git

An Introduction

What is it?
Why should you use it?
How does it work?

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

25.04.19

CRC-TR 211
Strong-interaction matter under extreme conditions

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What is it?

*"Git is a free and open source **distributed version control system**, which is fast and efficient."*

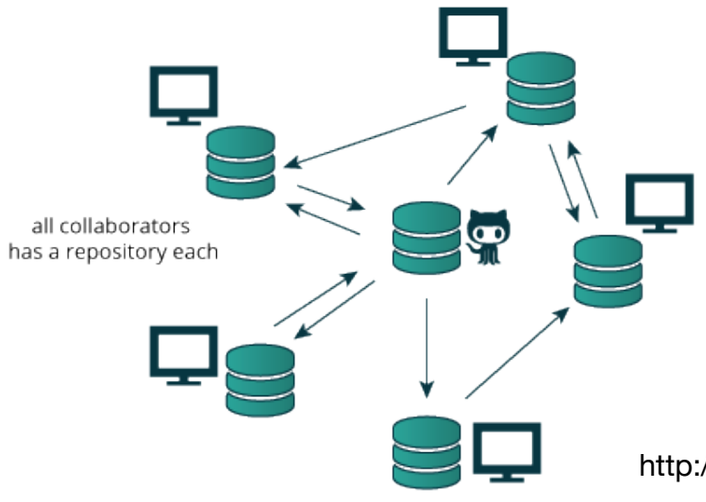
- Git Homepage

- Version control system = tracks versions of files

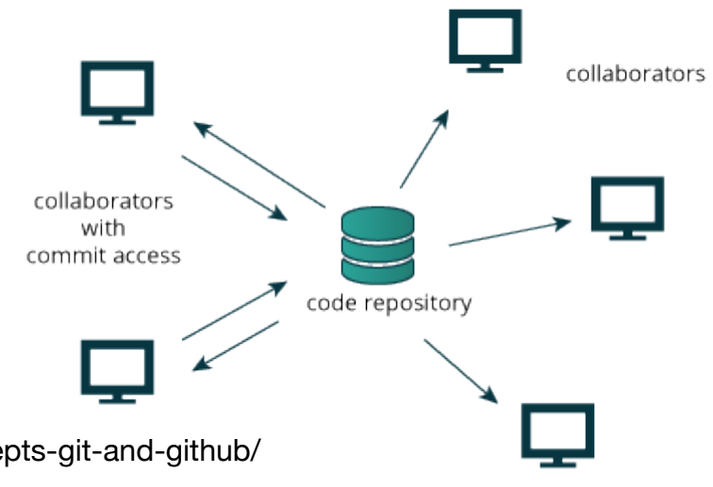
  e.g. source code, LaTeX thesis, paper or talk, website html, etc.
  (Rule of thumb: Everything you edit in text editors)

- Distributed = everyone has a full local copy of the repository

<u>distributed</u>

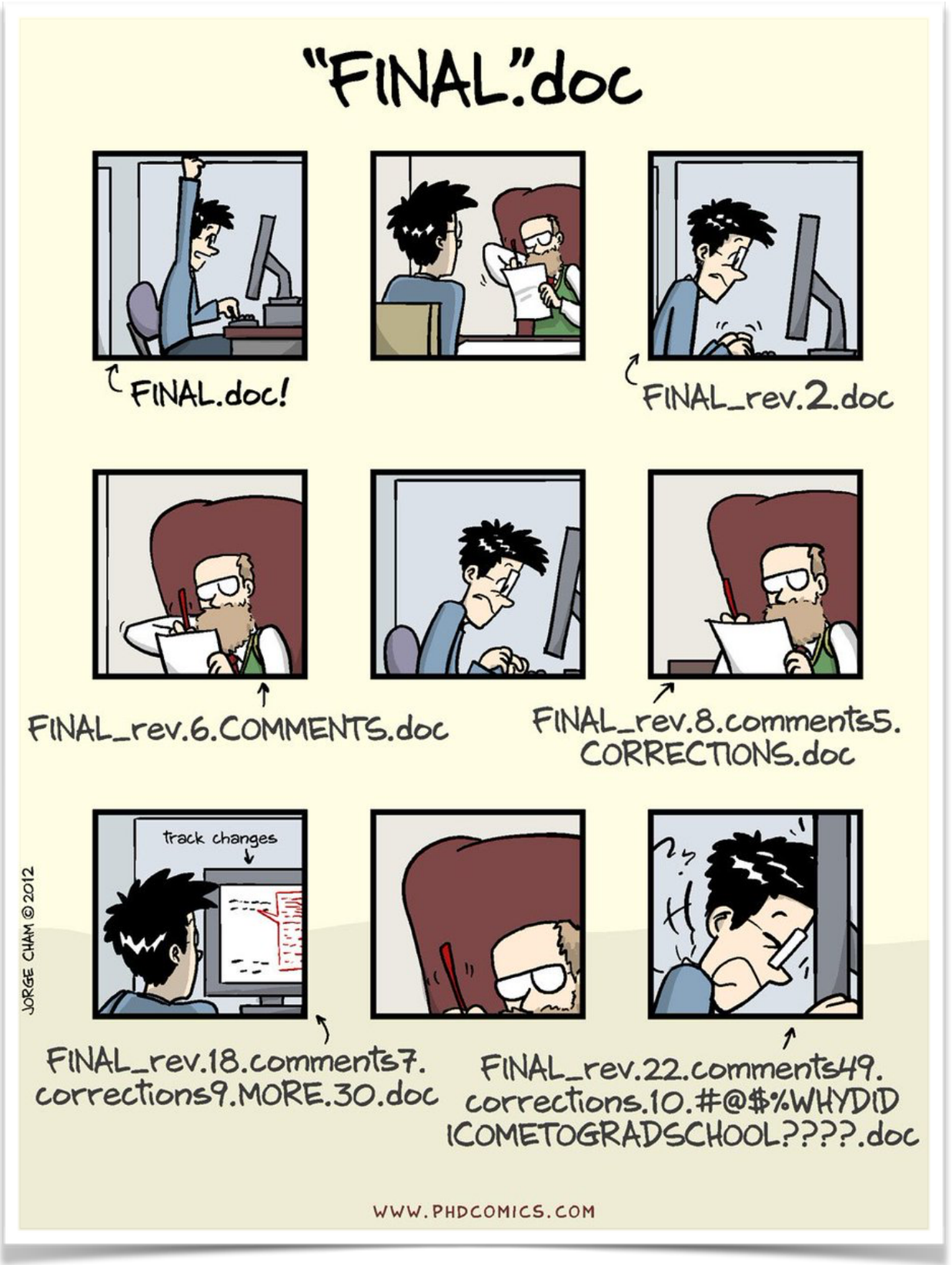


centralized



http://thepilcrow.net/explaining-basic-concepts-git-and-github/

Why should you use it?



Why should you use it?

It helps you!

- Transparent history of all changes
- Moving back and forth in time
- Everything is easily traceable and reversible (e.g. errors)

Good scientific practices:

- Reproducibility and traceability
- Enables collaboration

How does it work?

