Git Good

How to understand Git

Sumner Evans

14 February 2023

Mines ACM

A bit about me

My name is Sumner, I'm a **software engineer at Beeper**.

- I graduated from Colorado School of Mines in 2018 with my bachelor's in CS and 2019 with a master's in CS.
- I am an adjunct professor. Currently I'm teaching CSCI 341. I've taught 400, 406, and 564 in the past as well.
- I enjoy skiing, volleyball, and soccer.
- I'm a 4th degree black belt in ATA taekwondo.

Overview

1. Why use Git?
2. Commits
3. Branches
4. Merging
5. Rebasing

This talk is interactive!

If you have questions at any point, feel free to interrupt me.

Why use Git?

Example Scenario 1

1. You start a project called “my-proj” and write a ton of code.
2. You finally get it to (kinda) work.
3. You decide to make a copy of “my-proj” for backup purposes.
4. You continue development on “my-proj” but then screw something up really bad.
5. You decide to revert back to your copy.
6. Then you realize your copy doesn’t have a bug fix that you actually wanted.
7. You then proceed to manually compare the files in the backup to those in your new code and figure out what you still want to have.

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1. You start working on a project with a partner.
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3. You email the code in a `.zip` file, then go home for the weekend.
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- VCS keeps track of *revisions*, changes in the code in entities called *changesets* or *commits*.
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Git is popular

Git is a very popular version control system.

Services such as GitHub and GitLab provide free hosting for Git repositories.

It has become the de-facto industry standard for source control.

Git is a distributed version control system

Distributed because you can use it without being connected to a central server. You have a full copy of the code on your own computer.

Version control because it keeps track of changes to files.

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Commits

Commits: what are they?

Commits are sets of differences (diffs) in files.[1]

Commits reference their parent(s) and contain information about the changes made in the repo since that parent commit.

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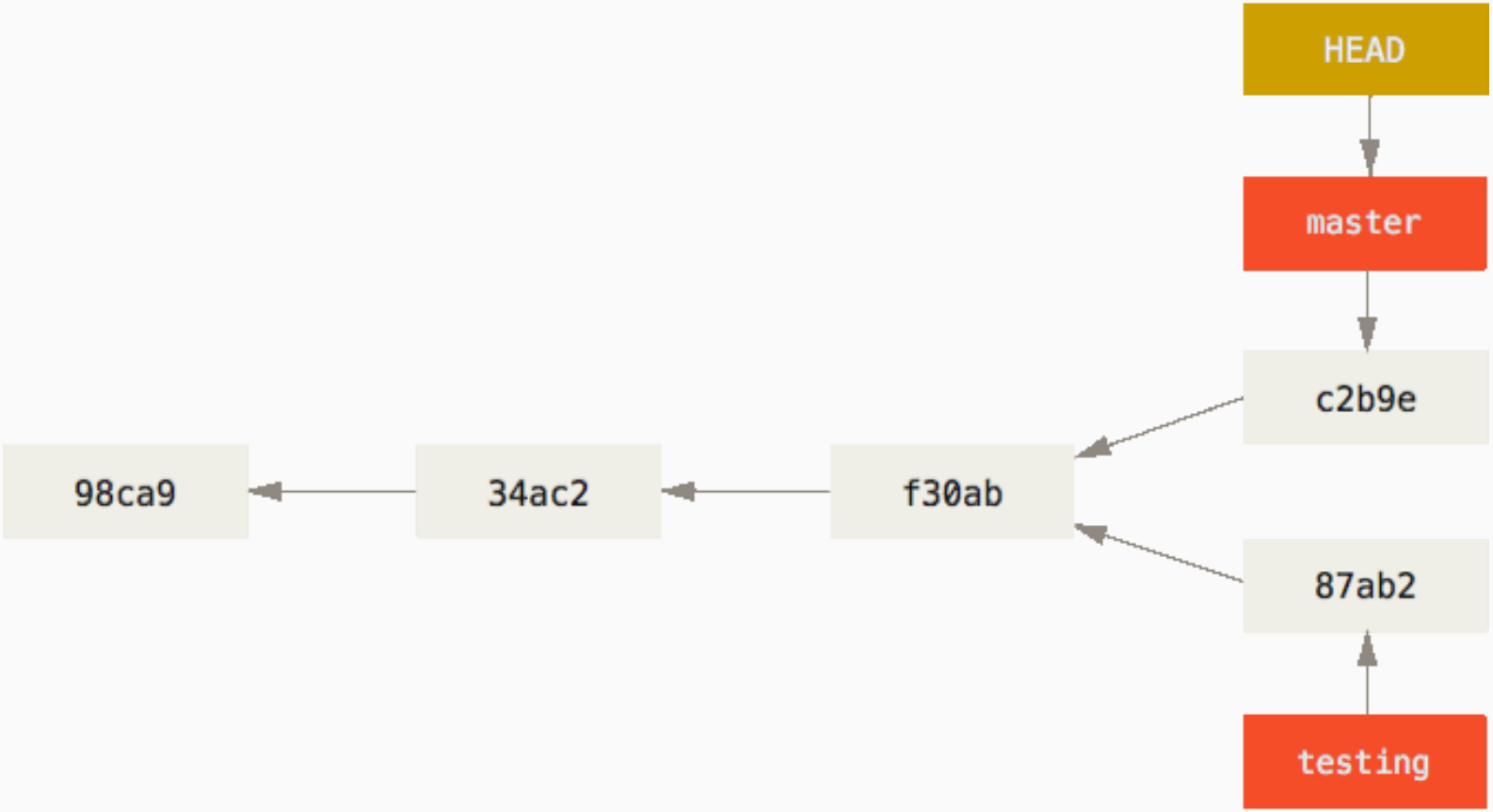

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Commits: creating

You can create a commit by running `git commit`. This will create a commit based on the checked-out commit with the changes that you have "staged".

- You can stage changes by running `git add` and passing a list of files.
- You can stage all changes by running `git add -A`.
- Pro tip: If you want to add specific parts of files, use `git add -p`.

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If you ever want to know what will be included in your commit, you can run `git status` to show the list of files staged for commit.

```
> git status
On branch master
Your branch is up to date with 'origin/master'.

Changes to be committed:
  (use "git restore --staged <file>..." to unstage)
        modified:   git.tex

Changes not staged for commit:
  (use "git add <file>..." to update what will be committed)
  (use "git restore <file>..." to discard changes in working directory)
        modified:   git.pdf
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The `git.tex` file has only some lines staged for commit.

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Commits: what will be committed, but with more detail?

To see the details of the changes that are staged (that is, will be committed), you can run `git diff --cached`.

If you want to see the details of the changes that are *not* staged, you can run `git diff`.

`git diff` optionally accepts a list of files to diff.

```
diff --git a/git.tex b/git.tex
index 2c01a7b..91148d1 100644
--- a/git.tex
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@@ -33,9 +33,7 @@

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Use `git add` and `git reset` (or variants) to stage/unstage changes for your.

