Introduction to Git — Fall 2023

Lecture 5: Branches

Slides: https://hackmd.io/@git-fall-2023/L5-branches#/

Repetition

Not starting with “R”

- `checkout` - go/move HEAD to branch or specific commit (hash)
  - Applying to a file discards all unstaged changes made to the file
  - will never move the reference
- `clean` - clear **unstaged** files
  - `--dry-run` to check what will happen
- `diff` - compare
  - lists unstaged changes
  - `--staged` - commit vs staged
  - HEAD - commit vs working tree
- `log` - history of commit tree
  - `--graph` - graphically see the branches
- `show` - shows info for commit
- `stash` - temporarily **stores the staged** changes to the working tree
- `switch` - go to branch only (more clear for this use)
- `tag` - tag (like version number), **naming commits** (not branches)

Repetition

Starting with “R”

- `rebase -i HEAD~3` - interactively rebase last 3 **commits**
  - with `squash` - summarize last 3 **commits**
- `reflog` - log of commits that changes the head
- `reset` - as `checkout` but takes options to also do updates
  - `<filename>` - **unstages** the file
  - may move the reference and thereby update the branch
- `restore` - restore **file** in work dir
  - `--staged` - **unstages**
  - does not update your branch
- `revert` - makes **inverse of** the previous **commit**. The commit tree is not modified, rather two cancelling commits.
- `rev-parse --short` - find short hash for references, like `HEAD~~`
- `rm` - remove from repo

Objectives

- Get some more hands-on working with branches
  - creation
  - switching
  - merging
  - deletion
  - handling uncommitted changes
    - stashing
    - discarding
    - checkout with merge
  - merging and merge conflicts
  - rebasing: combining a sequence of commits to a new base commit.
  - cherry-picking

What is a Git branch?

- A pointer to a commit (ref: named pointer)
- Defined as all points reachable in the commit graph from the named commit (the “tip” of the branch)
- The ref HEAD determines what branch you are on.
- If HEAD is a symbolic ref for an existing branch, then you are “on” that branch.
- If HEAD is a simple ref directly naming a commit by its SHA-1 ID, you are not “on” any branch - you are in “detached HEAD” mode, which happens when you check out some earlier commit to examine.

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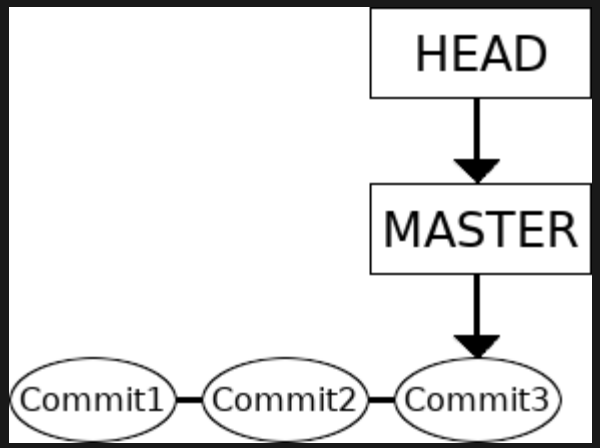
- We want to develop new features, but not risk changing the working main code yet
- Test different directions for a project
- Several projects members would like to work on their own copy of the code
- Bug fixes that are not yet tested, but will later be merged into the main version

What is a Git branch?