- Repository = database containing all versions of the files
- Snapshot-based system
  - Snapshots are called ***commits***
  - Commits are named by checksums (also used to ensure data integrity)
- Almost every operation is local
  - Working without network connecting
  - Distributed system (everyone carries a backup)

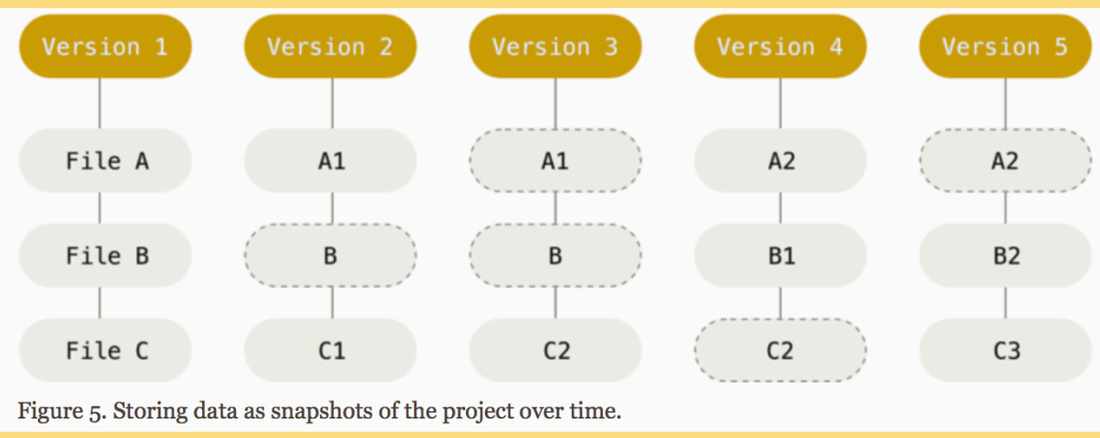
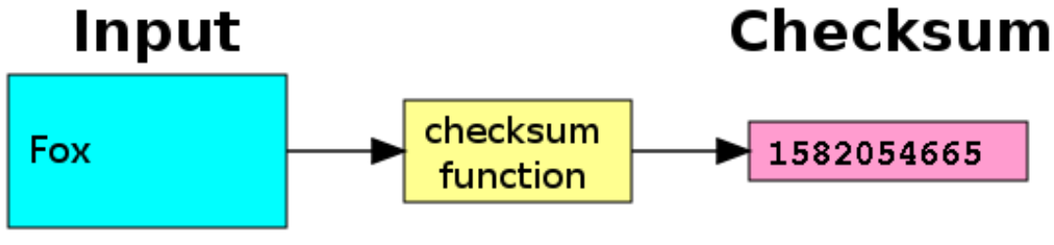


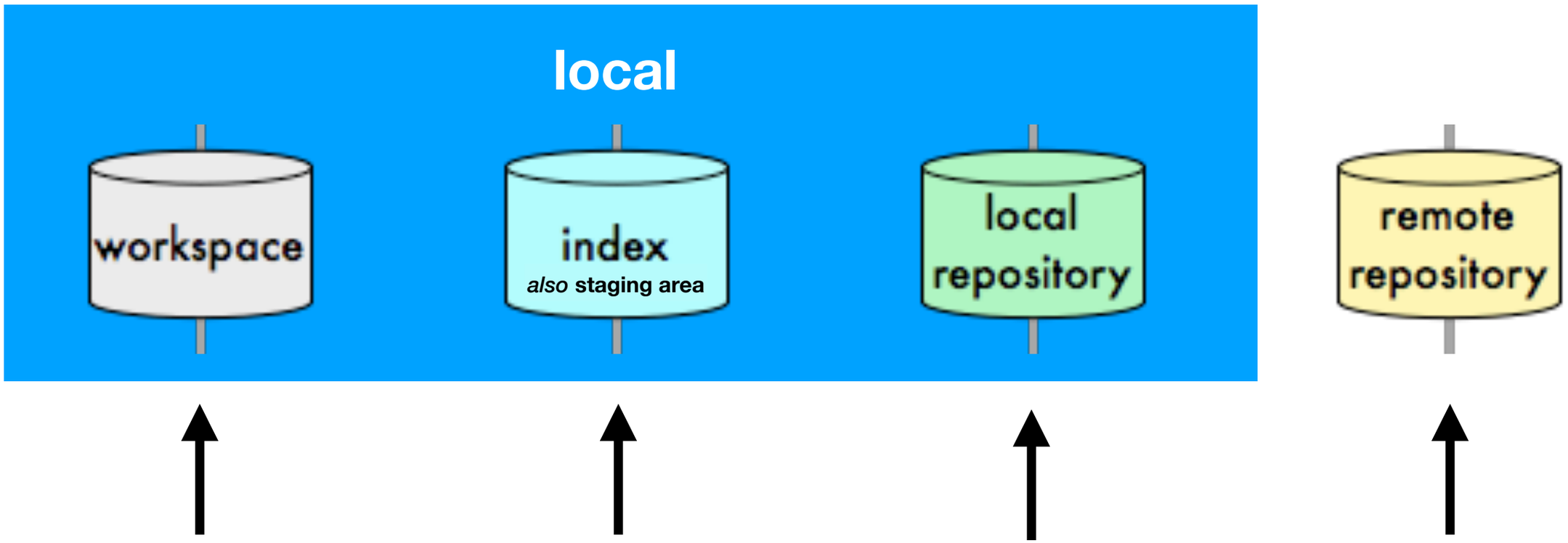
Figure 5. Storing data as snapshots of the project over time.

https://git-scm.com/book/en/v2/Getting-Started-Git-Basics



How does it work?

4 distinct places



All of your (to be) edited project files

For now: All changes go here first
(Later: Helps disentangling changes)

Manually synced copies of all committed versions of all project files

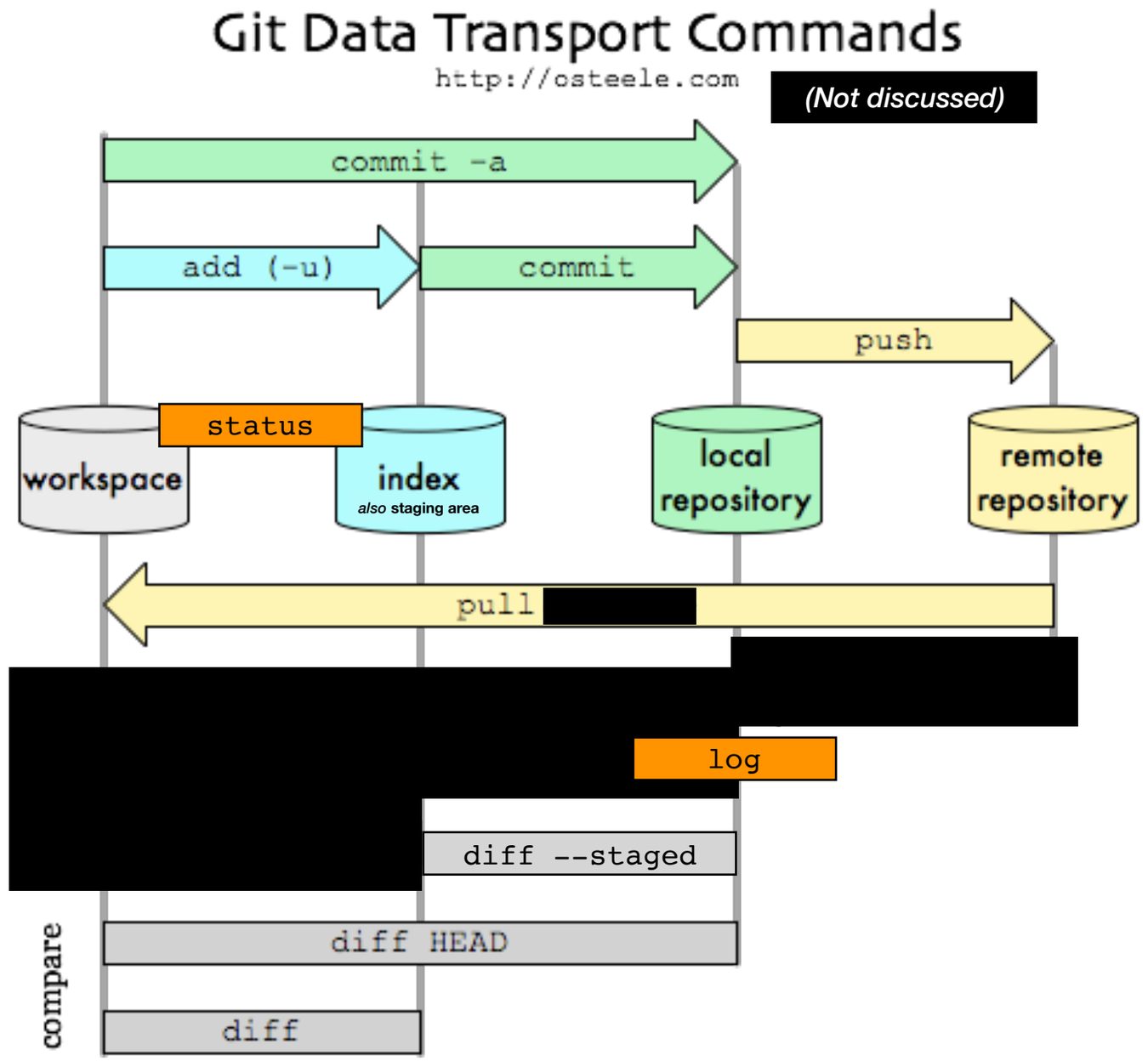
How does it work?

