# CS 241: Systems Programming
# Lecture 5. Version Control/Git

Fall 2019

Prof. Stephen Checkoway

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- Why you changed it

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- Development
- Release

# 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

- Master 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 master 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

- Master repo stored on some server, e.g., `vcs.oberlin.edu:/vcs/program`
- Users on many different machines can checkout copies, e.g., clyde.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

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A distributed version control system

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- 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 'Stephen Checkoway'
$ git config --global user.email \
    'stephen.checkoway@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`

# Creating a repository

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

Creates a `.git` folder in `project`

No files are currently being tracked or managed

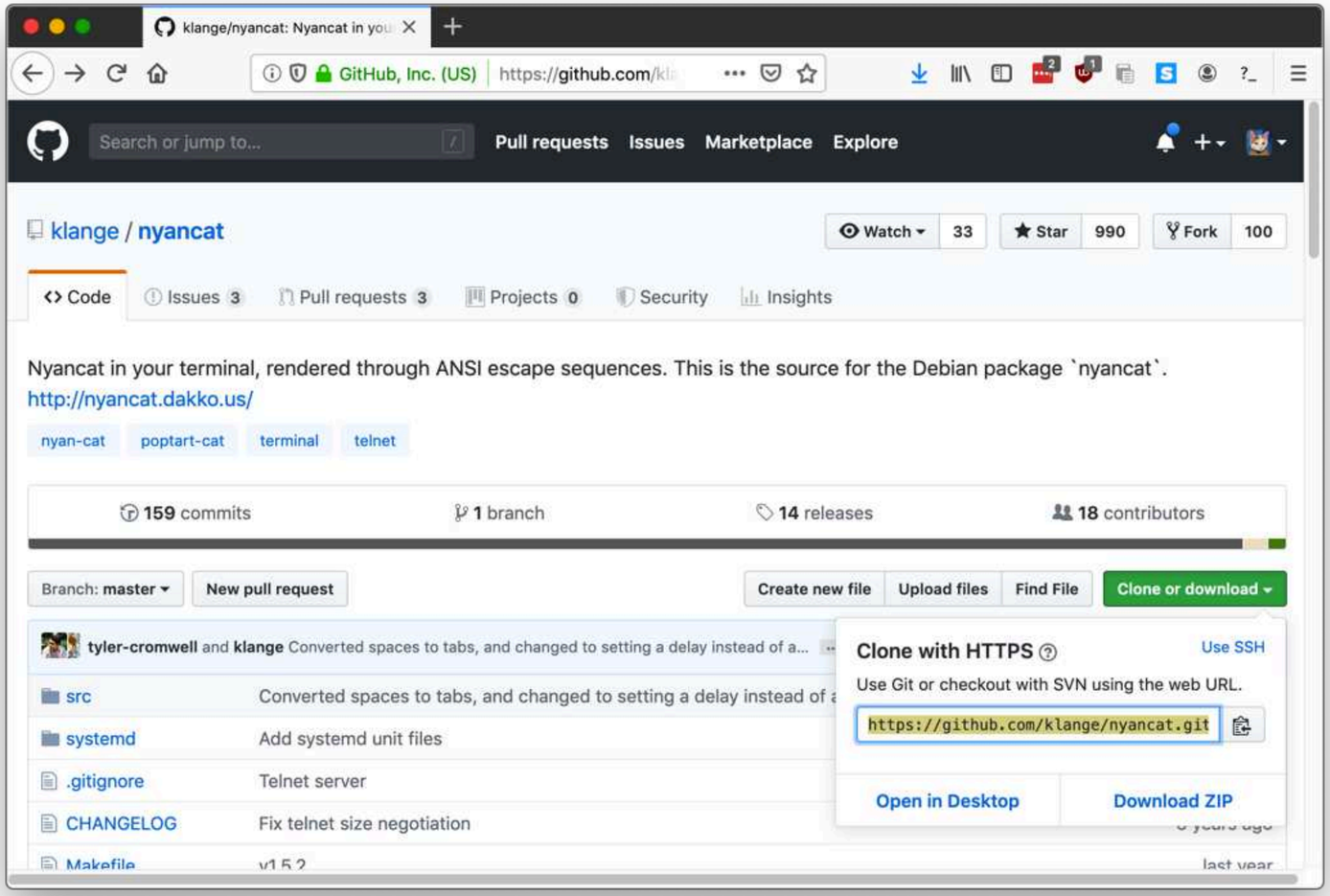
No remote server

# 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



# Cloning a (remote) repository

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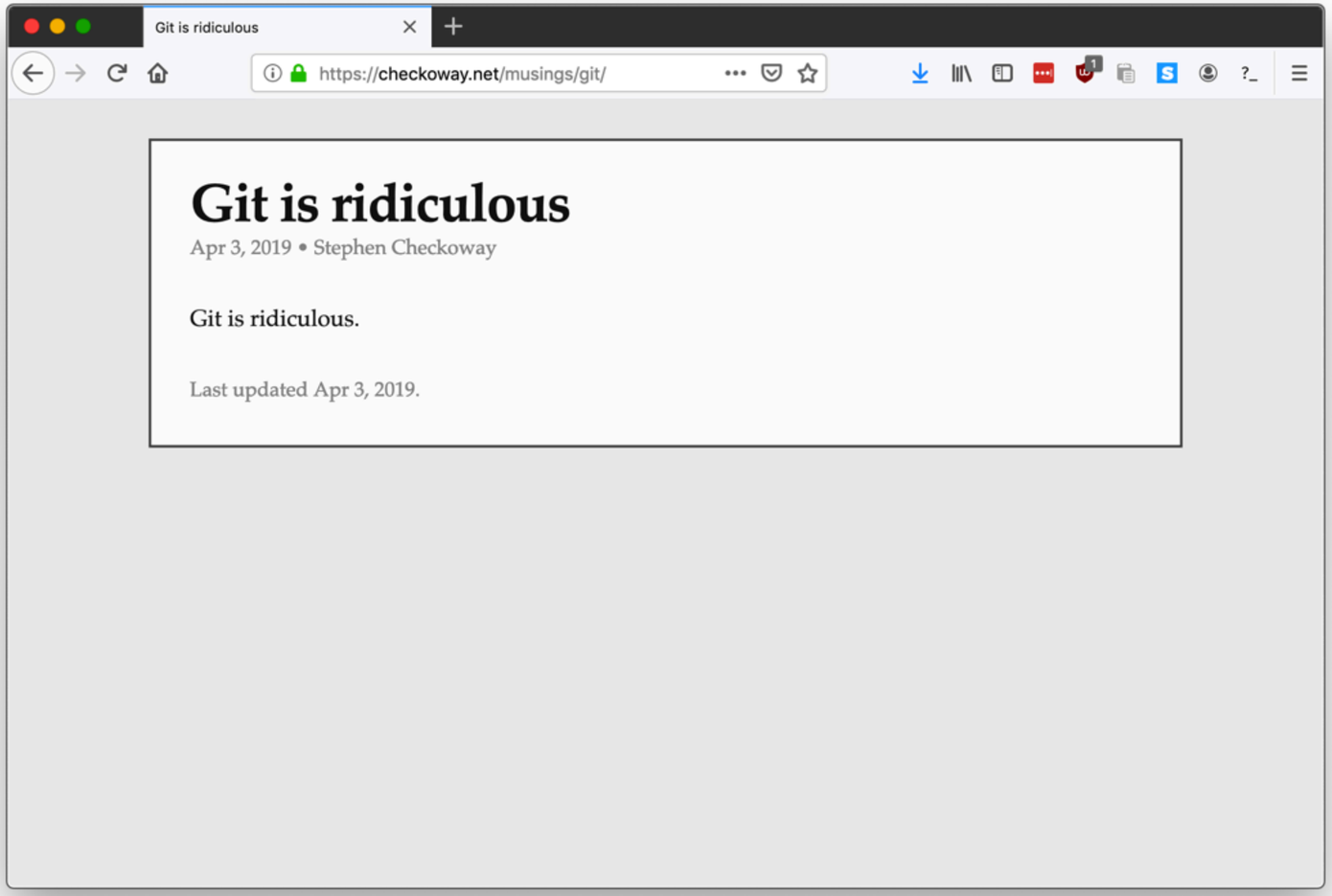
# Warning: Git is ridiculous



