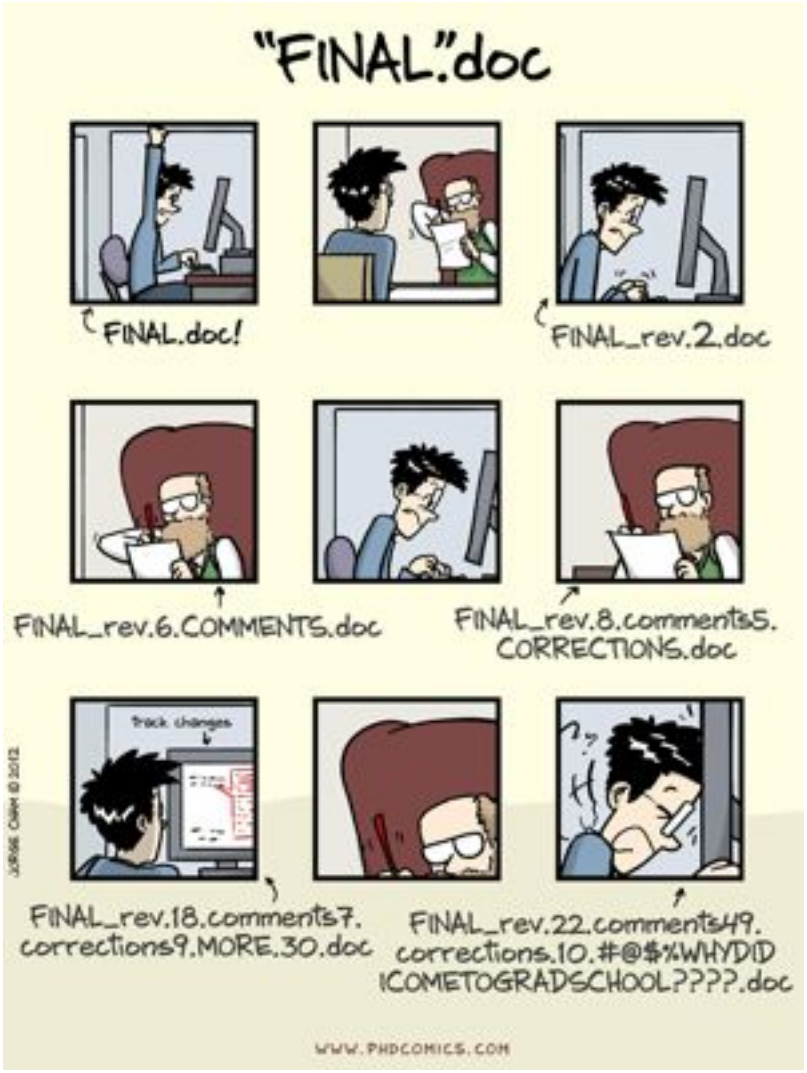
VERSION CONTROL WITH GIT AND GITHUB

Keeping history of changes



The lame way

- Multiple dated files with largely the same content
- Periodically zipping files up into numbered/dated archives

The right way

Version control is the only reasonable way to keep track of changes in code, manuscripts, presentations, and data analysis projects

- Backup of your entire project
- Promotes transparency
- Facilitates reproducibility
- Faster recover from errors
- Easier collaborations

"Piled Higher and Deeper" by Jorge Cham, http://www.phdcomics.com

Why version control

- Version control is not strictly necessary for reproducible research, and it's admittedly some extra work (to learn and to use) in the short term, but the long term benefits are enormous

- People are more resistant to version control than to any other tool, because of the short-term effort and the lack of recognition of the long-term benefits

- Imagine that some aspect of your code has stopped working at somepoint. You know it was working in the past, but it's not working now. How easy is it to figure out where the problem was introduced?

http://guides.beanstalkapp.com/version-control/getting-started-with-git.html

What is Git

- Git is an open-source distributed version control system
  - Developed by Linus Torvalds (developer of Linux)
- Distributed, distinct from centralized (subversion)
  - Authors can work asynchronously without being connected to a central server and synchronize their changes when possible
- Complete audit trail of changes, including authorship
- Freedom to explore new ideas without disturbing the main line of work
- Collaborate with elegance – on any file at any time

https://git-scm.com/downloads

Sequential snapshots of incremental changes

Advantages of version control:

- It's easy to set up
- Every copy of a Git repository is a full backup of a project and its history
- A few easy-to-remember commands are all you need for most day-to-day version control tasks

STEPS IN VERSION CONTROL

First steps with Git

Download and install Git, https://git-scm.com/downloads.
Do not install GUI client

- `man <command>`. `man git` - not always good
- `git --help [<command>]`

Setting up git

- `git config --global user.name "Your name here”`
- `git config --global user.email your_email@example.com`
- `git config --global color.ui “auto”`
- `git config core.fileMode false`
- `git config --list`