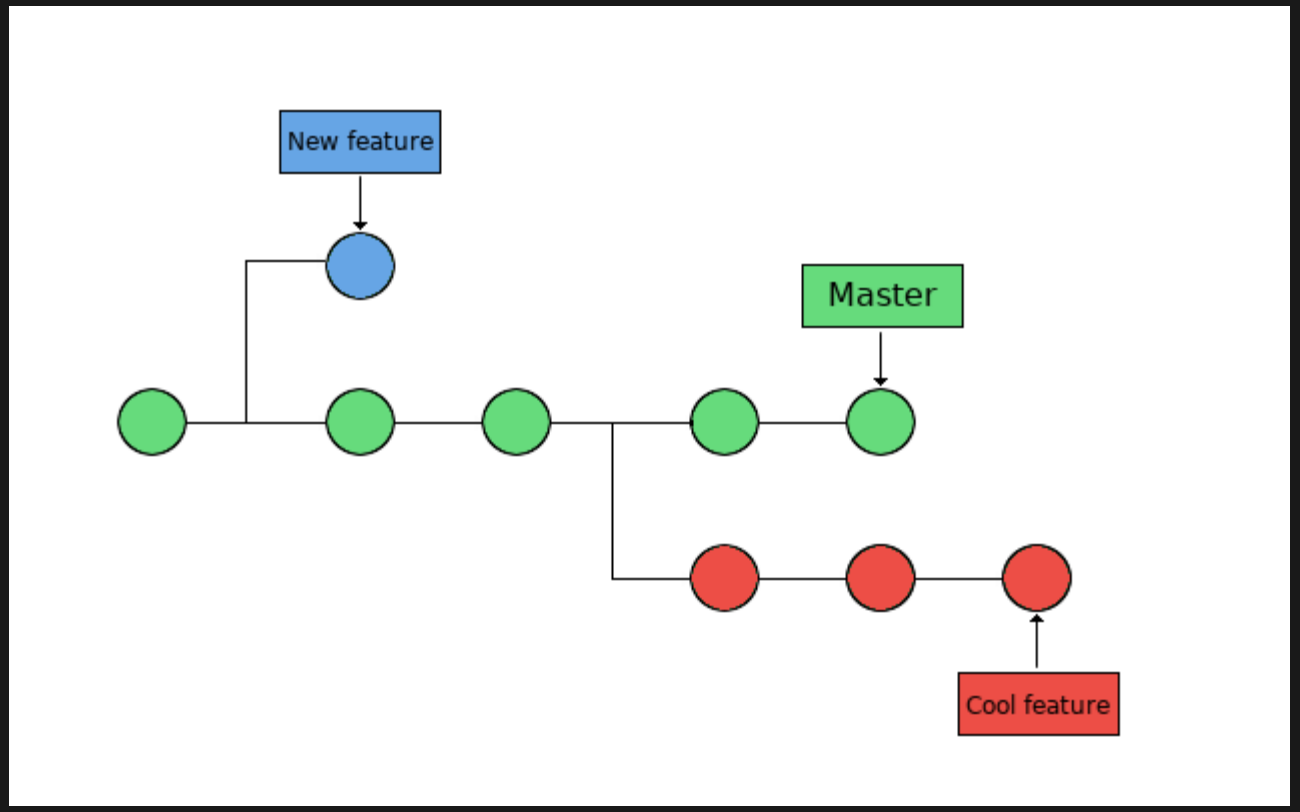
Until now, we have worked with a repository that only have one branch, with the commits done one at a time:



In the above picture, the master branch points to a commit. The current position is HEAD. (Time goes rightwards)

What is a Git branch - basic concepts

Now we want to look at repositories with several branches:



Branches are used to create another line of development. They are “individual projects” within a git repository. (Time goes rightwards)

- The branch is the commit and all its parent commits, not just the one we are currently pointing at.

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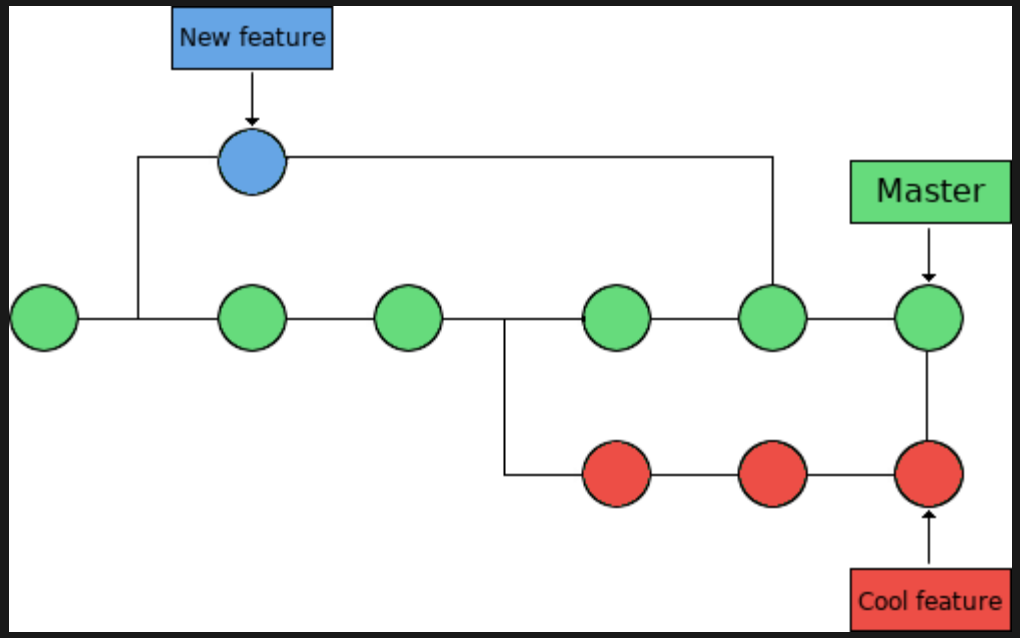
- The main line of development is usually called the “master” branch.
- Different branches within a repository can have
    - completely different files and folders
    - almost everything the same except for a few lines of code in a file

Usually, a branch is created to work on a new feature. Once the feature is completed, it is merged back with the master branch.



