git

...demystified

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Git introduction

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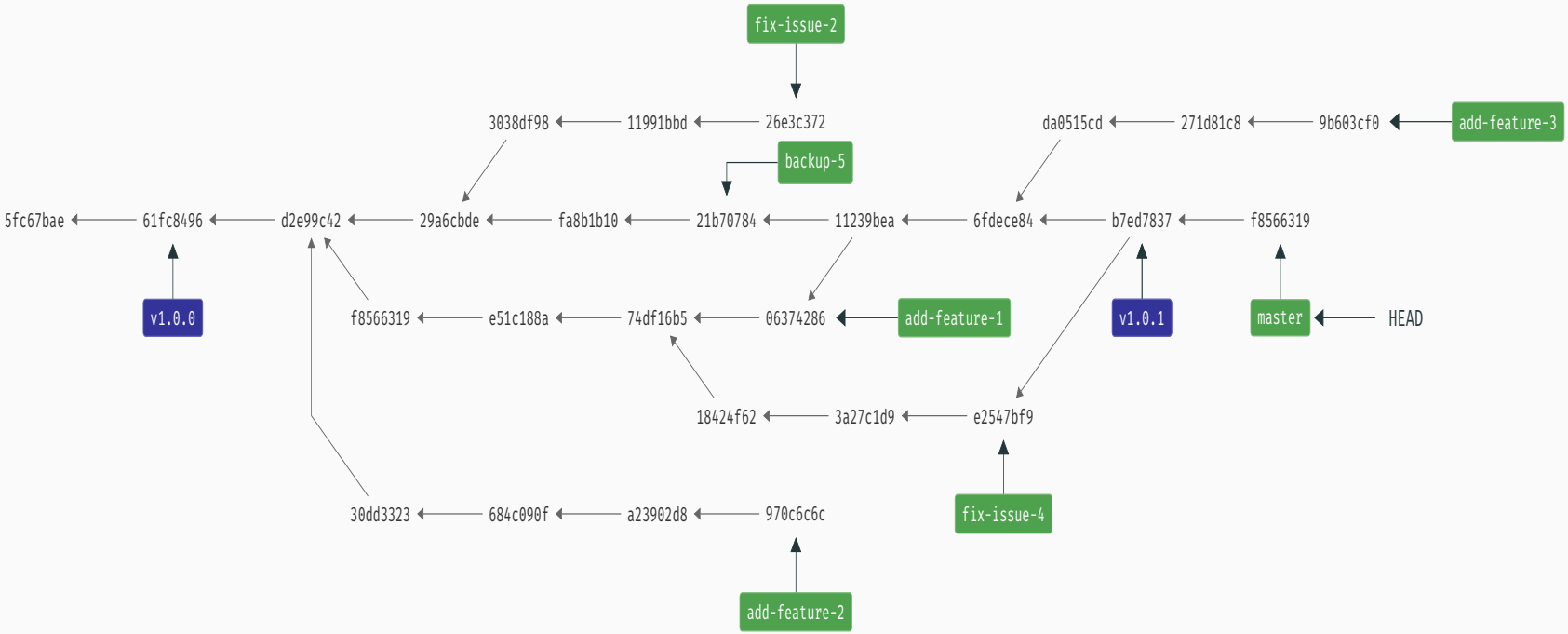
Git history

`git` = version-control system

- First commit (!) in April 2005 by Linus Torvalds.
  - Maintained since July 2005 mainly by Junio Hamano (Google).
  - Stable release: 2.19.1 (version < 2.13 no longer supported).
- Git repository of git itself:
  - `https://git.kernel.org/pub/scm/git/git.git/`
  - `https://github.com/git/git` (publish only)
- Documentation and useful resources:
  `https://git-scm.com/`

Git in one picture

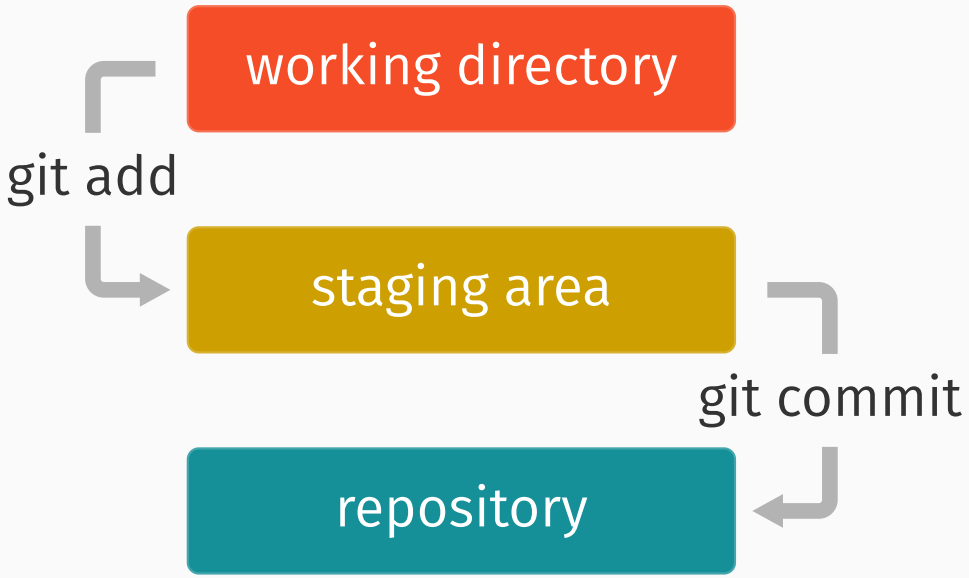
`git` is graph-based —



Git architecture

`git` manages 3 different zones locally:

- the working directory;
- the staging area (or index);
- the repository.



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Remote location of your repository (e.g., Github). Also called upstream.

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local repository	Local version of remote repository. Contains all the (synchronized) history of your project.
remote repository	Remote location of your repository (e.g., Github). Also called upstream.

Git architecture — In reality...

stash	Temporary zone to backup files when performing other `git` operations.
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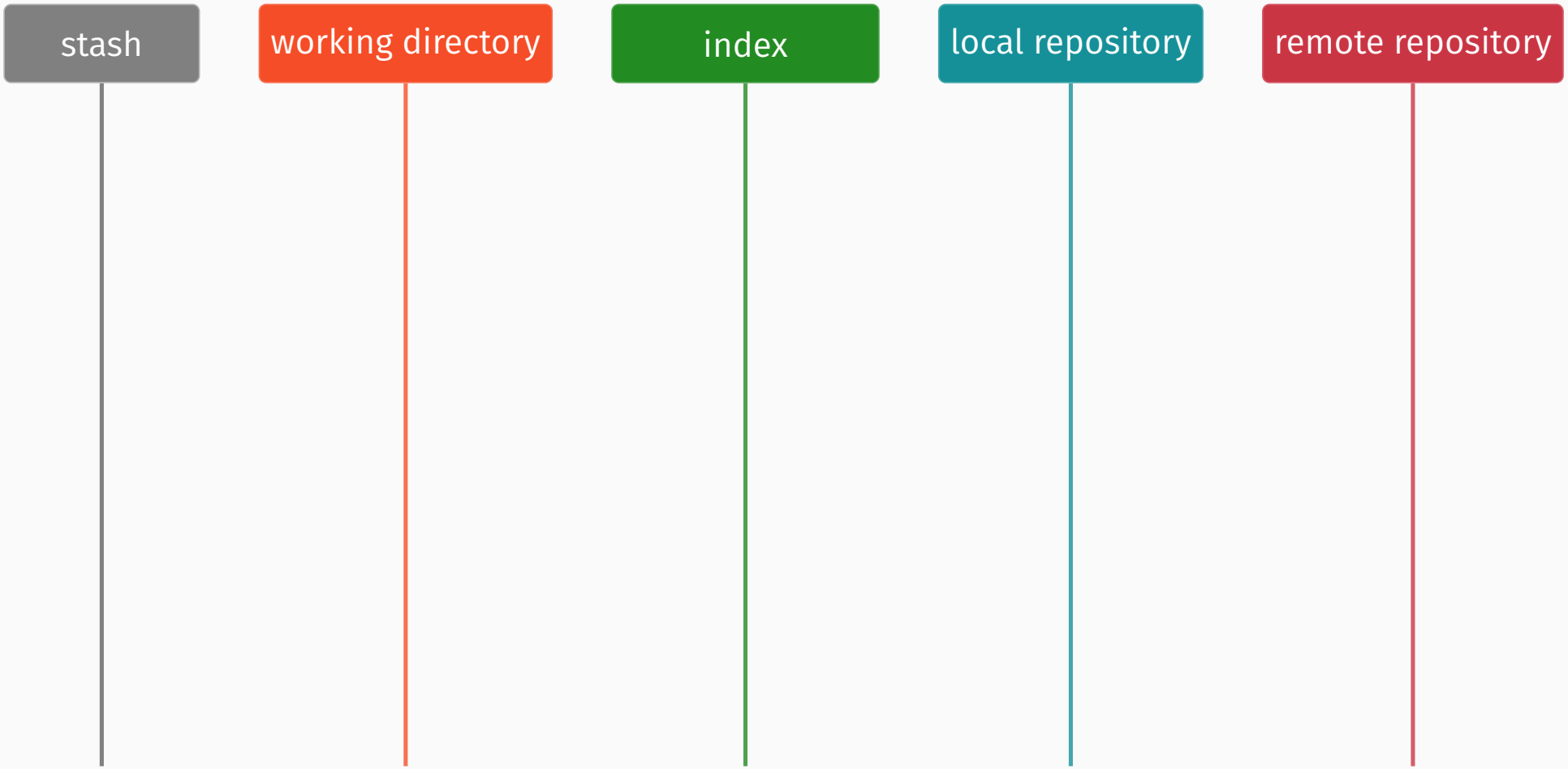

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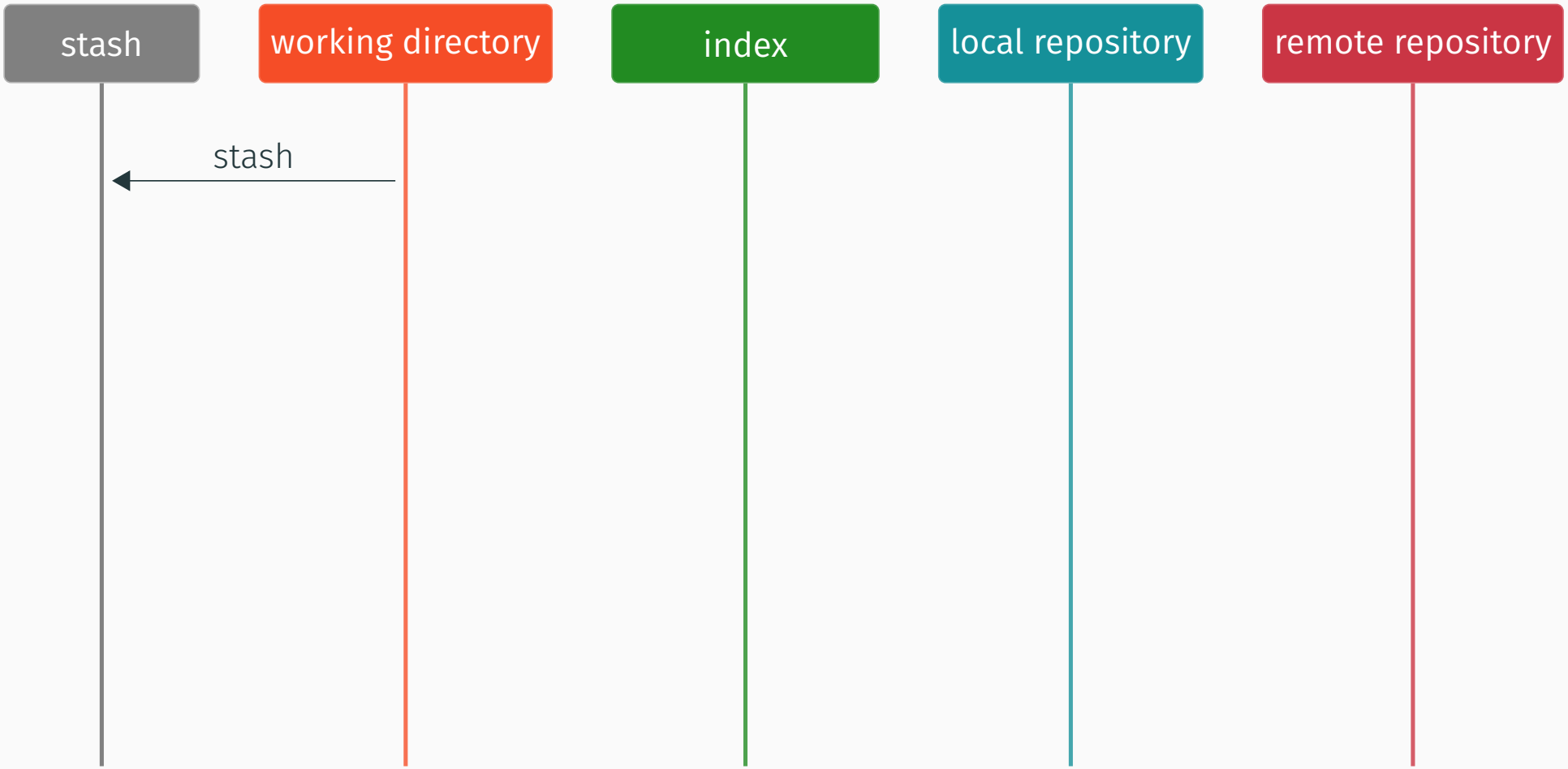

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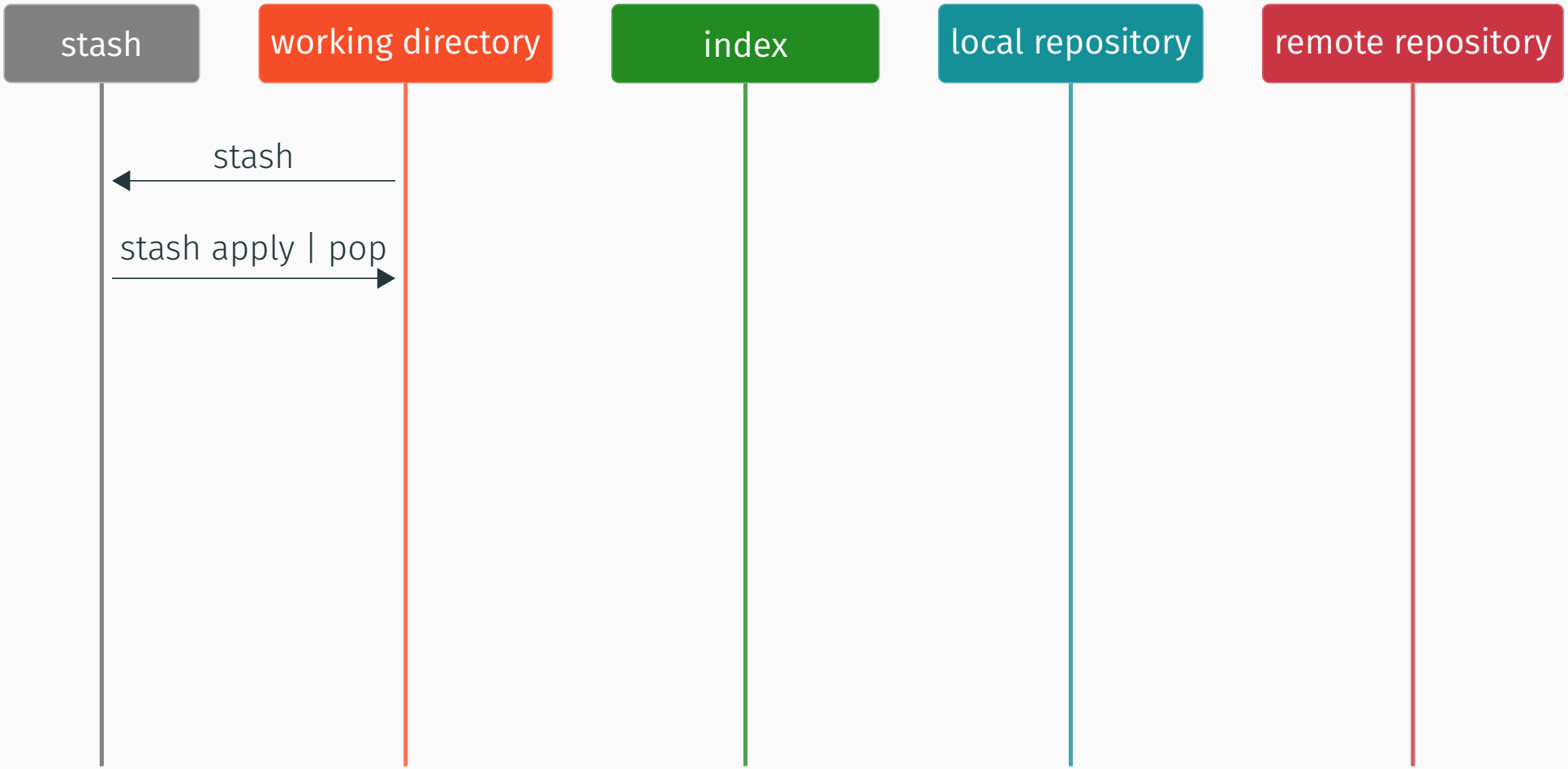

