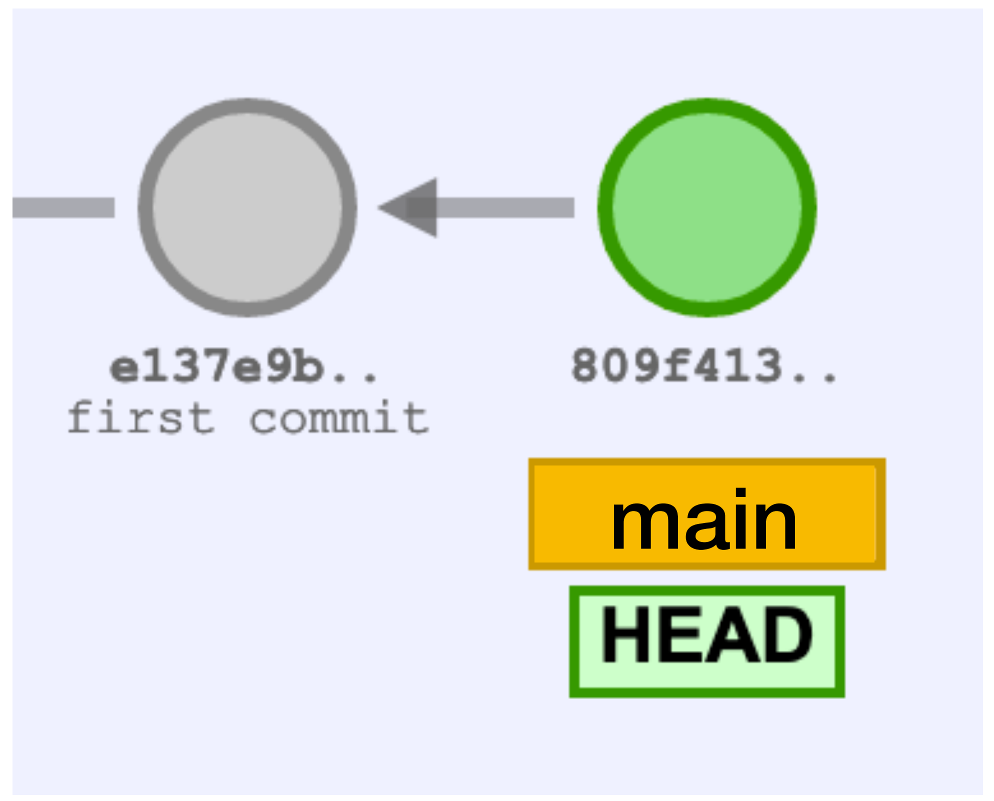
```
$ git clone …
```



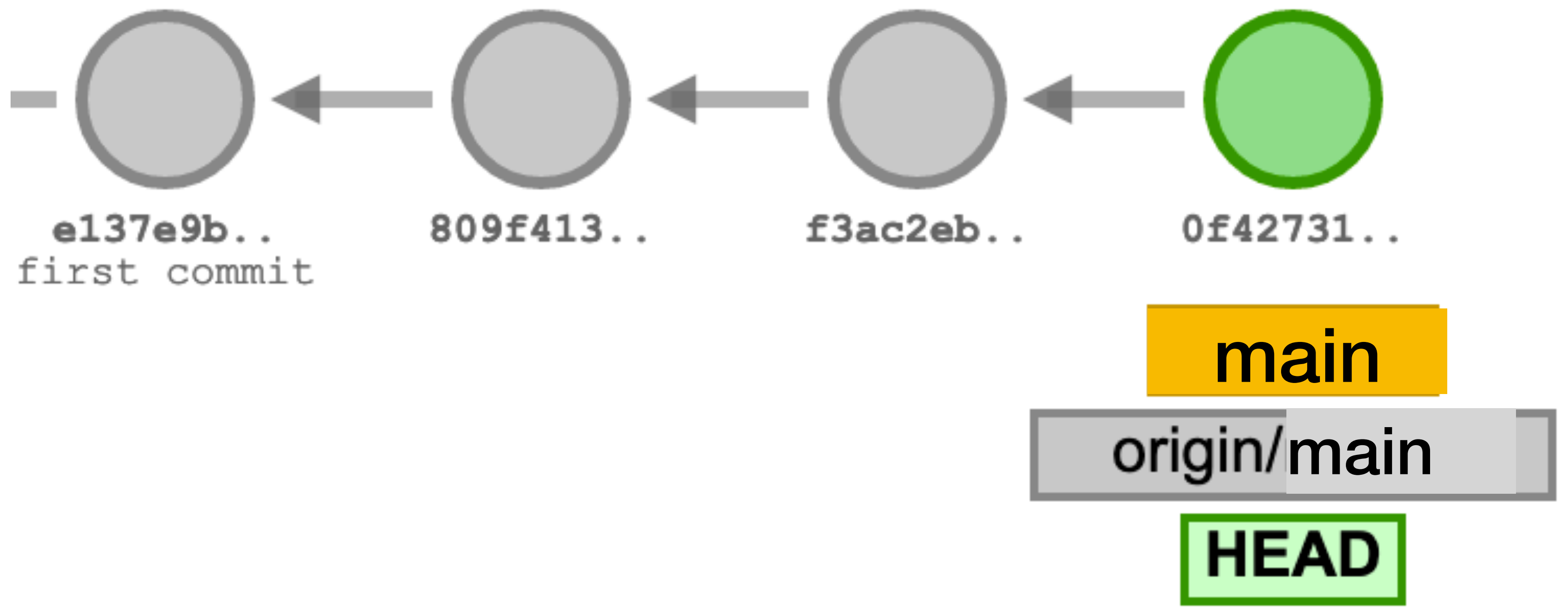


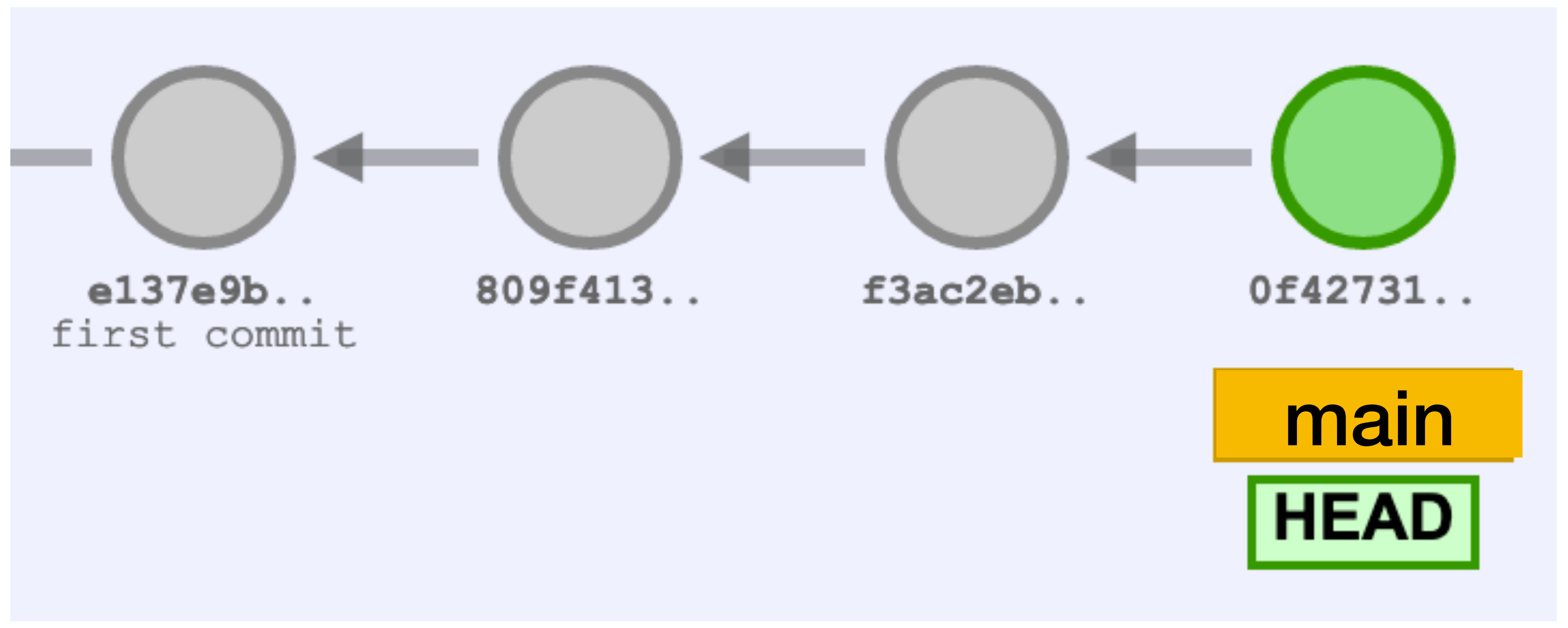
```
$ git add …
$ git commit
$ git add …
$ git commit
```





```
$ git push
```





Pulling from the remote server

```
$ git pull
```

Pulls changes from the remote server to the local repo and merges with the local changes

```
$ git pull --rebase
```

Pulls changes from the remote server to the local repo and rebases local commits on top of remote commits

Pulling with merging

Commits from the remote will be added to the local repository
If there are local commits, git tries to merge them by creating a new commit

```
      A---B---C main on origin
     /
D---E---F---G main
    ^
    origin/main in your repository


      A---B---C origin/main
     /         \
D---E---F---G---H main
```