- Overview of most common commands
- Most common use by command line

Don’t Panic

This is an introduction.

It is worth it.



Gist of this Introduction

Command by command

1. The basic workflow: Set up a local repository and save changes to it
   —> Exercise 1

2. Branches: Work on different features in parallel
   —> Exercise 2

3. Basic interactions with a remote repository

Notation

`$` what follows are commands to be entered on the command line e.g. `$ git log`

`<...>` marks names and other variables that change during use e.g. `$ git branch <branch_name>`

Advanced:

Tips for more advanced user will be in green boxes

`$ git help`

Get help for any command

```
$ git help <command>
```

```
$ git <command> --help
```

```
$ man git-<command>
```

Works offline!

Installation: Good changes it is already installed, if not [Link]

Commands

config

init

status

add

commit

diff

log

branch

checkout

merge

clone

push

pull

`$ git config`

Before doing anything else: **Identify yourself**

```
$ git config --global user.name <your_name>
$ git config --global user.email <your_email>
```

Make sure this is consistent across all your machines

Make your life easier:
Set up **tab completion**
[Link]

Advanced:

Aliases

```
$ git config --global alias.st „status“
```

„Did you mean?“

```
$ git config --global help.autocorrect 10
```

`$ git init`

Initalizing a empty (local) Git repository

```
$ git init
Initialized empty Git repository in /path/to/
example_repo/.git/
```

Adds a hidden `.git` directory, where git stores all of its information

Git only uses relative paths (source directory can be moved freely)

$ git status

Display **status information** of working directory and staging area

```
$ git status
On branch master

No commits yet

Untracked files:
  (use "git add <file>..." to include in what will be
committed)

  hello.cpp

nothing added to commit but untracked files present
(use "git add" to track)
```

(Output for a newly initialized repo with one new file `hello.cpp`)

$ git add

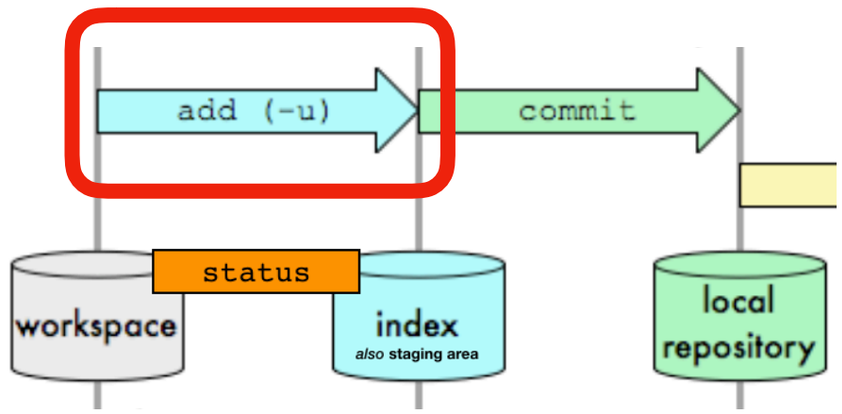
Adding changes to the staging area

```
$ git add <file_name>
```

Adds all changes of a file to the staging area

```
$ git add <directory_name>
```

Adds all changes of all files in the directory to the staging area.



Advanced:

You can also add only specific changes to a file (so called *hunks*) to the staging area.

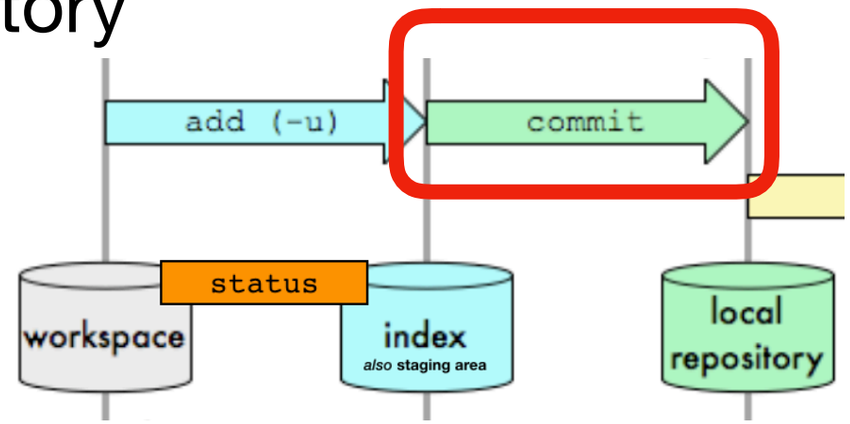
```
$ git add -p <file_name>
```

Ignore certain files with .gitignore [Link]

`$ git commit`

Committing *staged* changes to your repository

```
$ git commit
```



External text editor (most likely `vi`) will open and ask for a commit message

Don’t like `vi`: `$ git config --global core.editor „nano“`

Invest in good commit messages!

- Subject line + body (Follow 50/72 rule [Link])
- Write them like a email to yourself / the other developers
- Document why you made the changes

Good commits are *small and often, conceptually separated, only include source files & at best working code*

`$ git diff`

Display changes to your tracked files

```
$ git diff
```

To be precise: Differences between working directory and staging area ➡ only unstaged changes

Helpful to inspect what you have done

`$ git log`

Display history of your commits

```
$ git log
```

See the last changes that were made

including the commit message (at least per default)

Exercise 1

config

init

status

add

commit

diff

log

branch

checkout

merge

Solutions
can be found at the end of the slides

Exercise 1

1. Configure your git setup by setting your name and mail address. If you done that, check the `.gitconfig` file in your home directory.