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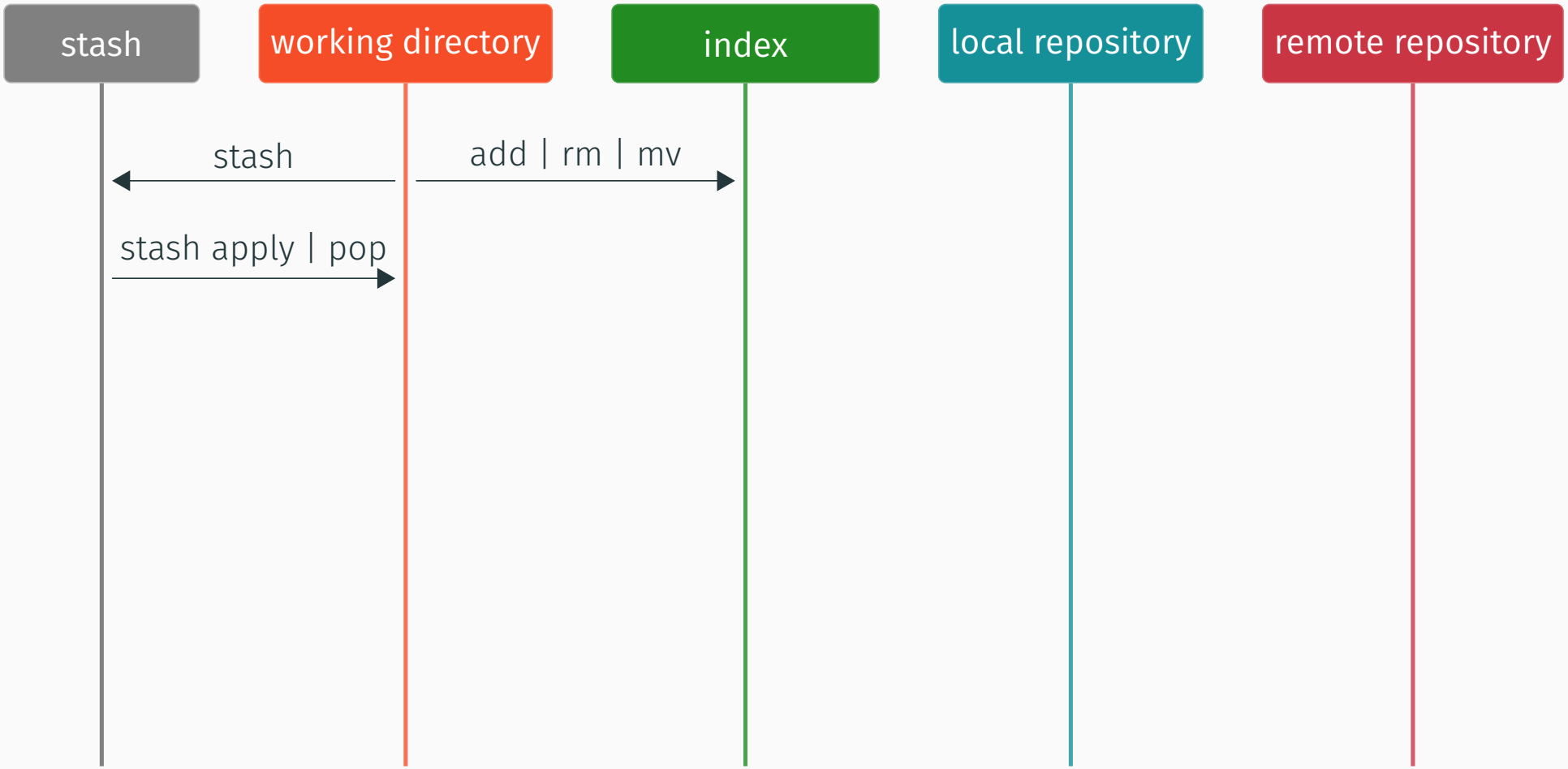

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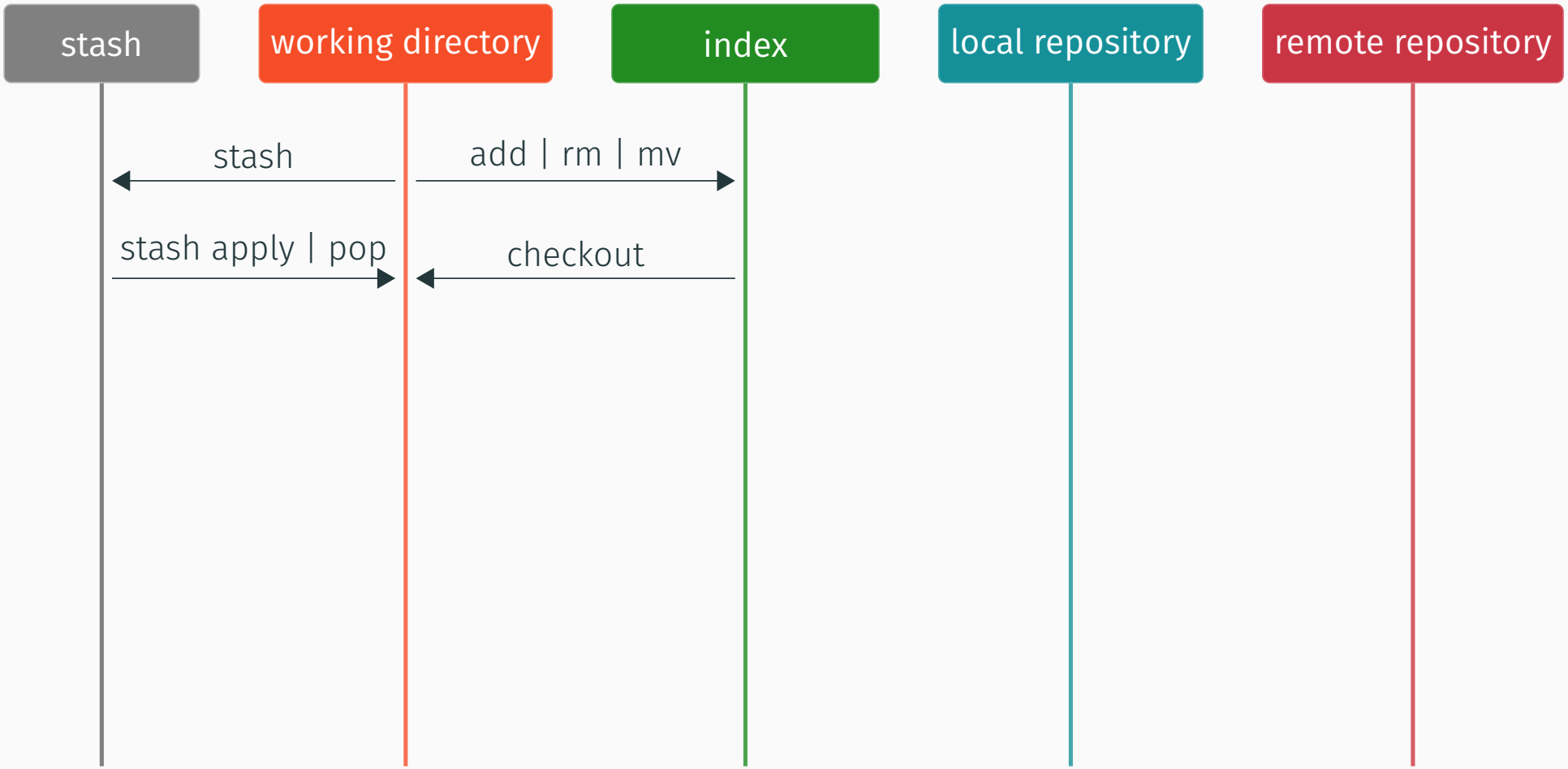

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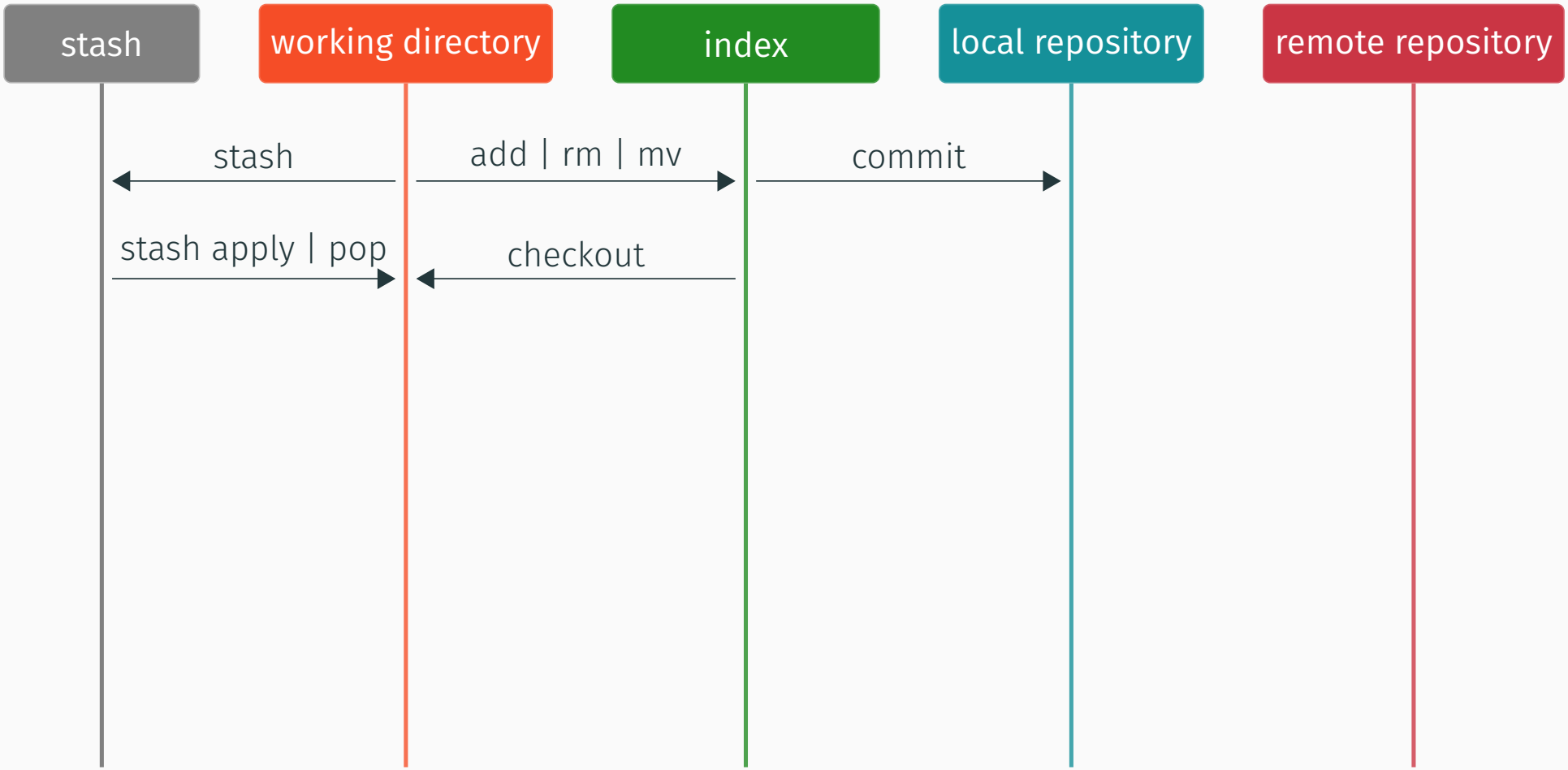

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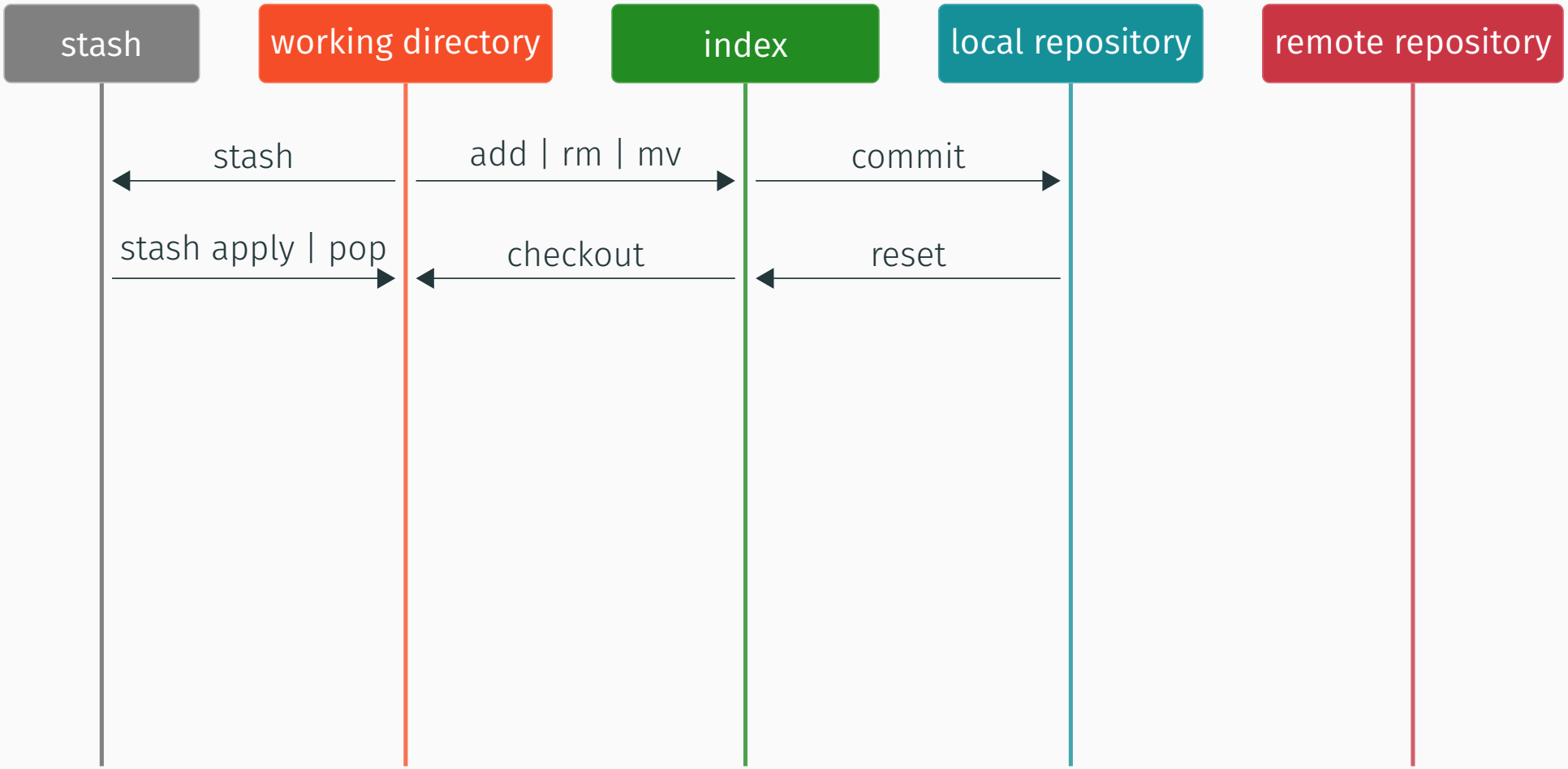

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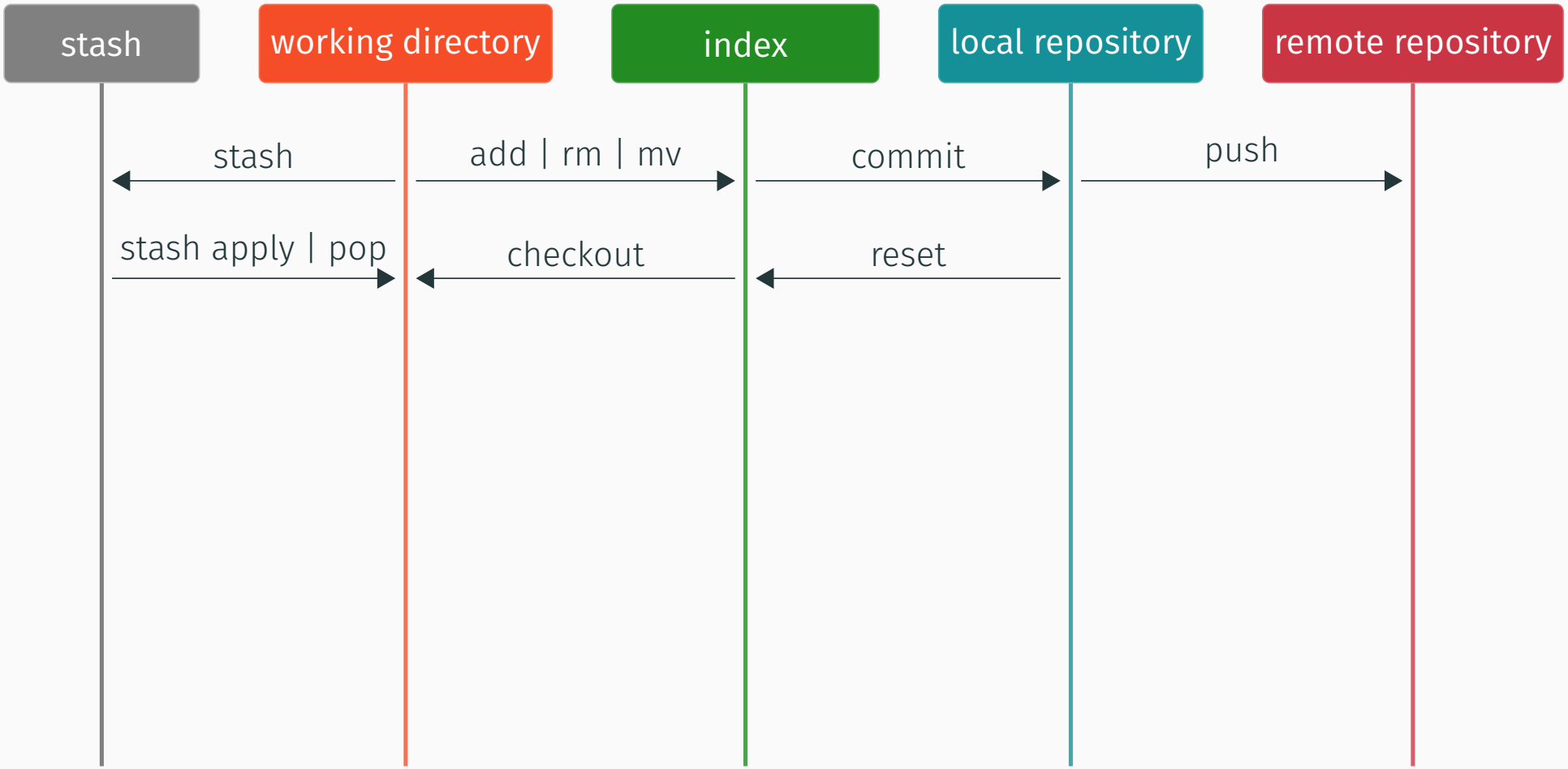

