

Reset Demystified

One of the topics that I didn't cover in depth in the Pro Git book is the reset command. Most of the reason for this, honestly, is that I never strongly understood the command beyond the handful of specific use cases that I needed it for. I knew what the command did, but not really how it was designed to work.

Since then I have become more comfortable with the command, largely thanks to [Mark Dominus's article](#) re-phrasing the content of the man-page, which I always found very difficult to follow. After reading that explanation of the command, I now personally feel more comfortable using reset and enjoy trying to help others feel the same way.

This post assumes some basic understanding of how Git branching works. If you don't really know what HEAD and the Index are on a basic level, you might want to read chapters 2 and 3 of this book before reading this post.

The Three Trees of Git



The way I now like to think about reset and checkout is through the mental frame of Git being a content manager of three different trees. By 'tree' here I really mean "collection of files", not specifically the data structure. (Some Git developers will get a bit mad at me here, because there are a few cases where the Index doesn't exactly act like a tree, but for our purposes it is easier - forgive me).

Git as a system manages and manipulates three trees in its normal operation. Each of these is covered in the book, but let's review them.

Tree Roles

The HEAD	last commit snapshot, next parent
The Index	proposed next commit snapshot

The Working Directory sandbox

The HEAD last commit snapshot, next parent

The HEAD in Git is the pointer to the current branch reference, which is in turn a pointer to the last commit you made or the last commit that was checked out into your working directory. That also means it

will be the parent of the next commit you do. It's generally simplest to think of it as **HEAD is the snapshot of your last commit**.

In fact, it's pretty easy to see what the snapshot of your HEAD looks like. Here is an example of getting the actual directory listing and SHA checksums for each file in the HEAD snapshot:

```
$ cat .git/HEAD
ref: refs/heads/master

$ cat .git/refs/heads/master
e9a570524b63d2a2b3a7c3325acf5b89bbeb131e

$ git cat-file -p e9a570524b63d2a2b3a7c3325acf5b89bbeb131e
tree cfd3bf379e4f8dba8717dee55aab78aef7f4daf
author Scott Chacon 1301511835 -0700
committer Scott Chacon 1301511835 -0700

initial commit

$ git ls-tree -r cfd3bf379e4f8dba8717dee55aab78aef7f4daf
100644 blob a906cb2a4a904a152... README
100644 blob 8f94139338f9404f2... Rakefile
040000 tree 99f1a6d12cb4b6f19... lib
```

The Index next proposed commit snapshot

The Index is your proposed next commit. Git populates it with a list of all the file contents that were last checked out into your working directory and what they looked like when they were originally checked out. It's not technically a tree structure, it's a flattened manifest, but for our purposes it's close enough. When you run `git commit`, that command only looks at your Index by default, not at anything in your working directory. So, it's simplest to think of it as **the Index is the snapshot of your next commit**.

```
$ git ls-files -s
100644 a906cb2a4a904a152e80877d4088654daad0c859 0      README
100644 8f94139338f9404f26296befa88755fc2598c289 0      Rakefile
100644 47c6340d6459e05787f644c2447d2595f5d3a54b 0      lib/simplegit.rb
```

The Working Directory sandbox, scratch area

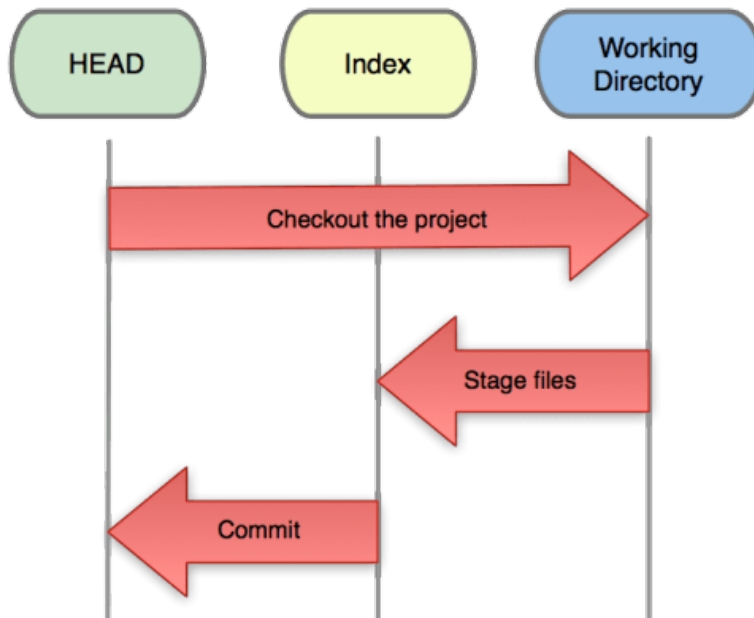
Finally, you have your working directory. This is where the content of files are placed into actual files on your filesystem so they're easily edited by you. **The Working Directory is your scratch space, used to easily modify file content.**

```
$ tree
.
├── README
├── Rakefile
└── lib
    └── simplegit.rb

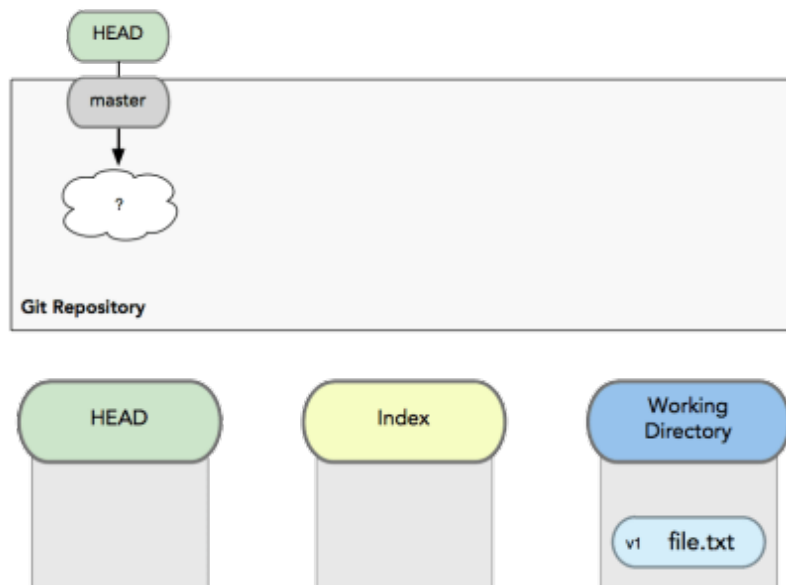
1 directory, 3 files
```