2. Create a new directory and initialize an empty git repository in it.

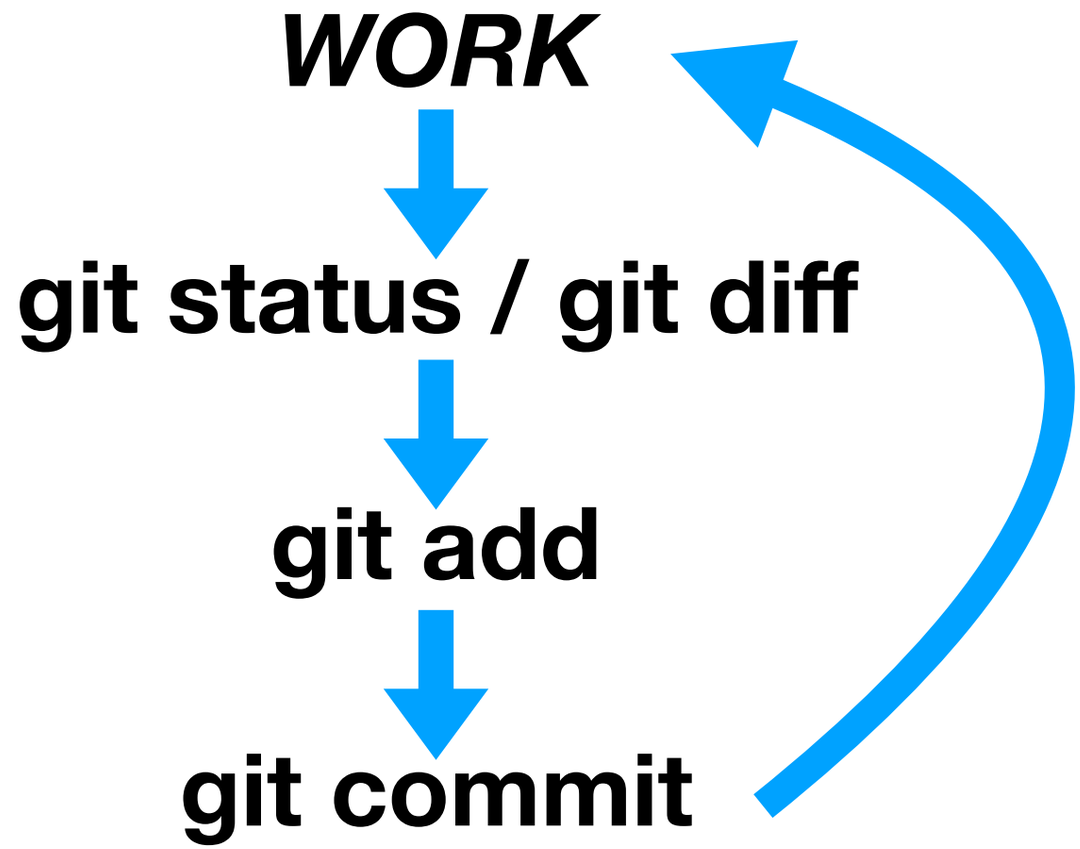
3. Create a simple sample code file in the directory and commit it.

4. Modify the sample code file and commit the changes. Check the changes first.

5. Look at the commit history you created.

***Optional**: If you currently work on a "code" project (remember, this also might e.g. be a LaTeX paper project), repeat step 2 and 3 and make it git repository. Instead of creating a sample file, you just commit your source files. Do not worry, your project files will remain untouched by this. The next time you change your project files, just commit your changes (step 4 and 5). Just continue to repeat step 4 and 5 every time you work on your project and you will have already mastered the main git workflow.*

Basic Workflow



`$ git commit -a`

Directly commit unstaged changes

```
$ git commit -a
```

Shortcut for

```
$ git add -u
$ git commit
```

Advanced:

Stage all changes to tracked files at once

```
$ git add -u
```

What is the purpose of the staging area?

- Allows to only commit part of your changes (*Assemble your commit to your liking*)
- Split changes across commits
- Also other use cases e.g. for reviewing your changes, …

Commands

```
config
 init
status
  add
commit
  diff
  log
```

branch

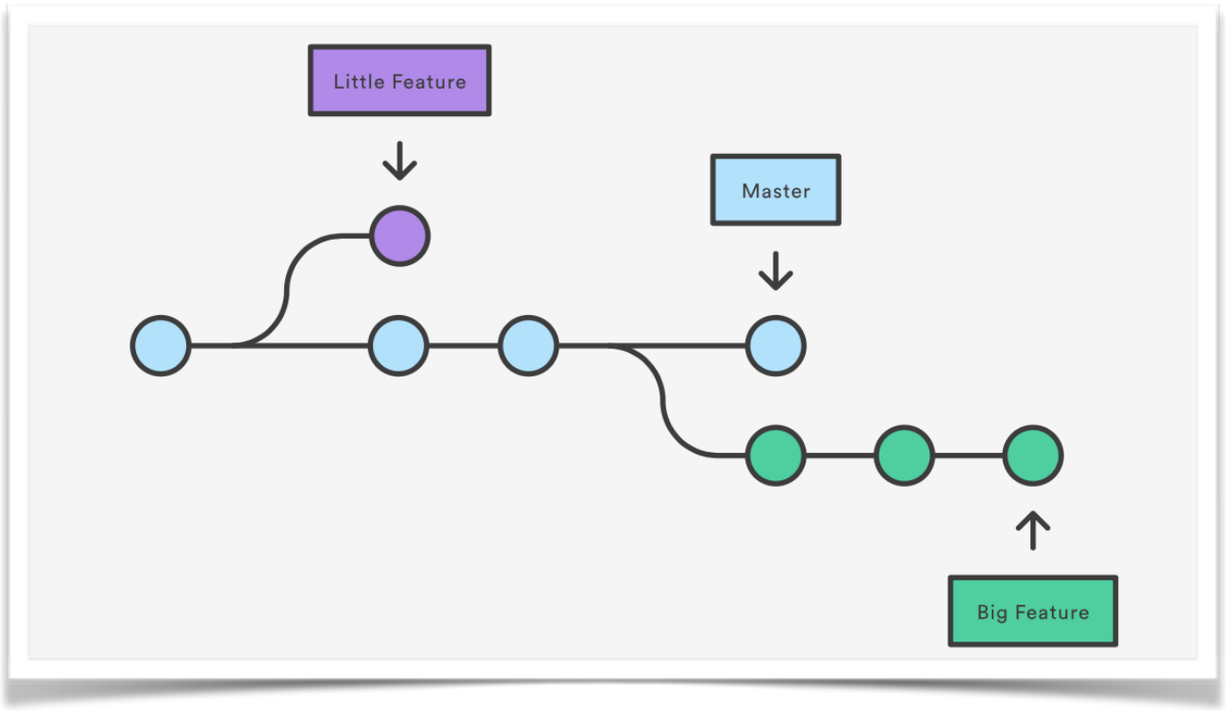
checkout

merge

```
clone
 push
 pull
```

Branches

- Branches store **different versions of your project**
- Parallel development
  - Implement new features
  - Fix bugs
  - Try out something
- Cheap to do in git
  (technically just pointers to a commit)
- Main branch = `master`
  - By default created at initialization
  - Usually development is done on other (feature) branches



https://www.atlassian.com/git/tutorials/using-branches

`$ git branch`

Create new branch

```
$ git branch <branch_name>
```

List all branches of local repository

```
$ git branch
```

Delete branch

```
$ git branch -d <branch_name>
```

Save option to delete a branch, since it prevents data loss

```
$ git branch -D <branch_name>
```