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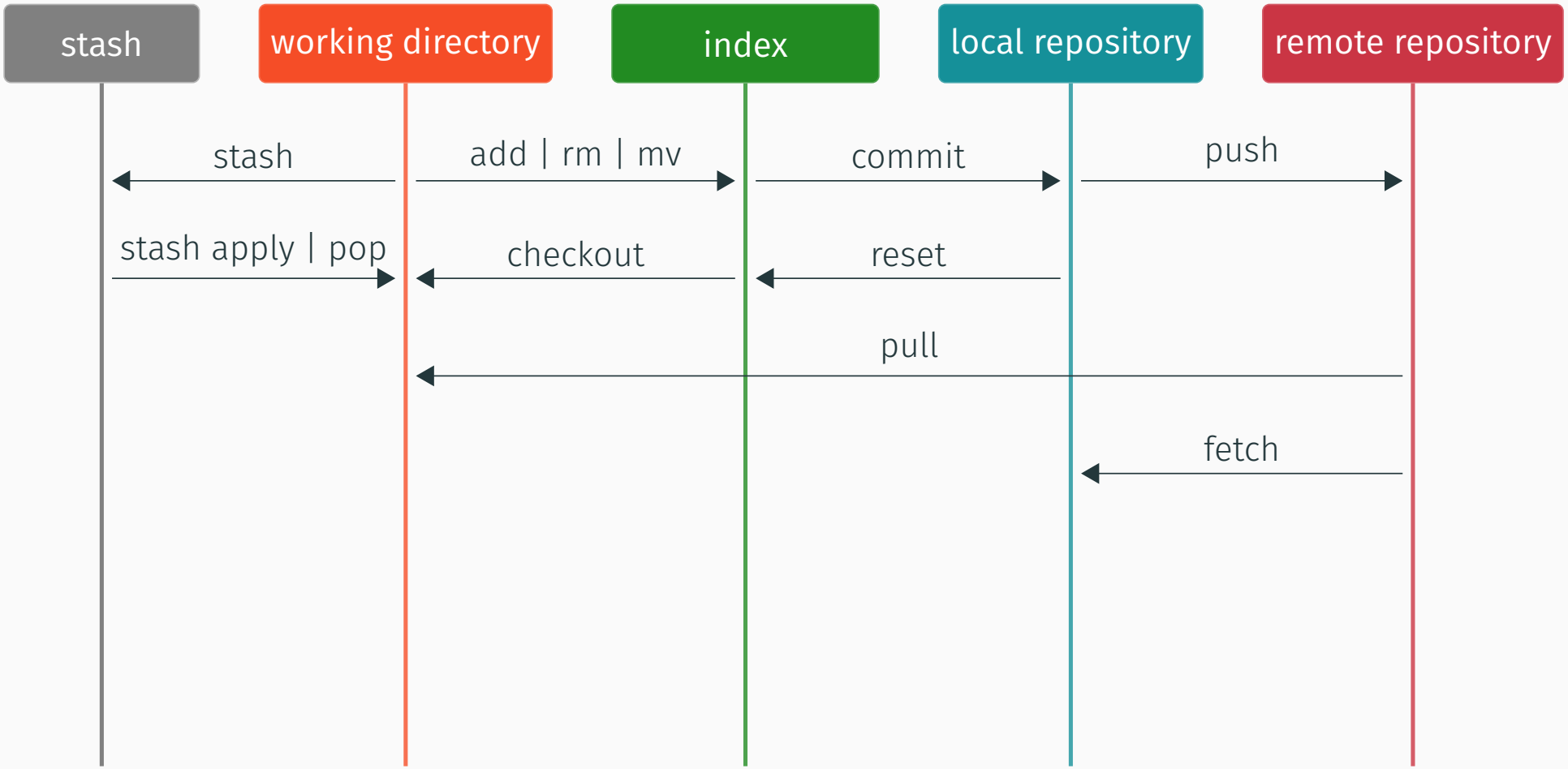

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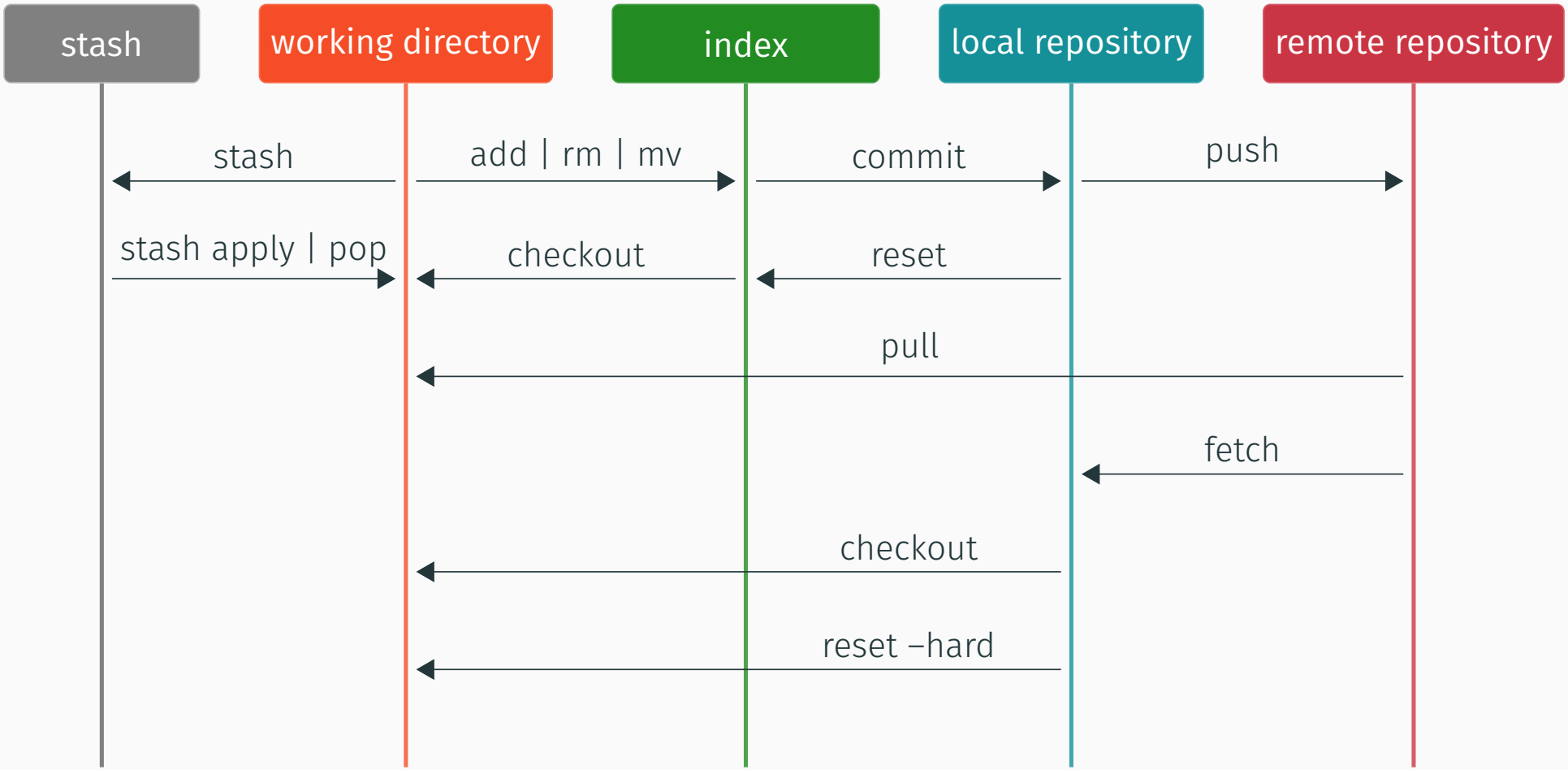

Where's my HEAD?

HEAD is a symbolic reference to (usually) the current branch —

- `HEAD` is stored in `.git/HEAD`;
- `HEAD` can be detached and points directly to a commit;
- `HEAD` is (indirectly) used to determine the parent(s) of new commits;
- by default, **`HEAD`** points to the `refs/heads/master` reference;
- there are many "`HEAD`"s: `HEAD`, `FETCH_HEAD`, `ORIG_HEAD`, ...

Git commands — An introduction

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Cheatsheet:
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Windows users? Use **Git Bash**, included when downloading the official `git` at `https://git-scm.com/download/win`.

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```
git log --oneline --left-
right <branch1> <branch2>
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`git fetch` — Update the local repository but not the index nor the working directory.

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`git reset --hard [<commit>]` — Reset the index and working tree to match the specified commit (default to the current HEAD). Discard all changes not already commited!

Git commands — An introduction

merge — Merging introduces the changes from a different branch into the current one, and create a new commit representing the “merge”.

> `git merge [--no-commit] [-m <msg>] <branch>` — Merge the change from the given **`<branch>`** into the current branch. The **`--no-commit`** performs the merge but does not commit the result. The **`-m`** option can be used to override the default commit message.

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`git merge --continue` — Continue the current merge process after resolving conflicts.

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- `git stash drop` — Drop the stash on top of the stack.
- `git stash pop` — Equivalent to `apply` then `drop`.

Resolving conflicts

Conflicts occurs when a file has two versions that must be merged, e.g., after a `merge`, a `rebase`, a `cherry-pick` or a `stash`.

```
<<<<<<< HEAD
Version 2
=======
Version 3
>>>>>>> Other branch
```

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4. Use a dedicated tool, e.g., `git mergetool`, Magit.

Git objects

`git` stores objects within the `.git/objects` directory (local):

- blob objects;
- tree objects;
- commit objects;
- (annotated) tag objects.

Each object represented by its SHA-1 checksum (20 bytes, 40 hexadecimal characters), e.g:

```
.git/objects/98/7c3be764396c5a315e2c5ea536d8956aba82bc
```

Once created, objects never change.

Git objects — blob

blob objects —

- a blob contains the content of a “file” (a binary array of data);
- identical contents means identical objects due to SHA-1 naming:
  - two identical files are represented by a single blob object;
- a blob has no metadata associated directly with it:
  - names of files are stored within tree objects and within the index;
- blob objects are usually created when (revision of) files are added to the repository (`git add`) or files are compared (`git diff`).

→ `git` does not store delta between file revisions.

Git objects — tree

tree objects —

- a tree is similar to a directory, it contains:
  - references to blob objects (files);
  - references to other tree objects (sub-directories);
- a tree associates names and modes to blob and tree objects it references;
- a tree object has no “name” by itself.

Git objects — tree

tree objects — possible modes:

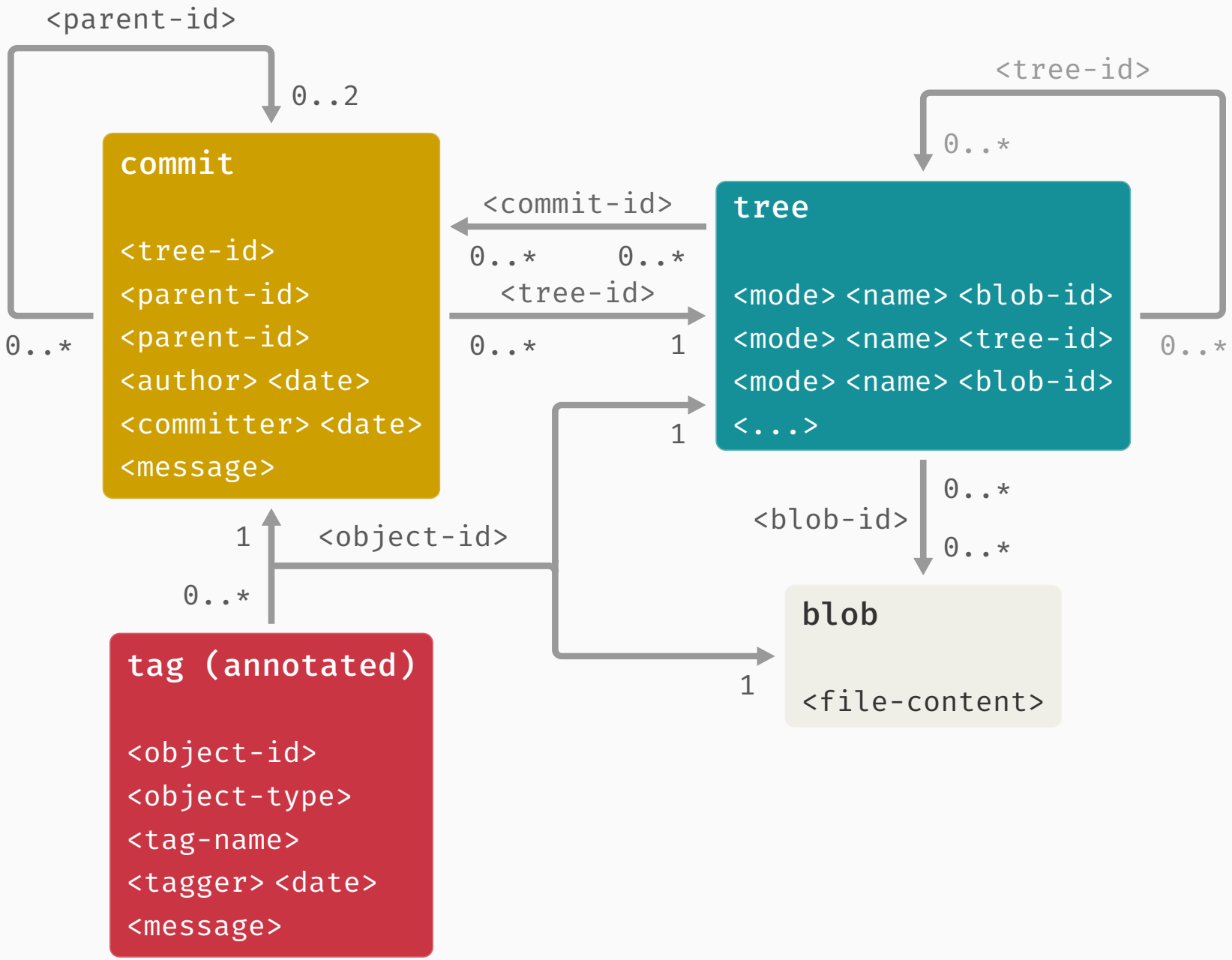
- `040000`: directory — `tree`
- `100644`: regular non-executable file — `blob`
- `100755`: regular executable file — `blob`
- `120000`: symbolic link — `blob`
- `160000`: gitlink (submodule) — `commit`

Git objects — commit

commit objects —

- commit objects are the building blocks of `git`;
- a commit object contains a snapshot of the working tree (a tree object) with associated metadata: author, committer, date, ...;
- commit objects are linked together by a parent-child relationship, creating a revision tree;
- references (branches, **HEAD**, tags) target commit objects using their SHA-1 checksums (names).