The Workflow

So, Git is all about recording snapshots of your project in successively better states by manipulating these three trees, or collections of contents of files.

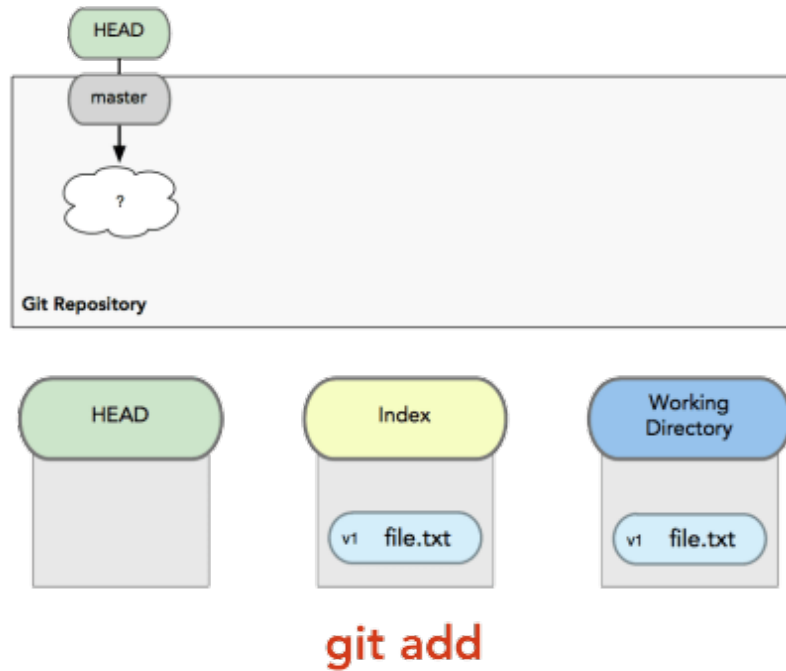


Let's visualize this process. Say you go into a new directory with a single file in it. We'll call this V1 of the file and we'll indicate it in blue. Now we run `git init`, which will create a Git repository with a HEAD reference that points to an unborn branch (aka, *nothing*)

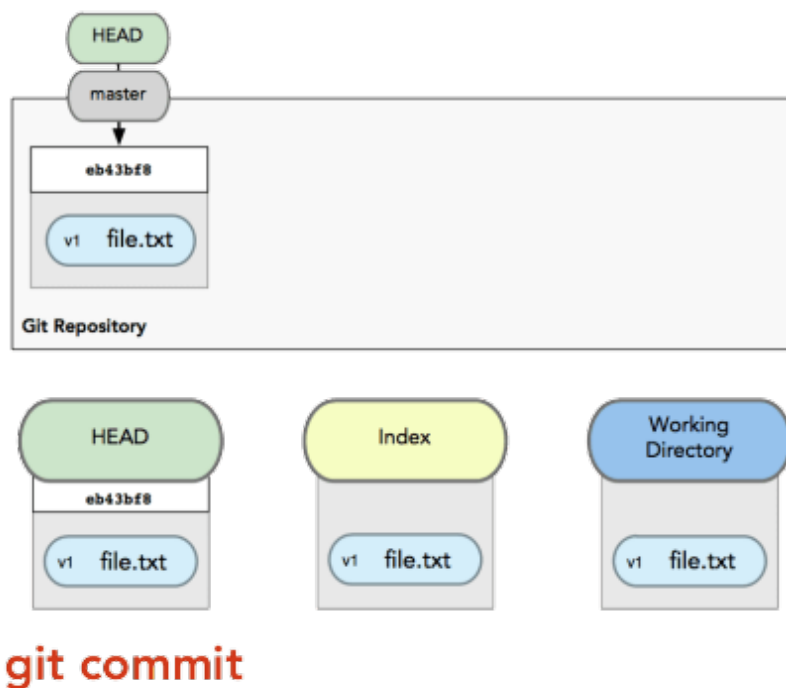


At this point, only the **Working Directory** tree has any content.