Configuring text editor

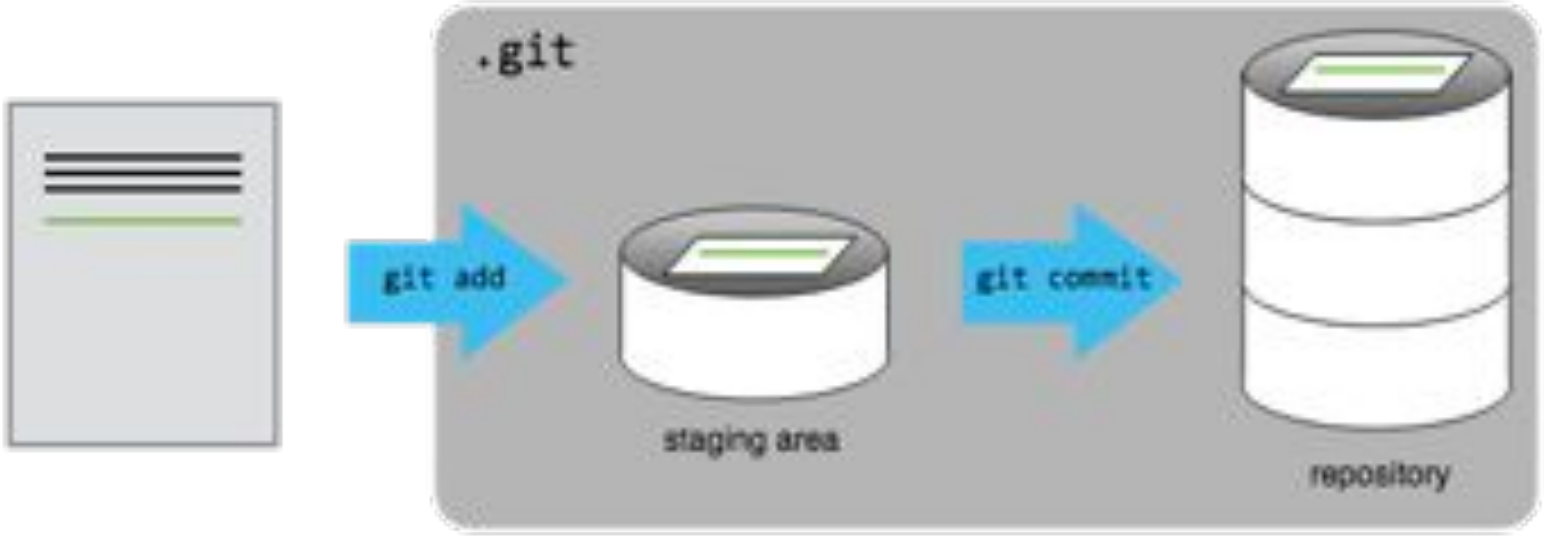
Editor	Configuration command
nano	`git config --global core.editor "nano -w"`
vim	`git config --global core.editor "vim"`
Text Wrangler	`git config --global core.editor "edit -w"`
Sublime Text (Mac)	`git config --global core.editor "subl -n -w"`
Sublime Text (Win)	`git config --global core.editor "'c:/program files/sublime text 2/sublime_text.exe' -w"`
Notepad++ (Win)	`git config --global core.editor "'c:/program files (x86)/Notepad++/notepad++.exe' -multiInst -notabbar -nosession -noPlugin"`
Kate (Linux)	`git config --global core.editor "kate"`
Gedit (Linux)	`git config --global core.editor "gedit -s"`

Git concepts

Two main concepts

- **commit -** a recorded *snapshot* of differences you made to your project's files
- **repository -** the history of all your project's commits

Files can be stored in a project's working directory (which users see), the staging area (where the next commit is being built up) and the local repository (where revisions are permanently recorded)



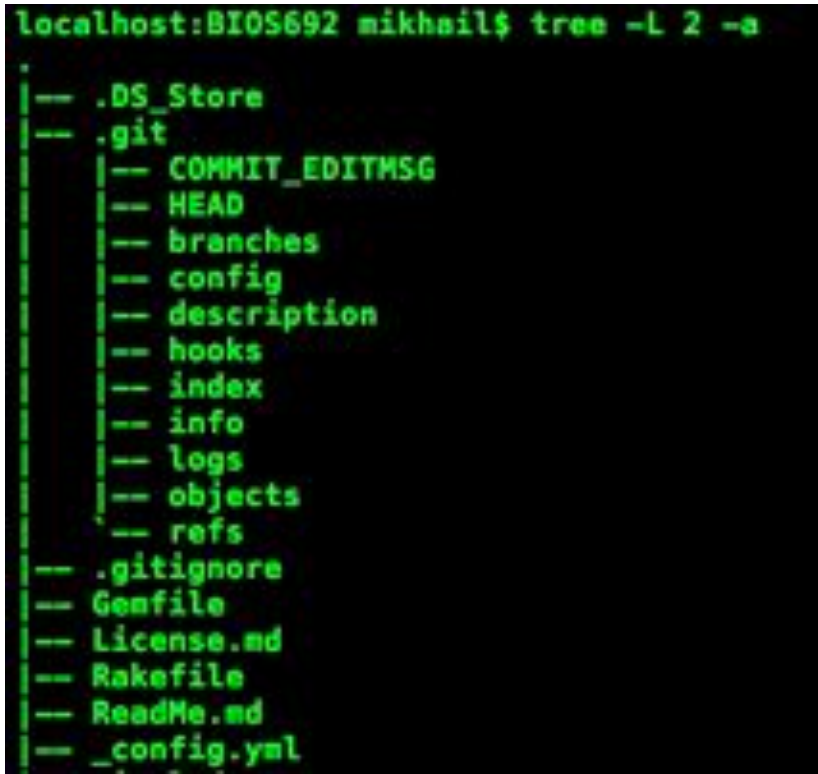
Starting git repository

Exercise:

- Make a folder. Check with **`ls`**
- **`git init –`** initializes a repository. **`.git`** folder contains all Git info - remove it and all will be lost
- **`git status –`** to see the status of your repository.