# Working dir vs staging vs .git

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

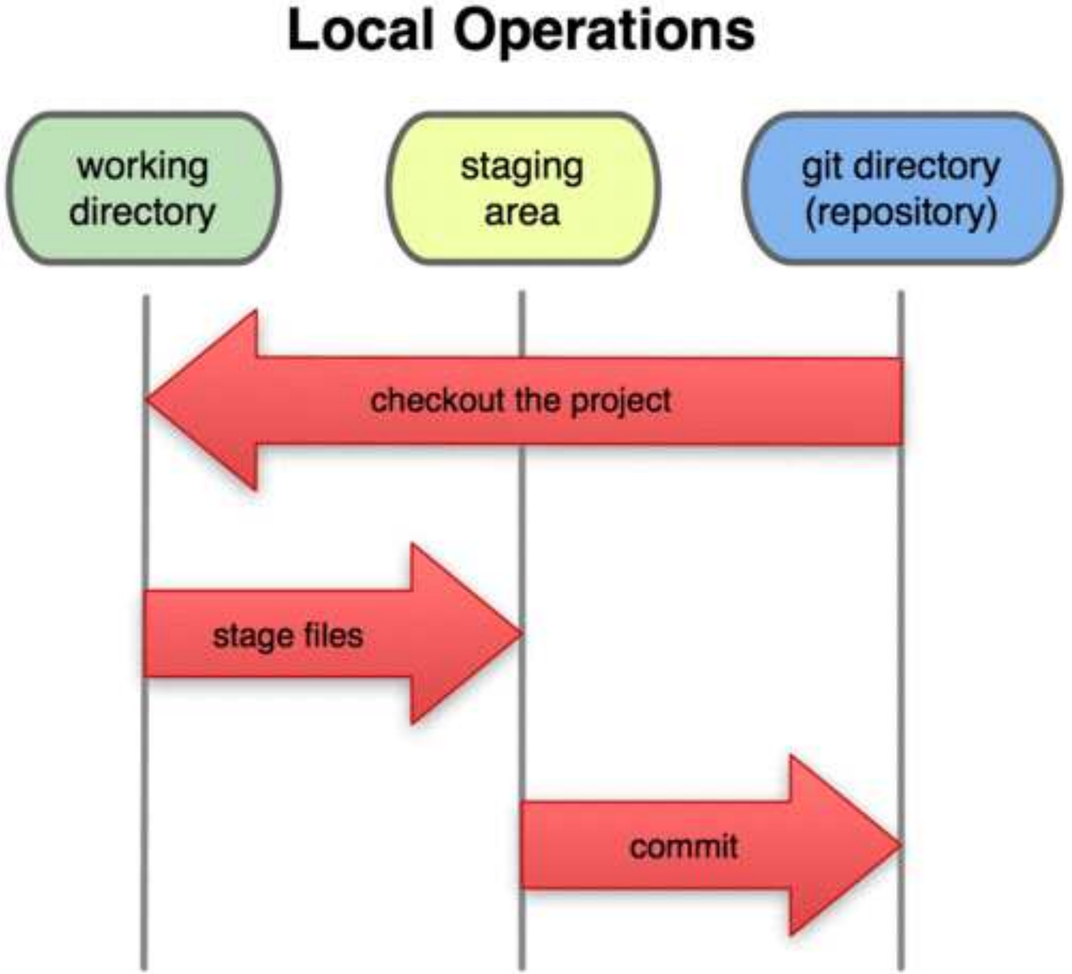
- Holds one version of the files in the repo

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



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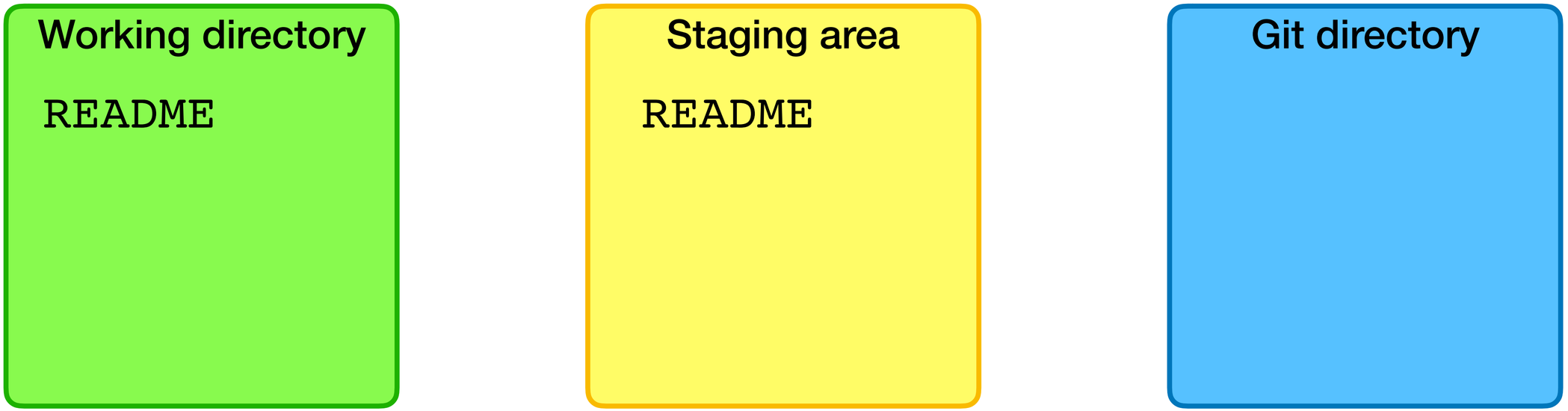