(Time goes right)

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To create a new branch (called cool-feature in the following):

```
$ git branch cool-feature
```

To move to another branch (switch):

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$ git checkout cool-feature
```

or…

```
$ git switch cool-feature
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If you wish to switch to a new branch that is not yet created, you can do so by adding the flag `-b` to `git checkout`.

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$ git checkout master
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$ git merge cool-feature
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- Then merge them:

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$ git merge cool-feature
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- You can now delete the extra branch:

```
$ git branch -d cool-feature
```

Example - Type along if you wish

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```
$ mkdir my-project; cd my-project/
$ git init
Initialized empty Git repository in /home/bbrydsoe/my-project/.git/
$ touch file.txt
$ git add file.txt
$ git commit -m "Committing the first file"
[master (root-commit) 1006b51] Committing the first file
 1 file changed, 0 insertions(+), 0 deletions(-)
 create mode 100644 file.txt
```

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$ git branch cool-feature
$ git checkout cool-feature
Switched to branch 'cool-feature'
$ echo "This is a text" > file.txt
$ git add file.txt
$ git commit -m "Added text to the first file"
[cool-feature 5bad966] Added text to the first file
 1 file changed, 1 insertion(+)
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$ git checkout master
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[master bdec2cf] Added a second file
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$ git config --global alias.graph "log --all --graph --decorate --oneline"
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$ git graph
* bdec2cf (HEAD -> master) Added a second file
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*   cf3e6b7 (HEAD -> master) Merge branch 'cool-feature'
|\
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* | bdec2cf Added a second file
|/
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```

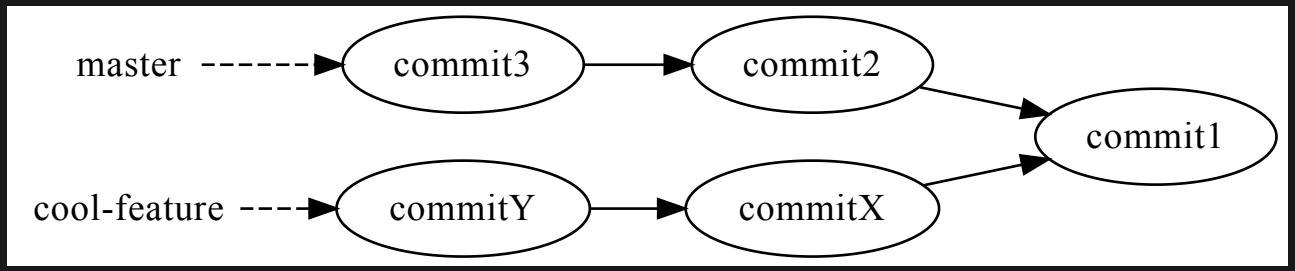
Now we can delete the new branch we had created, since all the content is now in the master branch.

```
$ git branch -d cool-feature
Deleted branch cool-feature (was 5bad966).
```

Comment: It is good practice to keep old branches for understanding of the development. Deletion could however be done for very evident mistakes or insignificant issues.

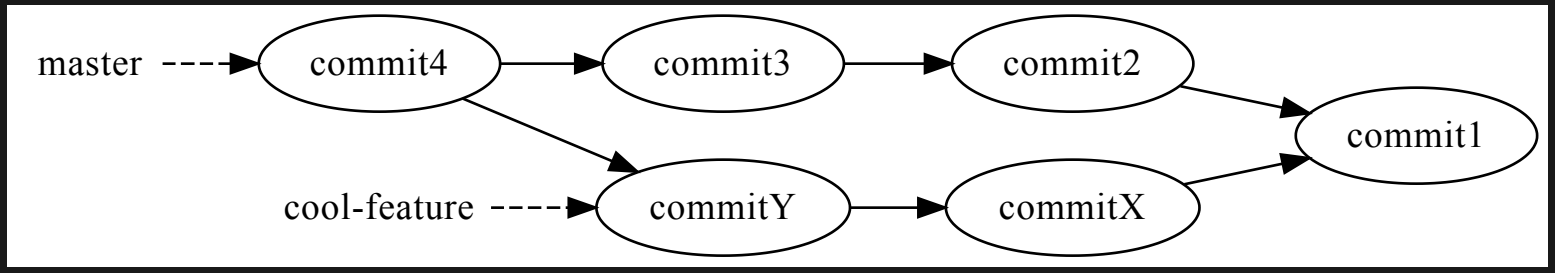
In a somewhat nicer format, it looks like this:

We commit stuff to both branches

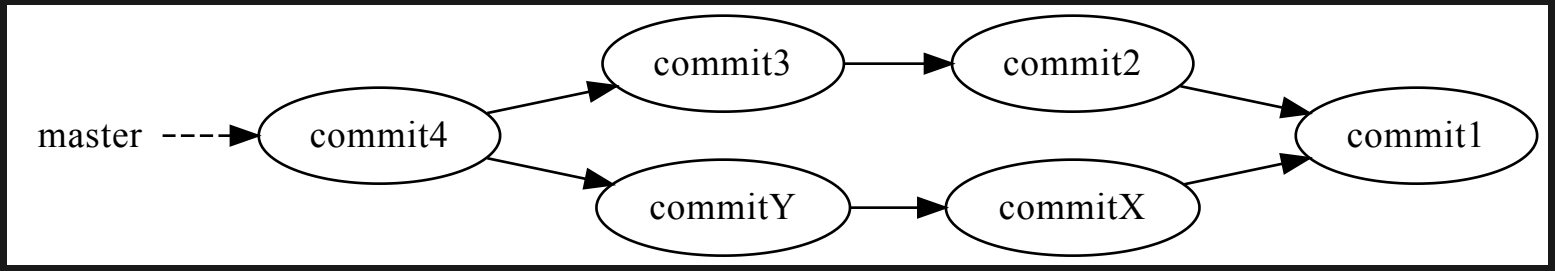


(Time goes leftwards)

Merge ‘cool-feature’ to ‘master’



Delete ‘cool-feature’



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What if there is a conflict?

- You will **not** be allowed to switch to the other branch.
- You must commit or stash any conflicting changes before switching branches.

Example - new file

We continue in the same repository!

Here we create a new branch, switch to it, then add a new file. Then we switch back to the master branch without committing the changes:

```
$ git checkout -b cool-feature
Switched to a new branch 'cool-feature'
$ touch newfile.txt
$ git add newfile.txt
$ git checkout master
A newfile.txt
Switched to branch 'master'
```

Git warns that there is a file added (A) in one branch but not the other, but the switch is allowed.

Example - modified file

We continue in the same repository!

First commit the `newfile.txt` in the cool-feature branch to clean the environment.

If we make changes to the file in one of the branches (go back to `cool-feature`) but not on the other and do not commit it, then git will again warn:

```
$ git switch cool-feature
$ git commit -m "newfile.txt"
$ echo "Adding some text" >> second-file.txt
$ git add second-file.txt
$ git checkout master
M second-file.txt
Switched to branch 'master'
```

Git warns that there is a file that is modified (`M`) in one branch but not the other, but the switch is allowed.

Example - uncommitted, conflicting changes

We continue in the same repository!

Assume two branches, “cool-feature” and “morefeatures”

Create the branch “morefeatures” without switching to it
Switch to branch “cool-feature”, add some text to a file, stage the file and commit it:

```
$ git branch morefeatures
$ git checkout cool-feature
Switched to branch 'cool-feature'
$ git commit -m "second-file.txt"
$ echo "add text" >> morefiles.txt
$ git add morefiles.txt
$ git commit -m "Some text"
[cool-feature 469542b] Some text
 1 file changed, 1 insertion(+)
 create mode 100644 morefiles.txt
```

Switch to branch “morefeatures”. Modify the same file, stage the file and commit it. Then try and switch back to the “cool-features” branch:

```
$ git checkout morefeatures
Switched to branch 'morefeatures'
$ echo "Adding yet some more text" >> morefiles.txt
$ git add morefiles.txt
$ git checkout cool-feature
error: Your local changes to the following files would be overwritten by checkout:
  morefiles.txt
Please commit your changes or stash them before you switch branches.
Aborting
```

Now Git complains and do not allow the switch.

Handling uncommitted changes

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- Commit the changes before switching branch

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- Discard the uncommitted changes

Handling uncommitted changes

So, what can we do if there is a conflict?

- Commit the changes before switching branch
- Stash the uncommitted changes
- Discard the uncommitted changes
- Checkout with Merge

Stashing

The command “stash” can be described as a **drawer** where you store uncommitted changes temporarily.

After stashing your uncommitted changes you can continue **working on other things** in a different branch.

The uncommitted changes that are stored in the stash **can be taken out and applied to any branch, including the original branch.**

Stashing, example (no type-along this time)

First do a `git status` in the branch where you may have uncommitted changes:

```
$ git status
On branch morefeatures
Changes to be committed:
  (use "git reset HEAD <file>..." to unstage)

  modified:   file.txt
  new file:   morefiles.txt
```

You can see the dirty status.

To fix it, let us use `git stash`:

```
$ git stash
Saved working directory and index state WIP on morefeatures: 4922606 Some tex
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On branch morefeatures
nothing to commit, working tree clean
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Checking again with `git status`:

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

You can now switch branches and work on something else.

Working with stashes (repetition)

You can have several stashes stored. To see them, use

```
$ git stash list
```

Example:

```
$ git stash list
stash@{0}: WIP on morefeatures: 4922606 Some text
stash@{1}: WIP on morefeatures: 4922606 Some text
stash@{2}: WIP on morefeatures: 4922606 Some text
```

Working with stashes - continued (repetition)

When you have done what you needed before committing the stashed changes you can reapply a stash (select branch first), using

```
$ git stash apply
```

which will apply the most recent stash. If you want to apply a different stash, you can name it.