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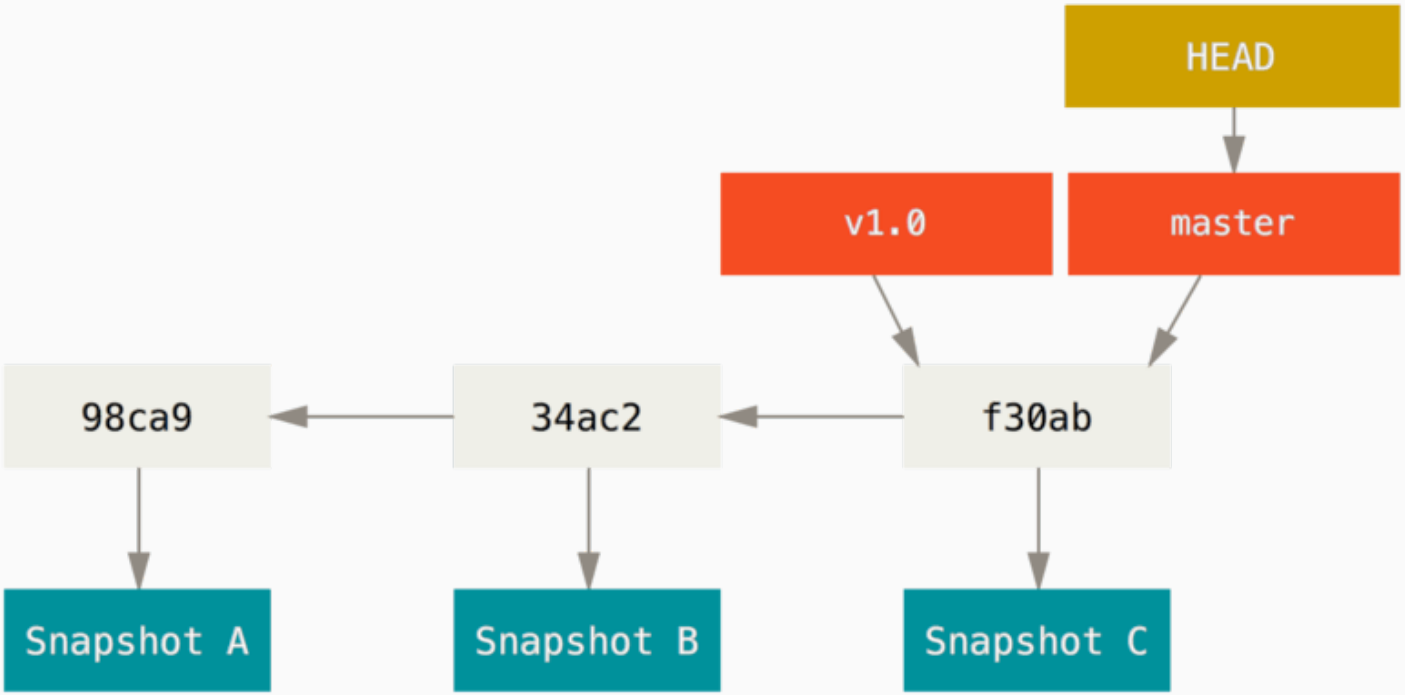
Branches

Branches: what are they?[2]

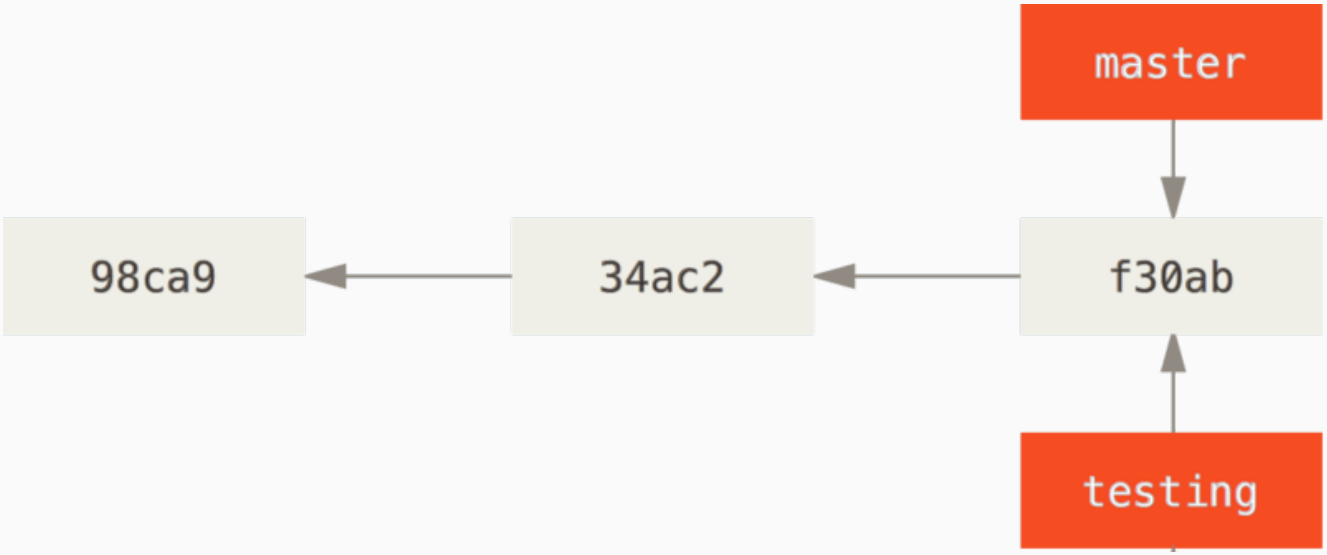
Branches are **pointers** to a specific commit.



[2]Info in the rest of the *Branches* section is mainly from `https://git-scm.com/book/en/v2/Git-Branching-Branches-in-a-Nutshell`

Branches: creating them

Branches can be created using the `git branch <branch name>` command. **This will not change your `HEAD` pointer.**



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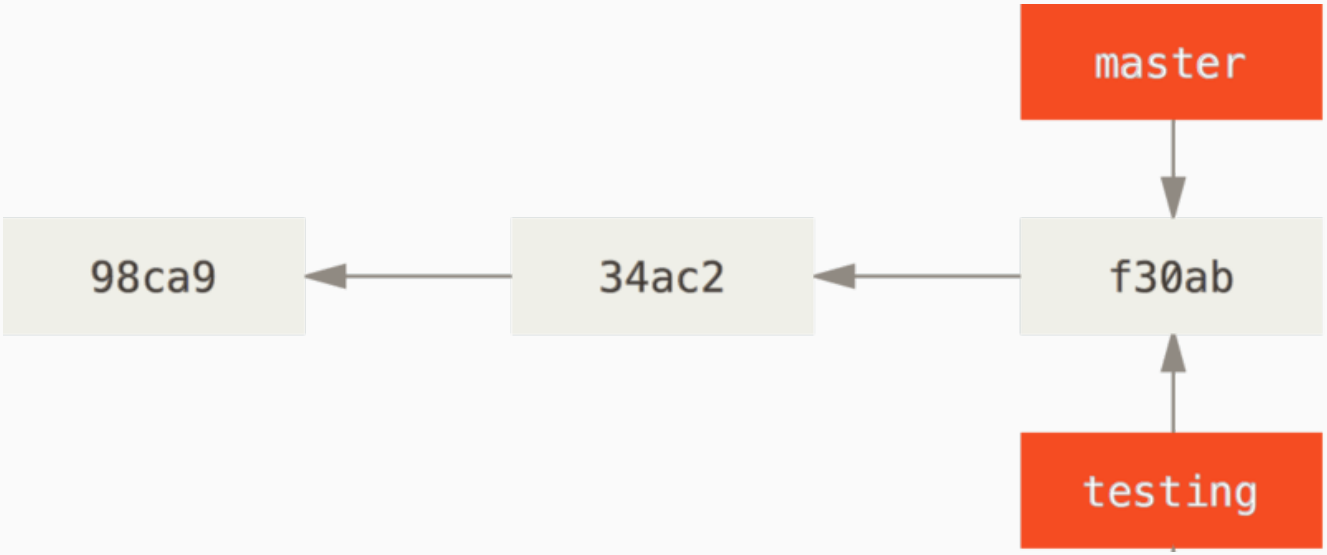

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Branches: moving `HEAD` around