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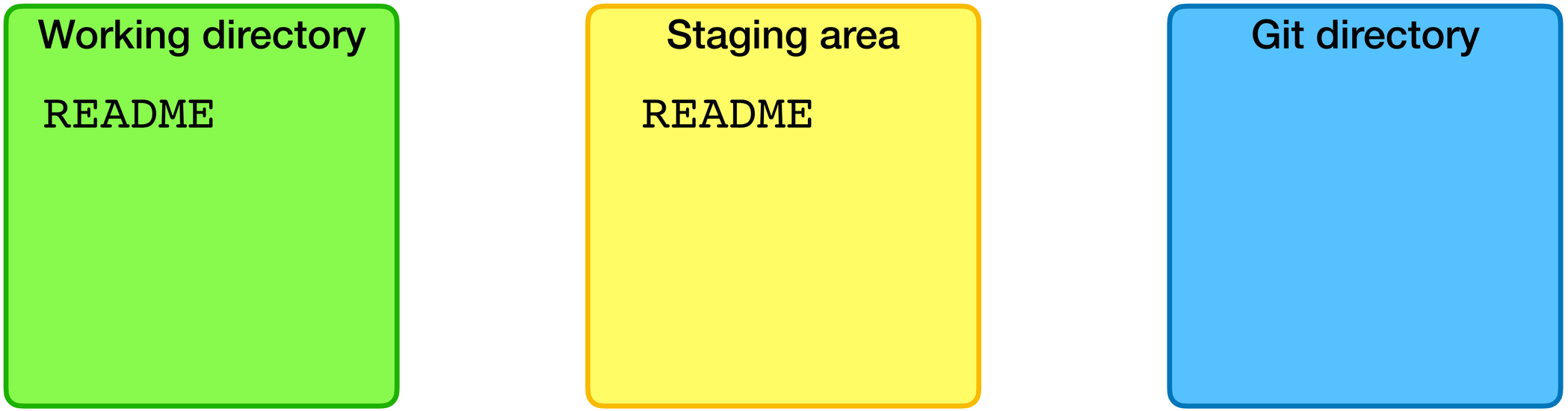

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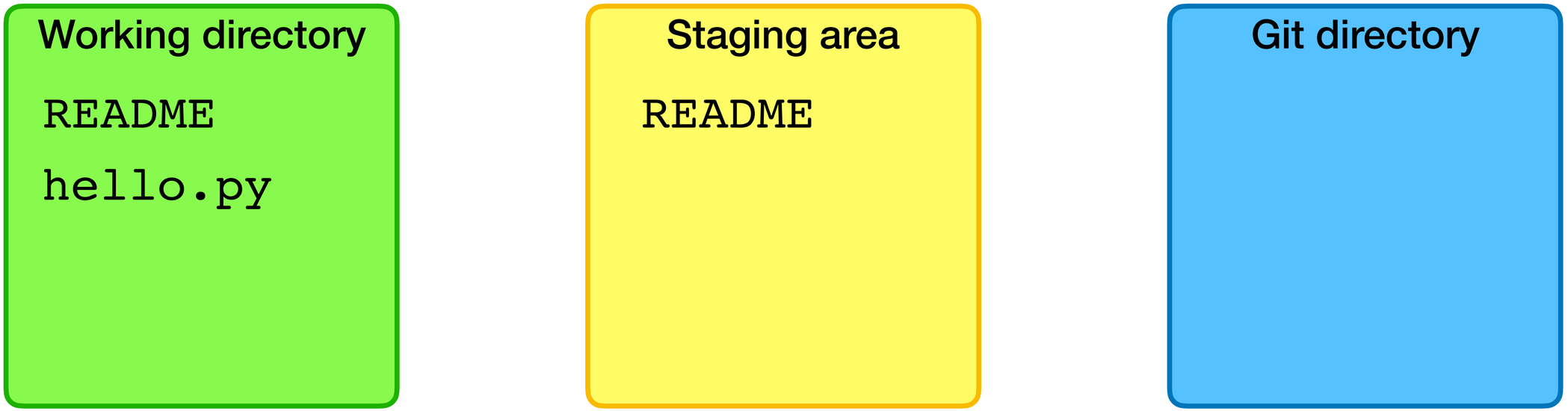

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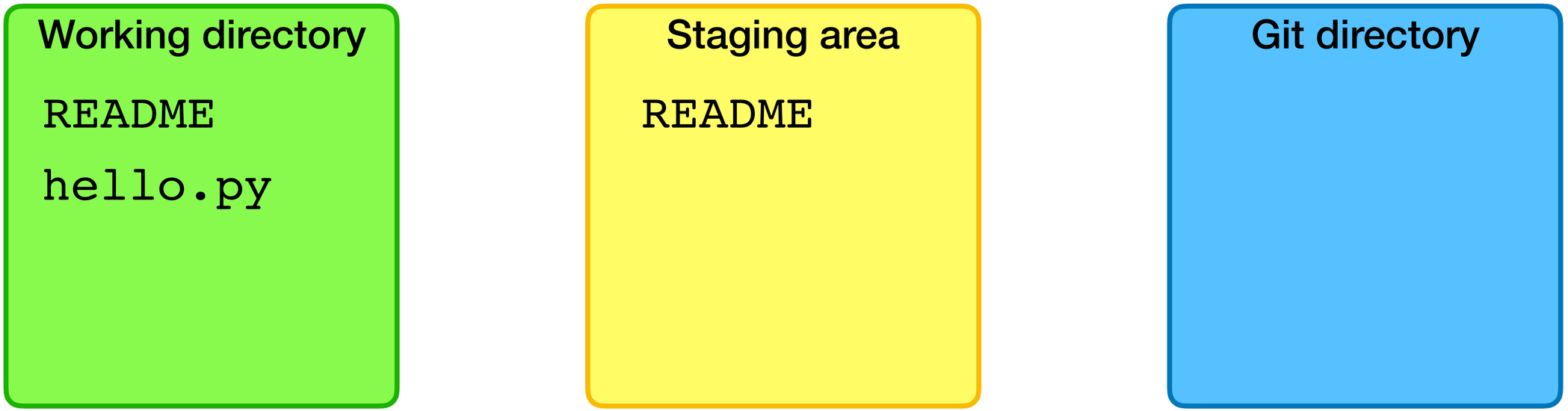

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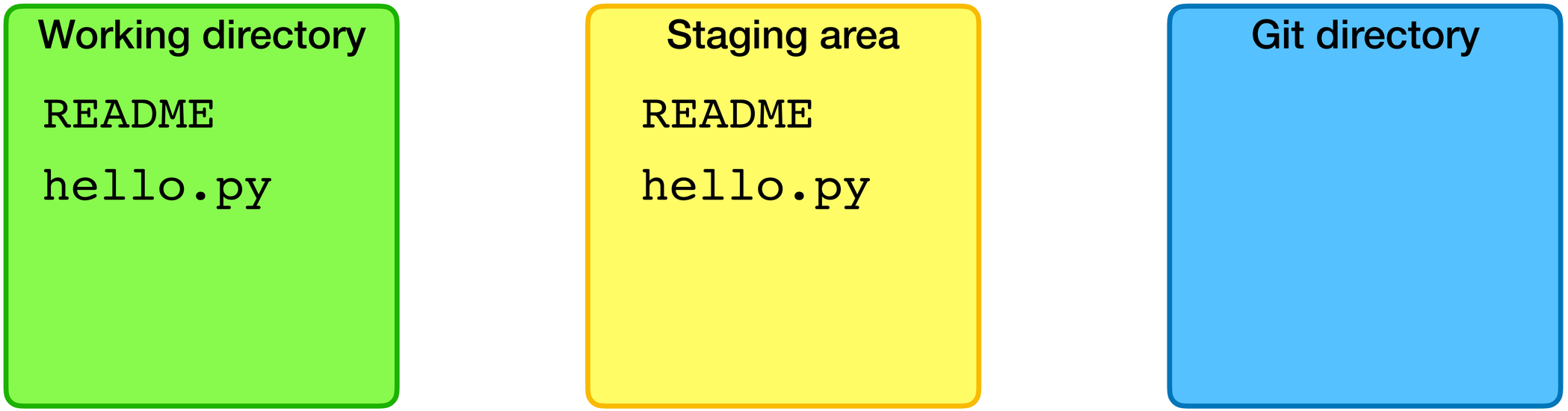