Example:

```
$ git stash apply stash@{0}
```

Discarding uncommitted changes

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You can safely test which files will be removed by running:

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You can safely test which files will be removed by running:

```
$ git clean --dry-run
```

Handling uncommitted changes - merging

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- After the merge, you will be on the new branch and the merged result will be in your working tree.
- NOTE: As with any merge, **conflicts may result** and you will then have to resolve those.

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Cannot merge. (Changes in staging area)
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- NOTE: Always check that you are on the right branch before merging! You check the branch with `git branch`.

Git can automatically try to merge when you give the command:

```
$ git merge <branch-to-merge-into-present-branch>
```

while standing on the branch you want to merge to.

Merge strategies

The most commonly used

- Fast Forward Merge
  - the commit history is one straight line.
  - You create a branch, you make some commits there, but no changes to the ‘master’. You then just merge onto the ‘master’. This just moves the pointer for the ‘master’ branch forward in a straight line.
- Recursive Merge (until 2.32)
  - make a branch and make some commits there, but also make new commits that are made on another branch, like the ‘master‘.
  - Then, when you want to merge, git will recurse over the branch and create a new merge commit. The merge commit will continue to have two parents.
- ORT (from git-2.33)
  - acronym for “Ostensibly Recursive’s Twin”
  - replacement for the previous default algorithm, recursive.
  - This is the default merge strategy when pulling or merging one branch.

Merge conflicts, example

Here we create a merge conflict:

```
$ mkdir merge-test
$ cd merge-test/
~/merge-test$ git init
Initialized empty Git repository in /home/bbrydsoe/merge-test/.git/
~/merge-test$ echo "Creating a file with some text to play with." >> myfile.txt
~/merge-test$ git add myfile.txt
~/merge-test$ git commit -m "First commit"
[master (root-commit) 9badcc6] First commit
 1 file changed, 1 insertion(+)
 create mode 100644 myfile.txt
~/merge-test$ git checkout -b mergebranch
Switched to a new branch 'mergebranch'
~/merge-test$ echo "Adding text to the file in order to merge." > myfile.txt
```

```
~/merge-test$ git add myfile.txt
~/merge-test$ git commit -m "Changed the content of myfile.txt"
[mergebranch 41b0e36] Changed the content of myfile.txt
 1 file changed, 1 insertion(+), 1 deletion(-)
~/merge-test$ git checkout master
Switched to branch 'master'
~/merge-test$ echo "Put more text to the file" >> myfile.txt
~/merge-test$ git add myfile.txt
bbrydsoe@enterprise-a:~/merge-test$ git commit -m "Added more text"
[master c17e479] Added more text
 1 file changed, 1 insertion(+)
~/merge-test$ git merge mergebranch
Auto-merging myfile.txt
CONFLICT (content): Merge conflict in myfile.txt
Automatic merge failed; fix conflicts and then commit the result.
```

So Git complains

We can get some more information with the `git status` command:

```
~/merge-test$ git status
On branch master
You have unmerged paths.
  (fix conflicts and run "git commit")
  (use "git merge --abort" to abort the merge)

Unmerged paths:
  (use "git add <file>..." to mark resolution)

  both modified:   myfile.txt

no changes added to commit (use "git add" and/or "git commit -a")
```

Looking inside the file myfile.txt:

```
~/merge-test$ cat myfile.txt
<<<<<<< HEAD
Creating a file with some text to play with.
Put more text to the file
=======
Adding text to the file in order to merge.
>>>>>>> mergebranch
```

Some “conflict dividers” have been added.

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If you made a mistake when you resolved a conflict and have completed the merge before realizing, you can roll back to the commit before the merge was done with the command `git reset --hard`.

Workflow - merge goes well

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Success!

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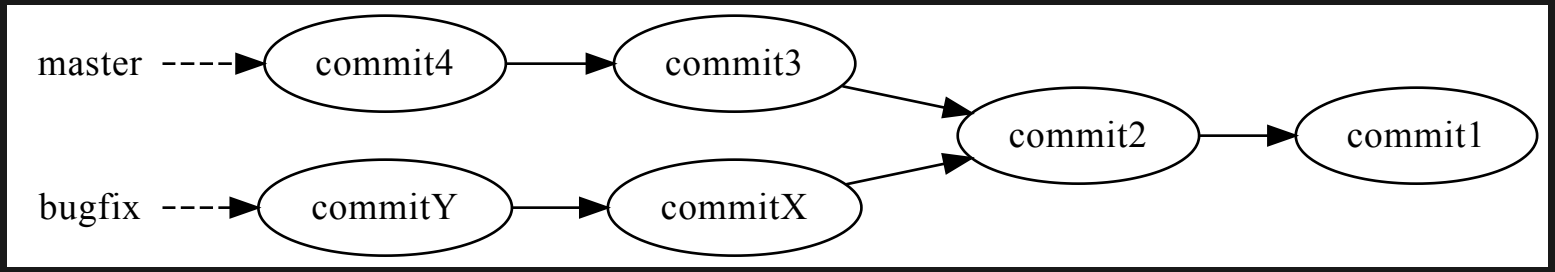
- It solves the same problem as git merge. The commands are both used to integrate changes from one branch into another branch, however the way they do it is very different.
- When you do a rebase, all the changes will be compressed together in a single “patch” which is then “applied” - rebasing creates new commits on the other branch for each commit in the original branch.