Now we want to commit this file, so we use `git add` to take content in your Working Directory and populate our Index with the updated content

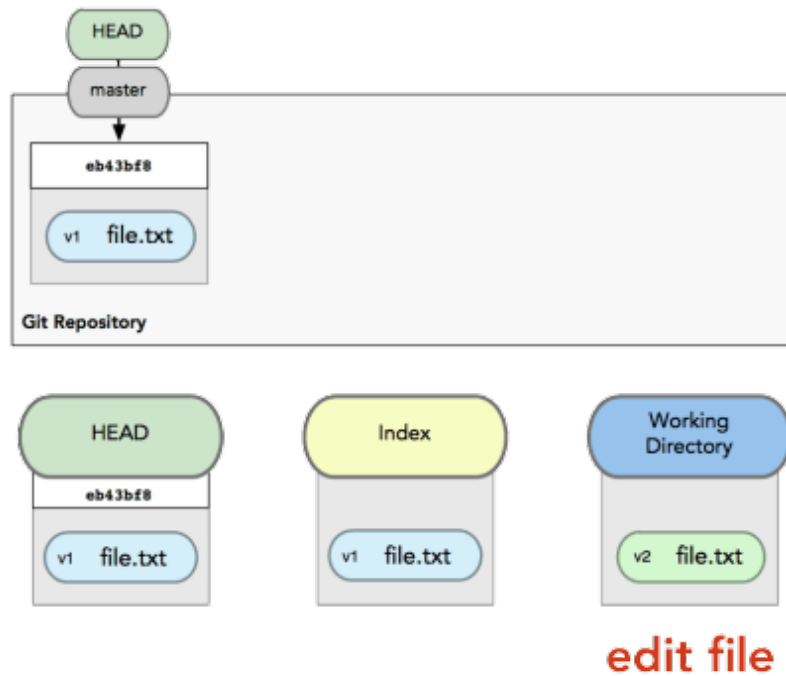


Then we run `git commit` to take what the Index looks like now and save it as a permanent snapshot pointed to by a commit, which HEAD is then updated to point at.

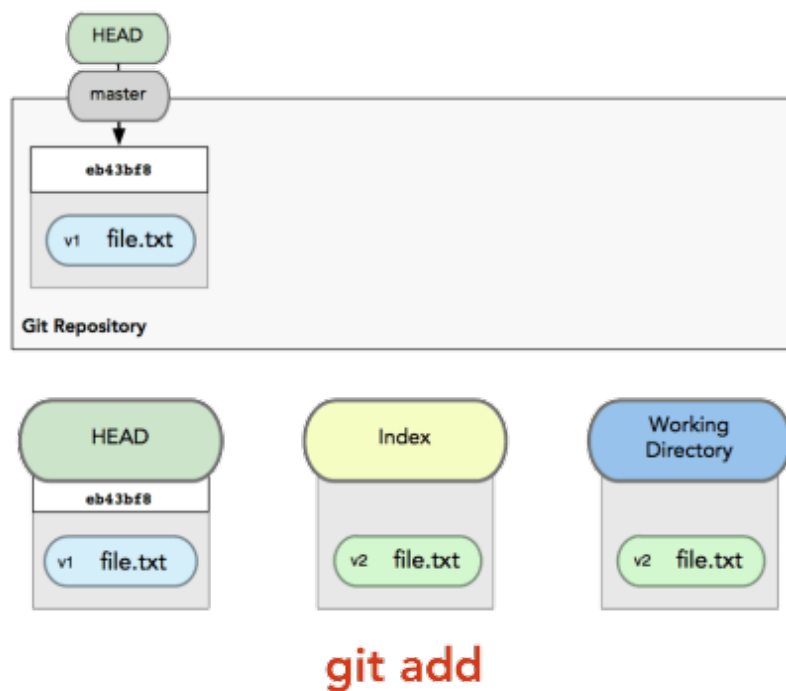


At this point, all three of the trees are the same. If we run `git status` now, we'll see no changes because they're all the same.

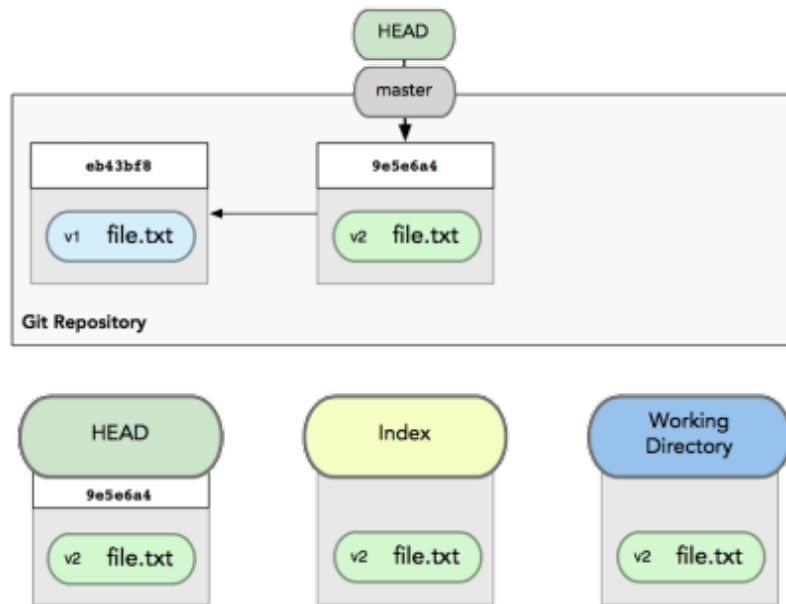
Now we want to make a change to that file and commit it. We will go through the same process. First we change the file in our working directory.



If we run `git status` right now we'll see the file in red as "changed but not updated" because that entry differs between our Index and our Working Directory. Next we run `git add` on it to stage it into our Index.