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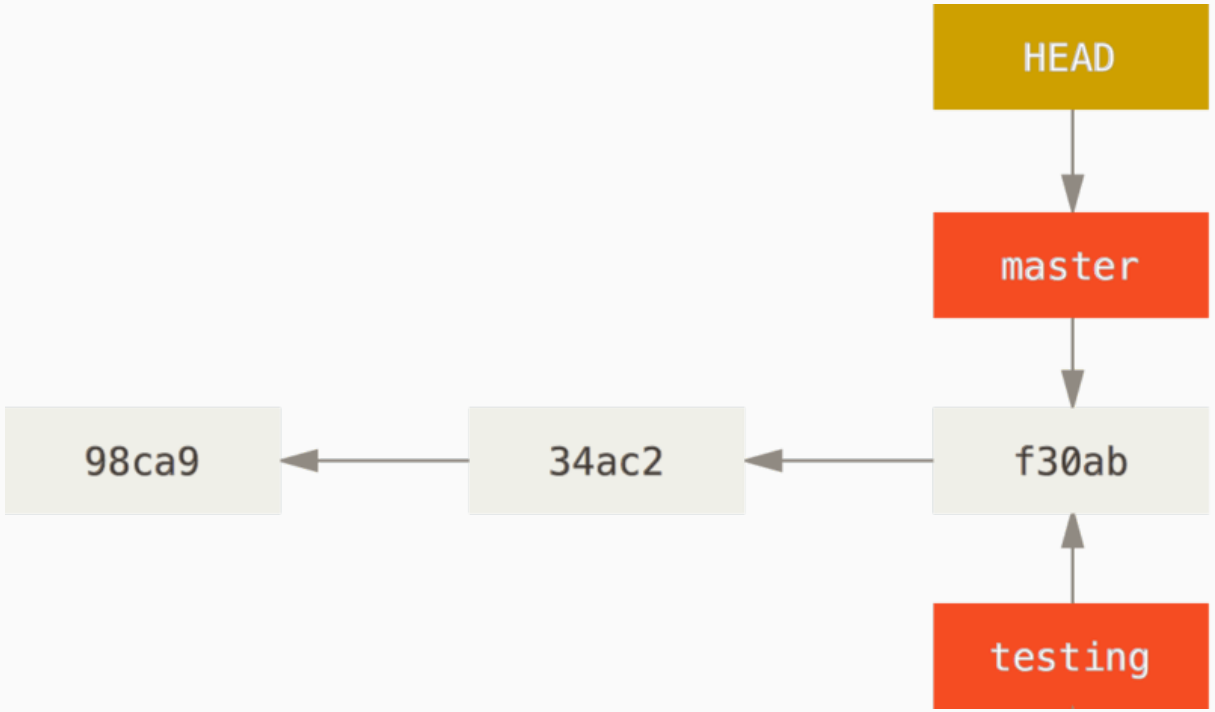

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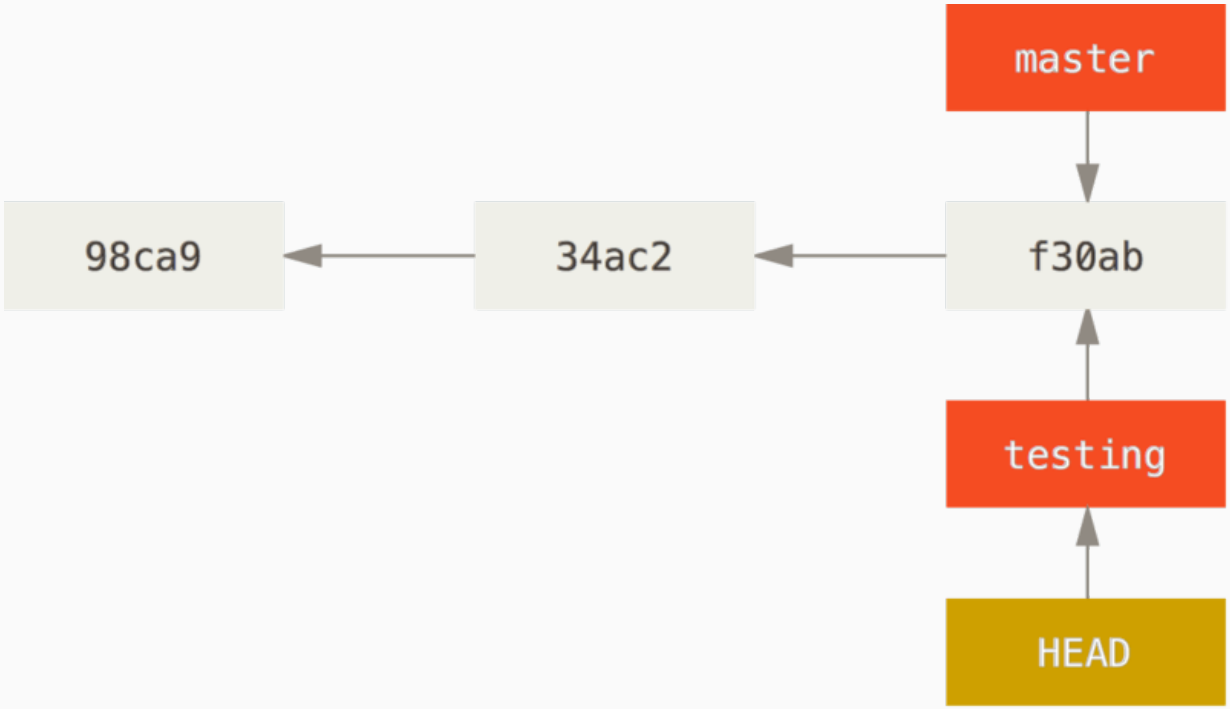

Branches: `checkout` gotchas and pro-tips

- If you checkout a commit hash, you will be in a `detached HEAD` state because your `HEAD` pointer is not pointing to a branch.
- If you have uncommitted changes, switching branches *might* fail.

  You can use `git stash` to save the changes in your working directory, then `checkout` the other branch, and then `git stash pop` to restore the changes.

  Alternatively, you can just create a WIP commit and then switch to the other branch.

Pro tip: You can use `-` to refer to the previously checked out object.

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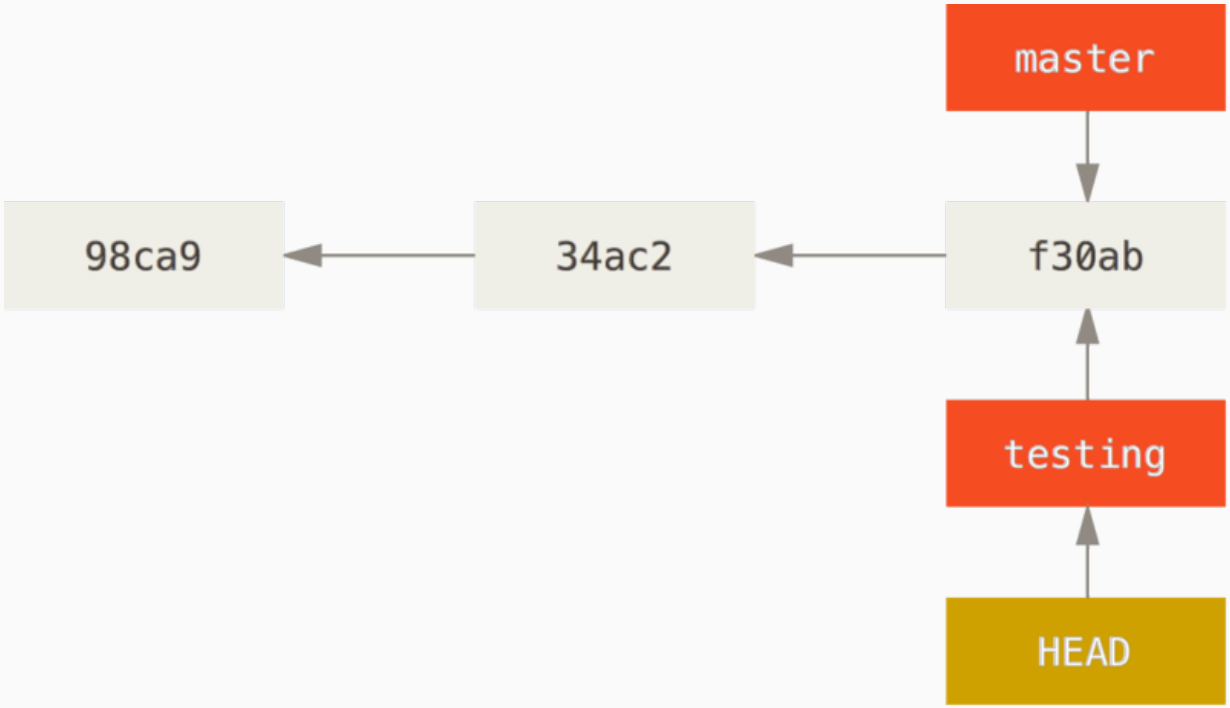