Git objects — Relation between objects



Git objects — Inspecting objects

```
# List files in the index.
$ git ls-files --stage
100644 fa49b077972391ad58037050f2a75f74e3671e92 0       foo.txt
100644 96ac8f82e27c18f4a736ebb277fb0aa9648b711f 0       test.txt

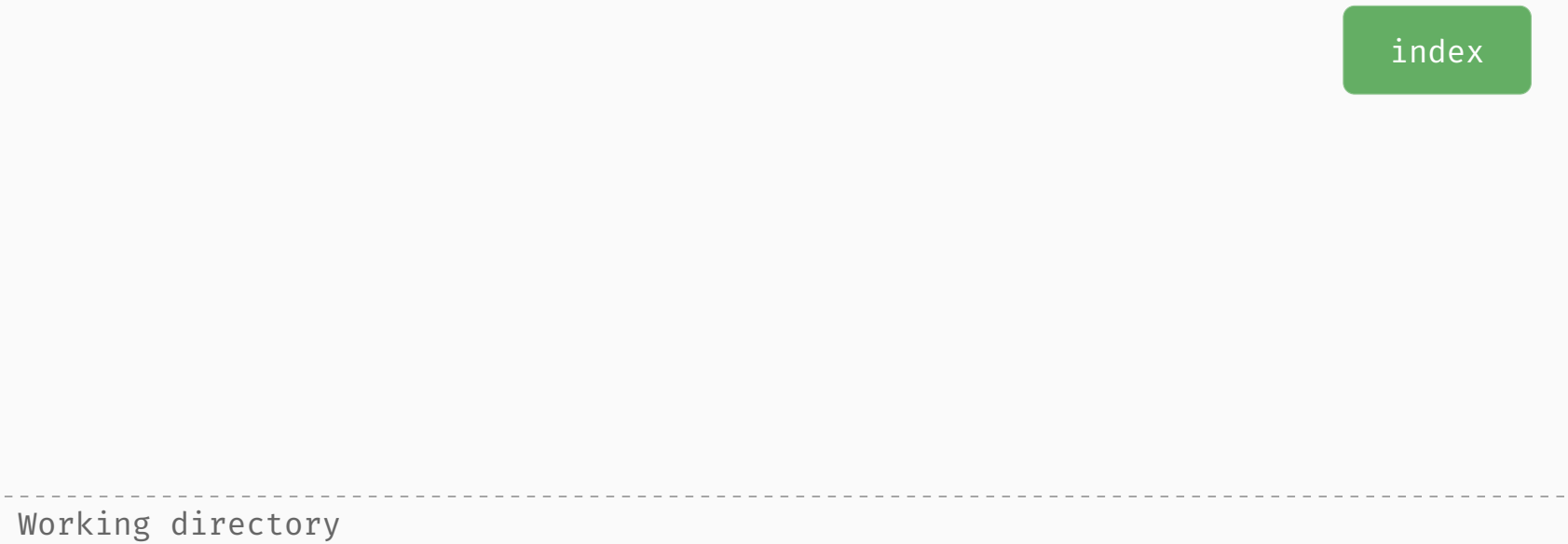
# Display the content of the given blob.
$ git cat-file -p 96ac8f82e27c18f4a736ebb277fb0aa9648b711f
version 4

$ git cat-file -p HEAD
tree 0f318b9fb1845be79439afc88c7b76dfa2ff8d91
parent eacd8426cd48c7e14f80b1650110439dbb13a7df
author Mikaël Capelle <mikael.capelle@irt-saintexupery.com> 1541587661 +0100
committer Mikaël Capelle <mikael.capelle@irt-saintexupery.com> 1541587661 +0100

third commit

$ git cat-file -p HEAD^{tree}
100644 blob fa49b077972391ad58037050f2a75f74e3671e92    new.txt
100644 blob 7170a5278f42ea12d4b6de8ed1305af8c393e756    test.txt
```

Git — Example




```
git init .
```

Git — Example

index

Working directory

test.txt
"version 1"

```
echo "version 1" > test.txt
```

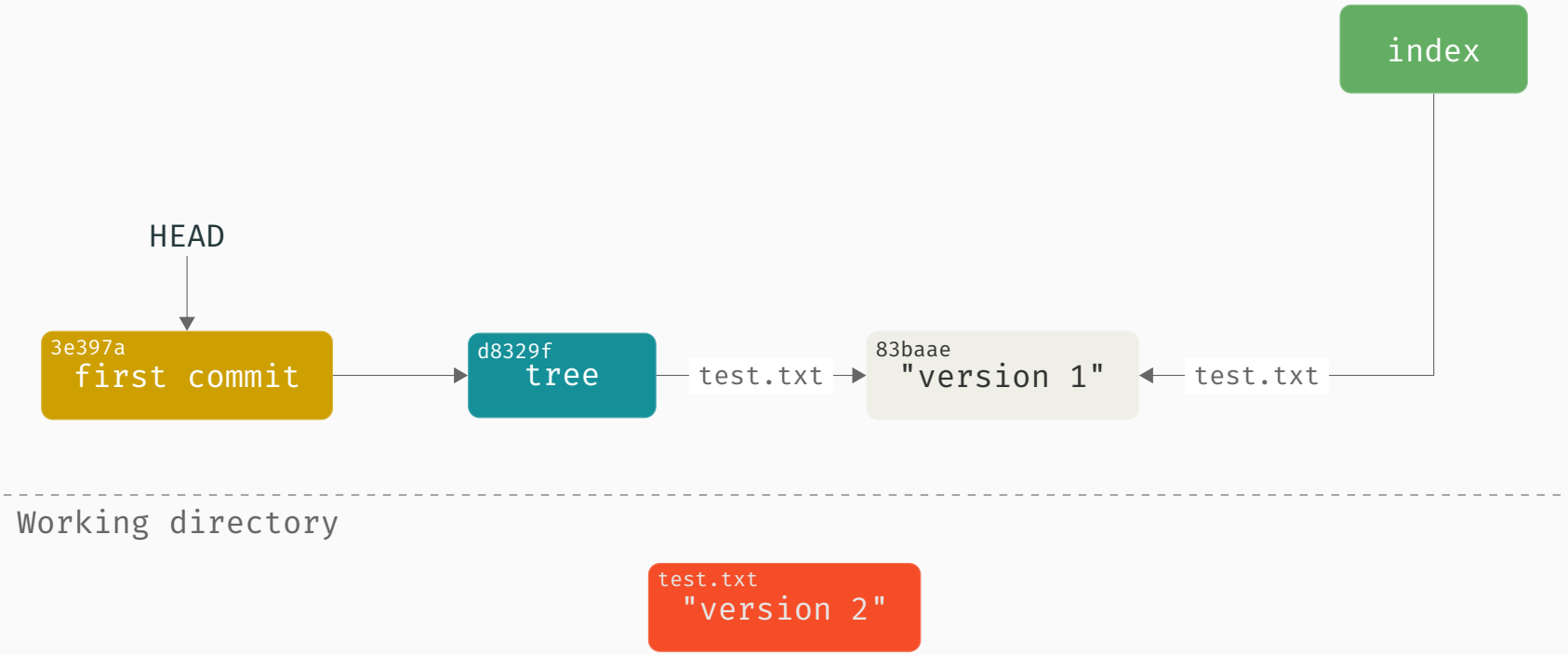
Git — Example


```
git add test.txt
```