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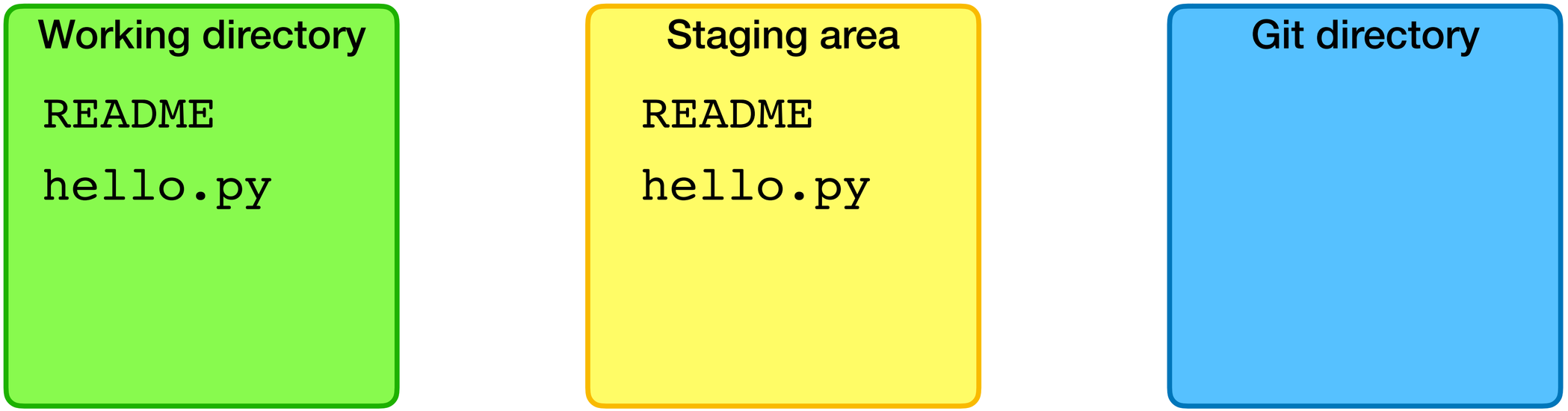

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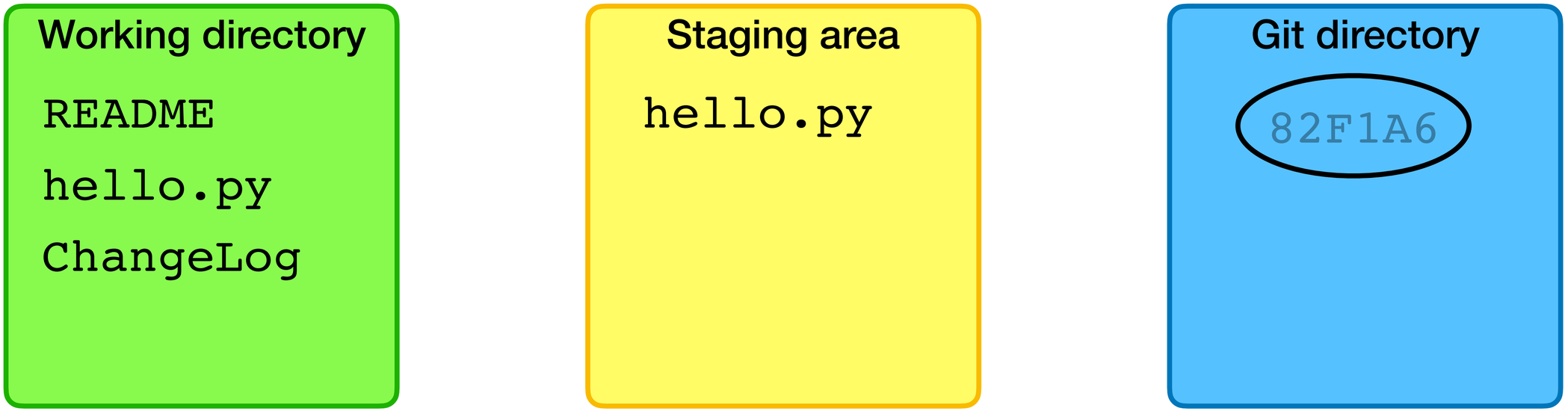

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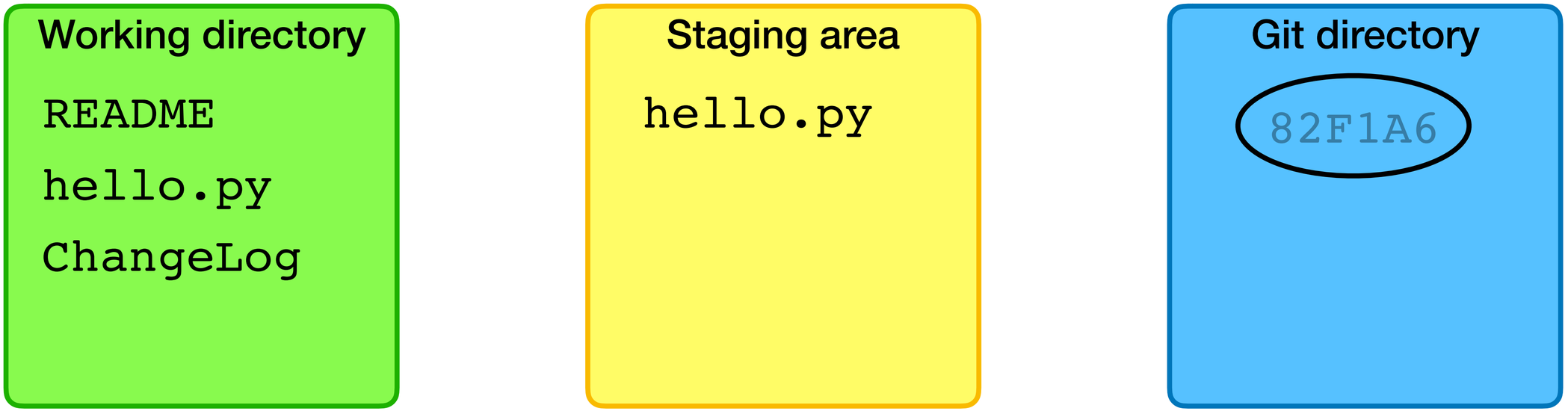