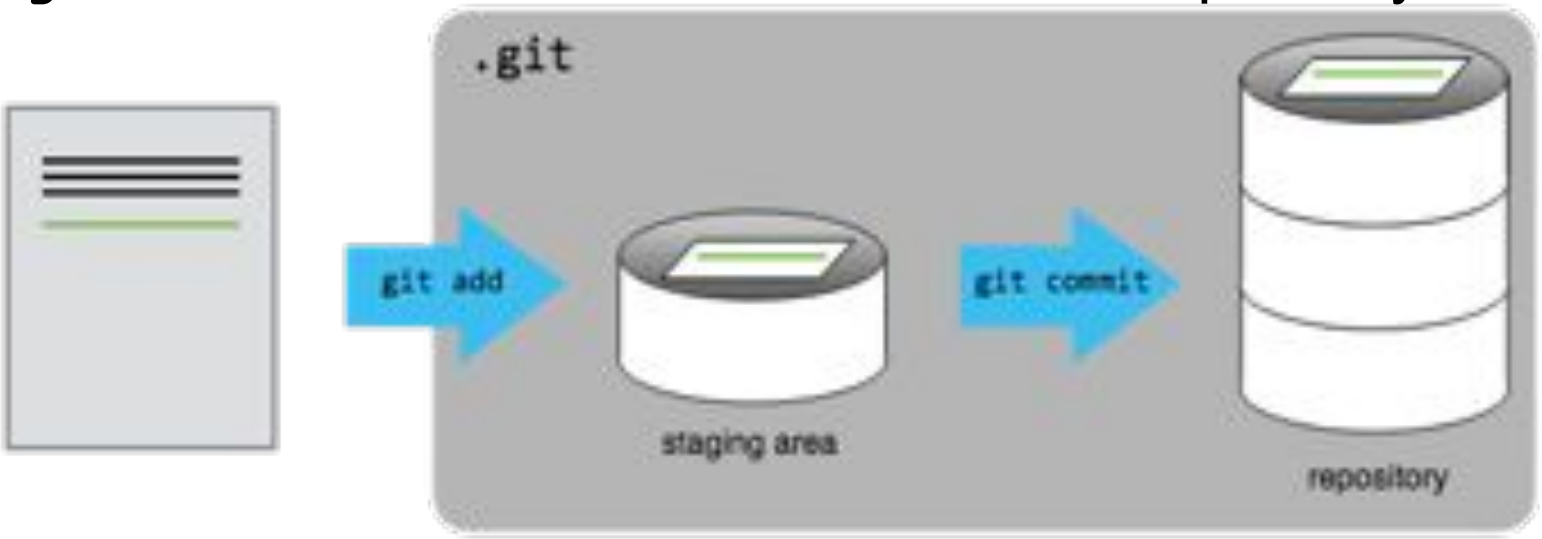
Lifecycle of files in Git repository

- Untracked
- Modified
- Staged
- Committed



Tracking Changes

- **`git add -`** puts files in the staging area
- **`git commit -`** saves the changes in the files on staging area to the local repository. Always write an informative commit message when committing changes, "**`-m`**" flag
- **`git status -`** shows the status of a repository



What to add

New repository from scratch

- The first file to create (and **`add`** and **`commit`**) is probably a **`README.md`** file, either as plain text or with Markdown, describing the project

A new repo from an existing project

Say you've got an existing project that you want to start tracking with git. Go into the directory containing the project

- Type **`git init –`** itinializes empty repository
- Type **`git add <file> [<file> <file>`** …**`] –`** start tracking all the relevant files
- Type **`git commit –`** saves the snapshot of your current files

What's not to add

`git add .`, `git add -u` – add all the changes (updates) in your files

- Don't include files that are derived from other files in the repository
- Be careful about committing binary files, or really big files. Git works best with text files, like code, you can see differences. With binary files, you just get a bloated repository. If you've committed a big file to your repository, it's there forever.
- Exercise: commit an image, overwrite it with another, **`git diff`**
- **`git rm <file>`** – removes a file from the current and future commits, but it remains in history/repository
- The **`.gitignore`** file tells Git what files to ignore. **`git add -f`** forces adding

Ignoring unnecessary files

- The various files in your project directory that you may not want to track will show up as such in **`git status`**
- Unnecessary files should be indicated in a **`.gitignore`** file
- Each subdirectory can have its own **`.gitignore`** file

Also, you can have a global gitignore, such in your home directory, e.g. **`~/.gitignore_global`**, which contains:

```
*~
.*~
.DS_Store
.Rhistory
.Rdata
.Rproj
```

You have to tell git about the global **`.gitignore_global`** file:

```
git config --global core.excludesfile ~/.gitignore_global
```

When to commit

- In the same way that it is wise to often save a document that you are working on, so too is it wise to save numerous revisions of your code
- More frequent commits increase the granularity of your “undo” button
- Good commits are atomic: they are the smallest change that remain meaningful

- One commit = one idea or one change
- Think of ONE feature/task/function that needs to be fixed/added
- Do the work
- Test that it is okay
- Add and commit

http://blog.no-panic.at/2014/10/20/funny-initial-git-commit-messages/
http://www.slideshare.net/rubentan/how-we-git-commit-policy-and-code-review

git commit best practices

ADVICE: Good commit messages

- A good commit message usually contains a one-line description of the changes since the last commit and indicating their purpose

- Informative commit messages will serve you well someday, so make a habit of never committing changes without at least a one-sentence description

BAD:
```
git commit -m 'add user.rb'
```

GOOD:
```
git commit -m 'create user model to
  store user session information'
```

http://docs.gitlab.com/ee/workflow/gitlab_flow.html
https://xkcd.com/1296/

Anatomy of git commits

- Each commit is identified by a unique “name” - SHA-1 hashtag
- SHA-1 is an algorithm that takes some data and generates a unique string from it
- SHA-1 hashes are 40 characters long
- Different data will always produce different hashes
- The same data will produce exactly the same hash

Exploring History

`git log -` lists all commits made to a repository in reverse chronological order.