Use CAREFULLY! Be sure you want to lose this progress

`$ git checkout`

for branches

Switch between existing branches

```
$ git checkout <branch_name>
```

Changes your project files

Only works with no uncommitted changes („Clean working tree“)

Shortcut: Create and checkout new branch

```
$ git checkout -b <new_branch_name>
```

The HEAD

HEAD = special pointer to currently checked out branch (commit)

```
$ git checkout master
```

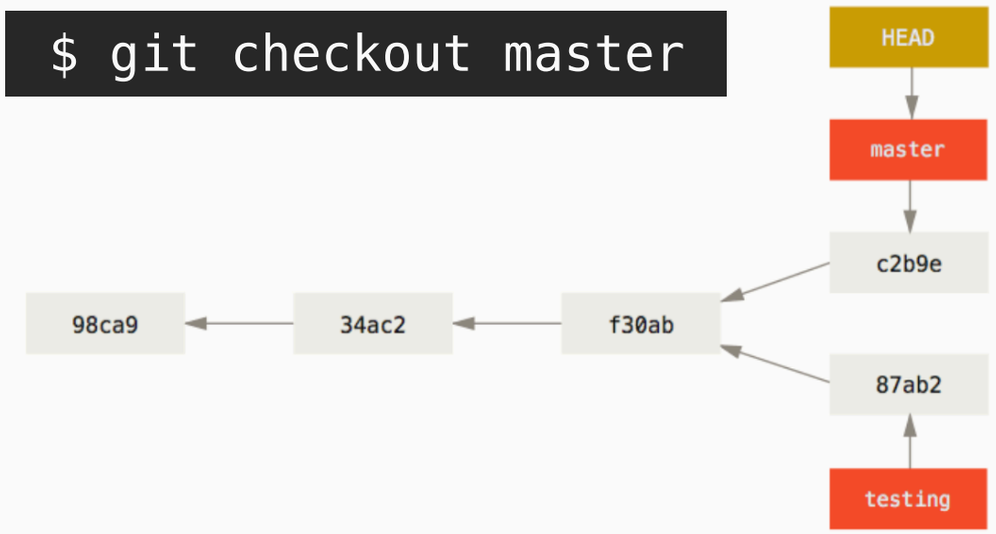


Figure 17. Divergent history

```
$ git checkout testing
```

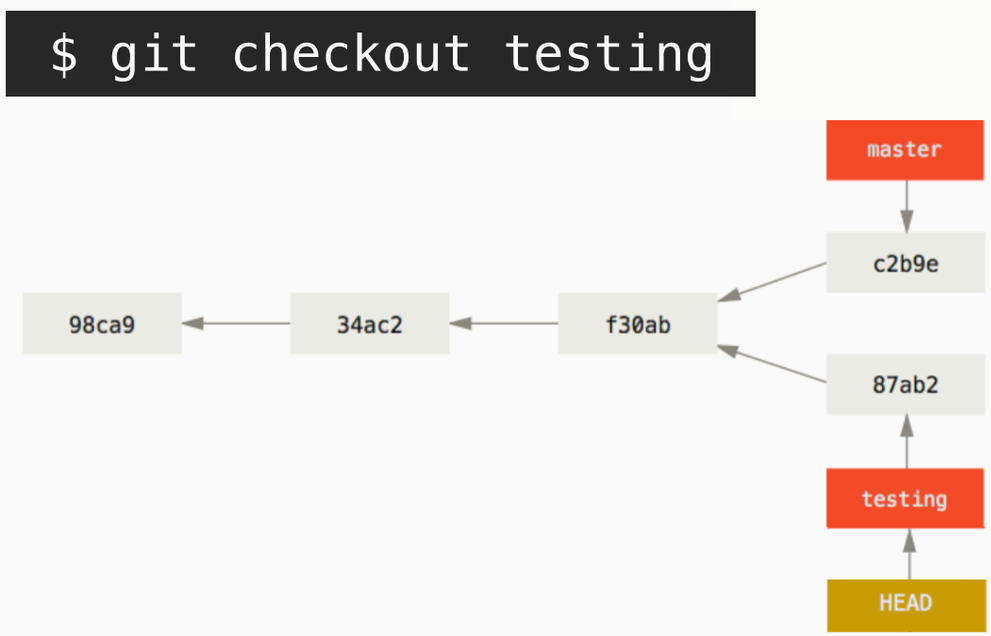


Figure 17. Divergent history

https://git-scm.com/book/en/v2/Git-Branching-Branches-in-a-Nutshell

`$ git diff`

Complete Overview

Display changes to your tracked files

already discussed

`$ git diff`

To be precise: Differences between working directory and staging area ➡ only unstaged changes

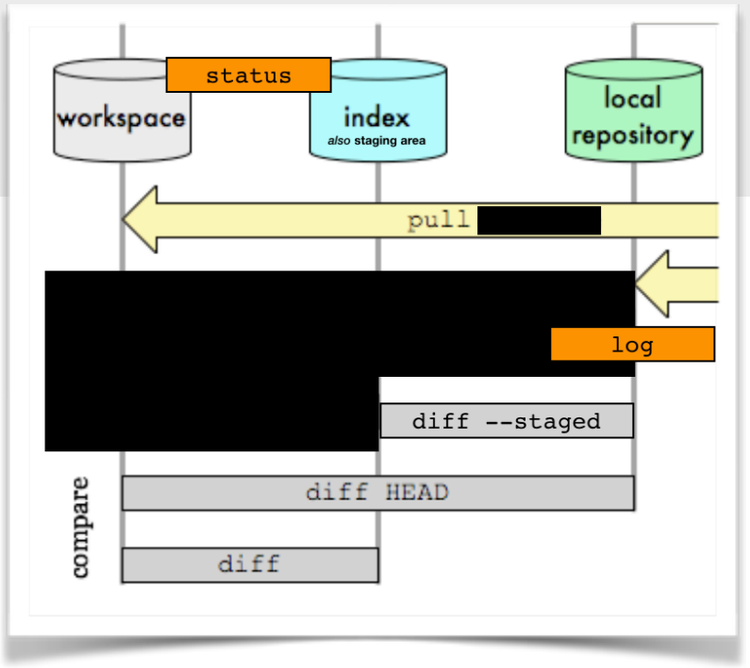
Helpful to inspect what you have done

`$ git diff HEAD`

Differences between working directory and HEAD (last commit)