Git — Example


```
git commit -m "first commit"
```

Git — Example

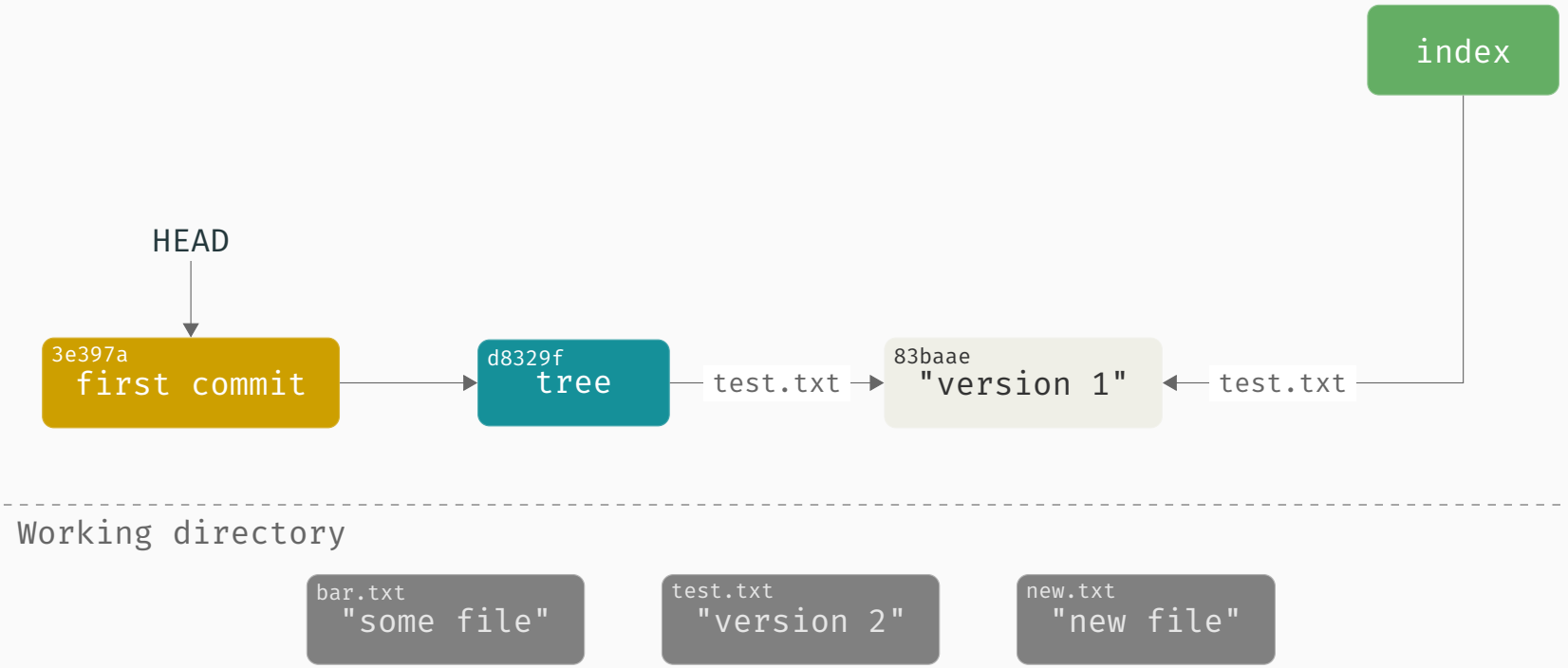



```
echo "version 2" > test.txt
```

Git — Example

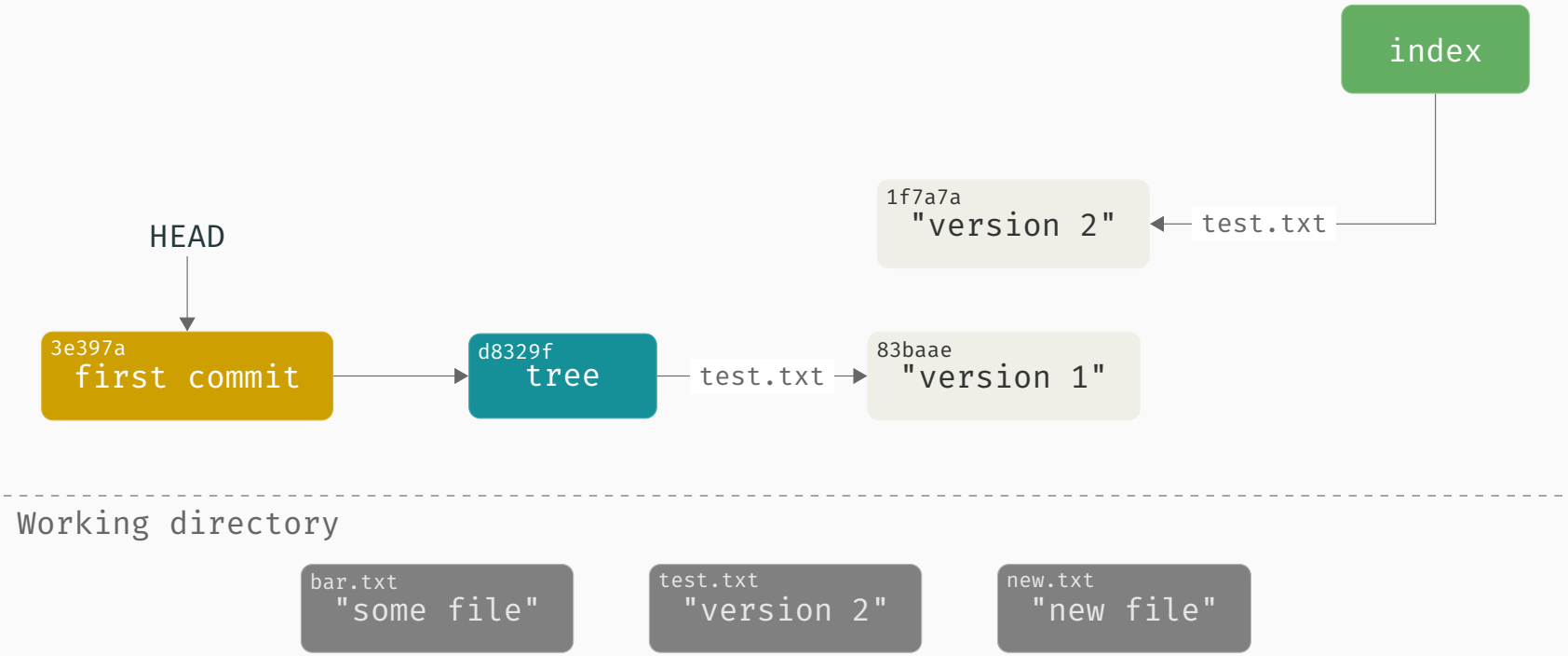

```
echo "some file" > bar.txt
```

Git — Example




```
echo "new file" > new.txt
```

Git — Example

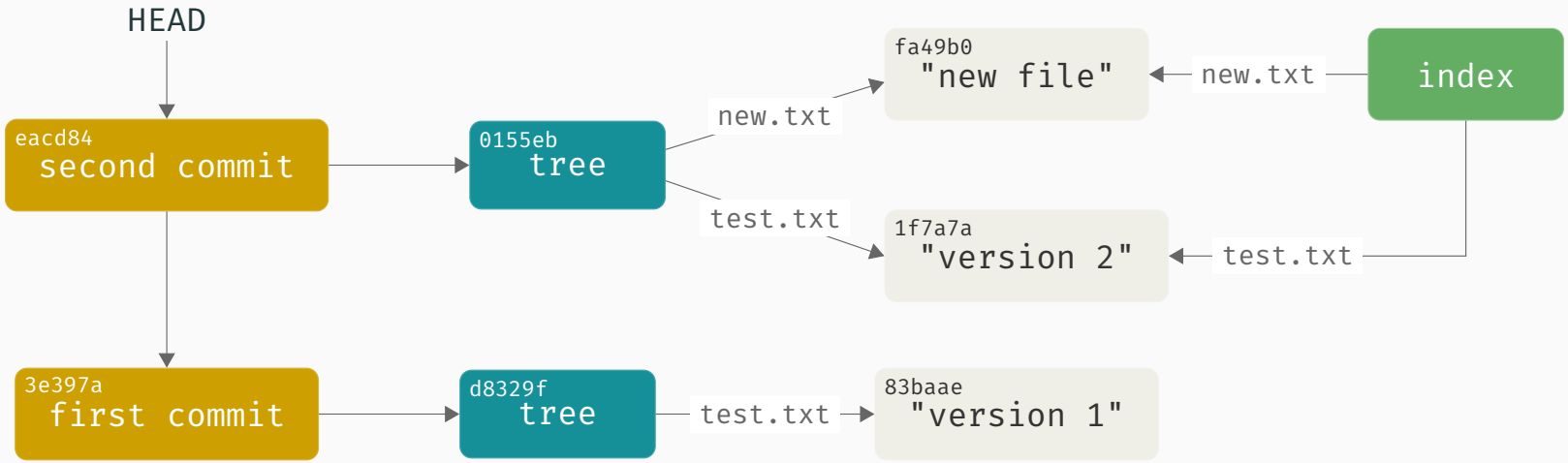



```
git add test.txt
```

Git — Example


```
git add new.txt
```

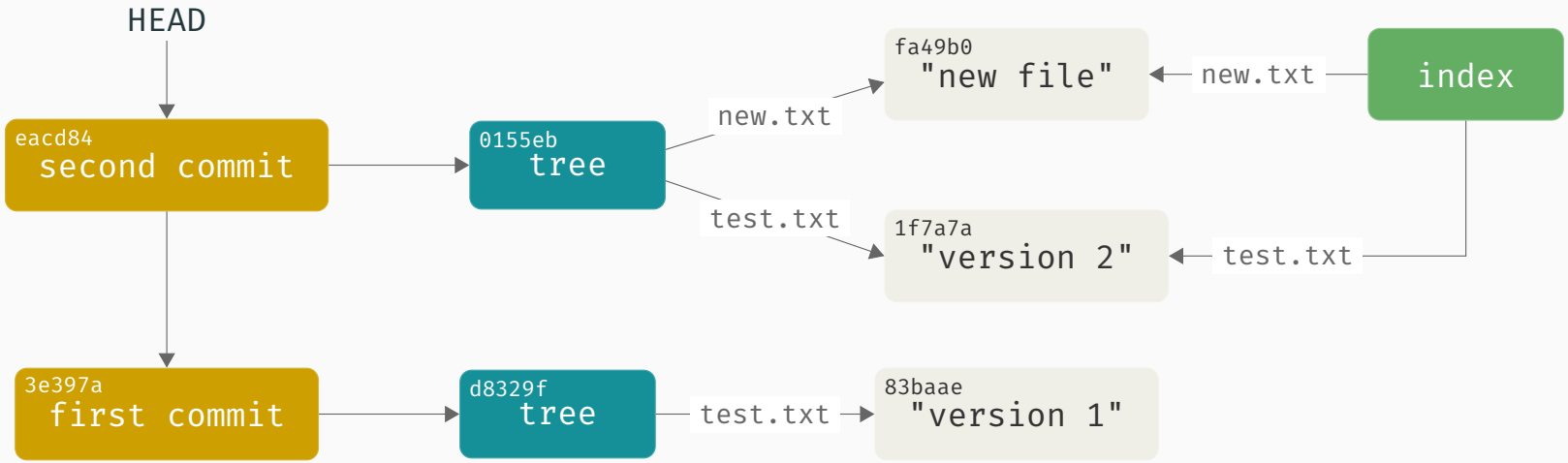
Git — Example



Working directory


```
git commit -m "second commit"
```

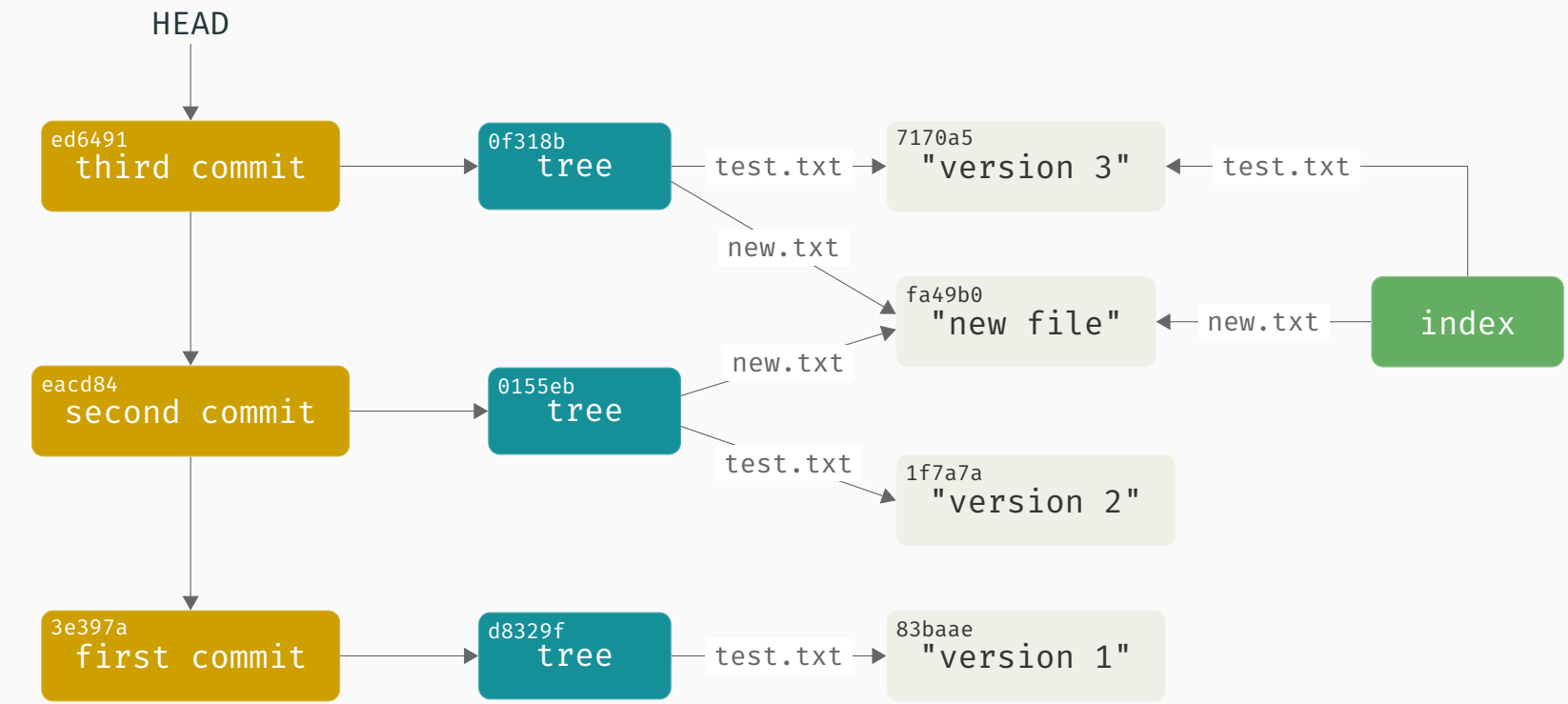
Git — Example



Working directory

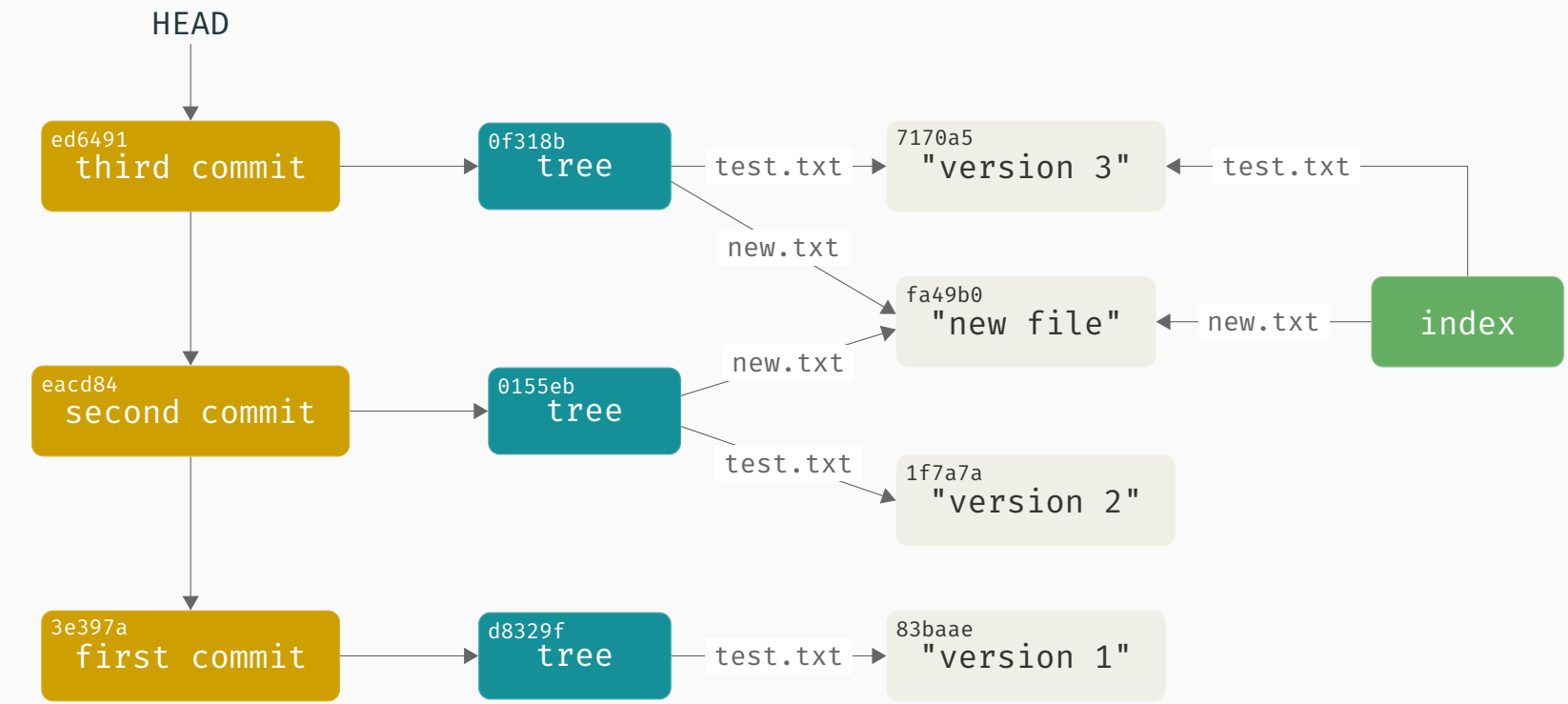

```
echo "version 3" > test.txt
```

Git — Example




```
git commit -am "third commit"
```

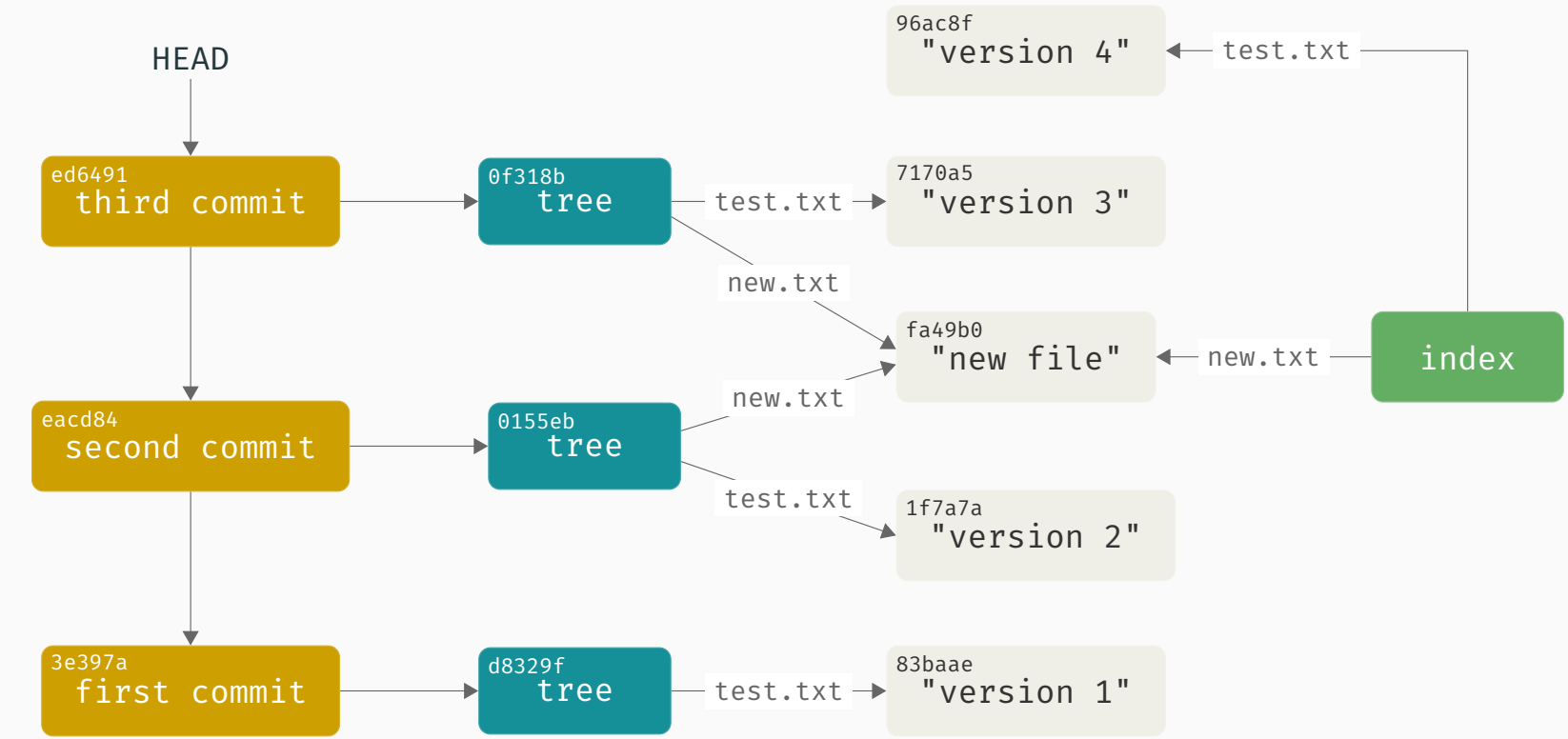
Git — Example