Useful flags

- **`-p -`** shows changes between commits
- **`-3 -`** last 3 commits, any number works
- **`--stat -`** shows comparative number of insertions/deletions between commits
- **`--oneline -`** just SHA-1 and commit messages
- **`--graph -`** prettier output
- **`--pretty=short/full/fuller/oneline`**
- **`--since=X.minutes/hours/days/weeks/months/years or YY-MM-DD-HH:MM`**
- **`--until=X.minutes/hours/days/weeks/months/years or YY-MM-DD-HH:MM`**
- **`--author=<pattern>`**

Exploring changes

Exactly what changes have you made?

`git diff –` shows all changes that have been made from a previous commit, in all files

`git diff R/modified.R -` see your changes of a particular file

To see the differences between commits, use hashtags: **`git diff 0da42ba  5m5lpac`**

The differences between commits for a specific file can be checked using **`git diff HEAD~2 HEAD -- <file>`**

Undoing things: Unstaging

There are a number of ways that you may accidentally stage a file that you don't want to commit

```
git add password.txt
```

Check with status to see that it is added but not committed

You can now unstage that file with:

```
git reset password.txt
```

Check with status

Undoing things: discarding changes

Perhaps you have made a number of changes that you realize are not going anywhere. Add what you ate for breakfast to **`README.md`**. Check with status to see that the file is changed and ready to be added

You can now return to previous committed version with:

```
git checkout -- README.md
```

Check with status and take a look at the file

You can return to a version of the file in a specific commit

```
git checkout m5ks318 README.md
```

If you want to correct the last commit message, do

```
git commit --amend -m "New commit message"
```

Undoing things: removing from repo

Sometimes you may want to remove a file from the repository after it has been committed. Create a file called **`READYOU.md`**, and add/commit it to the repository

You can now remove the file from the repository with:

`git rm READYOU.md`

List the directory to see that you have no file named **`READYOU.md`**. Use **`git status`** to determine if you need any additional steps

What if you delete a file in the shell without **git rm**?

`rm README.md`

What does **`git status`** say?

Oops! How can you recover this important file?

`git checkout -- README.md`

Undoing things: the big “undo” button

It is possible that after many commits, you decide that you really want to "rollback" a set of commits and start over. It is easy to revert all your code to a previous version

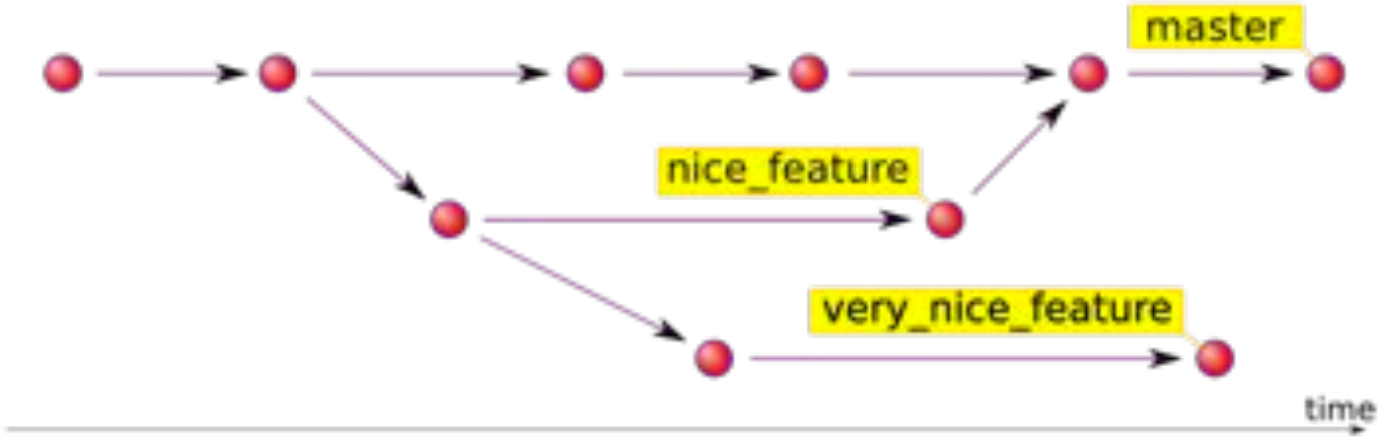
You can use **`git log`** and **`git diff`** to explore your history and determine which version you are interested in. Choose a version and note the hash for that version

```
git revert b5l9sa4
```

Importantly, this will not erase the intervening commits. This will create a new commit that is changed from the previous commit by a change that will recreate the desired version. This retains a complete provenance of your software, and be compared to the prohibition in removing pages from a lab notebook

Branches

- Branches are parallel instances of a repository that can be edited and version controlled in parallel, without disturbing the master branch
- They are useful for developing a feature, work on a bug, try out an idea
- If it works out, you can merge it back into the master
- if it doesn’t, you can trash it



https://hades.github.io/2010/01/git-your-friend-not-foe-vol-2-branches/

A typical branch workflow

`git branch –` list current branch(es). An asterisk (*) indicates which branch you're currently in.

`git branch test_feature -` create a branch called test_feature:

`git checkout test_feature –` switch to the test_feature branch

Make various modifications, and then add and commit.