`$ git diff --staged`

Differences between staging area and HEAD



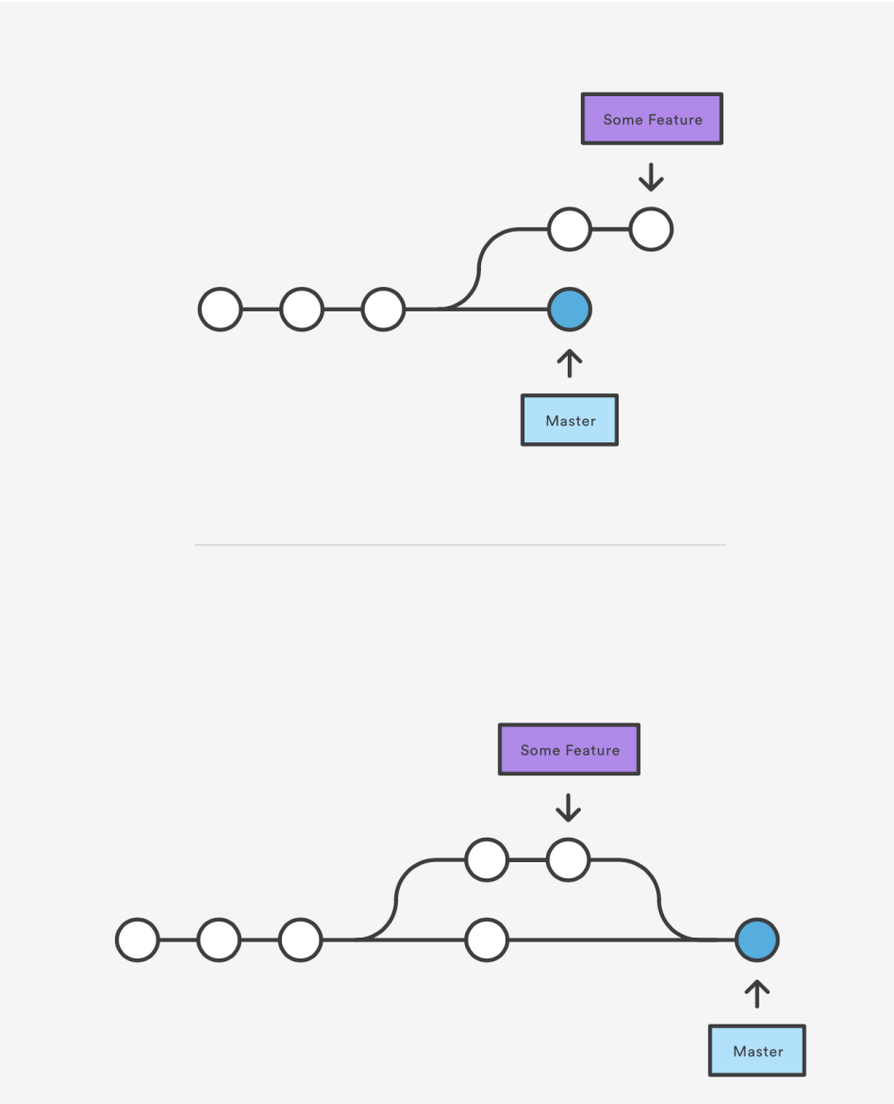
$ git merge

Merge changes in checked out branch

```
$ git merge <feature_branch>
```

Smart automatic three-way merges

Only changes the checked out branch (ensure you are on the correct branch)

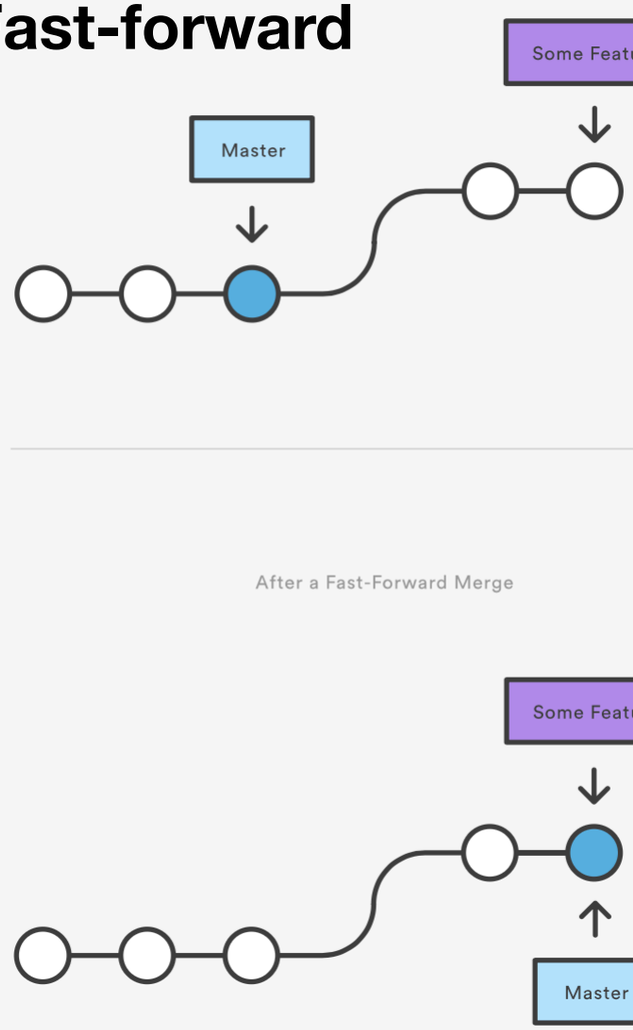


https://www.atlassian.com/git/tutorials/using-branches/git-merge

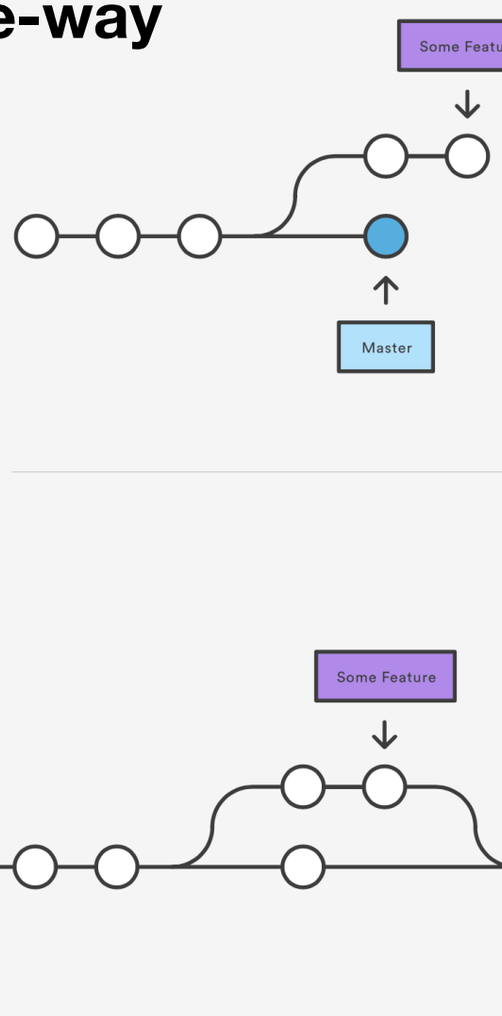
$ git merge

Two different merges:

Fast-forward



Three-way



Only three-way merges have merge commits

and potential merge conflicts

https://www.atlassian.com/git/tutorials/using-branches/git-merge

$ git merge

Merge conflicts

```
$ git merge <branch_name>
Auto-merging <file>
CONFLICT (content): Merge conflict in <file>
Automatic merge failed; fix conflicts and then commit the result.
```

Conflicts if same part of file (*hunk*) is changed in both branches

Resolve

1. Run `git status` to see „unmerged paths“
2. Find problematic hunks: Highlighted in files by <<<<<<<, =======, >>>>>>>

```
…
<<<<<<< HEAD
 std::cout << "Hello!“;
=======
 std::cout << „Goodbye!“;
>>>>>>> say_goodbye_branch
…
```

3. Create the intended code version and remove <<<<<<< ,...

```
…
 std::cout << „Goodbye!“;
…
```

4. Then `git add <file_with_merge_conflict>`
5. `git commit` (Auto-generated merge commit message)

Commands

```
config
init
status
add
commit
diff
log
branch
checkout
merge
clone
push
pull
```