Working directory


```
echo "version 4" > test.txt
```

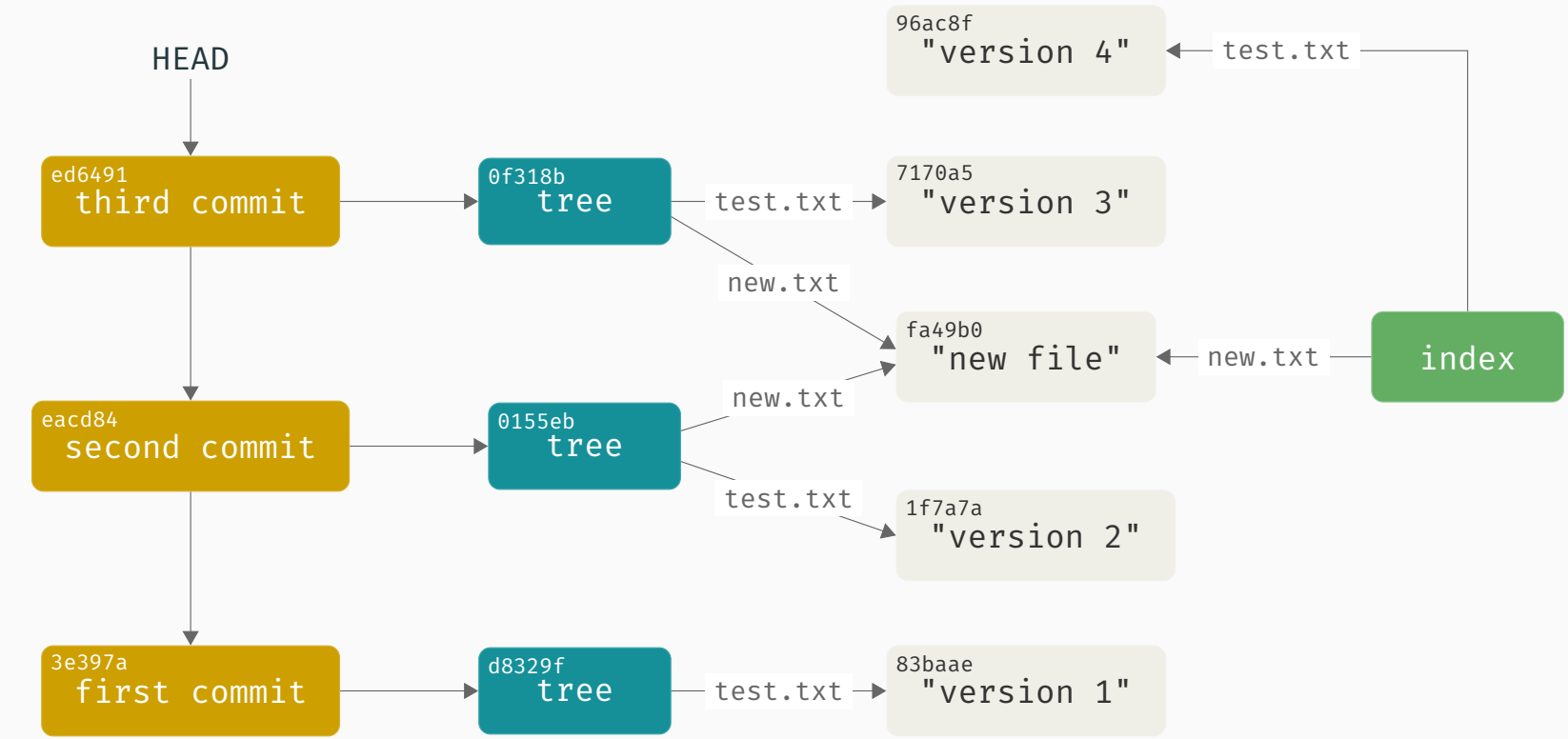
Git — Example



Working directory


```
git add -u
```

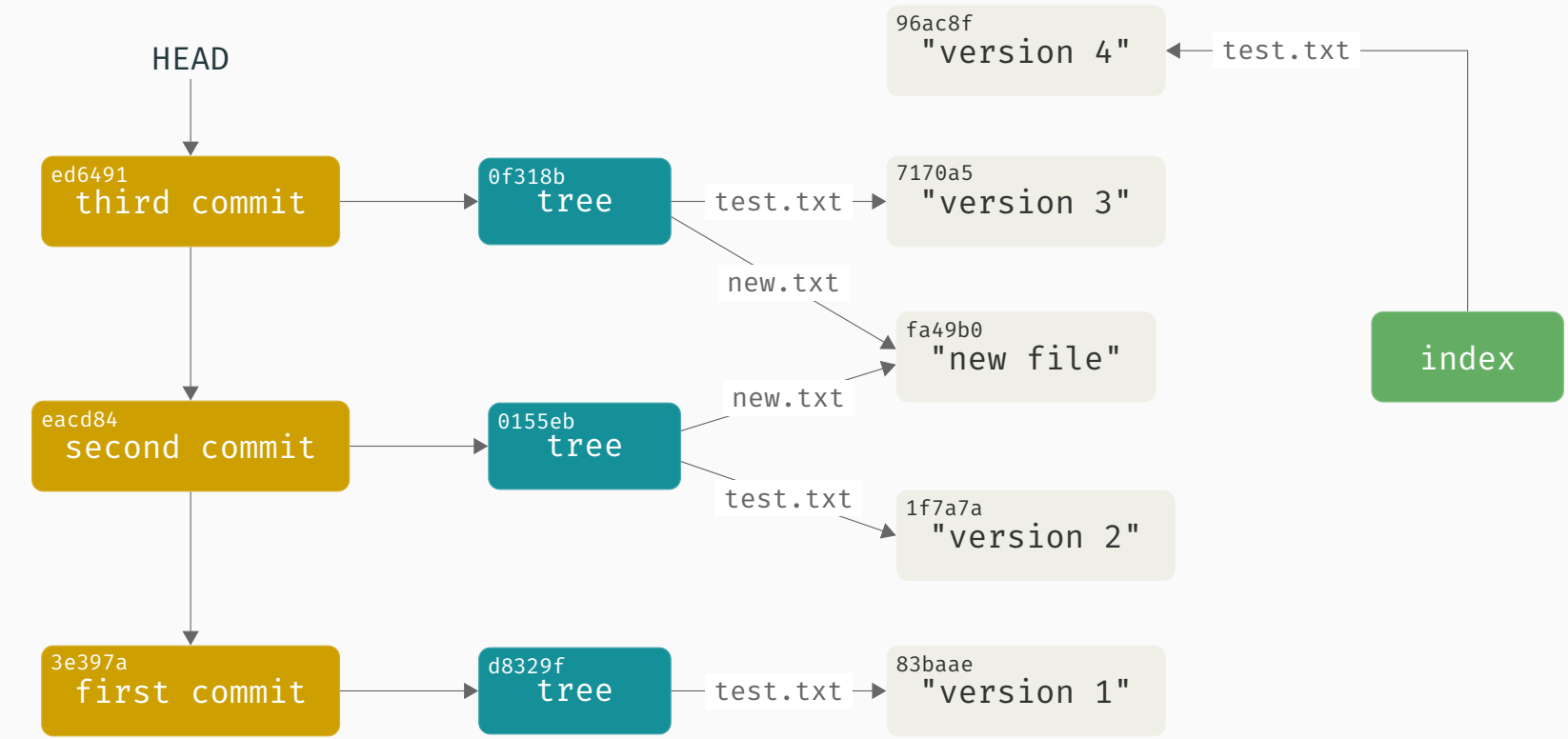
Git — Example



Working directory


```
mv new.txt foo.txt
```

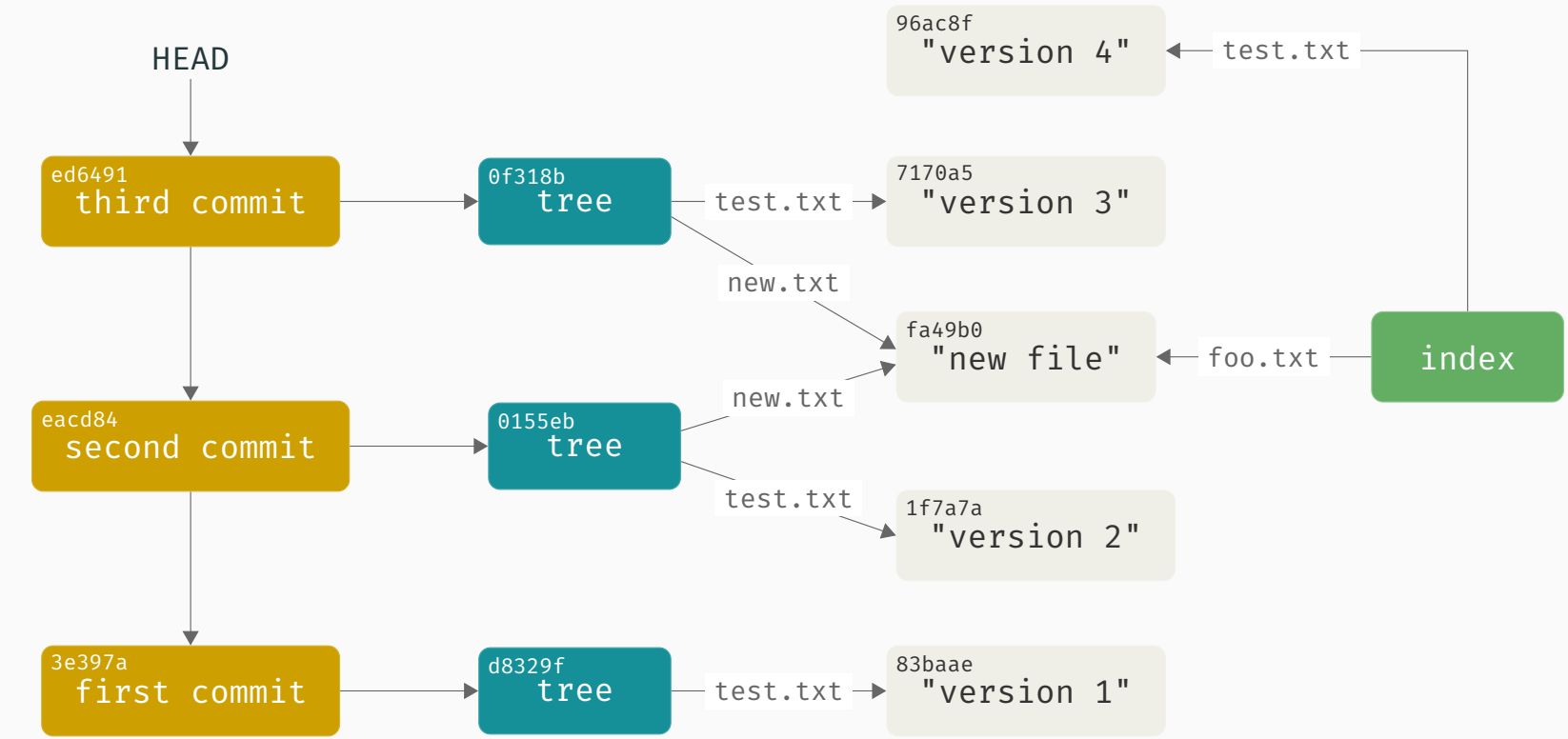
Git — Example



Working directory


```
git rm new.txt
```

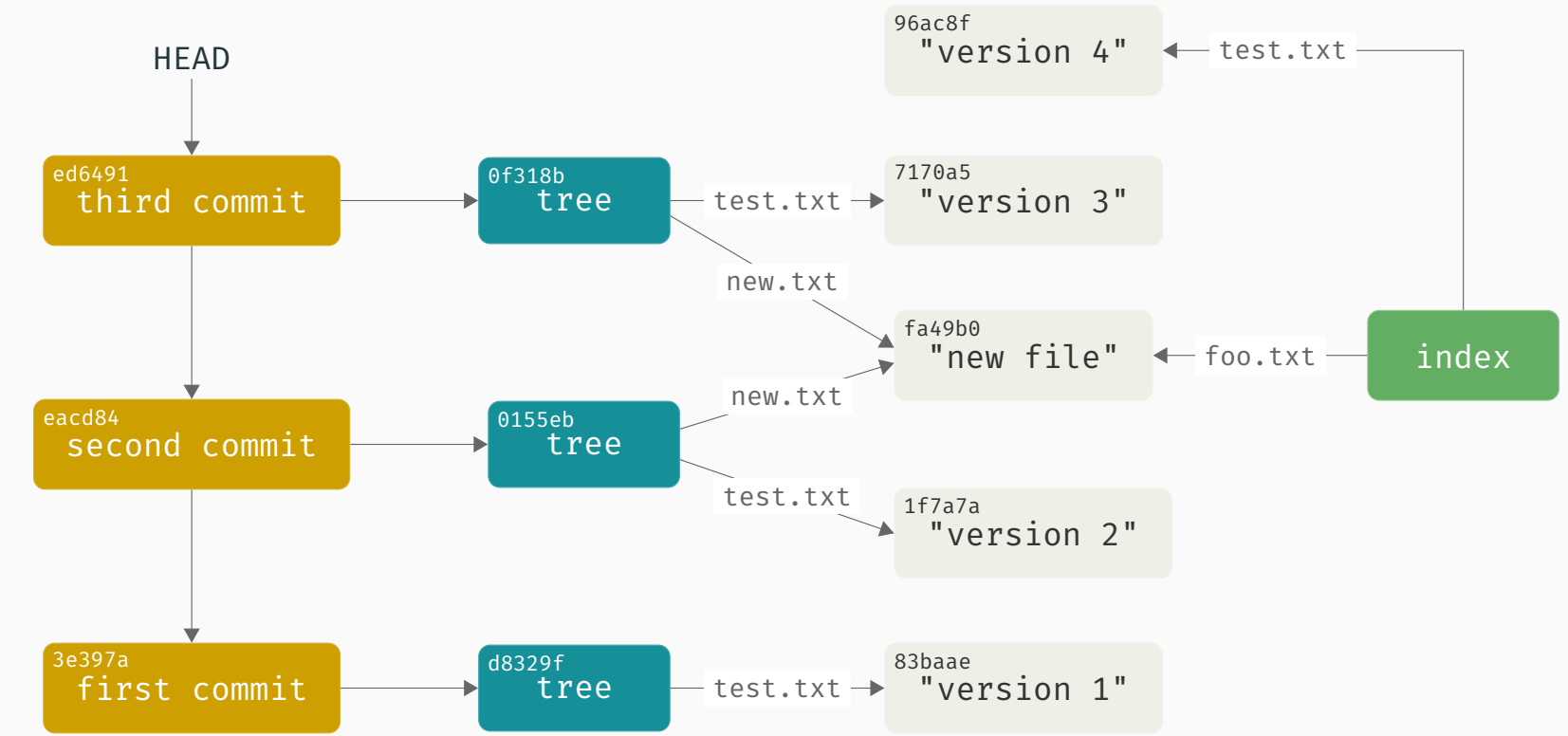
Git — Example



Working directory


```
git add foo.txt
```

Git — Example



Working directory


```
echo "version 5" > test.txt
```

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

        renamed:    new.txt -> foo.txt
        modified:   test.txt

Changes not staged for commit:
  (use "git add <file>..." to update what will be committed)
  (use "git checkout -- <file>..." to discard changes in working dire