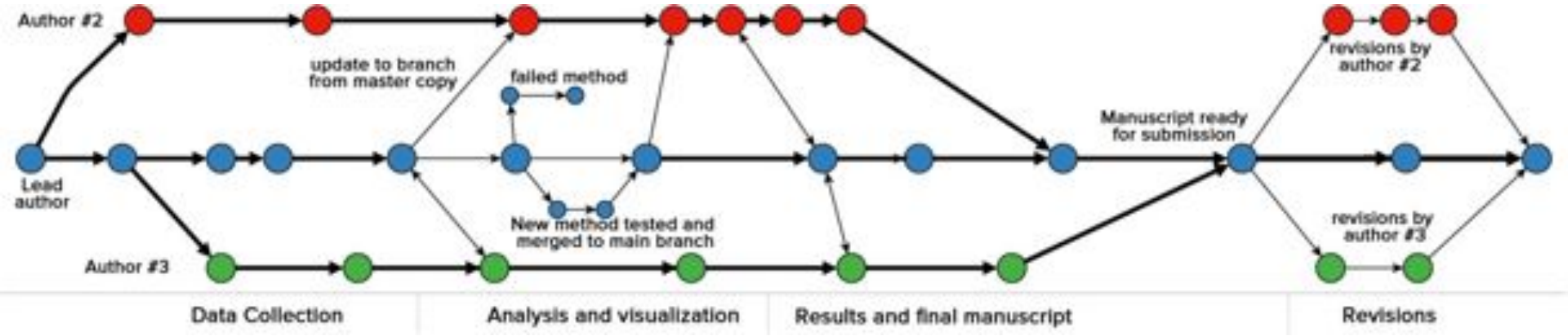
`git checkout master -` go back to the master branch

`git merge test_feature –` combine changes made in the test_feature branch with the master branch

`git branch –d test_feature –` deletes the test_feature branch

Branches for collaboration

- Multiple authors can work on parallel branches, even on the same document
- Conflicts must be resolved manually (using human intelligence)



Ram, Karthik. “Git Can Facilitate Greater Reproducibility and Increased Transparency in Science.” Source Code for Biology and Medicine 8, no. 1 (2013): 7. doi:10.1186/1751-0473-8-7.

Resolving conflicts

Conflicts may occur when two or more people change the same content in a file at the same time

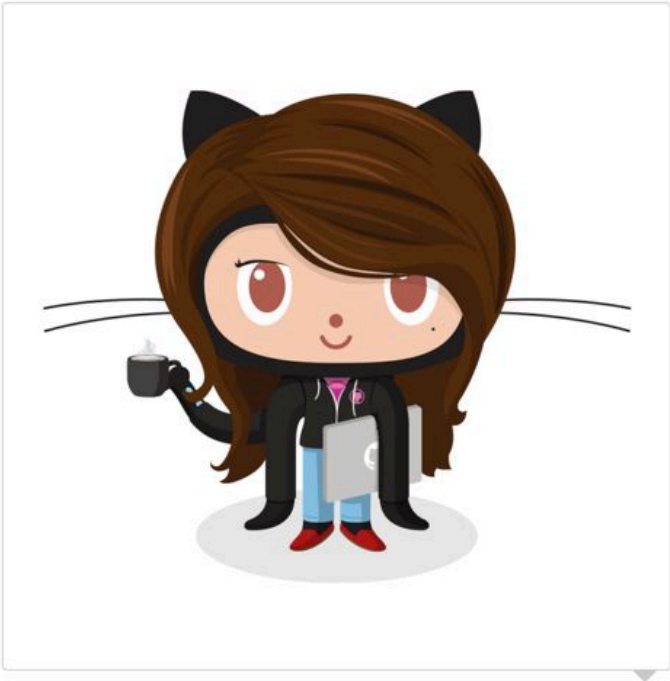
```
Auto-merging README.md
CONFLICT (content): Merge conflict in README.md
Automatic merge failed; fix conflicts and then commit the
result
```

The version control system does not allow people to blindly overwrite each other's changes. Instead, it highlights conflicts so that they can be resolved. If you try to push while there are some changes, your push will be rejected, need to pull first. Pull, conflicts, resolve manually.

```
<<<<<<< HEAD
Your current changes
=======
Conflicting changes need to be resolved
>>>>>>> dabb4c8c450e8475aee9b14b4383acc99f42af1d
```

GitHub

#71 the **Codercat** by



#103 the **Femalecodertocat** by

https://octodex.github.com/

Collaboration the right way

- **GitHub** is a hosting service where many people store their open (and closed) source code repositories. It provides tools for browsing, collaborating on and documenting code.
- Like facebook for programmers
- Free 2-year ”micro” account for students - https://education.github.com/ - free private repositories. Alternatively - Bitbucket, GitLab, gitolite
- Exercise: Create a GitHub account, https://github.com/

Why use GitHub

True open source

Graphical user interface for git

- Exploring code and its history
- Tracking issues

Facilitates

- Learning from others
- Seeing what people are up to
- Contributing to others' code

Lowers the barrier to collaboration

- ”There's a typo in your documentation.” vs.”Here's a correction for your documentation.”

Remotes in GitHub

A local Git repository can be connected to one or more remote repositorie

`git remote add origin https://github.com/username/reponame`

Check your work **`git remote -v`**

Use the **`https://`** protocol (not **`git@github.com`**) to connect to remote repositories until you have learned how to set up SSH

`git push origin master -` copies changes from a local repository to a remote repository

`git pull origin master -` copies changes from a remote repository to a local repository

Asynchronous Collaborating

- Fork someone's repository on GitHub – this is now YOUR copy
- **`git clone`** it on your computer
- Make changes, **`git add, git commit`**
- **`git push`** changes to your copy
- Create New pull request on GitHub

Keeping in sync with the owner's repo

Add a connection to the original owner's repository

```
git remote add upstream https://github.com/
username/reponame # upstream - alias to other repo
```

`git remote –v -` check what you have

`git pull upstream master –` pull changes from the owner's repo

Make changes, **`git add, git commit`**

`git push` – push your changes to GitHub.

Question: Where will they go? Can you do **`git push upstream master`**?