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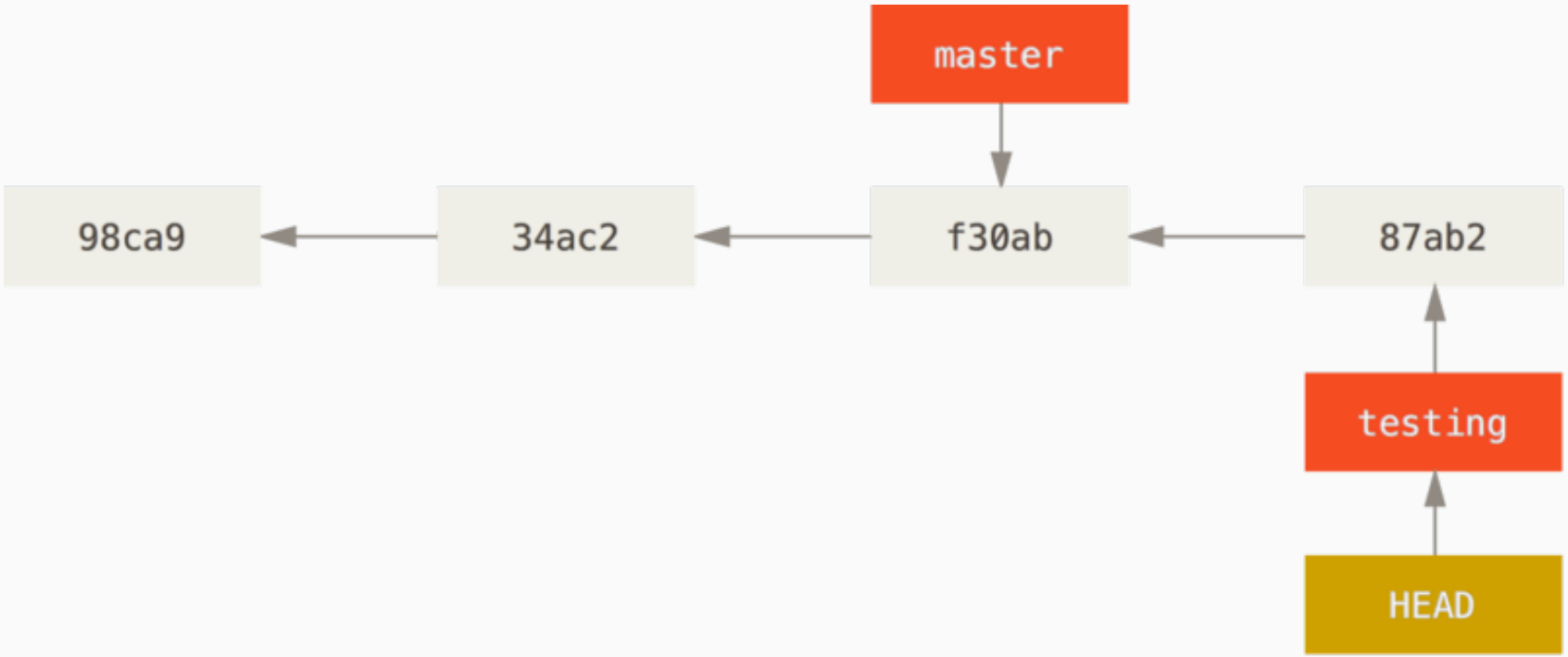
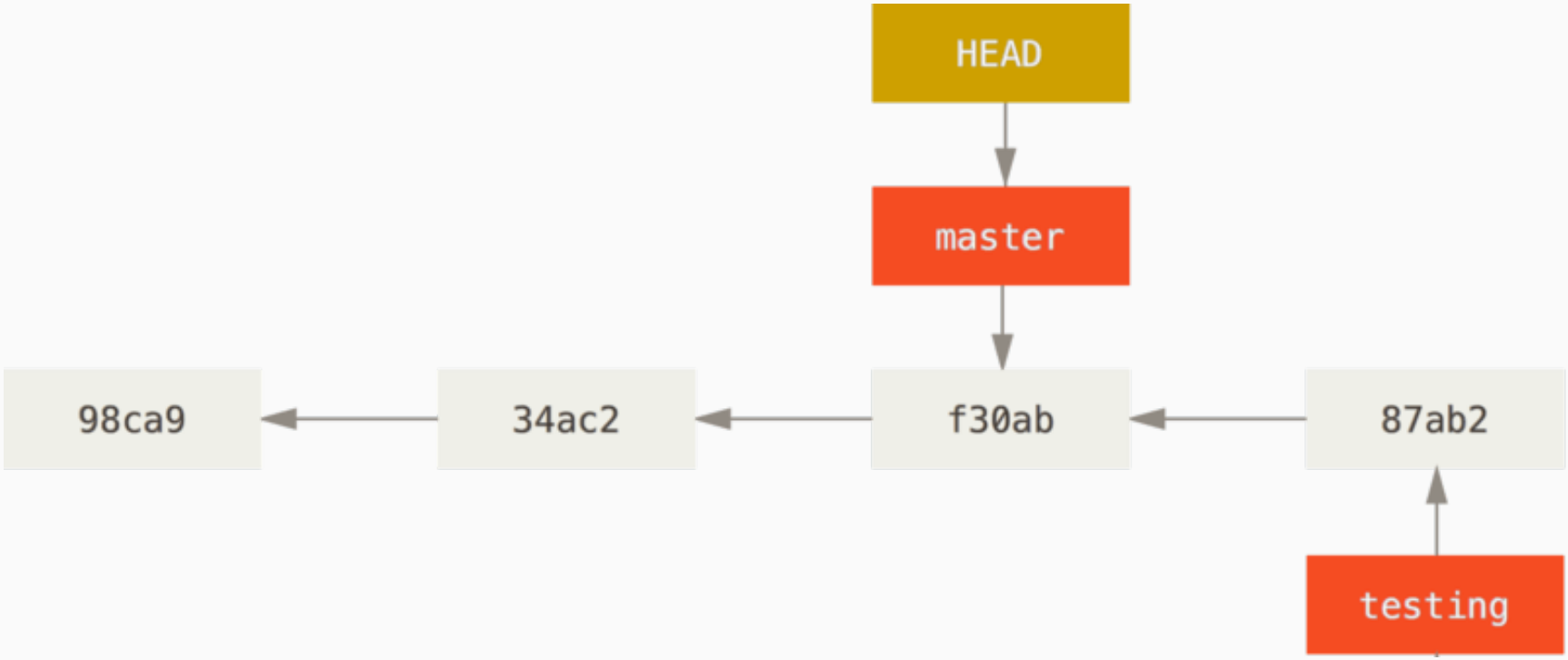