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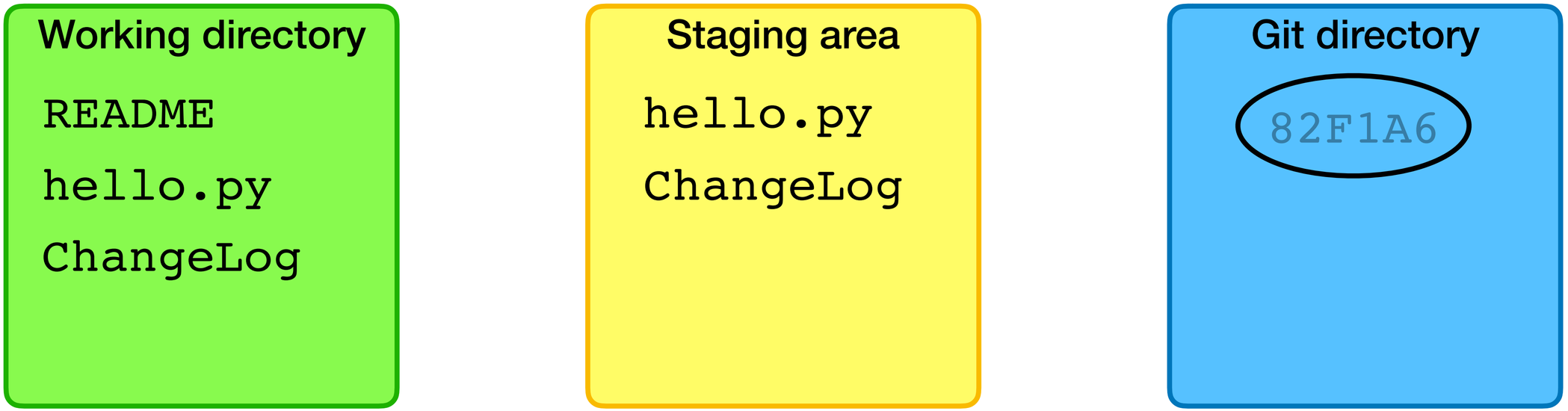

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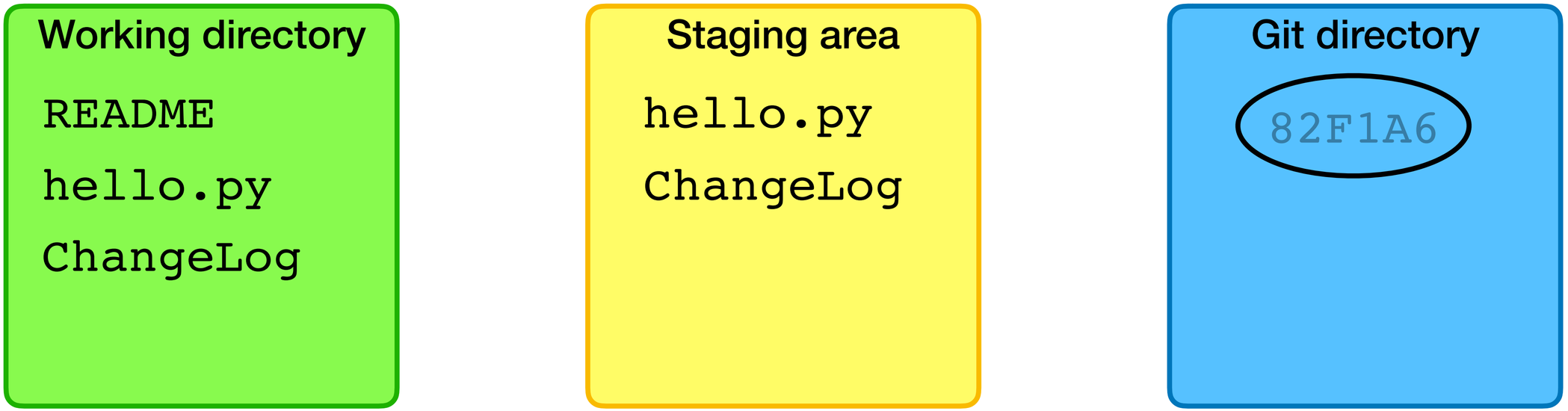

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# Commit Message

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?

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
```

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

A.
```
$ git add foo
```

B.
```
$ git commit foo
```

C.
```
$ git add foo
$ git commit
```

D.
```
$ git add foo
$ git push
```

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

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

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

A.
```
$ git add foo
```

B.
```
$ git commit foo
```

C.
```
$ git add foo
$ git commit
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D.
```
$ git commit foo
$ git push
```