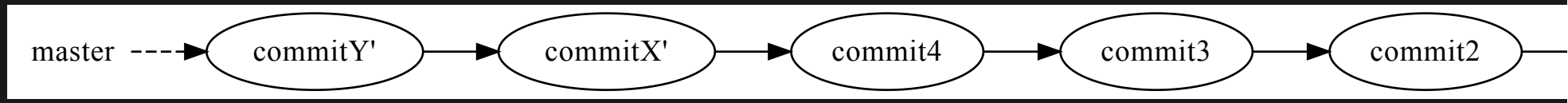
Rebasing - illustration

Branch ‘bugfix’ was branched from ‘master’



(Time goes leftwards)

Rebasing ‘bugfix’ to the ‘master’ branch



(Time goes leftwards)

Rebasing - continued

Assume a master branch and the branch “cool-features” and that you want to rebase the branch “cool-features” onto the master branch:

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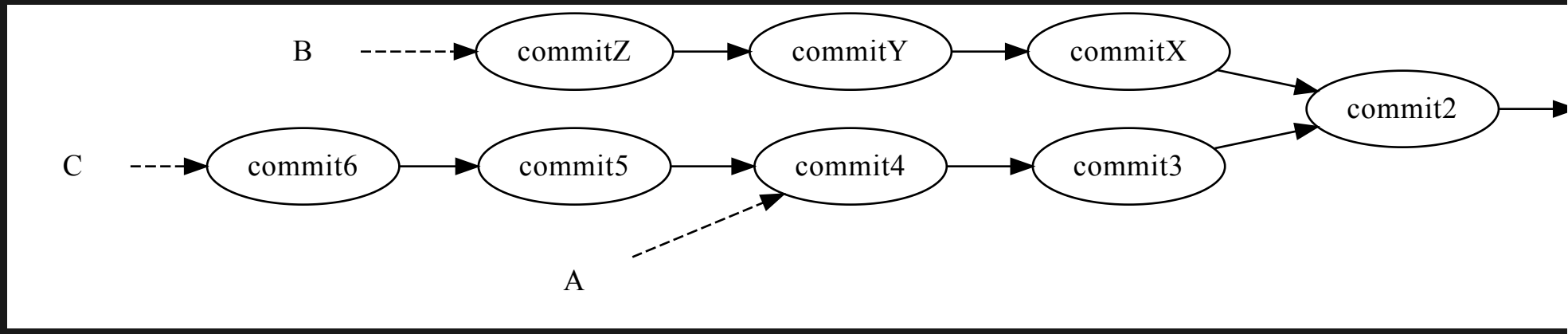
- saving those diffs to temporary files
- resetting the current branch to the same commit as the branch you are rebasing onto
- apply each change in turn

Rebasing vs. Fast-forward merge

Not the same! A rebase moves a branch from one base to another. A fast-forward merge moves a branch head from the current commit to a commit for a descendant.



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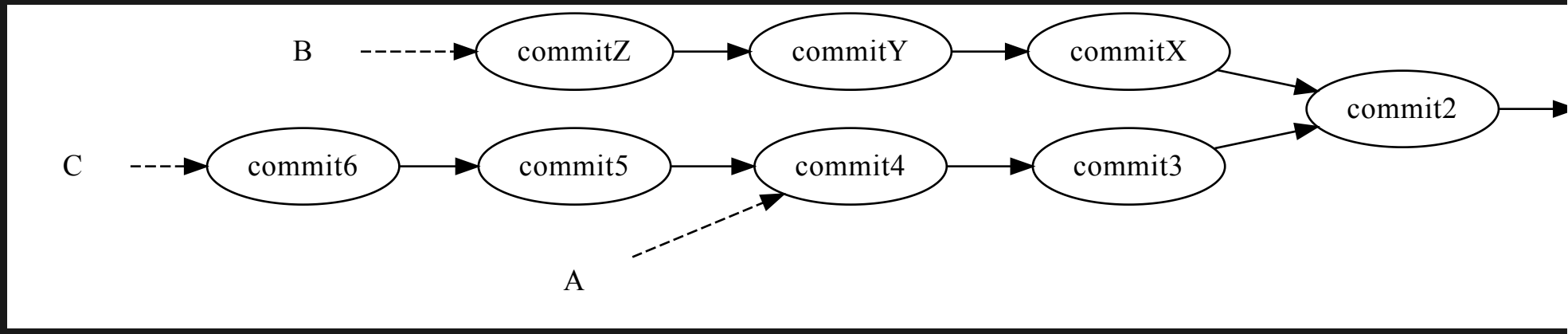
Example:



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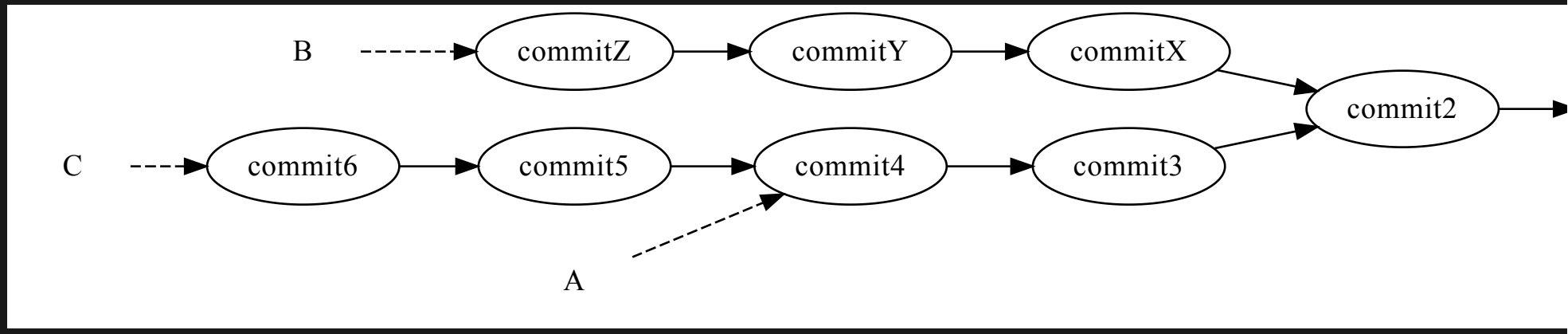

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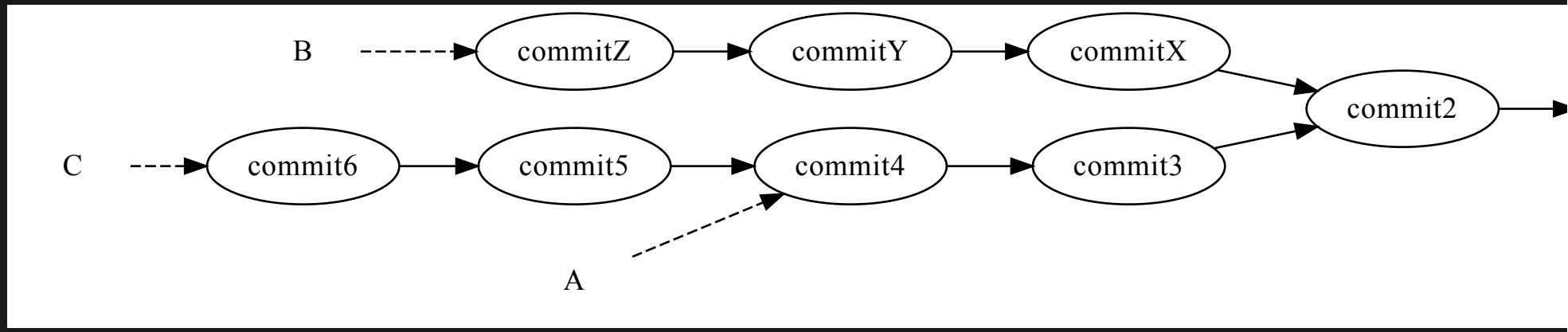
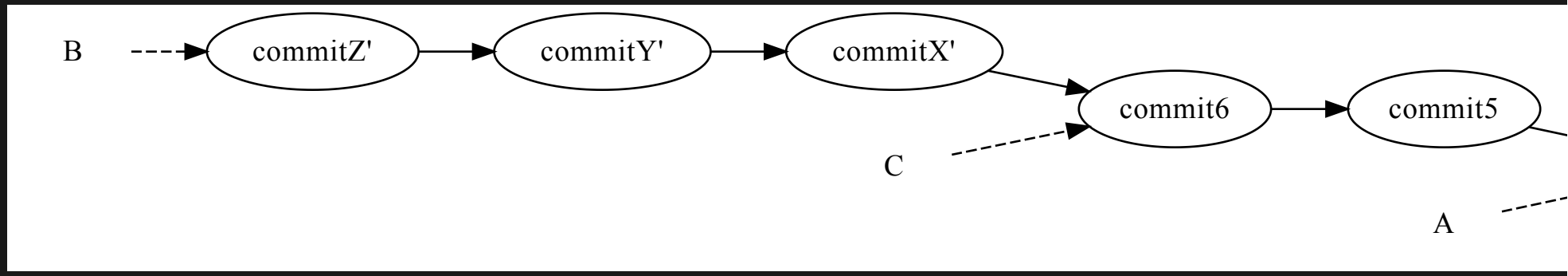
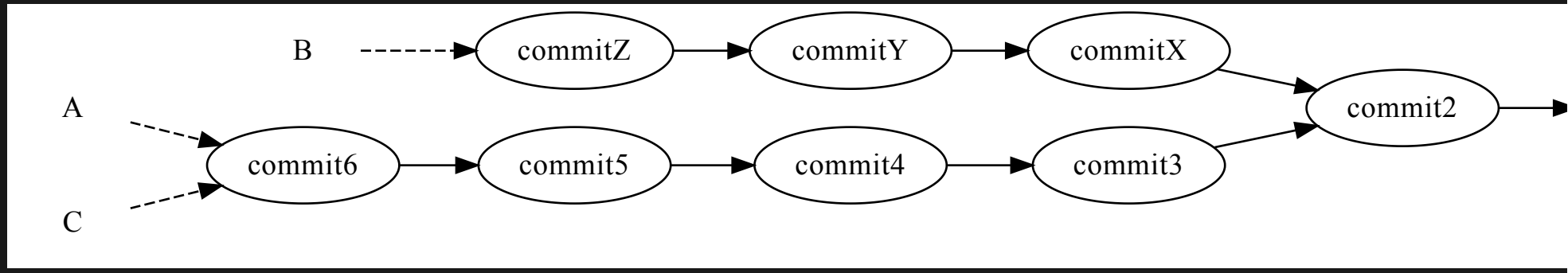