Create pull request

Go to your version of the repository on GitHub

Click the **New pull request** button at the top

Note that the owner's repository will be on the left and your repository will be on the right

Click the **Create new pull request** button. Give a succinct and informative title, in the comment field give a short explanation of the changes and click the green button "Create pull request" again

What others see/do with pull requests

The owner goes to his version of the repository. Clicks on **Pull requests** at the top. A list of pull requests made to his repo comes up

Click on the particular request. The owner can see other's comments on the pull request, and can click to see the exact changes

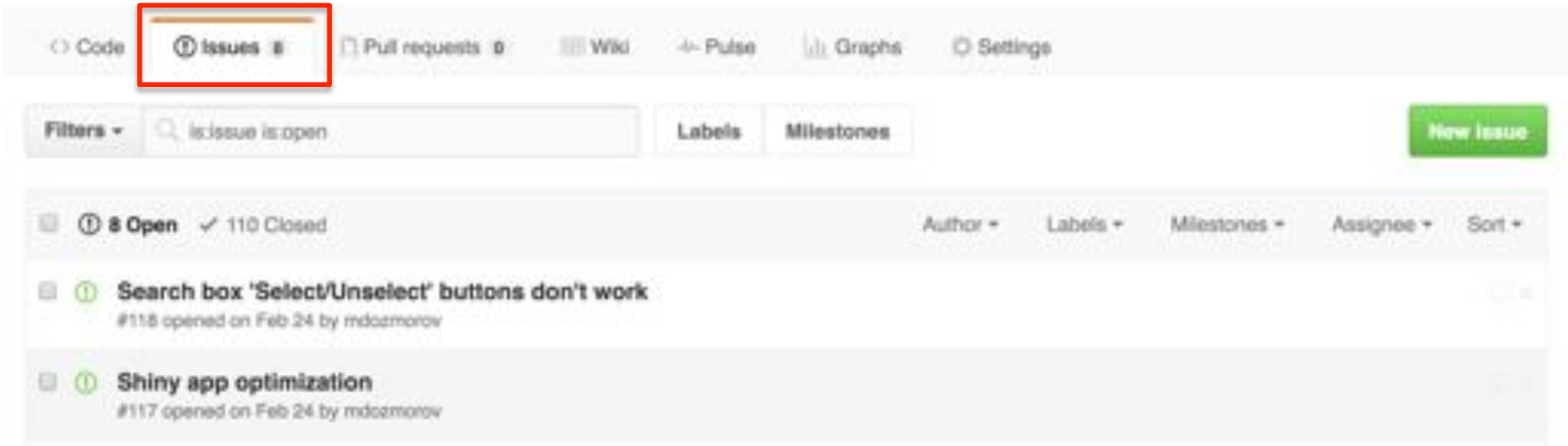
If the owner wants someone to make further changes before merging, he add a comment

If the owner hates the idea, he just click the "Close" button

If the owner loves the idea, he clicks the "Merge pull request"

Track and resolve issues

- Issues keep track of tasks, enhancements, and bugs for your projects
- They can be shared and discussed with the rest of your team
- Written in Markdown, can refer to @collaborator, #other_issue



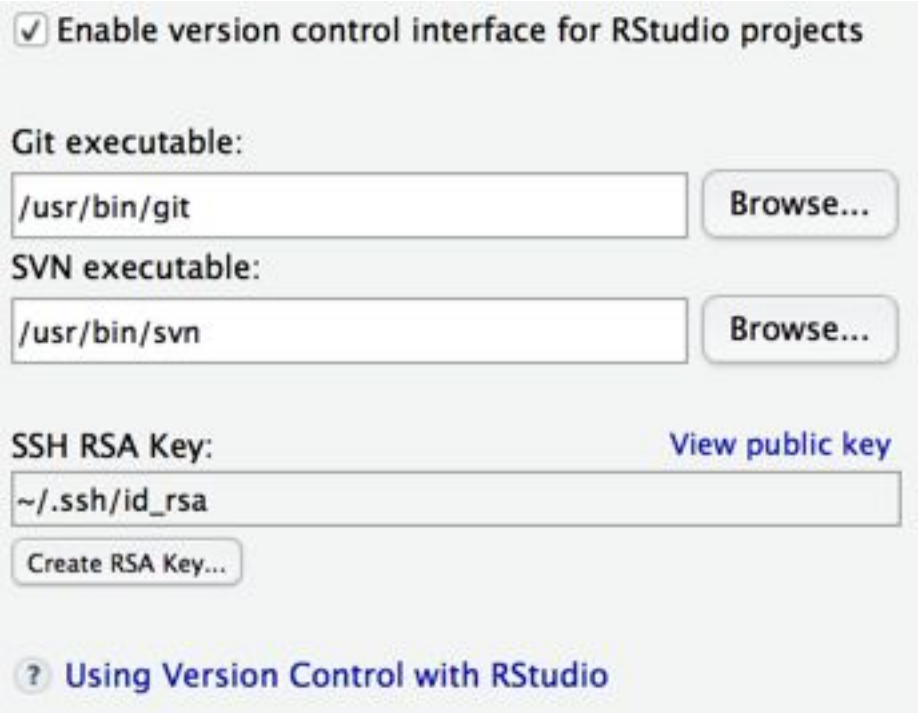
- Can use commit messages to fix issues, e.g., "**`Add missing tab, fix #100`**". Use any keyword, "**`Fixes`**", "**`Fixed`**", "**`Fix`**", "**`Closes`**", "**`Closed`**", or "**`Close`**"

Rstudio and GitHub

RStudio has built-in facilities for git and GitHub. Set up git in *Tools/ Global Options*