At this point if we run `git status` we will see the file in green under 'Changes to be Committed' because the Index and HEAD differ - that is, our proposed next commit is now different from our last commit. Those are the entries we will see as 'to be Committed'. Finally, we run `git commit` to finalize the commit.



git commit

Now `git status` will give us no output because all three trees are the same.

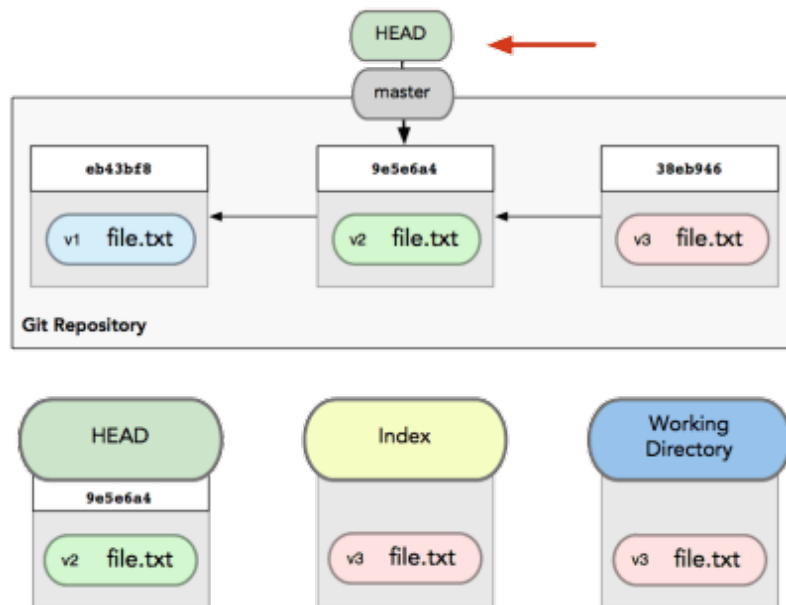
Switching branches or cloning goes through a similar process. When you checkout a branch, it changes **HEAD** to point to the new commit, populates your **Index** with the snapshot of that commit, then checks out the contents of the files in your **Index** into your **Working Directory**.

The Role of Reset

So the `reset` command makes more sense when viewed in this context. It directly manipulates these three trees in a simple and predictable way. It does up to three basic operations.

Step 1: Moving HEAD killing me --soft ly

The first thing `reset` will do is move what **HEAD** points to. Unlike `checkout` it does not move what branch **HEAD** points to, it directly changes the SHA of the reference itself. This means if **HEAD** is pointing to the 'master' branch, running `git reset 9e5e6a4` will first of all make 'master' point to 9e5e6a4 before it does anything else.



`git reset --soft HEAD~`

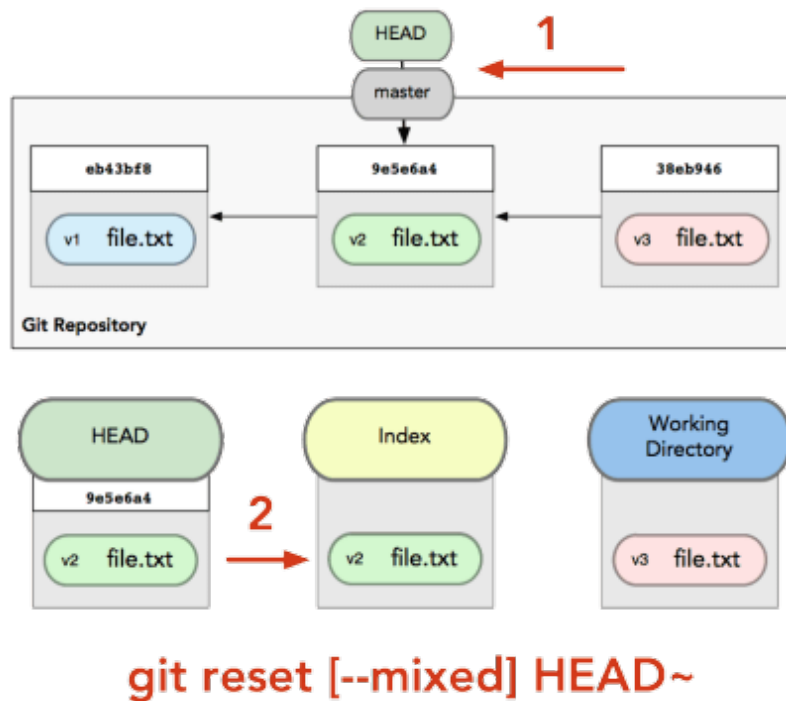
No matter what form of reset with a commit you invoke, this is the first thing it will always try to do. If you add the flag `--soft`, this is the **only** thing it will do. With `--soft`, reset will simply stop there.

Now take a second to look at that diagram and realize what it did. It essentially undid the last commit you made. When you run `git commit`, Git will create a new commit and move the branch that `HEAD` points to up to it. When you reset back to `HEAD~` (the parent of `HEAD`), you are moving the branch back to where it was without changing the Index (staging area) or Working Directory. You could now do a bit more work and commit again to accomplish basically what `git commit --amend` would have done.

Step 2: Updating the Index having `--mixed` feelings

Note that if you run `git status` now you'll see in green the difference between the Index and what the new `HEAD` is.

The next thing reset will do is to update the Index with the contents of whatever tree `HEAD` now points to so they're the same.