Exercise 2

```
config
init
status
add
commit
diff
log
```

branch

checkout

merge

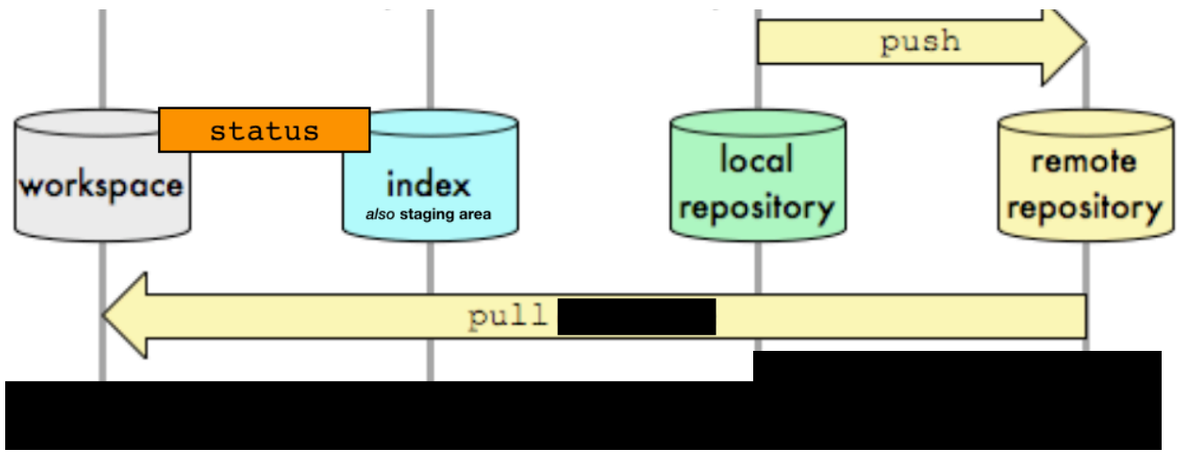
Solutions
can be found at the end of the slides

Exercise 2

1. Create a new branches and check that you created them by looking at the branch list.
2. Delete the new branches right away without risking data loss.
3. Create and directly switch to another new branch (e.g. name it add_readme) using only one command. Check again that you created the branch and that it is checked out.
4. Add a new file on the branch (e.g. a README) and commit the new file.
5. Switch back to master. Verify that the new file is gone. Merge the branch with the new file (Notice that this was a fast-forward merge). Check the history and that the new file is now reappeared. Safely delete the merged branch, which is possible now that the changes are in master.
6. Provoke a merge conflict by creating a new branch (e.g. name it edit_sample_file) and change the sample file from Exercise 1. Commit the changes on the new branch. Edit the same part of the file back on master and also commit the changes. Now, try merging the new branch with the edited sample file.
7. Fix the merge conflict.

Interacting with Remotes

- So far everything were local operations
- Following interactions with a remote repository require network connection
- Remote repositories enable **collaboration** and backup
- Local repository has to be **manually synced** with remote repository



Advanced:

Note: In the following only tracking branches are used to interact with a remote repository to keep it simple.

`$ git clone`

Clone (download) a remote repository

```
$ git clone <link_to_repository>
```

Creates directory with project name in current directory

Remote repository is (by default) referred to as `origin`

You can also clone on the same machine locally

See all remote branches of repository

```
$ git branch -r
```

Branches that are in remote are prefixed by `origin/` then the `<branch_name>`

`$ git pull`

Checkout a branch of the repository (as usual)

```
$ git checkout <branch_name>
```

Do not use the `origin/` prefix here

Update a branch with the new version from the remote repository

```
$ git pull
```

… while the branch is checked out

Changes your working directory

Make sure you pull before committing and merging to stay in sync! (especially on master, maybe someone else updated it)

`$ git push`

Create a new branch in the remote repository

```
$ git push -u origin <branch_name>
```

from the currently checked out branch

Update the remote branch from the local branch afterwards

```
$ git push
```

Only changes that are committed are pushed

If the remote and local history diverge (e.g. forgot to pull before committing) pushes will be rejected

Make sure you push after committing and merging to stay in sync!

The Rest

Other useful commands worth looking up yourself

```
$ git stash
```

Quickly stash away your changes for later to obtain clean working tree

```
$ git revert
$ git reset
```

Undoing changes and commits
—> good tutorial under this [Link]

```
$ git blame
  <file>
```

See line for line, who and which commit is responsible for the last change to this line

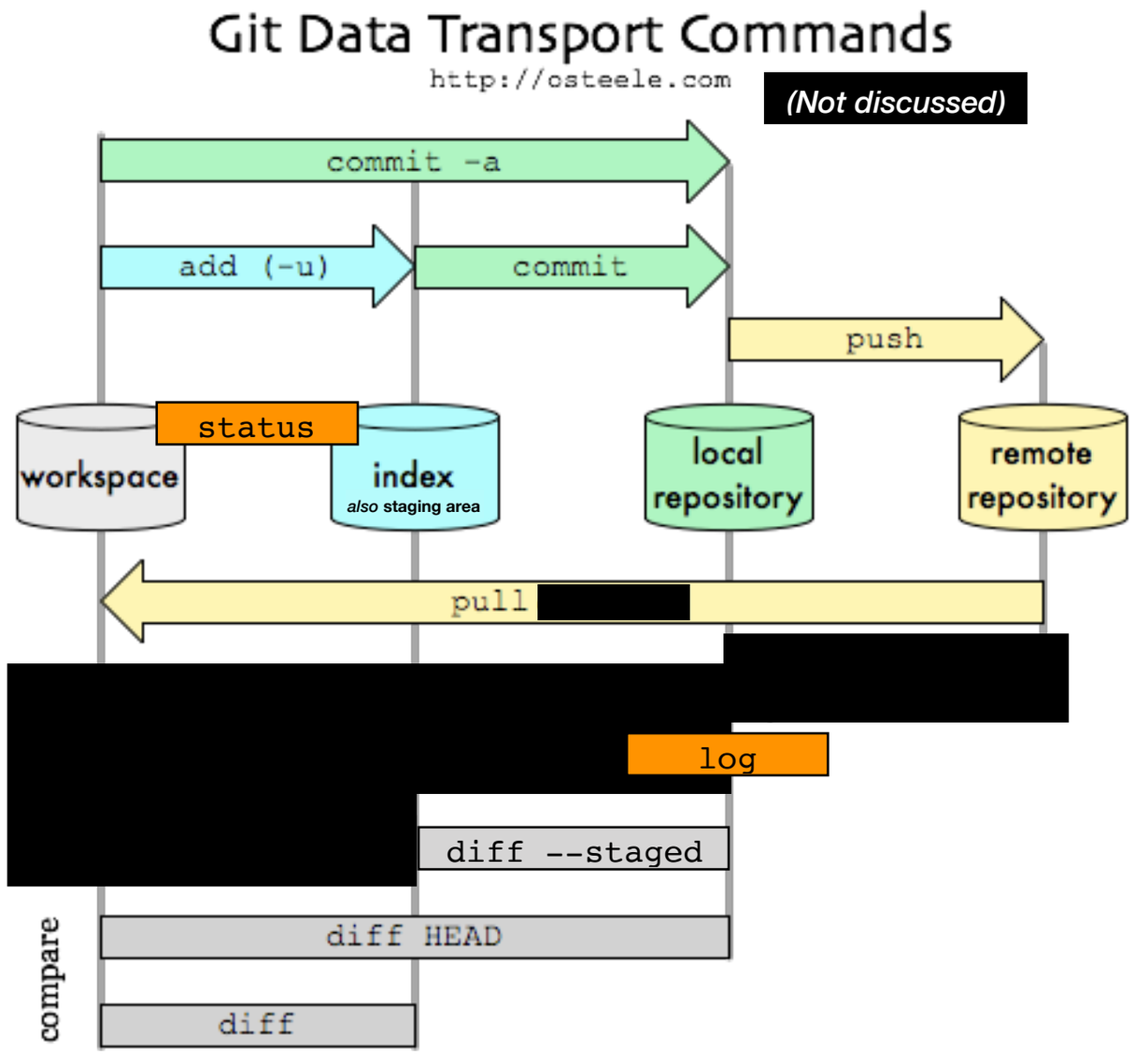
```
$ git bisect
```

Bisect the git history to find which commit introduced a bug

Summary

```
config
  init
status
   add
commit
  diff
   log
```

```
branch
checkout
   merge
   clone
    push
    pull
```