E.
```
$ git add --commit foo
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# Commits

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

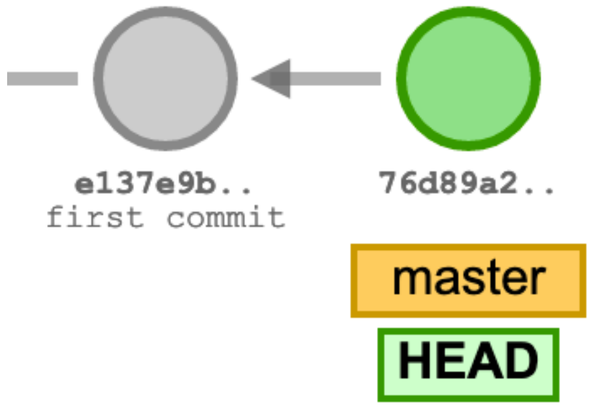
Commits are named by a hash of their contents, e.g.,
`c37ce054c766b79a3577aba898b296d3557c3d24`,
often just the first 7 digits: `c37ce05`

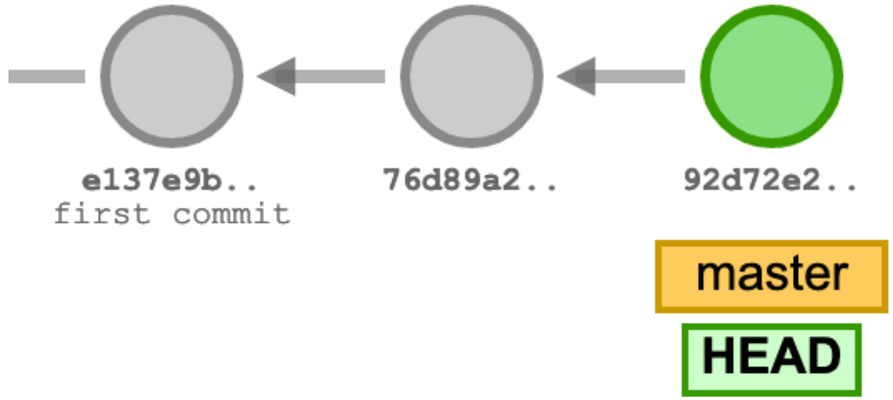
Each commit links to its parent commit(s)

Individual commits can have human-readable names

- `HEAD` is the currently checked out commit
- `master` is most recent commit on the default **branch**

# Example

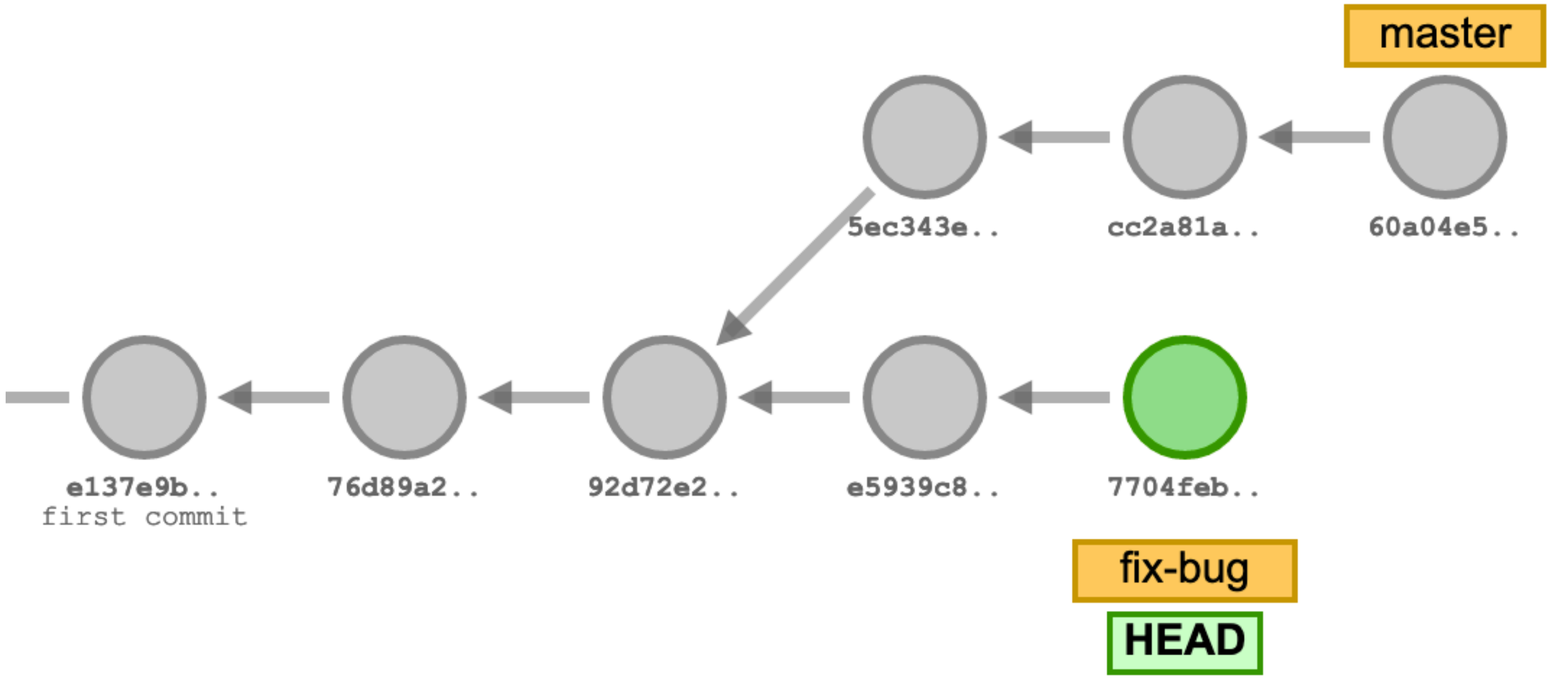



After two commits, `HEAD` and `master` point to the second commit

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

# `HEAD != master`




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

We can also keep committing to `master`

`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)

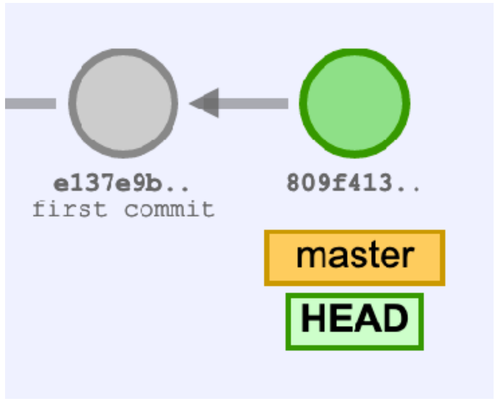
Remote servers are called remotes

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

# Example

**Local repository**

**Origin**



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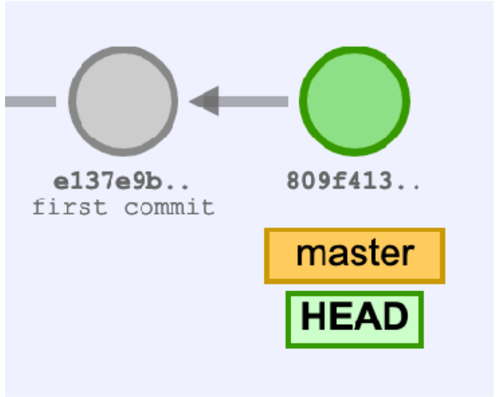


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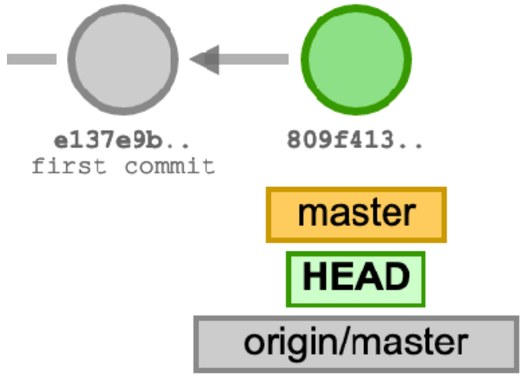


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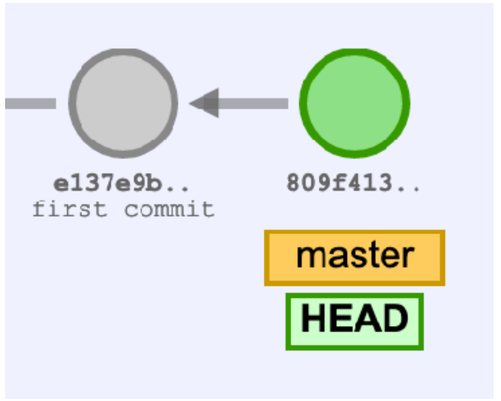