        modified:   test.txt

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

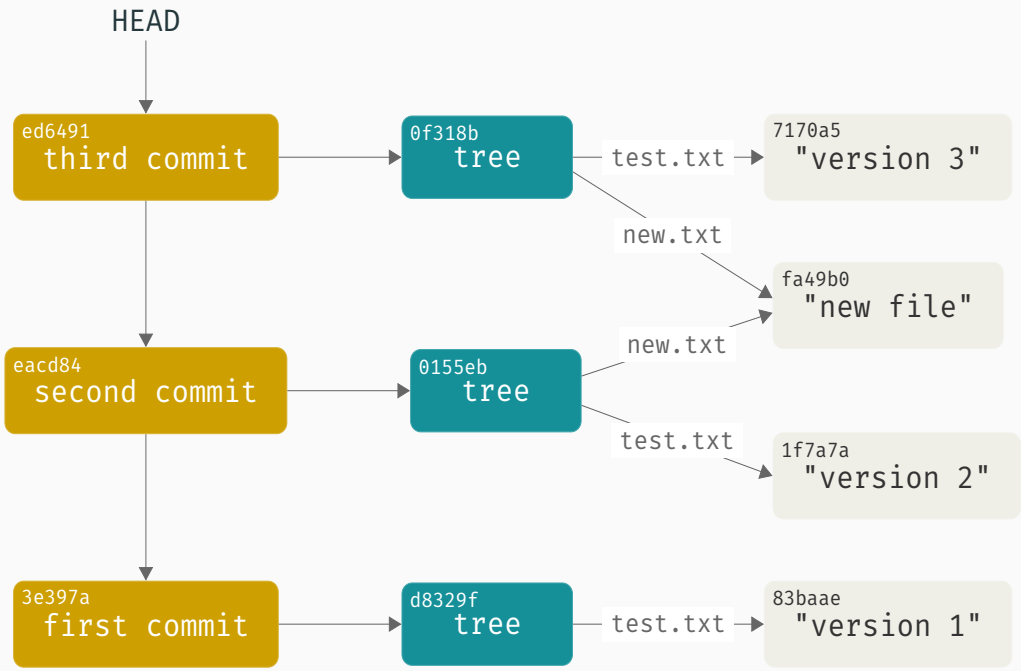
        bar.txt
```

Branch & References

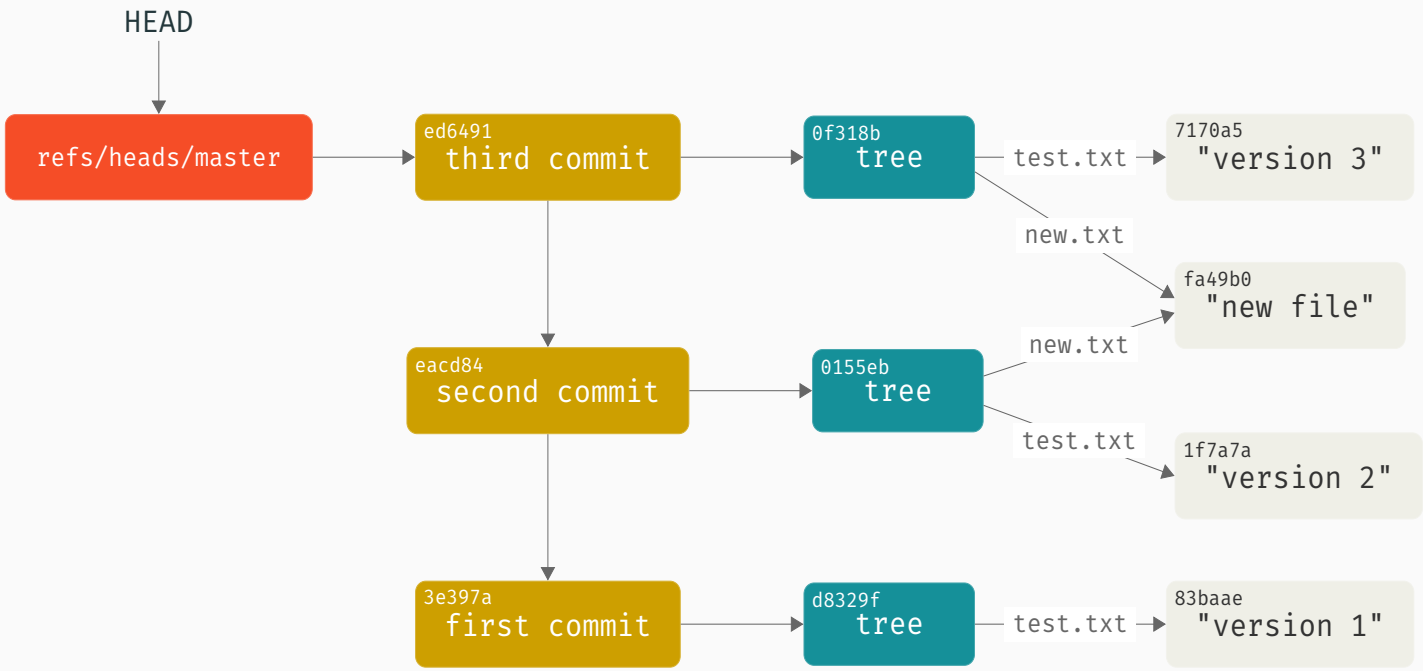
reference = human-readable name for a SHA-1 hash —

- references are stored under `.git/refs`;
- there a three main types of references:
  - heads — head of local branches;
  - remotes — head of remote branches;
  - tags.

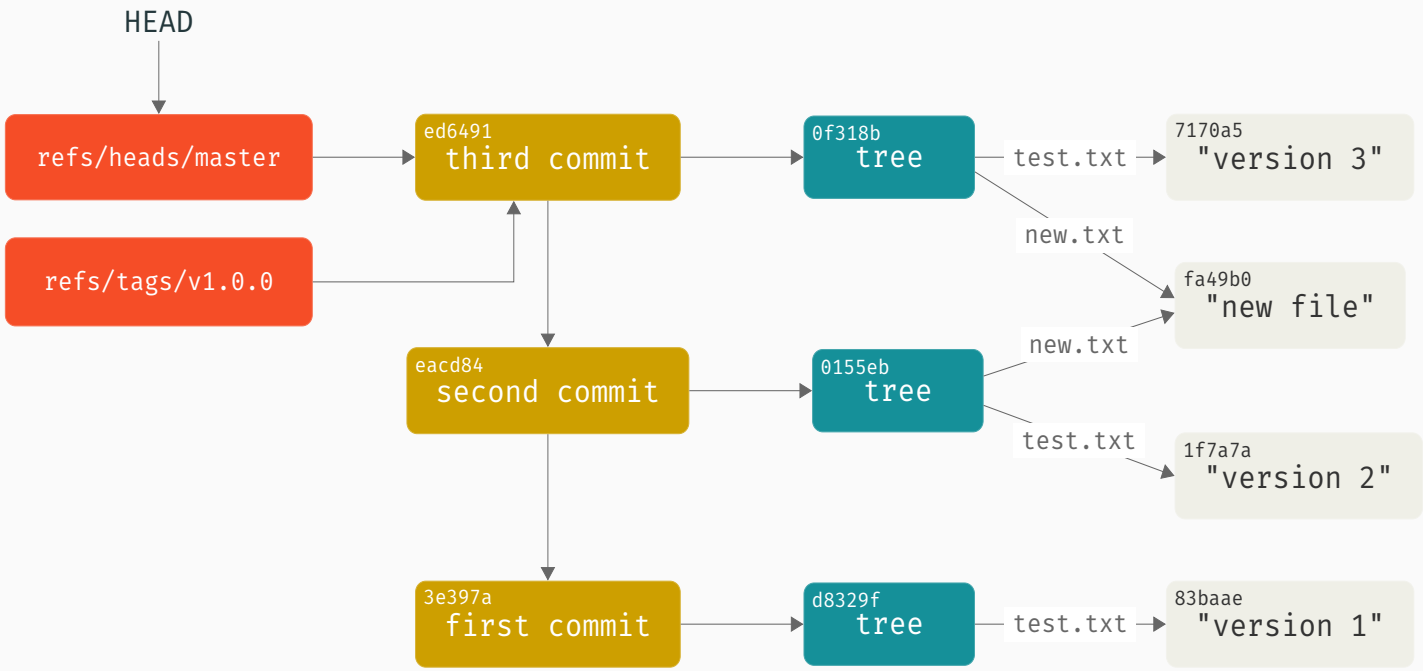
References


HEAD
ed6491
third commit
0f318b
tree
test.txt
7170a5
"version 3"
new.txt
fa49b0
"new file"
eacd84
second commit
0155eb
tree
new.txt
test.txt
1f7a7a
"version 2"
3e397a
first commit
d8329f
tree
test.txt
83baae
"version 1"

References

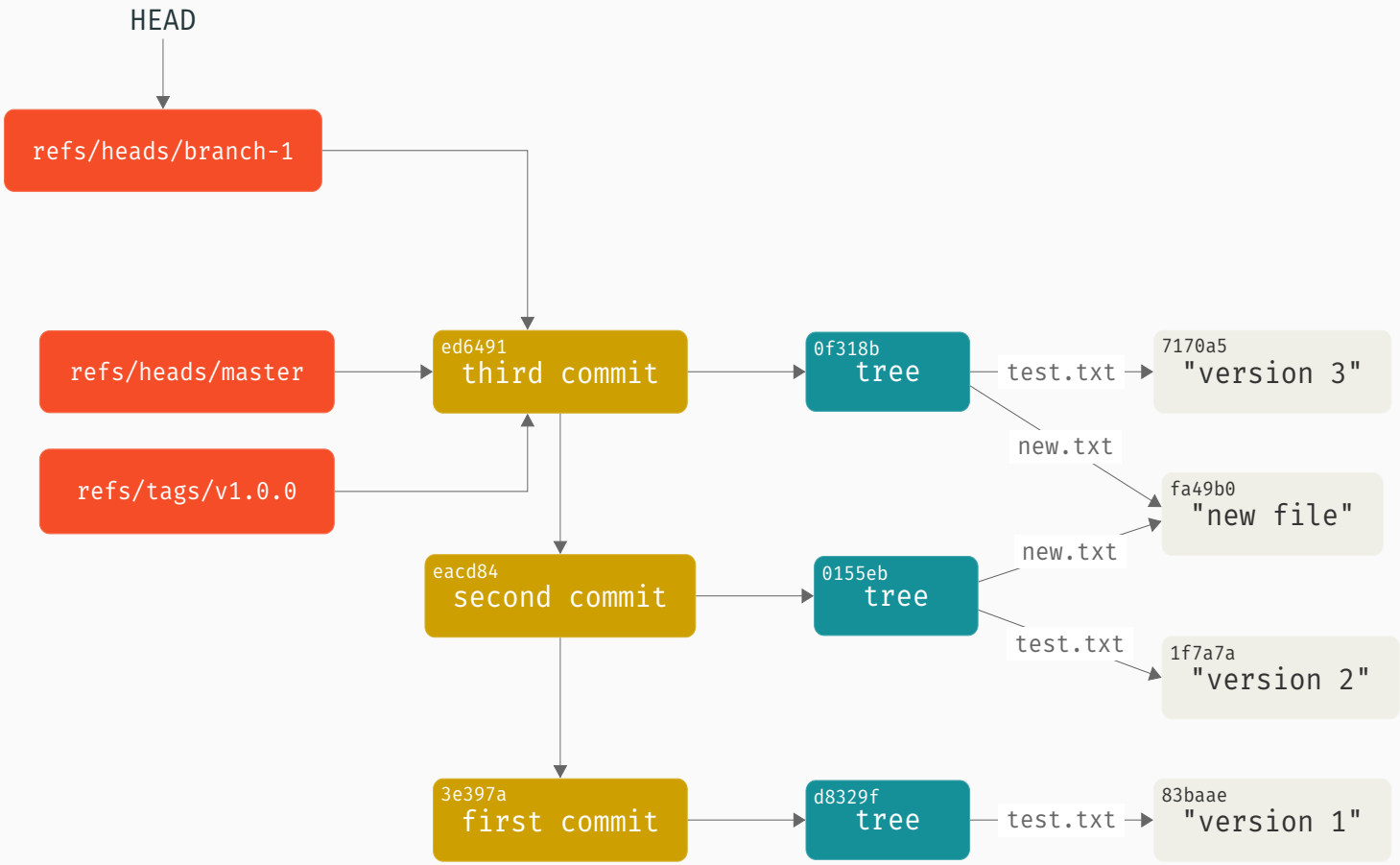

HEAD
refs/heads/master
ed6491
third commit
0f318b
tree
test.txt
7170a5
"version 3"
new.txt
fa49b0
"new file"
eacd84
second commit
0155eb
tree
new.txt
test.txt
1f7a7a
"version 2"
3e397a
first commit
d8329f
tree
test.txt
83baae
"version 1"

References



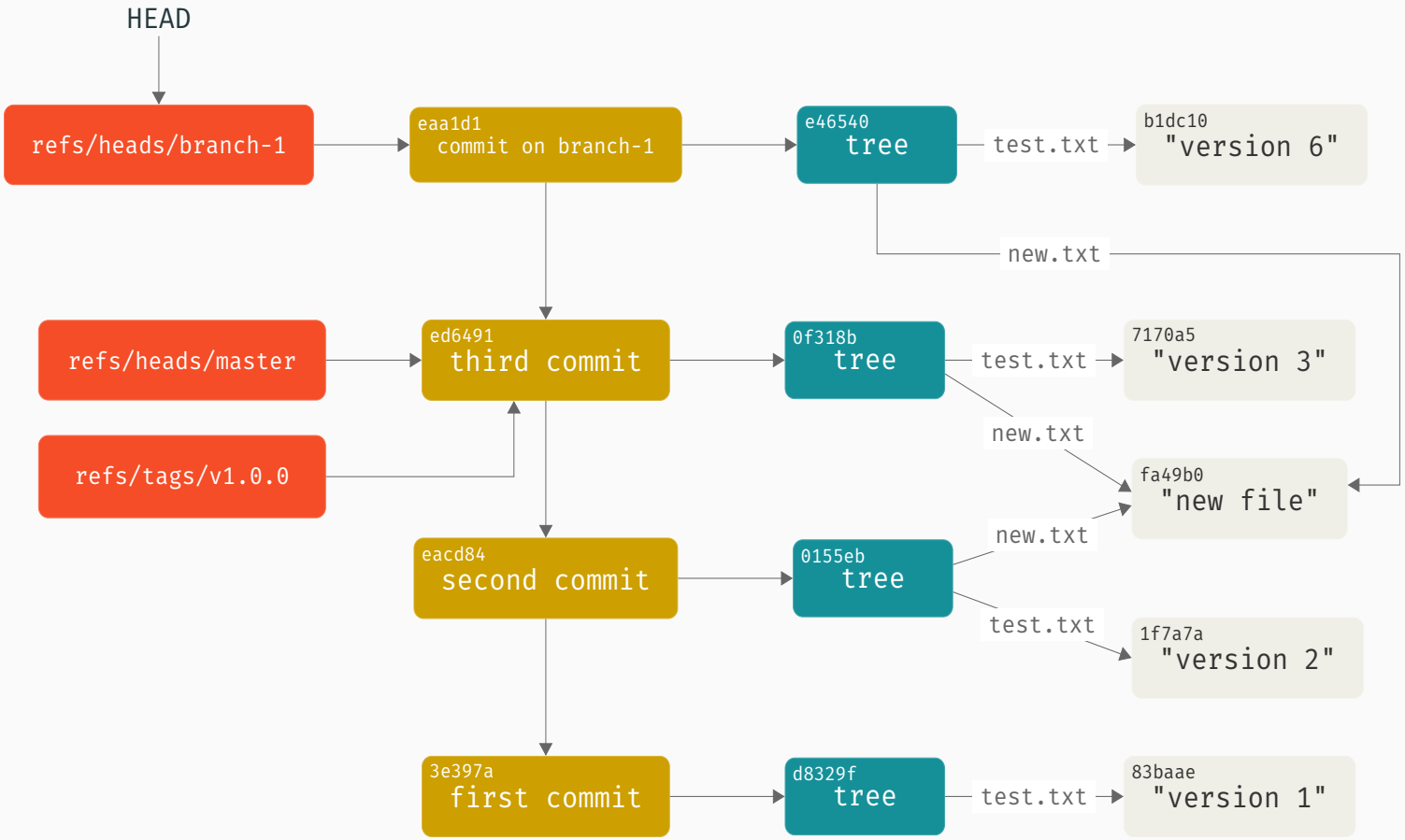

```
git tag v1.0.0
```

References



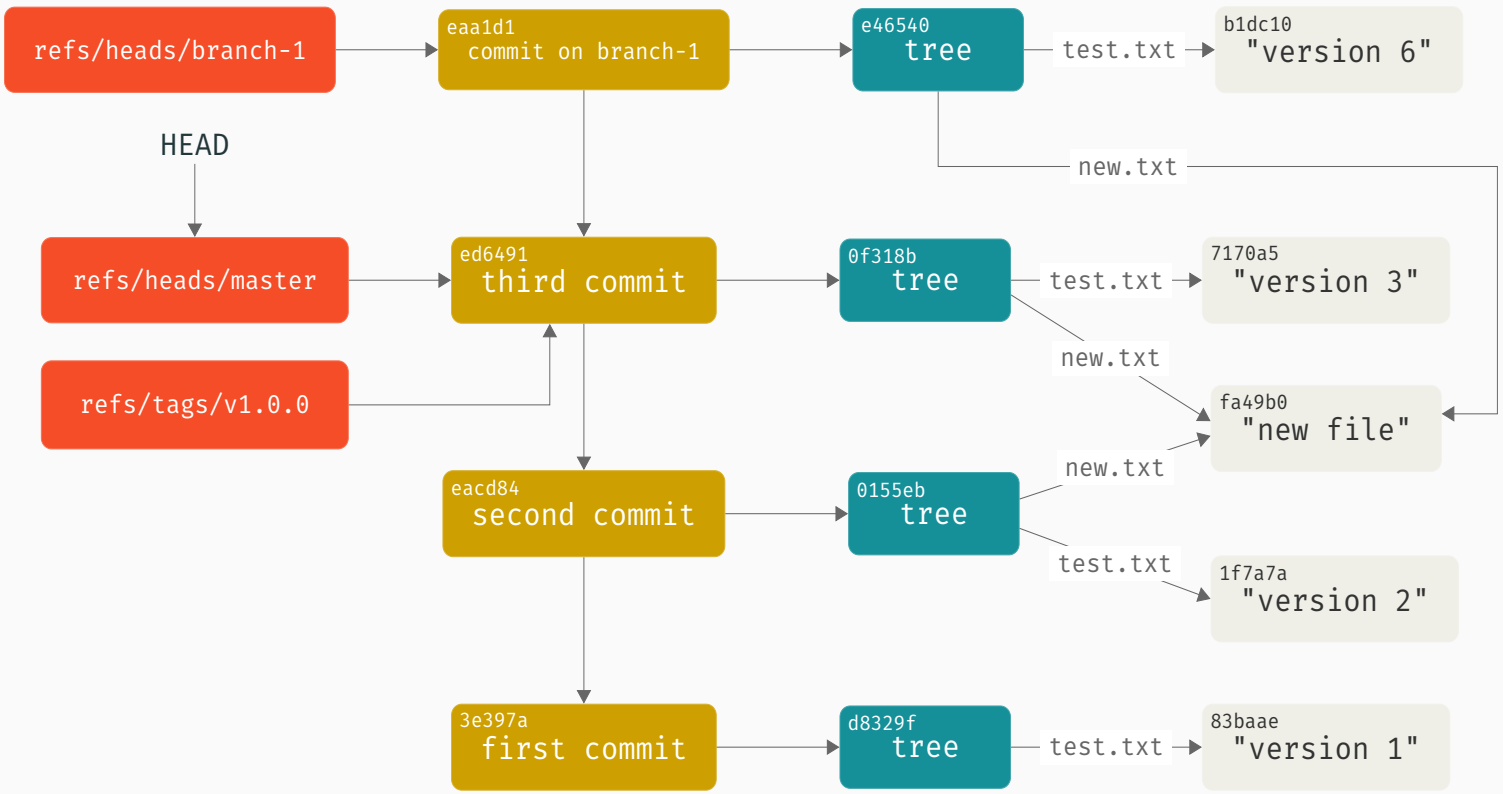

```
git checkout -b branch-1
```

References



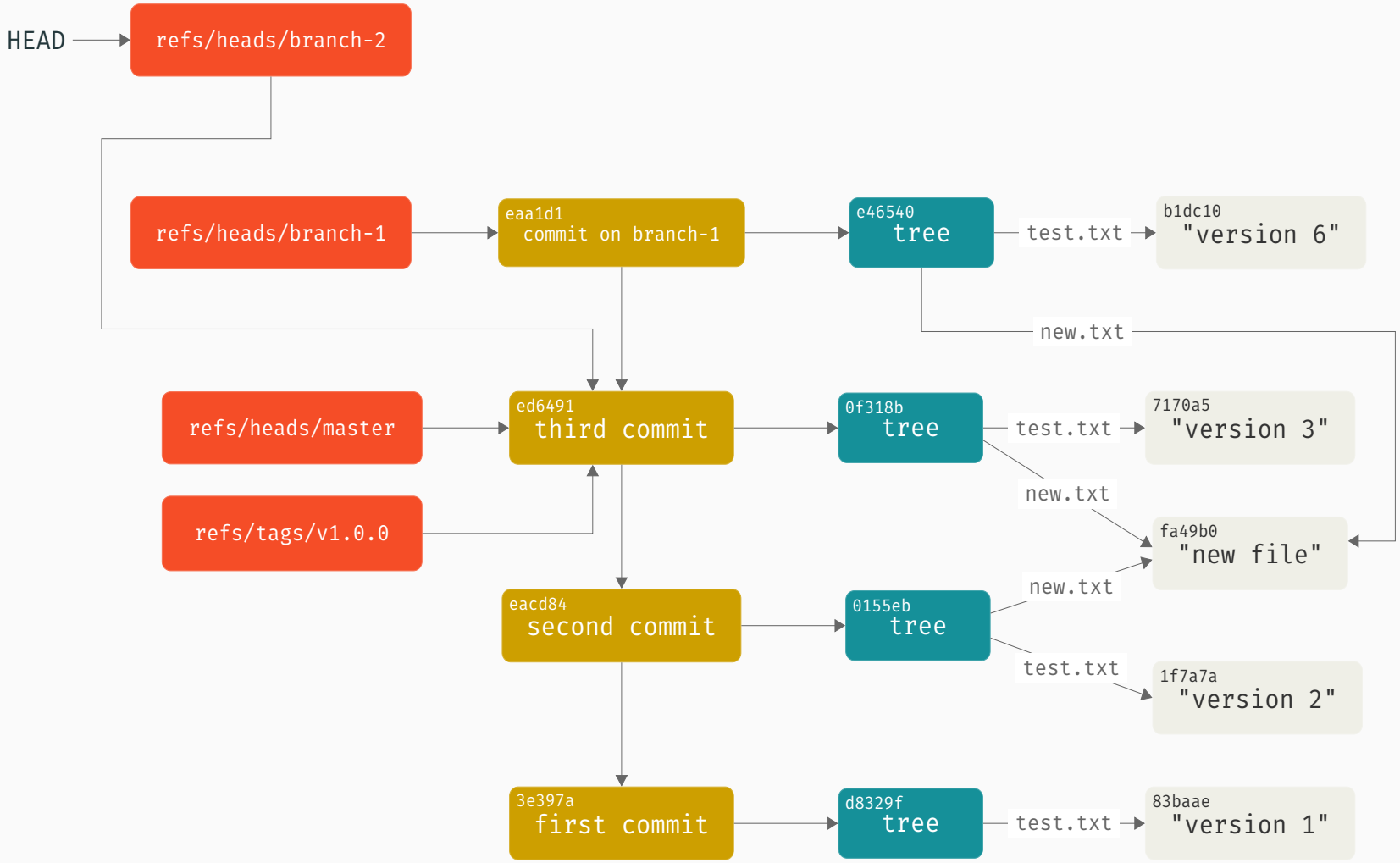