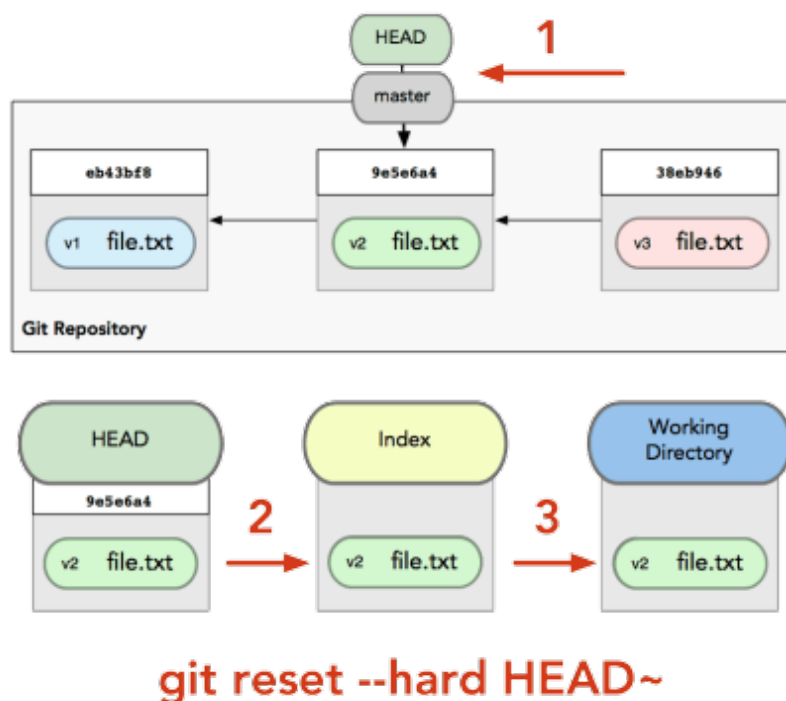


If you specify the `--mixed` option, reset will stop at this point. This is also the default, so if you specify no option at all, this is where the command will stop.

Now take another second to look at THAT diagram and realize what it did. It still undid your last commit, but also *unstaged* everything. You rolled back to before you ran all your `git adds` *AND* `git commit`.

Step 3: Updating the Working Directory with `--hard`, let's go shopping

The third thing that reset will do is to then make the Working Directory look like the Index. If you use the `--hard` option, it will continue to this stage.



Finally, take yet a third second to look at *that* diagram and think about what happened. You undid your last commit, all the `git adds`, *and* all the work you did in your working directory.

It's important to note at this point that this is the only way to make the `reset` command dangerous (ie: not working directory safe). Any other invocation of `reset` can be pretty easily undone, the `--hard` option cannot, since it overwrites (without checking) any files in the Working Directory. In this particular case, we still have `v3` version of our file in a commit in our Git DB that we could get back by looking at our `reflog`, but if we had not committed it, Git still would have overwritten the file.

Overview

That is basically it. The `reset` command overwrites these three trees in a specific order, stopping when you tell it to.

- #1) Move whatever branch HEAD points to (stop if `--soft`)
- #2) THEN, make the Index look like that (stop here unless `--hard`)
- #3) THEN, make the Working Directory look like that

There are also `--merge` and `--keep` options, but I would rather keep things simpler for now - that will be for another article.

Boom. You are now a reset master.

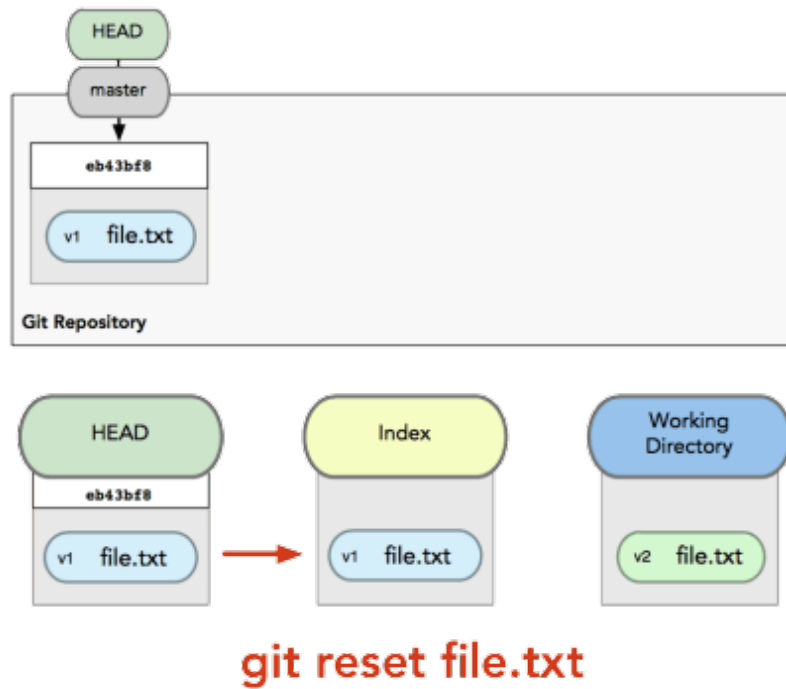
Reset with a Path

Well, I lied. That's not actually all. If you specify a path, `reset` will skip the first step and just do the other ones but limited to a specific file or set of files. This actually sort of makes sense - if the first step is to move a pointer to a different commit, you can't make it point to *part* of a commit, so it simply doesn't do that part. However, you can use `reset` to update part of the Index or the Working Directory with previously committed content this way.