Your Rstudio project can be your git repository

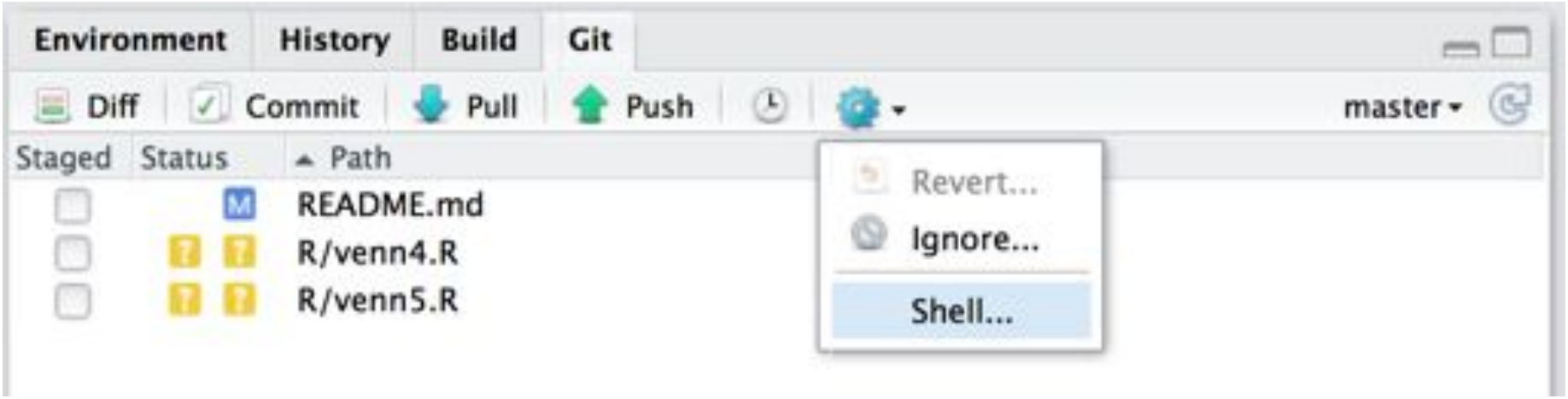
- Create a project with checkbox "Create a git repository" checked
- Add existing project to version control by selecting git in *Tools/ Version control/Project setup*



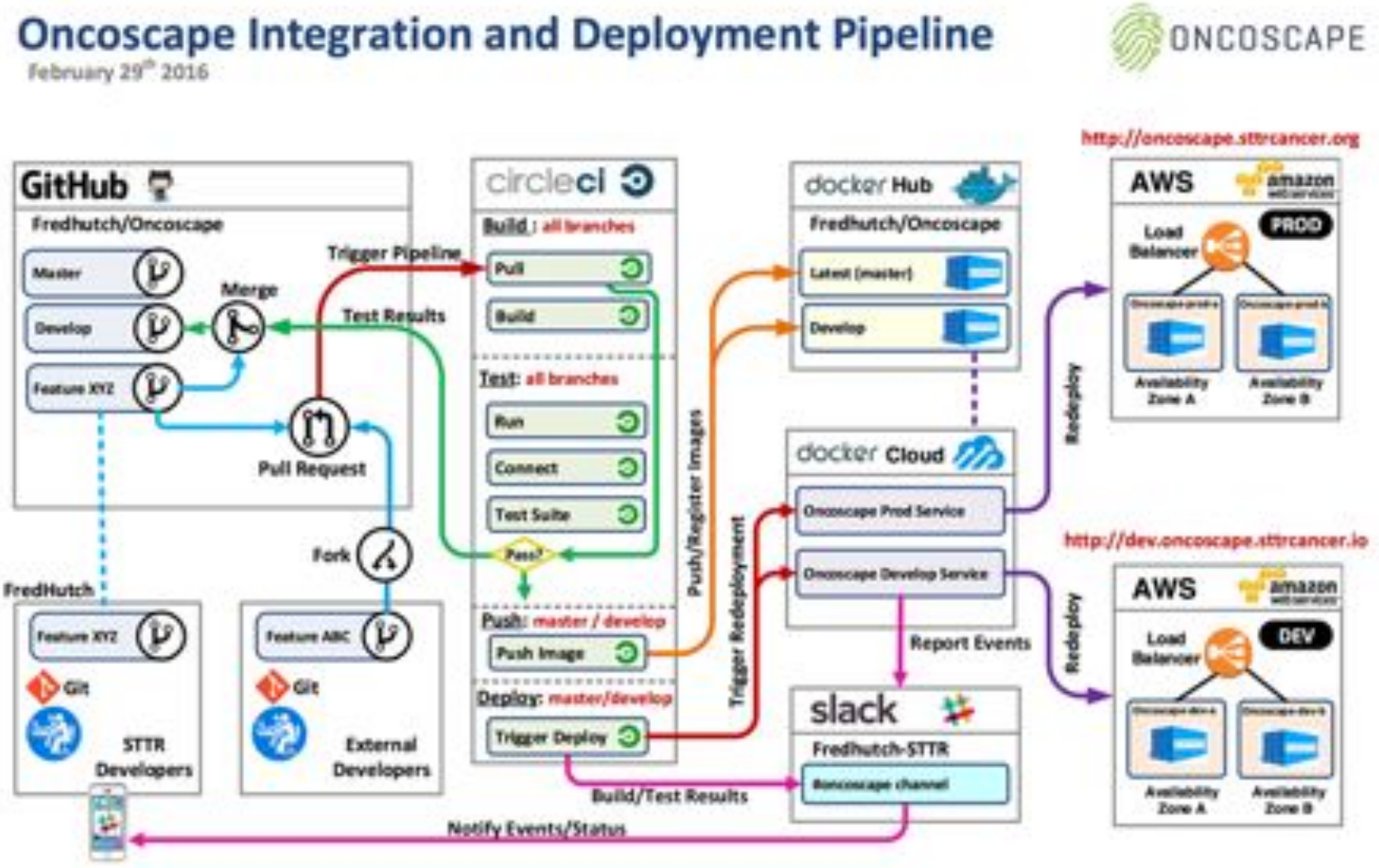
Rstudio and GitHub

Basic commands are available

- See which files are untracked, modified, stage
- What branch you are in
- Add files, commit, push/pull
- See differences, history
- Revert changes, ignore files
- For heavy lifting git, use shell