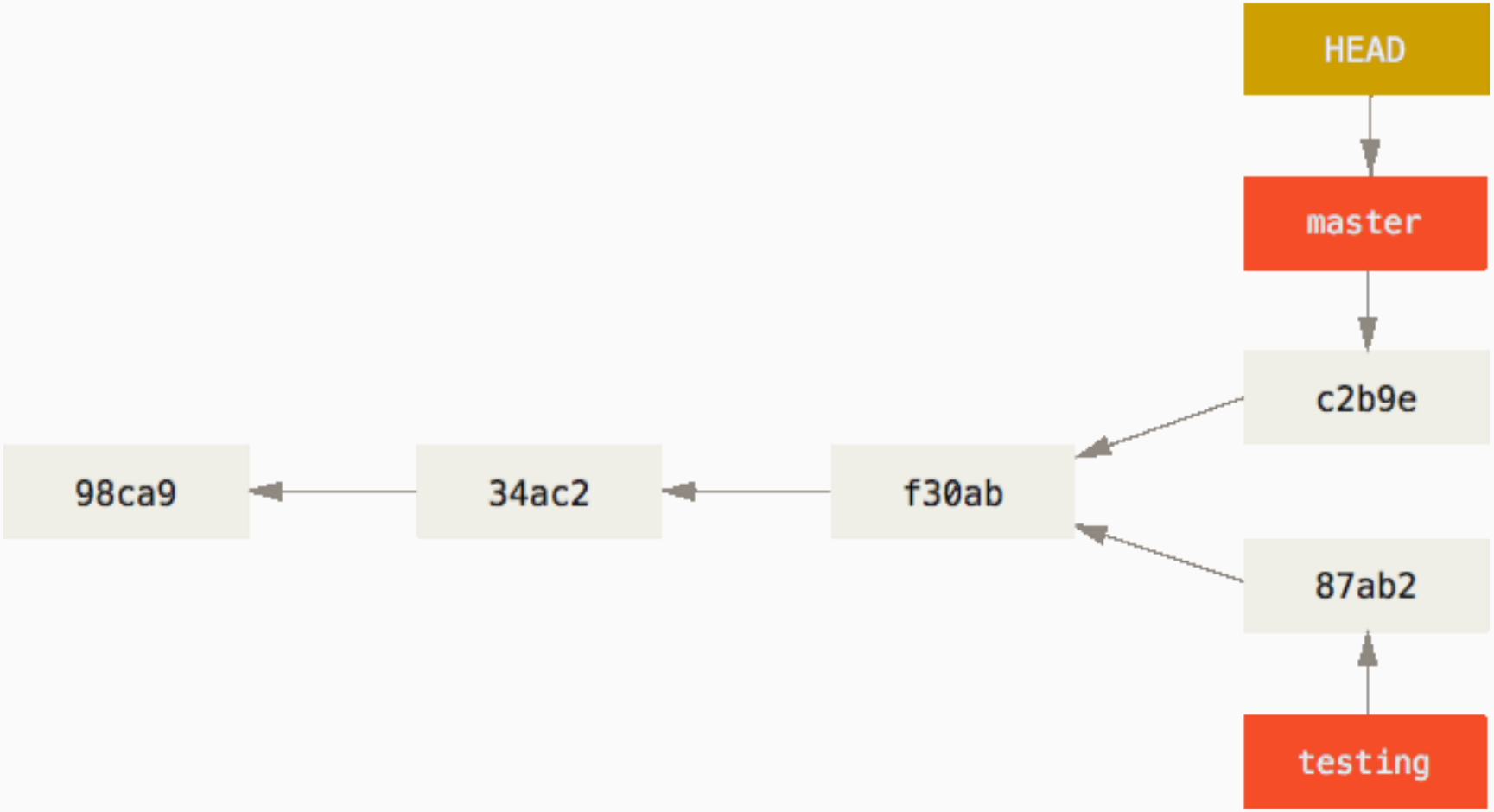
Branches: using multiple branches

Of course, you can always switch back to `master` using `git checkout master`.



Branches: divergence

If you make a commit on the master branch, the `master` pointer moves to that new commit creating **divergent** branch histories.



Branches: where am I?

Often, you want to get a summary of where you are in the repository. That's where `git log` comes in.

```
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commit b08107c144003ba42495995d59234595d2d875b4 (HEAD -> master, origin/master, origin/HEAD)
Author: Sumner Evans <me@sumnerevans.com>
Date:   Mon Feb 13 14:35:57 2023 -0700

    fix some things

    Signed-off-by: Sumner Evans <me@sumnerevans.com>

commit 6c1f8b53ac774dc6b0376810b4745951bd572519
Merge: 47bc626 67f0f4d
Author: Ethan Richards <42894274+ezrichards@users.noreply.github.com>
Date:   Mon Feb 13 14:06:08 2023 -0700

    Merge branch 'master' of github.com:ColoradoSchoolOfMines/mineshspc.com

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```

This is mostly useless. Let's make it better.

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`git log`: but actually good

For `git log` to be useful, you want it to show *all* branches, show a graph, and get rid of most of the details.