Good Resources

Beginner:

- Bitbucket Tutorials for git
- Resources to learn by Github (includes interactive tutorials)
- Git Documentation

More advanced:

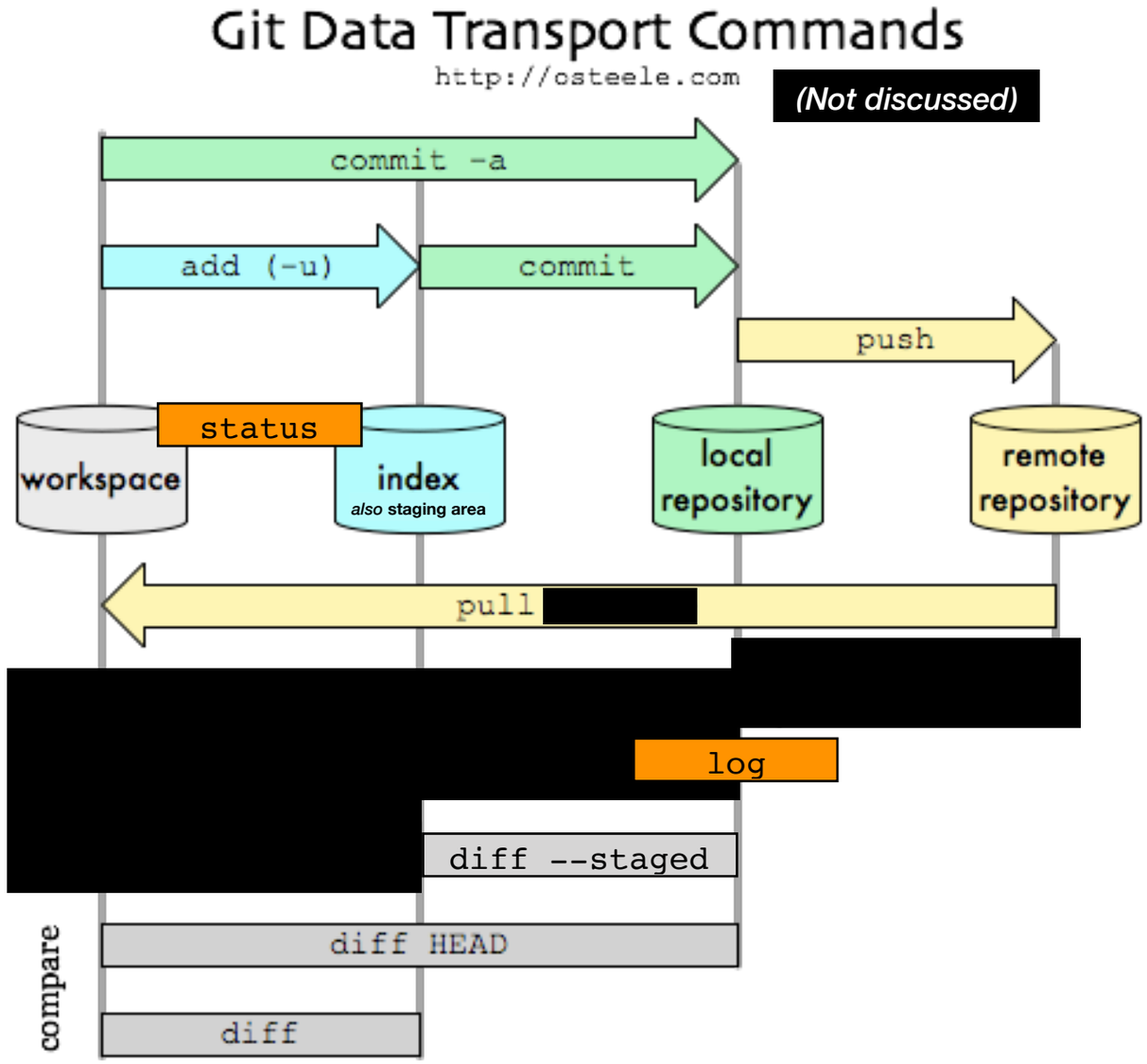
- Pro Git by Scott Chacon and Ben Straub: THE git book (free)
- Good talk: Introduction to git with Scott Chacon of GitHub
- Good talk: Linus Torvalds (creator of git) on git

Summary

Feedback and questions welcome!
staudenmaier@fias.uni-frankfurt.de

```
config
init
status
add
commit
diff
log
```

```
branch
checkout
merge
clone
push
pull
```



***Online Slides with the hands-on exercises*:**
CRC Redmine Z02 Project Wiki or Transport Meeting Website

Solutions to Exercise 1

```
# Part 1 #
$ git config --global user.name <your_name>
$ git config --global user.email <your_email>
$ less ~/.gitconfig

# Part 2 #
$ mkdir sample_project; cd sample_project
$ git init
$ ls -a  # see hidden .git directory

# Part 3 #
$ vi sample_file.cpp  # create sample file
$ git status
$ git add sample_file.cpp
$ git status
$ git commit  # editor open, type commit message, save and quit

# Part 4 #
$ vi sample_file.cpp  # modify sample file
$ git diff
$ git status
$ git add sample_file.cpp
$ git status
$ git commit  # editor open, type commit message and save

# Part 5 #
$ git log
```

Solutions to Exercise 2

Part 1/2

```
# Part 1 #
$ git branch new_branch
$ git branch

# Part 2 #
$ git branch -d new_branch  # small d important

# Part 3 #
$ git checkout -b add_readme
$ git branch  # star marks the currently checked out branch

# Part 4 #
$ vi README.md  # create README file
$ git status
$ git add README.md
$ git commit
$ git status  # shows working tree clean, so we can check out another branch

# Part 5 #
$ git checkout master
$ ls  # README is gone again
$ git merge add_readme  # notice it says fast-forward merge
$ git log  # has commit from add_readme
$ ls  # README file now on master
$ git branch -d add_readme
```

Builds on repository created for Ex. 1

Solutions to Exercise 2

Part 2/2

```
# Part 6 #
$ git checkout -b edit_sample_file
$ vi sample_file.cpp  # modify file
$ git diff  # always check you changes
$ git commit -a  # only small change
$ git checkout master
$ vi sample_file.cpp  # modify same part/line of file
$ git diff
$ git commit -a
$ git merge edit_sample_file  # should have a merge conflict

# Part7 #
$ git status  # see unmerged paths
$ vi sample_file.cpp  # create intended code version + rm comments
$ git add sample_file
$ git commit  # auto-generated merge commit message
```