Big data analysis the right way



https://aws.amazon.com/blogs/aws/building-bridges-for-better-cancer-treatment-with-the-fred-hutchinson-cancer-research-center/

SEAMLESS INTERACTION WITH GITHUB

password-less login to any SSH connection

Encryption concepts

Public and private keys

- Both public and private keys are generated by one individual – they are yours
- A public key is a “lock” that can be opened with the corresponding private key
- Public key can be placed on any other computer you want to connect to
- Private key stays private on any machine you’ll be connecting from
- Only your private key can “open” your public key

Private Key

Public Key

https://wogan.me/tag/public-key-encryption/

Getting public and private keys

Generate your public and private keys

- First, check if you already have them, **`ls -al ~/.ssh`**
- If not, generate

`ssh-keygen -t rsa -b 4096 -C your_email@example.com`

Private Key

Public Key

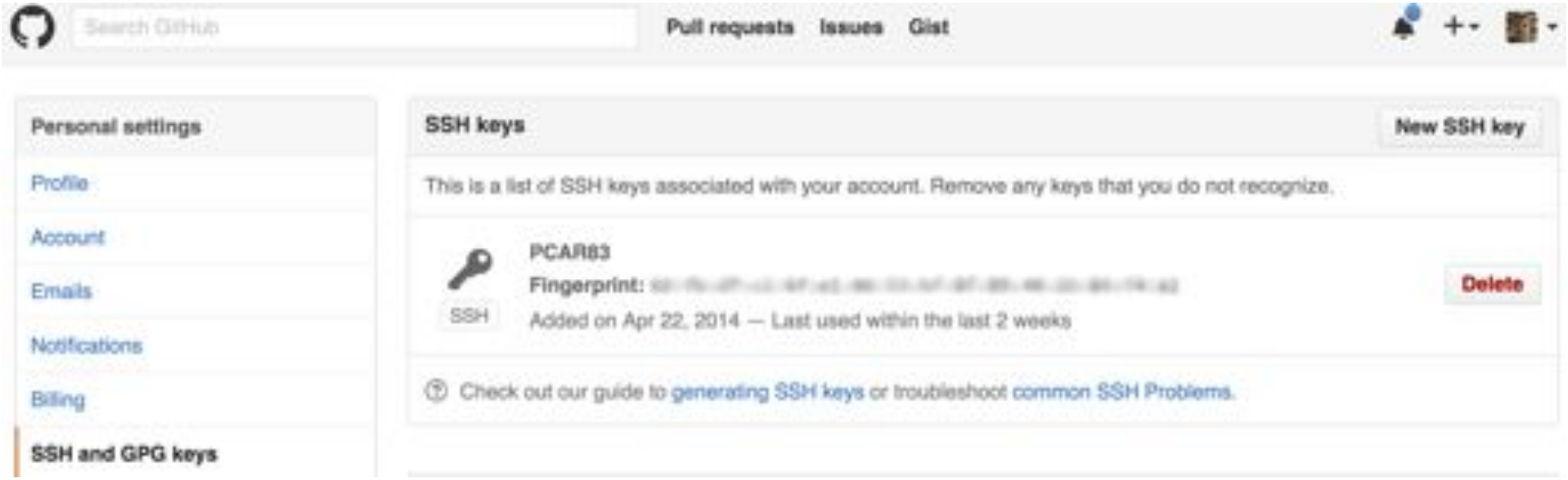
`~/.ssh/id_rsa` **`~/.ssh/id_rsa.pub`**

`~/.ssh/authorized_keys`

Add public key to GitHub

Add your public key to your GitHub account

- Go to your GitHub Account Settings
- Click “SSH and GPG keys” on the left.
- Click “New SSH Key” on the right.
- Add a label (like “My laptop”) and paste your public key into the text box.
- Test it, **`ssh -T git@github.com`**. You should see something like “Hi username! You've successfully authenticated but Github does not provide shell access.”



https://help.github.com/articles/generating-an-ssh-key/
https://www.cs.utah.edu/~bigler/code/sshkeys.html

Add public key to any machine

- Copy your public key **`~/.ssh/id_dsa.pub`** to a remote machine

- Add the content of your public key to **`~/.ssh/authorized_keys`** on the remote machine

- Make sure the **`.ssh/authorized_keys`** has the right permissions (read+write for user, nothing for group and all)

```
cat ~/.ssh/id_dsa.pub | ssh user@remote.machine.com
'mkdir -p .ssh; cat >> .ssh/authorized_keys; chmod 600
authorized_keys'
```

Password-less login

Your private key should be visible to your terminal session

- Start SSH agent
- Add auto-start function in your **~/.bashrc**

```
# Start ssh-agent
 SSH_ENV=$HOME/.ssh/environment
 function start_agent {
    echo "Initializing new SSH agent..."
    # spawn ssh-agent
    /usr/bin/ssh-agent | sed 's/^echo/#echo/' > "${SSH_ENV}"
    echo succeeded
    chmod 600 "${SSH_ENV}"
    . "${SSH_ENV}" > /dev/null
    /usr/bin/ssh-add
 }

 if [ -f "${SSH_ENV}" ]; then
    . "${SSH_ENV}" > /dev/null
    ps -ef | grep ${SSH_AGENT_PID} | grep ssh-agent$ > /dev/null || {
        start_agent;
    }
 else
    start_agent;
 fi
```

http://mah.everybody.org/docs/ssh
https://gist.github.com/rezlam/850855

Copy files over ssh

- **`scp <file> user@remote.host.com:~/work/`**

- **`rsync -arvh -progress <file> user@remote.host.com:~/work/`**