```
> git log --all --graph --decorate --oneline
* b08107c (HEAD -> master, origin/master, origin/HEAD) fix some things
*   6c1f8b5 Merge branch 'master' of github.com:ColoradoSchoolOfMines/mineshspc.com
|\
| * 67f0f4d fix background color bug
* | 47bc626 Fix accordion
|/
* 186b52a Archive overhaul
* 385666b Fix accordion arrows
* 3d0f64a Archive preliminary updates
* aaae02b Update FAQ and archive pages
*   b2a64f7 Merge branch 'master' of github.com:ColoradoSchoolOfMines/mineshspc.com
|\
| * 1450745 make footer reveal
* | f7ddfa2 Fix alt text
|/
* 0f89721 created student confirm registration page
* 7b15e86 editing teams: ensure that you can't change from in-person to remote or vice versa
* e15bda6 save team below member list
* 853dcd1 add ability to add team members
```

Branches: summary

- Branches are **pointers** to commits.
- Use `git checkout` to move between branches.
- Use `git log` to see where you are.

Merging

Merging: resolving divergent histories[3]

If you want to merge the changes from branch `A` into another branch `B`, you need to:

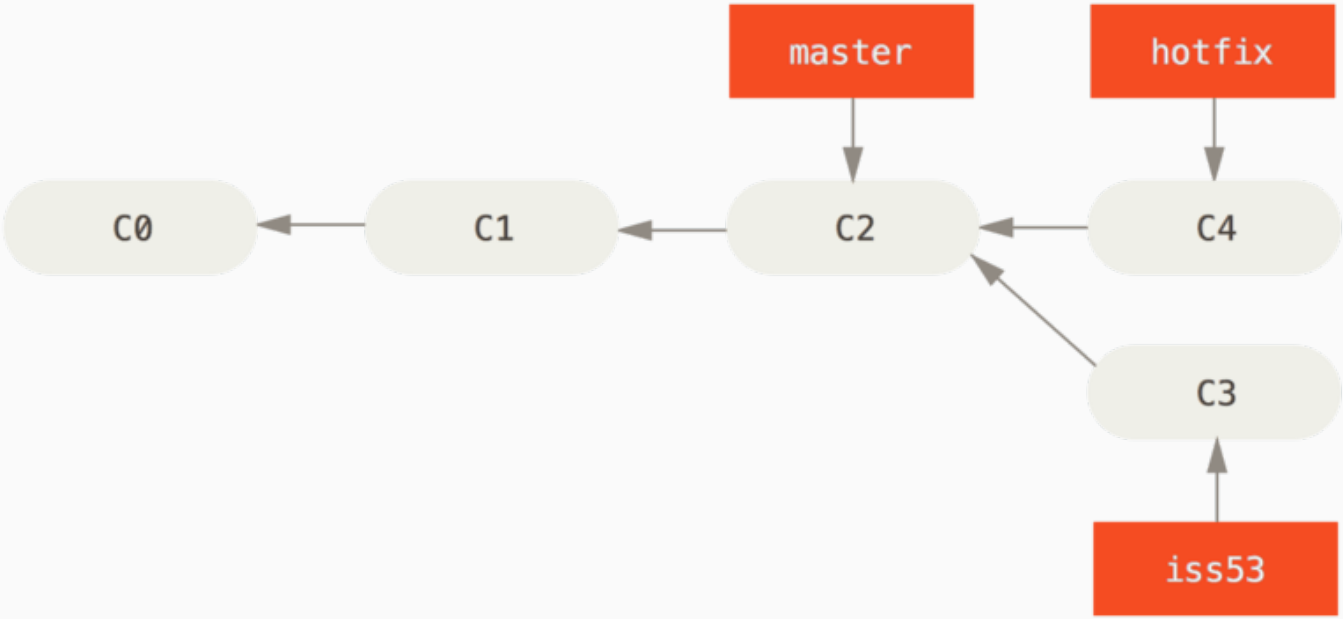
1. Switch to branch `B` (`git checkout B`)
2. Run `git merge A`.

This will do one of two things: fast-forward or create a merge commit.

[3] Info in the rest of the *Merging* section is mainly from `https://git-scm.com/book/en/v2/Git-Branching-Basic-Branching-and-Merging`

Merging: fast-forwarding

If the branch you are merging is directly ahead of the branch you are merging into, Git will just move the pointer in a **fast-forward merge**.



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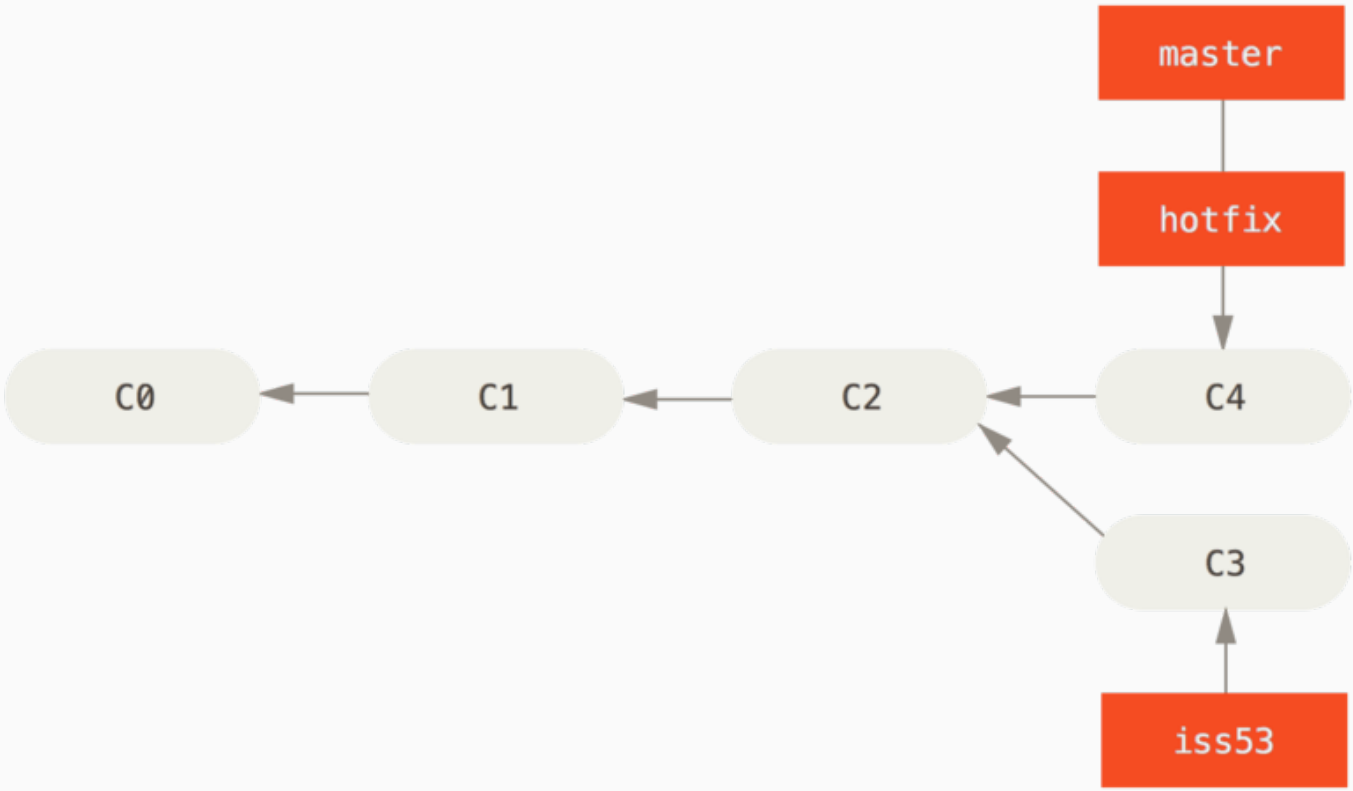
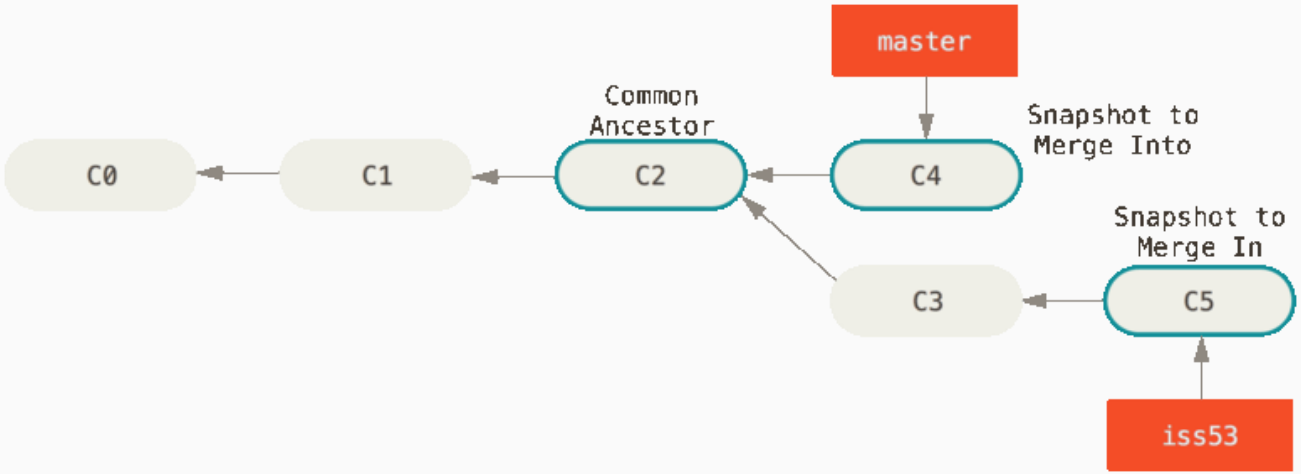


Merging: creating a merge commit

If the branch you are merging has diverged from the one you are merging into, Git will create a merge commit through a **three-way merge**.



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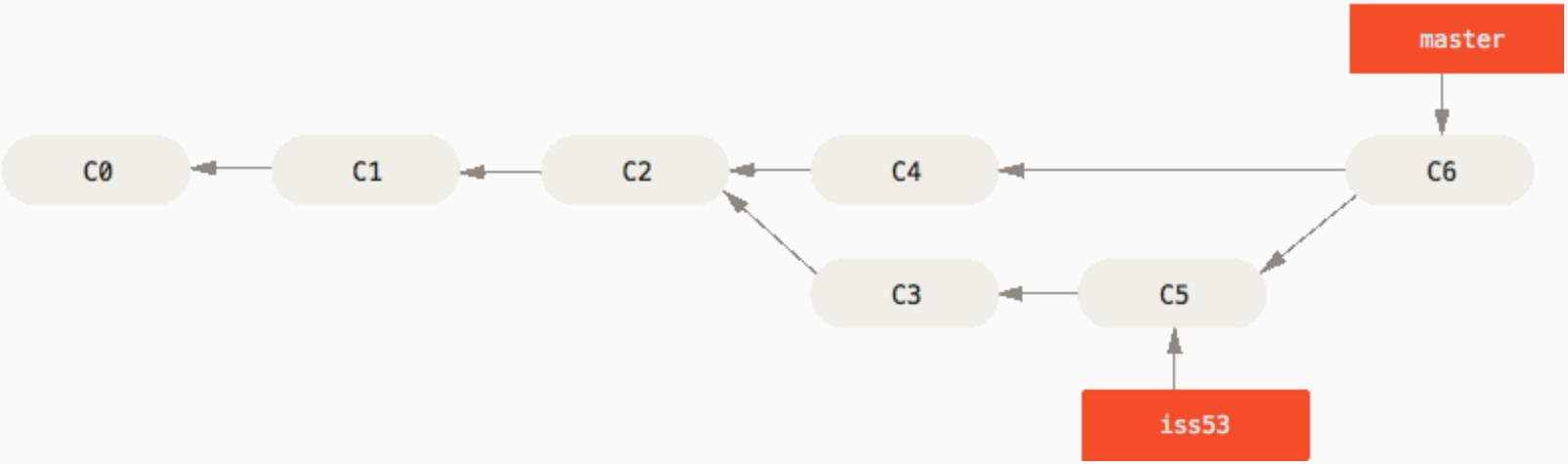

Merging: resolving conflicts

Occasionally, this process doesn't go smoothly. If you changed the same part of the same file differently in the two branches you're merging, Git won't be able to merge them cleanly.