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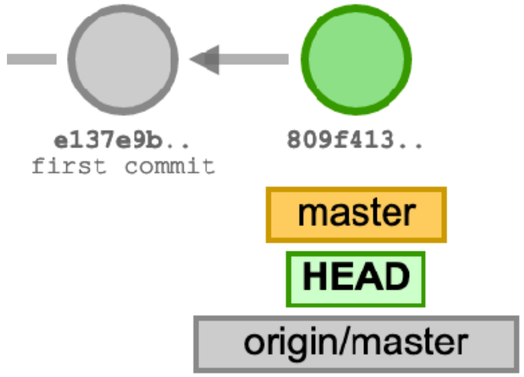


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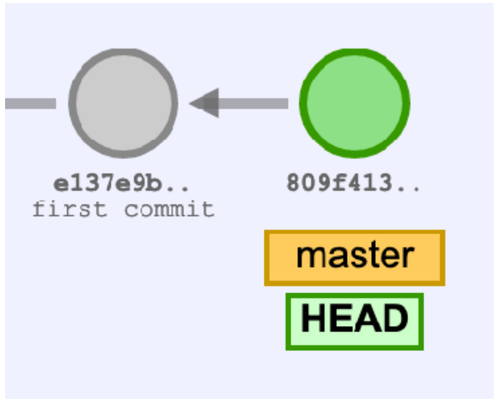

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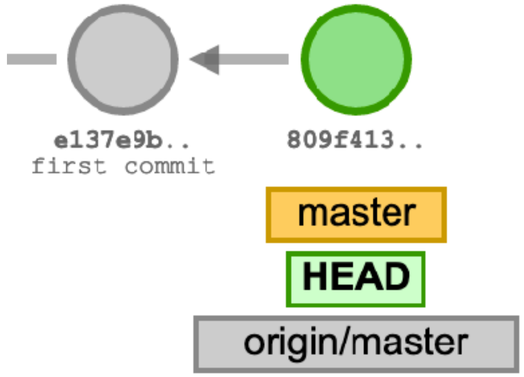


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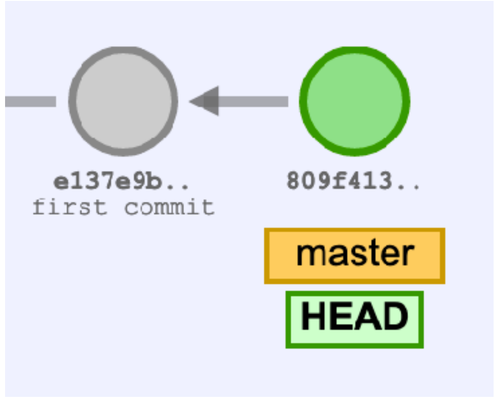


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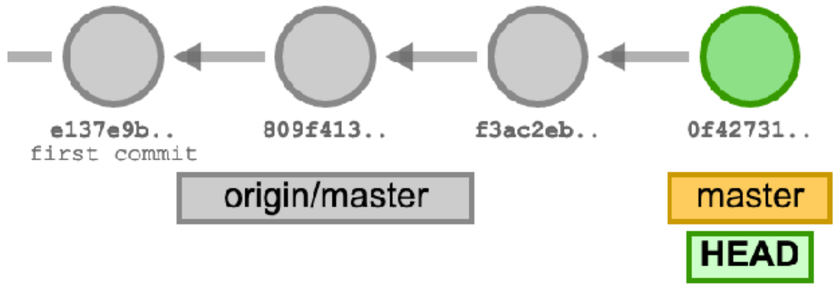


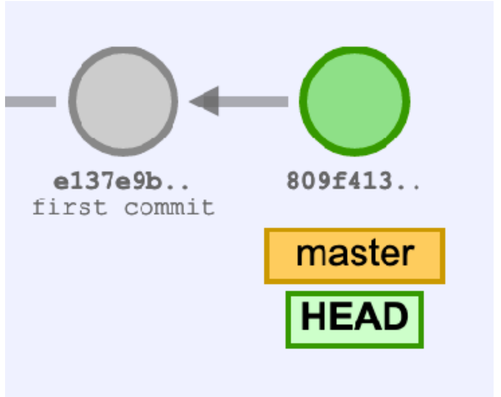

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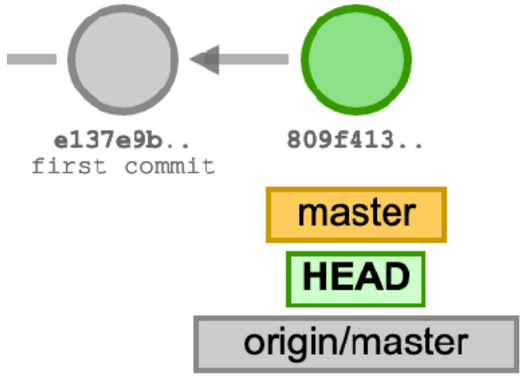


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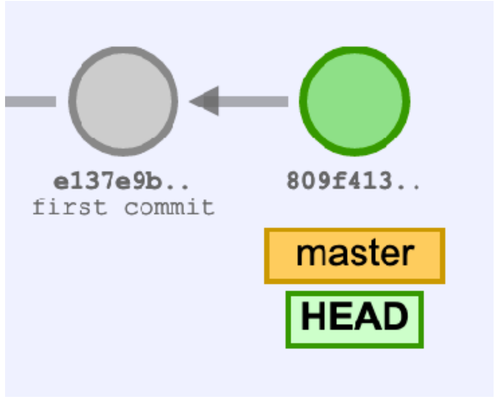


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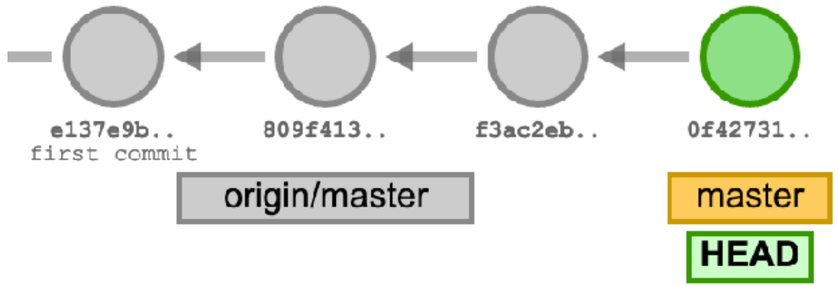


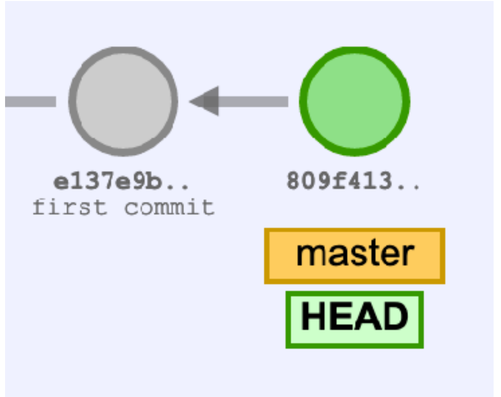


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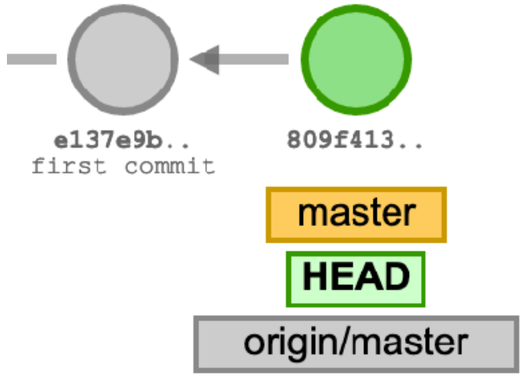


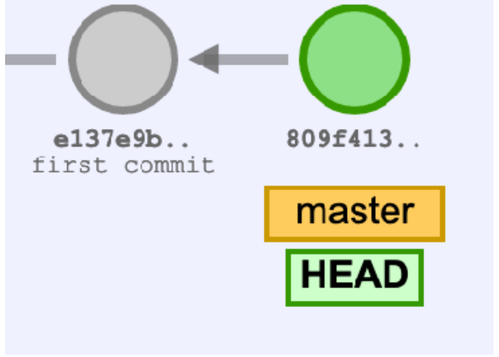


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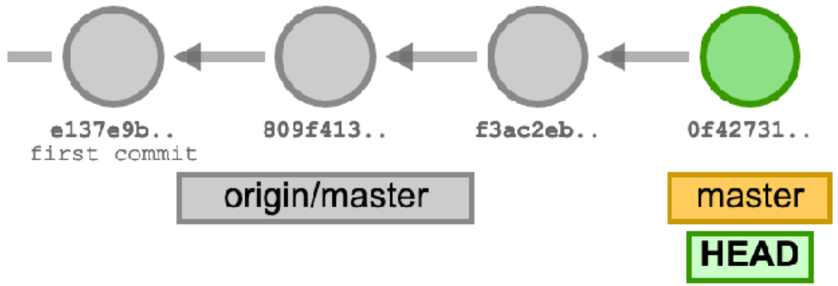


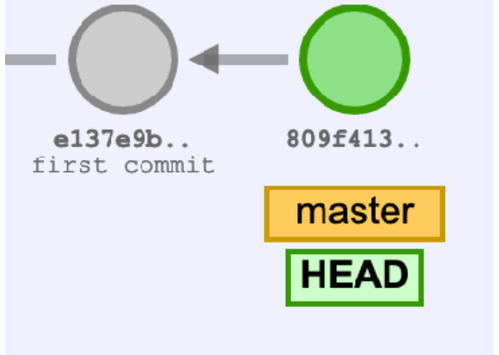


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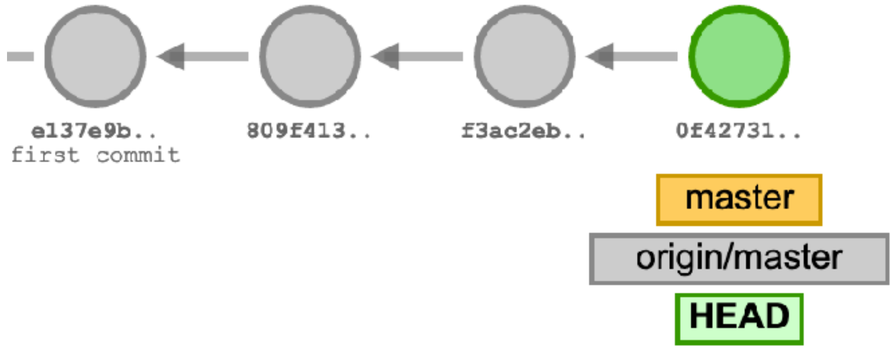
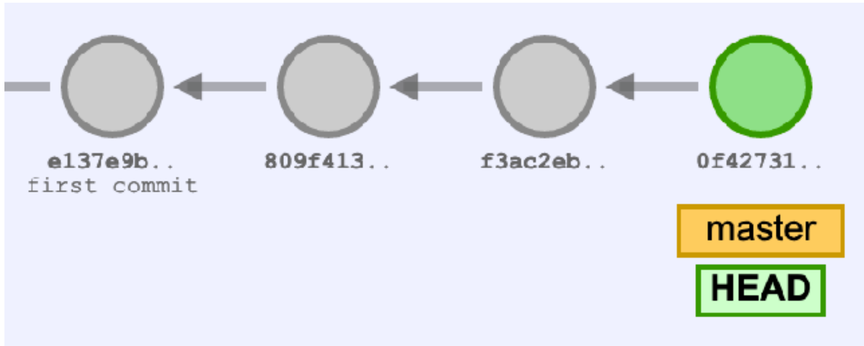


# Pulling from the remote server