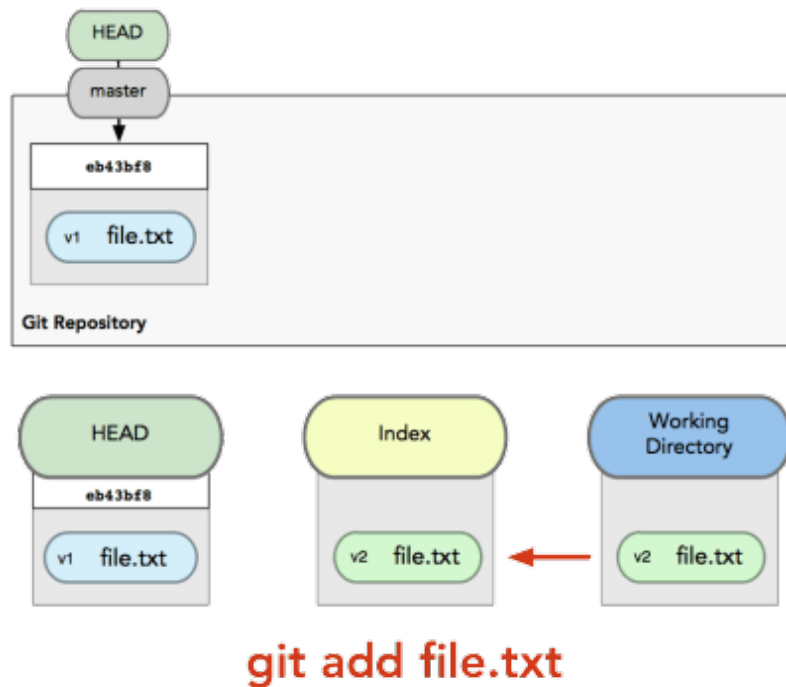
So, assume we run `git reset file.txt`. This assumes, since you did not specify a commit SHA or branch that points to a commit SHA, and that you provided no `reset` option, that you are typing the shorthand for `git reset --mixed HEAD file.txt`, which will:

- ~~#1) Move whatever branch HEAD points to (stop if `--soft`)~~
- #2) THEN, make the Index look like that ~~(stop here unless `--hard`)~~

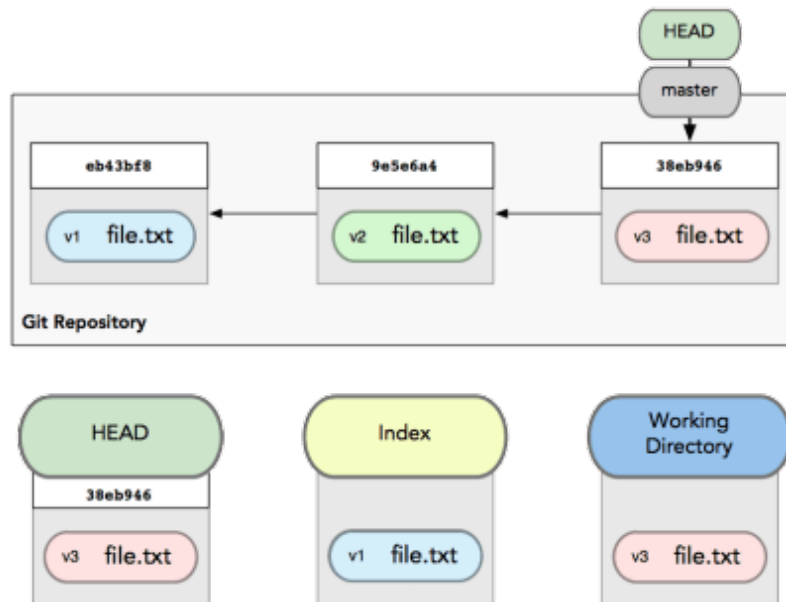
So it essentially just takes whatever `file.txt` looks like in HEAD and puts that in the Index.



So what does that do in a practical sense? Well, it *unstages* the file. If we look at the diagram for that command vs what `git add` does, we can see that it is simply the opposite. This is why the output of the `git status` command suggests that you run this to unstage a file.



We could just as easily not let Git assume we meant "pull the data from HEAD" by specifying a specific commit to pull that file version from to populate our Index by running something like `git reset eb43bf file.txt`.



git reset eb43 -- file.txt

So what does that mean? That functionally does the same thing as if we had reverted the content of the file to **v1**, ran `git add` on it, then reverted it back to **v3** again. If we run `git commit`, it will record a change that reverts that file back to **v1**, even though we never actually had it in our Working Directory again.