```
> git merge iss53
Auto-merging index.html
CONFLICT (content): Merge conflict in index.html
Automatic merge failed; fix conflicts and then commit the result.
```

You can always use `git status` to see what has been automatically merged and what files have conflicts.

```
> git status
On branch master
You have unmerged paths.
  (fix conflicts and run "git commit")

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

    both modified:      index.html

no changes added to commit (use "git add" and/or "git commit -a")
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Merging: editing files to resolve merge conflicts

You can use a merge tool to resolve conflicts, however I find that it's easier to just manually resolve the conflicts.

Visual Studio Code has a good UI for this. The process you should follow is as follows:

1. Open a file with the conflict.
2. Find one of the conflict-resolution markers.
3. Make edits to resolve the conflict.
4. Run `git add` on the file.
5. Repeat steps 1-4 until all conflicts are resolved.
6. Run `git commit` to commit the merge.

Merging: understanding conflict-resolution markers

In order to find the conflict-resolution markers, search for <<<<<<<. Each conflict-resolution block should look something like this:

```
<<<<<<< HEAD:index.html
<div id="footer">contact : email.support@github.com</div>
=======
<div id="footer">
 please contact us at support@github.com
</div>
>>>>>>> iss53:index.html
```

The first part (between <<<<<<< and =======) is what the branch you are merging *into* has. The second part (between ======= and >>>>>>>) is what the branch you are merging *from* has.

Sometimes, you just one one side of the conflict, other times you need to be more nuanced in your merge.

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Merging: summary

- Merging allows you to pull changes from one branch into another branch.
- Use `git merge A` to merge branch `A` into the current branch.
- Git will do a fast-forward merge if possible, otherwise it will create a merge commit.
- You might have to resolve merge conflicts.

Rebasing

Rebasing: maintaining linear histories

Advanced Topics

Gitignore

Aliases

How to use Git with a remote

- Add Remote (`git remote add [name] [url]`): Adds a *remote*, a version of the repository hosted externally from your local machine. Most likely on something like Github or an company's internal network.
- Push (`git push -u origin master`): Pushes all changes on the given branch to the remote.
- Clone (`git clone`): Copies the entire repository to the location.
- Fetch (`git fetch`): Retrieves changes from the remote.
- Merge (`git merge`): Merges a branch into another branch. (More on branches later, but in this case, we are merging the `origin/master` into our local `master` branch.)
- Pull (`git pull`): Retrieves any new changes from the remote and merges them with your local changes.

Undoing Things

- Undo the last n commits (given that you haven't pushed them yet) `git reset --hard HEAD~n`
- Undo the n^{th} to last commit by creating a new commit that reverts all of the changes `git revert HEAD~n`
- Somebody's done it before. Just Google it.

Merging Changes I

What happens if multiple developers make changes to the same file? This will cause *merge conflicts*.

There are plenty of tools which you can use to *resolve* such conflicts. None of them are that good because merge conflicts are just terrible in general.

Play around with a bunch of them and see which one you like best. Here are a few to get you started: `Meld`, `KDiff3`, and `vimdiff`.

Merging Changes II

Invoking the *mergetool*: use `git mergetool`.

For each *conflict*, you can choose to take their version, your version, a combination of the two or neither.

Most UIs will give you three panes: one for the *remote* version of the file, one for the *local* version of the file and one for the merged version of the file.

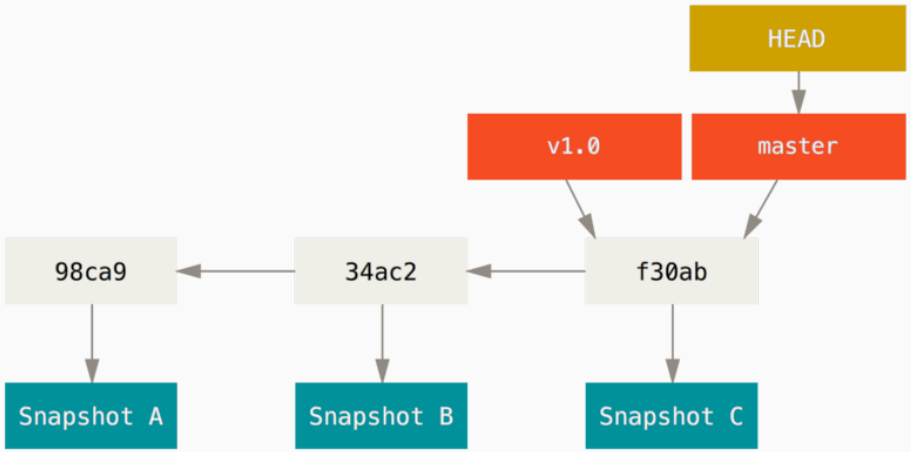
Branches I

Branches allow you to separate develop a given functionality without affecting the original code base.

For example, if you have an established product and you want to add a feature but you are uncertain about its viability, you can create a branch and build a prototype on that branch. If it fails, you can delete the branch and never see it again or if it works, you can *merge* the branch back into `master`.

Branches[4] II

Branches can be thought of as *bookmarks* pointing to a specific changeset.

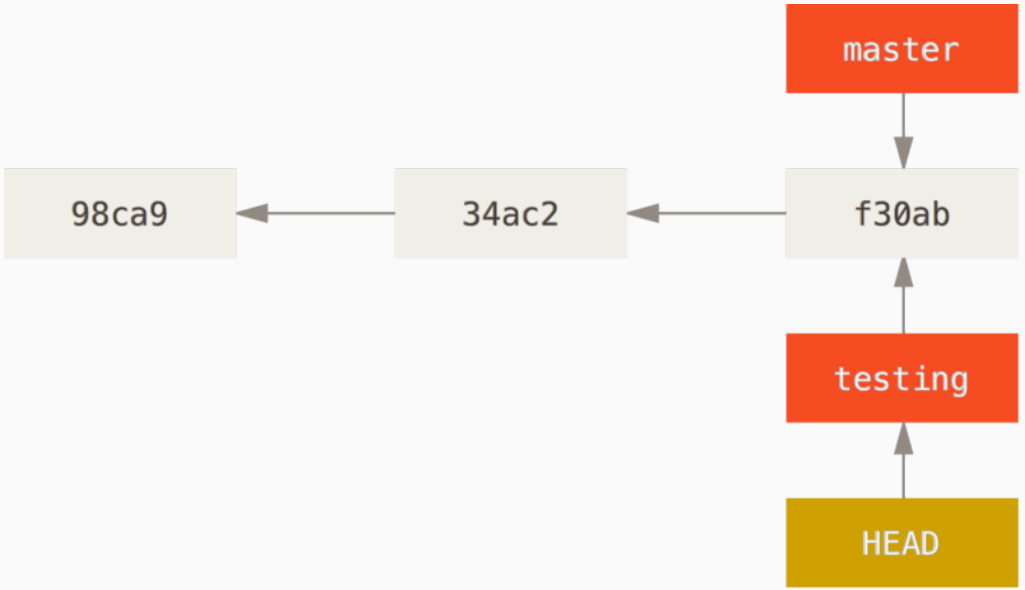


Note, `HEAD` is pointer to the current branch.