```
$ 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 master on origin
     /
D---E---F---G master
    ^
    origin/master in your repository
```

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

# Pulling with rebasing

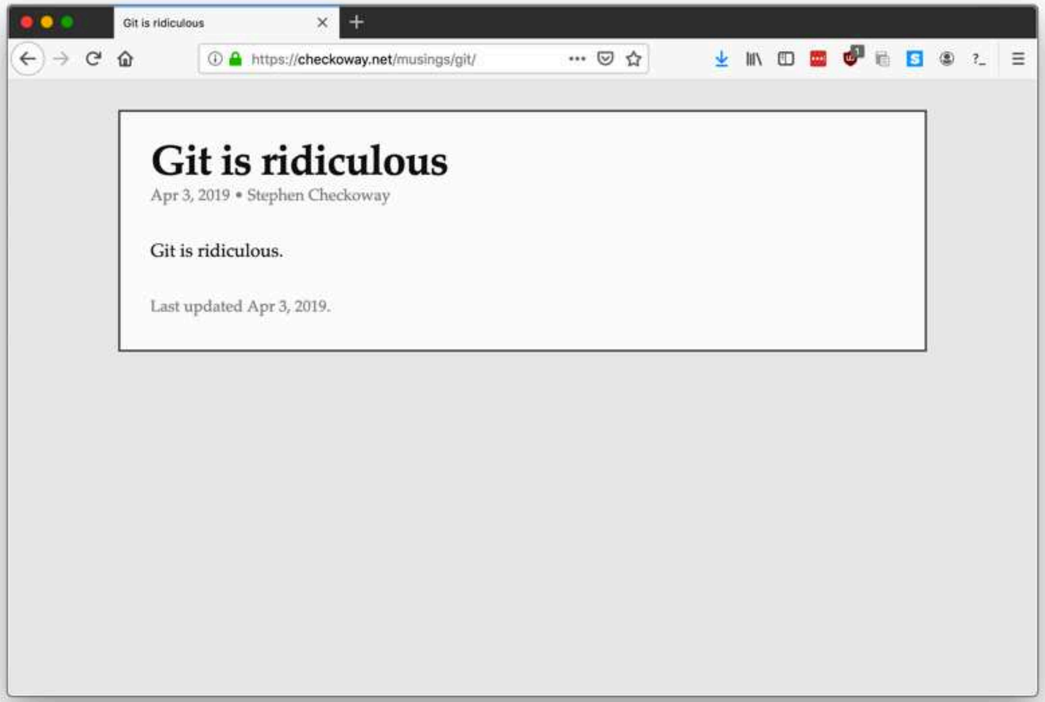
Commits from the remote will be added to the local repository
If there are local commits, git replays them on top of the new commits

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


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

# Reminder: Git is ridiculous

## Warning: Git is ridiculous



# Gitting help

```
$ git --help

$ git init --help

$ git clone --help

$ git add --help

$ git commit --help

$ git push --help

$ git pull --help
```

# 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://git-school.github.io/visualizing-git/#free-remote

# Basic Workflow

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Push files to the server using `$ git push`

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

# In-class exercise

https://checkoway.net/teaching/cs241/2019-fall/exercises/Lecture-05.html

Grab a laptop and a partner and try to get as much of that done as you can!