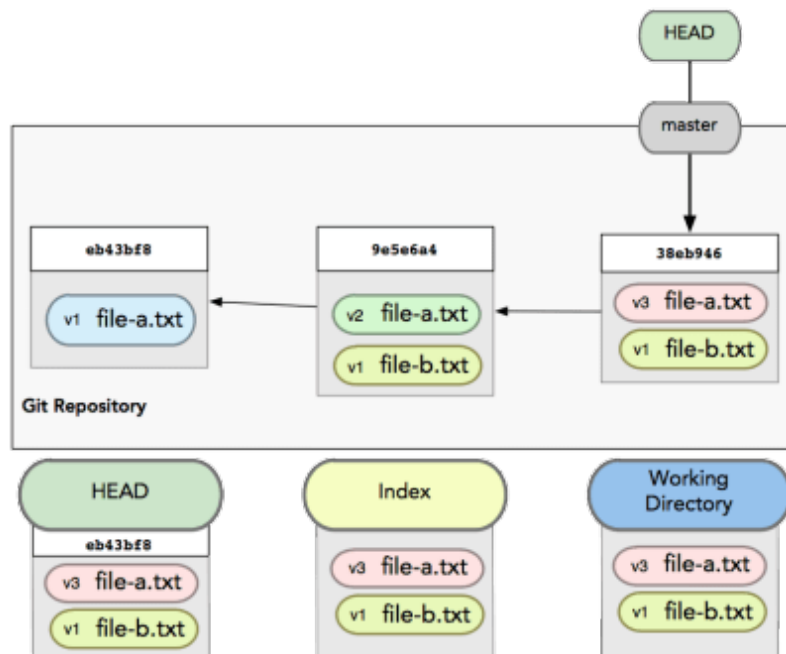
It's also pretty interesting to note that like `git add --patch`, the reset command will accept a `--patch` option to unstage content on a hunk-by-hunk basis. So you can selectively unstage or revert content.

A fun example

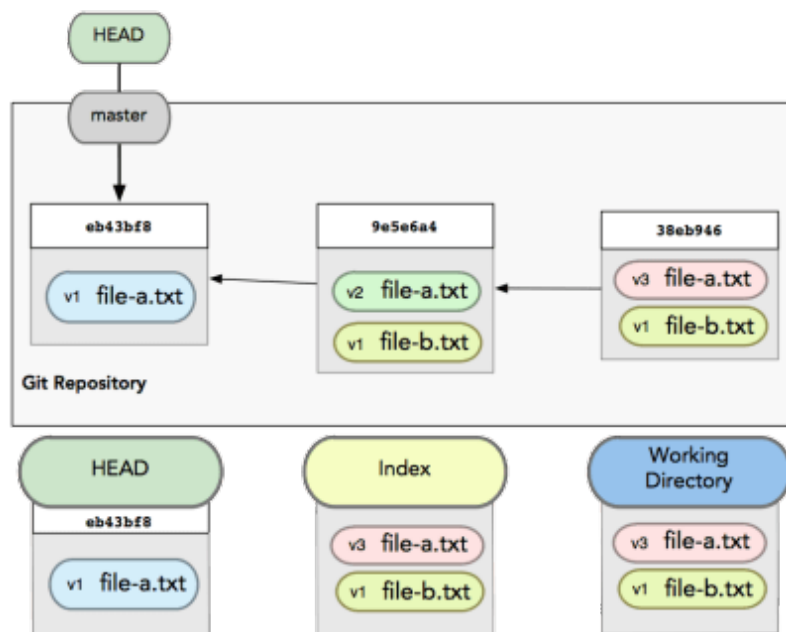
I may use the term "fun" here a bit loosely, but if this doesn't sound like fun to you, you may drink while doing it. Let's look at how to do something interesting with this newfound power - squashing commits.

If you have this history and you're about to push and you want to squash down the last N commits you've done into one awesome commit that makes you look really smart (vs a bunch of commits with messages like "oops.", "WIP" and "forgot this file") you can use reset to quickly and easily do that (as opposed to using `git rebase -i`).

So, let's take a slightly more complex example. Let's say you have a project where the first commit has one file, the second commit added a new file and changed the first, and the third commit changed the first file again. The second commit was a work in progress and you want to squash it down.

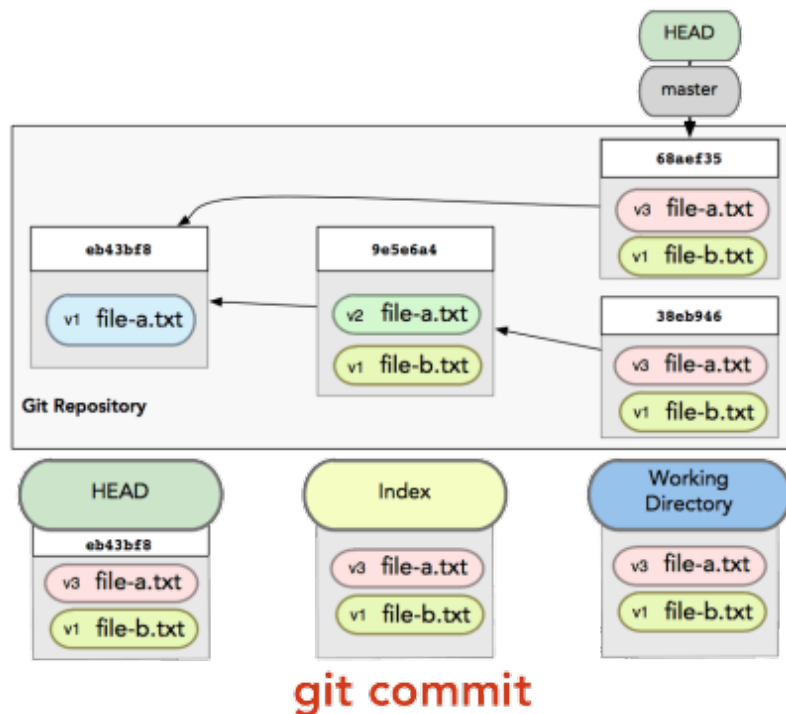


You can run `git reset --soft HEAD~2` to move the HEAD branch back to an older commit (the first commit you want to keep):



git reset HEAD~2

And then simply run `git commit` again:



Now you can see that your reachable history, the history you would push, now looks like you had one commit with the one file, then a second that both added the new file and modified the first to it's final state.