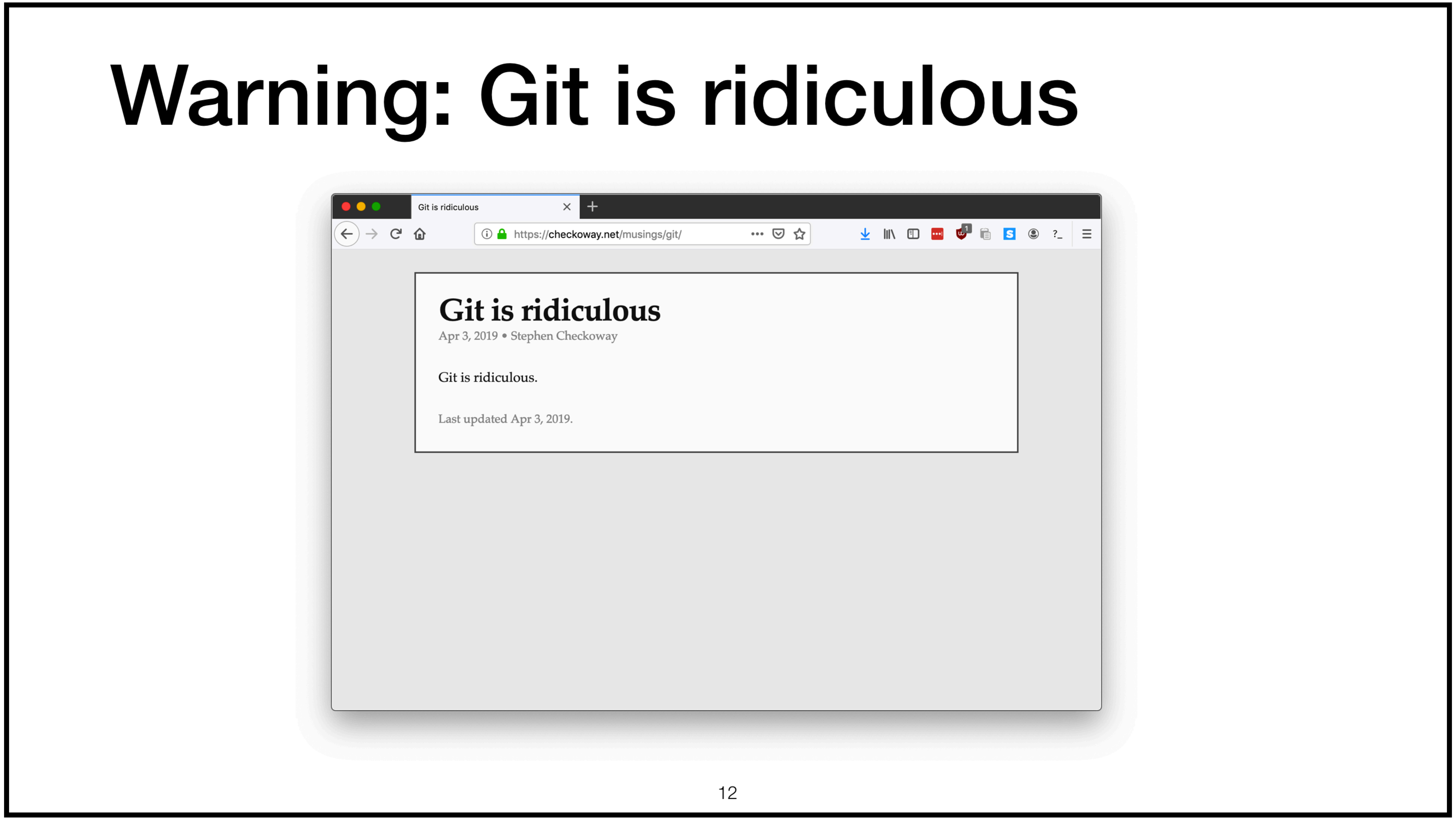
Pulling with rebasing

Commits from the remote will be added to the local repository
If there are local commits, git replays them on top of the new commits

```
      A---B---C main on origin
     /
D---E---F---G main
    ^
    origin/main in your repository


                origin/main
                v
D---E---A---B---C---F'--G' main
```

Reminder: Git is ridiculous



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Gitting help

```
$ git --help

$ git init --help

$ git clone --help

$ git add --help

$ git commit --help

$ git push --help

$ git pull --help
```

Basic Lab Workflow

Create the repository by clicking on the link in the lab

Clone the repository on lab machines using `$ gh repo clone ⟨url⟩`

Add files to be committed with `$ git add ⟨filename⟩`

Create a commit (snapshot) of added files using `$ git commit`

Push files to the server using `$ git push`

See the current state of the files using `$ git status`

Commit often

Commits are cheap, commit often

Commits can be reverted by `git revert`

- Makes a new commit that undoes the old commit
- `$ git revert ⟨commit_hash⟩`

Commits that haven't been pushed can be undone completely by `git reset`

- `$ git reset --hard ⟨commit_hash⟩`

Demo at https://jmegner.github.io/visualizing-git/

Fri Preview - Shell Scripting

- File permissions
- Loops
- Conditionals