(Time goes leftwards)

Rebase B onto C



FF merge C into A:



(Time goes leftwards)

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Then make sure you are on the right branch that you want to apply the commit to:

```
$ git checkout <branch>
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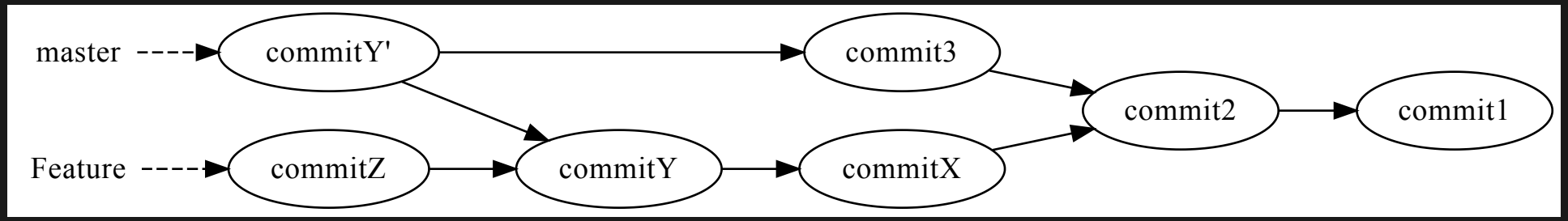
Now you execute the cherry-picking:

```
$ git cherry-pick <hash>
```

Cherry-picking — illustration (advanced)

Apply the commit Y to the master branch (called Y´)



(Time goes leftwards)

Take aways

- create or parse branch - `git branch`
- switch branch - `git checkout` or `git switch`
- merge branches - `git merge`
- rebase branch - `rebase` - like merge but end result is just one branch

Conflict?

- Commit or `stash` or discard (`clean`) the changes before switching branch or do a `checkout --merge` .

Workflow merge

- Work on files
- Stage and commit files
- Then do: `$ git merge <other-branch>`

Conflict?

- Fix problems
- Stage and commit files
- Then do: `$ git merge --continue <other-branch>`

Exercises

Each of the exercises has a README.md file with explanations and descriptions of what to do. You can find all of them in the subdirectory 5.branches. You should do them in the below order:

1. Fast-forward Merge (OK): This exercise will show an example where git can do a fast-forward merge. The exercise is in the subdirectory “1.merge-ok”
2. Recursive/ORT Merge (OK): In this exercise you will see an example where git can automatically merge two branches. This time git will use the recursive merge. The exercise can be found in the subdirectory “2.merge-ok-recursive”

Exercises

3. Merge (BAD): This exercise gives an example of a merge that cannot be done automatically with the merge command. The exercise can be found in the subdirectory “3.merge-bad”
4. Rebasing (OK): In this exercise you will try the command rebase and see that it succeeds. The exercise can be found in the subdirectory “4.rebase-ok”
5. Rebasing (BAD): This exercise again gives an example of rebasing two branches, but in this case the rebase fails. The exercise can be found in the subdirectory “5.rebase-bad”