Check it out

Finally, some of you may wonder what the difference between `checkout` and `reset` is. Well, like `reset`, `checkout` manipulates the three trees and it is a bit different depending on whether you give the command a file path or not. So, let's look at both examples separately.

git checkout [branch]

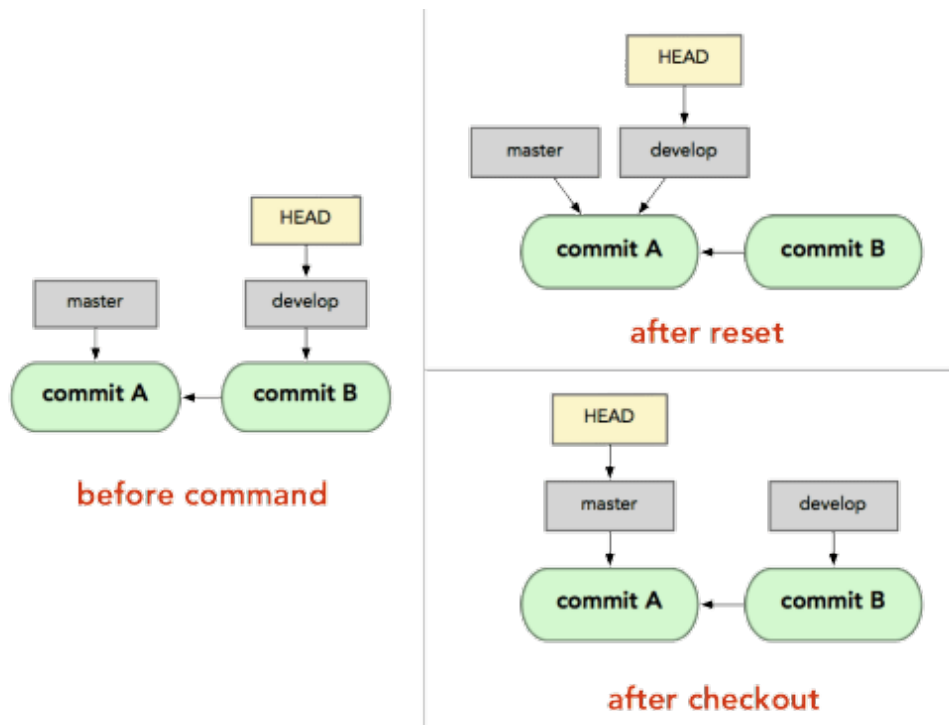
Running `git checkout [branch]` is pretty similar to running `git reset --hard [branch]` in that it updates all three trees for you to look like `[branch]`, but there are two important differences.

First, unlike `reset --hard`, `checkout` is working directory safe in this invocation. It will check to make sure it's not blowing away files that have changes to them. Actually, this is a subtle difference, because it will update all of the working directory except the files you've modified if it can - it will do a trivial merge between what you're checking out and what's already there. In this case, `reset --hard` will simply replace everything across the board without checking.

The second important difference is how it updates **HEAD**. Where `reset` will move the branch that **HEAD** points to, `checkout` will move **HEAD** itself to point to another branch.

For instance, if we have two branches, 'master' and 'develop' pointing at different commits, and we're currently on 'develop' (so **HEAD** points to it) and we run `git reset master`, 'develop' itself will now point to the same commit that 'master' does.

On the other hand, if we instead run `git checkout master`, 'develop' will not move, **HEAD** itself will. **HEAD** will now point to 'master'. So, in both cases we're moving **HEAD** to point to commit A, but *how* we do so is very different. `reset` will move the branch **HEAD** points to, `checkout` moves **HEAD** itself to point to another branch.



git checkout [branch] file

The other way to run checkout is with a file path, which like reset, does not move HEAD. It is just like `git reset [branch] file` in that it updates the index with that file at that commit, but it also overwrites the file in the working directory. Think of it like `git reset --hard [branch] file` - it would be exactly the same thing, it is also not working directory safe and it also does not move HEAD. The only difference is that reset with a file name will not accept `--hard`, so you can't actually run that.

Also, like `git reset` and `git add`, checkout will accept a `--patch` option to allow you to selectively revert file contents on a hunk-by-hunk basis.

Cheaters Gonna Cheat

Hopefully now you understand and feel more comfortable with the reset command, but are probably still a little confused about how exactly it differs from checkout and could not possibly remember all the rules of the different invocations.

So to help you out, I've created something that I pretty much hate, which is a table. However, if you've followed the article at all, it may be a useful cheat sheet or reminder. The table shows each class of the reset and checkout commands and which of the three trees it updates.

Pay especial attention to the 'WD Safe?' column - if it's red, really think about it before you run that command.

	head	index	work dir	wd safe
Commit Level				
<code>reset --soft [commit]</code>	REF	NO	NO	YES
<code>reset [commit]</code>	REF	YES	NO	YES
<code>reset --hard [commit]</code>	REF	YES	YES	NO
<code>checkout [commit]</code>	HEAD	YES	YES	YES
File Level				
<code>reset (commit) [file]</code>	NO	YES	NO	YES

checkout (commit) [file] NO YES YES NO

Good night, and good luck.

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Patches, suggestions and comments are welcome.

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