[3]Info in the rest of the *Branches* section is mainly from `https://git-scm.com/book/en/v1/Git-Branching-What-a-Branch-Is`

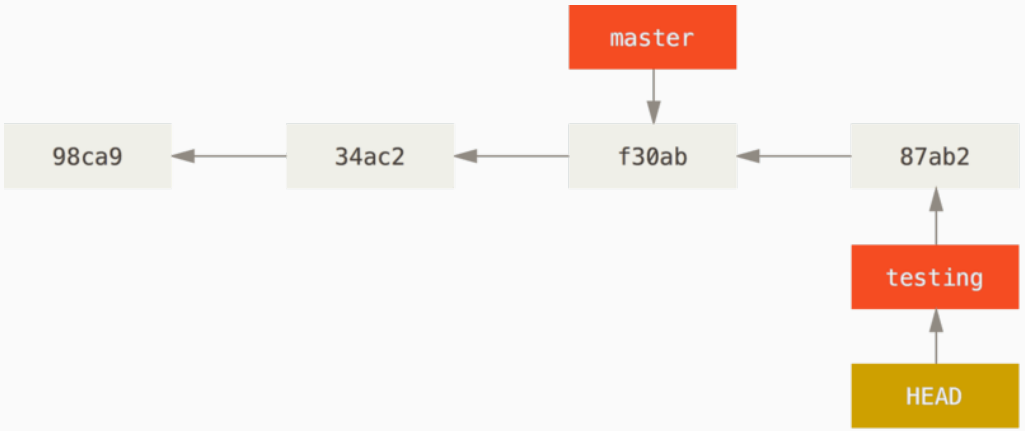
Branches III

To switch branches, use `git checkout [branch]`. This moves `HEAD` to point to your new branch.



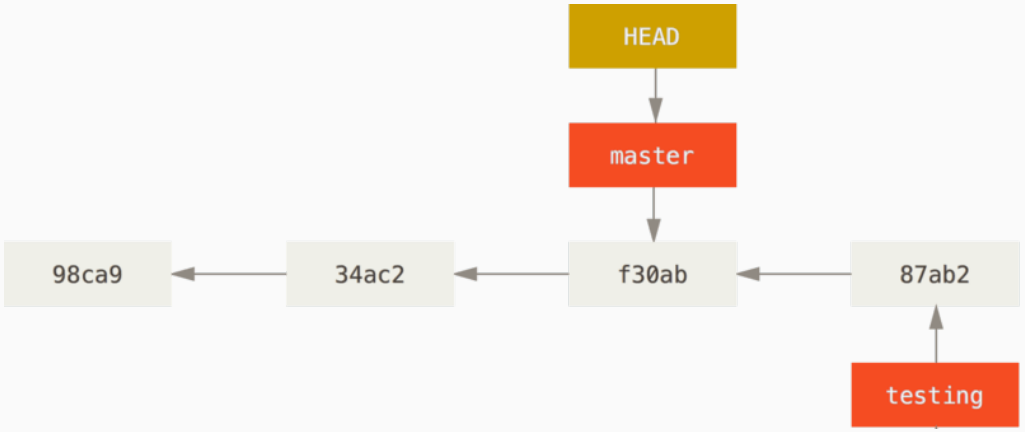
Branches IV

If you commit something to your new branch, the branch pointer moves to the new commit. The pointer to `master` will not move.



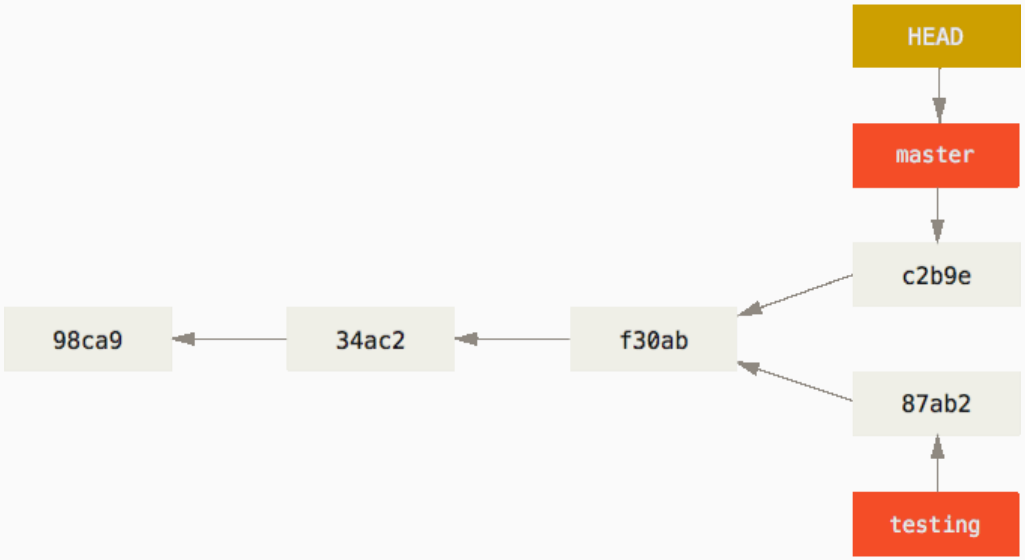
Branches V

Of course, you can always switch back to `master` using `git checkout master`.



Branches VI

If you make a commit on the master branch, the `master` pointer moves to that new commit. At this point, the branch histories have diverged.



Branches VII: How to actually do it

- **Create a Branch:** `git branch [branch_name]`
- **Switch to a branch:** `git checkout [branch_name]`
- **Create a new branch and switch to it:**
  `git checkout -b [branch_name]`
- **List branches:** `git branch`
- **Push branch to remote:** `git push -u [remote_name] [branch_name]`

Merging Changes: Branch Edition

If you want changes from a different branch in your current branch, you can use `git merge [other branch]`.

When you merge changes from another branch, one of two things will happen[5]:

1. Your branch will be fast-forwarded to the other branch.
   This means that there are no changes in your current branch that are not in the other branch.
2. A merge commit will be created and your branch pointer will be updated to point to this commit.
   This happens when there are changes in the current branch that are not in the other branch.

[4] These are the only ones I can thing of off the top of my head. You can force either of these functionalities with their respective command line options.

Branch and Development Workflow

Branches are extremely scalable so you can ignore them, or use them for everything, it's your choice.

One methodology used by companies in the industry is `Git Flow`. This is a system whereby new branches are created for every bugfix, new feature, release, and hotfix. If you want to learn more about it, look at this website: `http://nvie.com/posts/a-successful-git-branching-model/`

The Random Stuff: Stashing

When you have changes in your working directory, merges and switching branches (sometimes) doesn't work. You have two main options here:

1. Commit your changes. If you can do this, you should.
2. Occasionally you just don't want to commit. In this case, you will want to *stash* your changes using `git stash [save [stash_name]]`.
3. To un-stash, use `git stash pop`. You may have to resolve merge conflicts.

The Random Stuff: Submodules

What is a submodule? It is literally a repository inside of another repository.

Why is this useful? If you have a custom library shared between many projects, you can place that library in a standalone Git repository. Then you can add it as a submodule to your products via `git submodule add [clone_url]`.

The submodule is its own repository so it can be contributed to independently, but it can also be modified and contributed to as a submodule.

The Random Stuff: Rebasing

What is it good for? If you want to keep your graph clean, you can use rebasing to avoid merge commits.

Why would you use this? I don't know. I never have and I normally want to see all of the changes in a graph, but it's a thing that you can do in Git and if you want to learn more, read the docs.

The Random Stuff: Aliases

As one would expect from something designed and built by Linus Torvalds, Git supports the concept of *aliasing* one git command to another name.

For example, you might want to alias `checkout` to `co`. This particular alias can be achieved using
`git config --global alias.co checkout`.

Now you can invoke `git checkout` using `git co`.

Another option is using your shell's alias functionality. This is often more powerful, but that isn't part of this talk.

The Random Stuff: Resources/Tips

I obviously was unable to tell you about everything you can do with Git. I've really only scratched the surface.

- `man git *`: The man pages on Git are good. Use them as your first line of defense.
- `git-scm.com/book/en/v2`: A huge resource about how to do everything Git.
- `gitignore.io`: Generates a `.gitignore` file for a given project type, OS, and IDE.
- `git reset --hard HEAD`: Undoes all changes since the last commit.
- `git diff HEAD:file1 file2`: Shows the difference between `file1` and `file2`.

Where to Go from Here?

- If you haven't ever used Git, start by using it locally and with Github.
- If you know the basics, start exploring branches. Learn about them and find a flow which works best for you.
- If you know most things about Git, just keep using it. Try and start remembering how to do certain things that you find yourself often Googleing for.

Become the person everyone asks for Git advice. It's used in the industry, so many companies will want to see knowledge of this tool.

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