```
echo "version 6" > test.txt && git commit -am "commit on branch-
1"
```

References



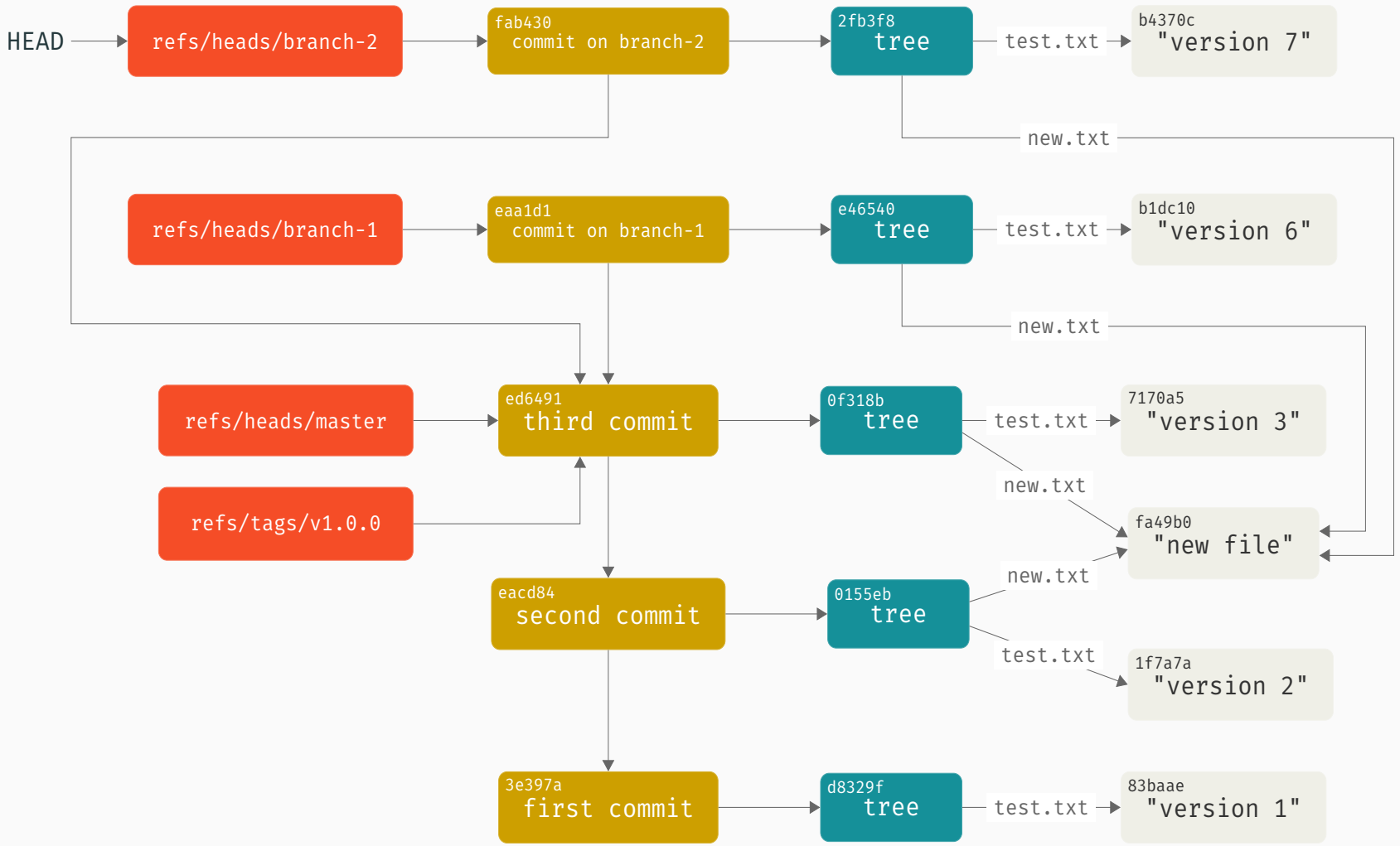

```
git checkout master
```

References




```
git checkout -b branch-2
```

References




```
echo "version 7" > test.txt && git commit -am "commit on branch-
2"
```

```
$ git show-ref --head
eaa1d1794759413c31d26fe0b66c6a9d73142d7f HEAD
eaa1d1794759413c31d26fe0b66c6a9d73142d7f refs/heads/branch-1
fab4302c8ab48a509b3f55bb22c8ad790cffcdde refs/heads/branch-2
ed64911b6d93a10de9beb6c6ea03c58afbf75e03 refs/heads/master
eaa1d1794759413c31d26fe0b66c6a9d73142d7f refs/remotes/origin/branch-1
ed64911b6d93a10de9beb6c6ea03c58afbf75e03 refs/remotes/origin/master
fab4302c8ab48a509b3f55bb22c8ad790cffcdde refs/remotes/public/branch-2
eaa1d1794759413c31d26fe0b66c6a9d73142d7f refs/remotes/public/master
ed64911b6d93a10de9beb6c6ea03c58afbf75e03 refs/tags/v1.0.0
```

Remotes

remote = “hosted” version of the repository —

- a remote is simply a `git` repository somewhere else:
  - a remote is often a bare repository (see `--bare` for the `init` and `clone` commands), i.e., a repository without a working directory;
- `git` handles four protocols to communicate with remotes:
  - local protocol — `file://` — for remotes that are on an accessible filesystem;
  - http(s) protocol — `http(s)://` — authenticated and unauthenticated access;;
  - ssh protocol — `ssh://` — easy to set-up, but does not allow unauthenticated access;
  - git protocol — `git://`.

Remotes

remote = “hosted” version of the repository —

- a remote is identified by its name:
  - the default remote after `clone` is `origin`;
- remotes are often configured to prevent hazardous behaviours:

```
$ git config --system receive.fsckObjects true
$ git config --system receive.denyNonFastForwards true
$ git config --system receive.denyDeletes true
```

- in order to enable branch-specific control, hooks must be used.

Remotes

remote = “hosted” version of the repository —

```
$ git init --bare
Initialized empty Git repository in /data/git/mikael/tutogit.git
$ git status
fatal: This operation must be run in a work tree
$ ls
config  description  HEAD  hooks  info  objects  refs
```

`git` commands

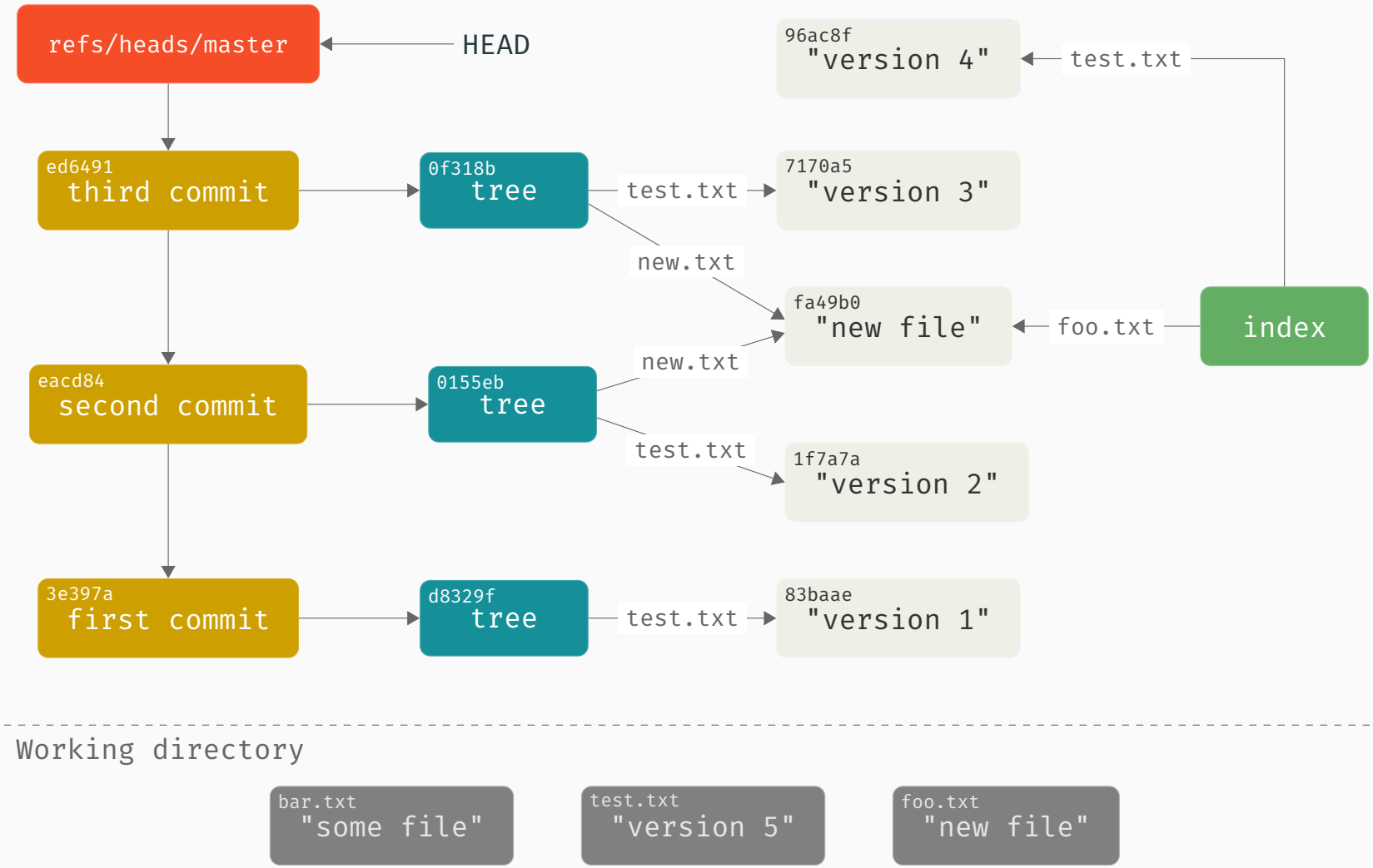
- Most commands are non-destructive:
  - most objects can be retrieved from the repository, even though it may be hard to find their names;
  - objects may have been added to the repository without a `git add`;
  - only a few commands erase files in the working directory.
- Some commands have very different behaviors when a path is specified at the end, e.g., `reset` or `checkout`.
- Some commands have a `-p|--patch` option to apply the command hunk by hunk, e.g., you can add a file partially to the index using `git add -p`.
- Most "hazardous"/destructive commands have a `-n|--dry-run` flag to perform a dry run of the command, i.e., printing what the command would do without actually doing anything.

`git reset` — V1

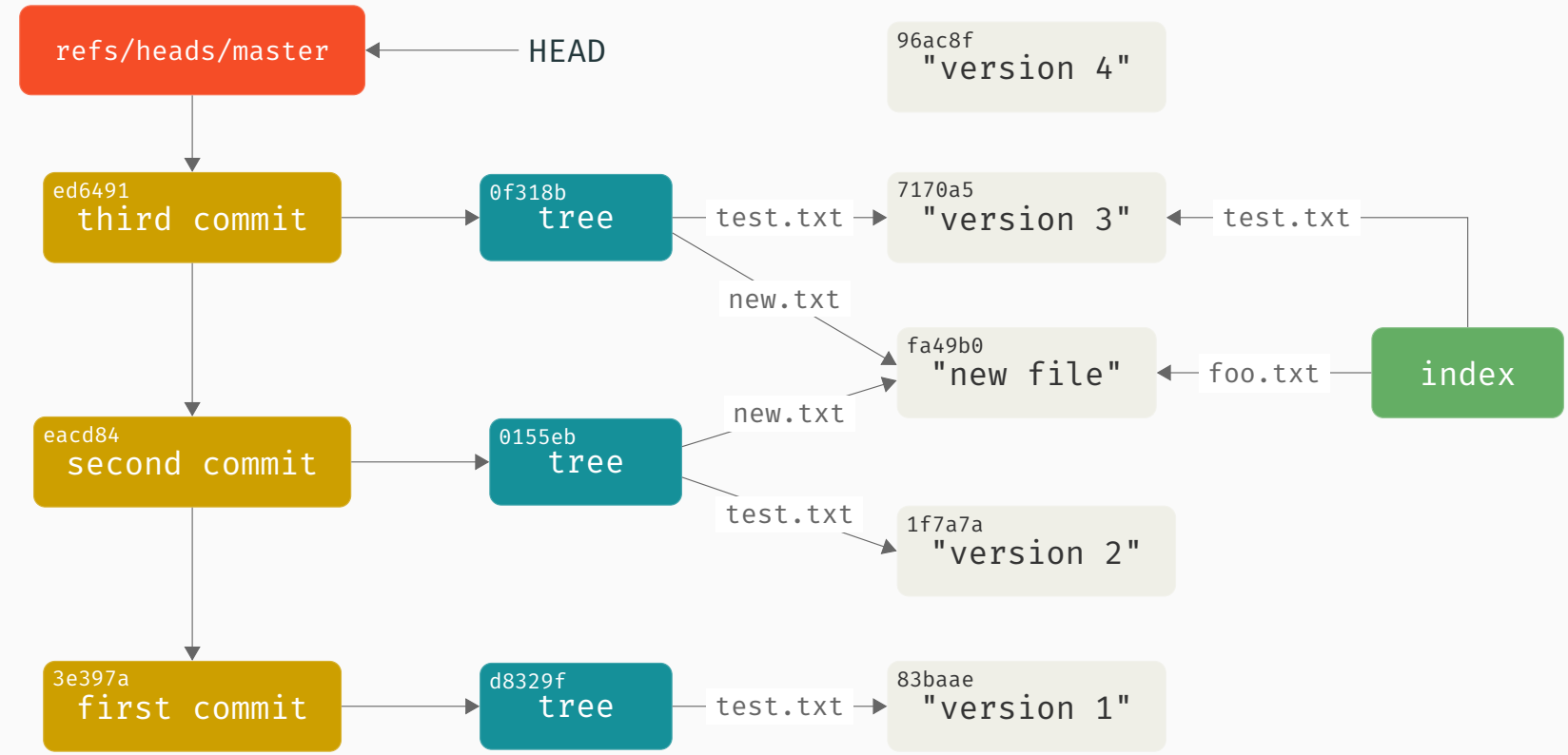
`git reset [-q] [<tree-ish>] [--] [<paths> … ]`

- reset the index entry for `<paths>` so that it points to the objects for `<paths>` in the `<tree-ish>` revision;
- does not update any files in the working directory;
- if a file did not exists in the `<tree-ish>` revision, remove the file from the index.

Git — Example


refs/heads/master
HEAD
96ac8f
"version 4"
test.txt
ed6491
third commit
0f318b
tree
test.txt
7170a5
"version 3"
new.txt
fa49b0
"new file"
foo.txt
index
eacd84
second commit
0155eb
tree
new.txt
test.txt
1f7a7a
"version 2"
3e397a
first commit
d8329f
tree
test.txt
83baae
"version 1"
Working directory
bar.txt
"some file"
test.txt
"version 5"
foo.txt
"new file"

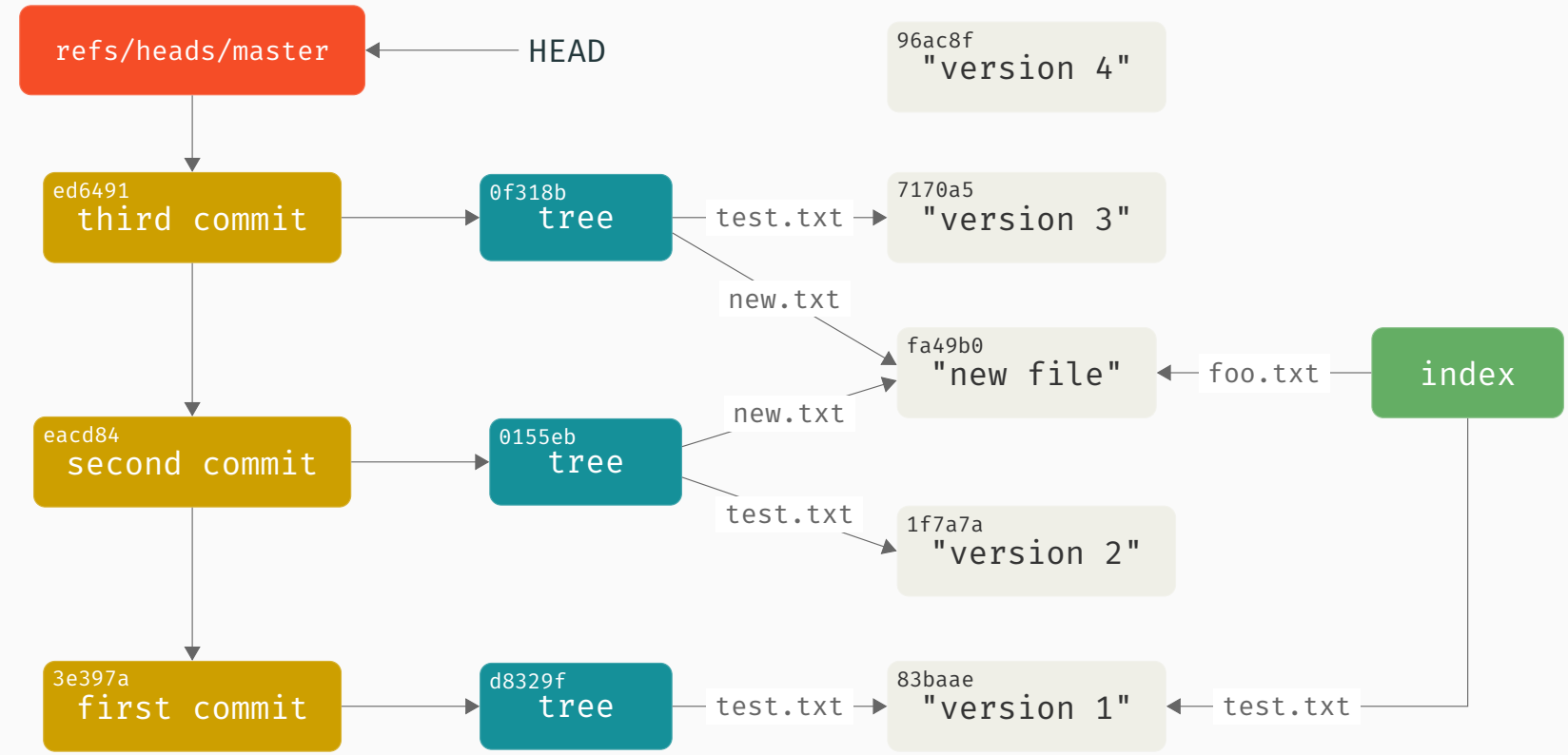
Git — Example



Working directory


```
git reset HEAD -- test.txt
```

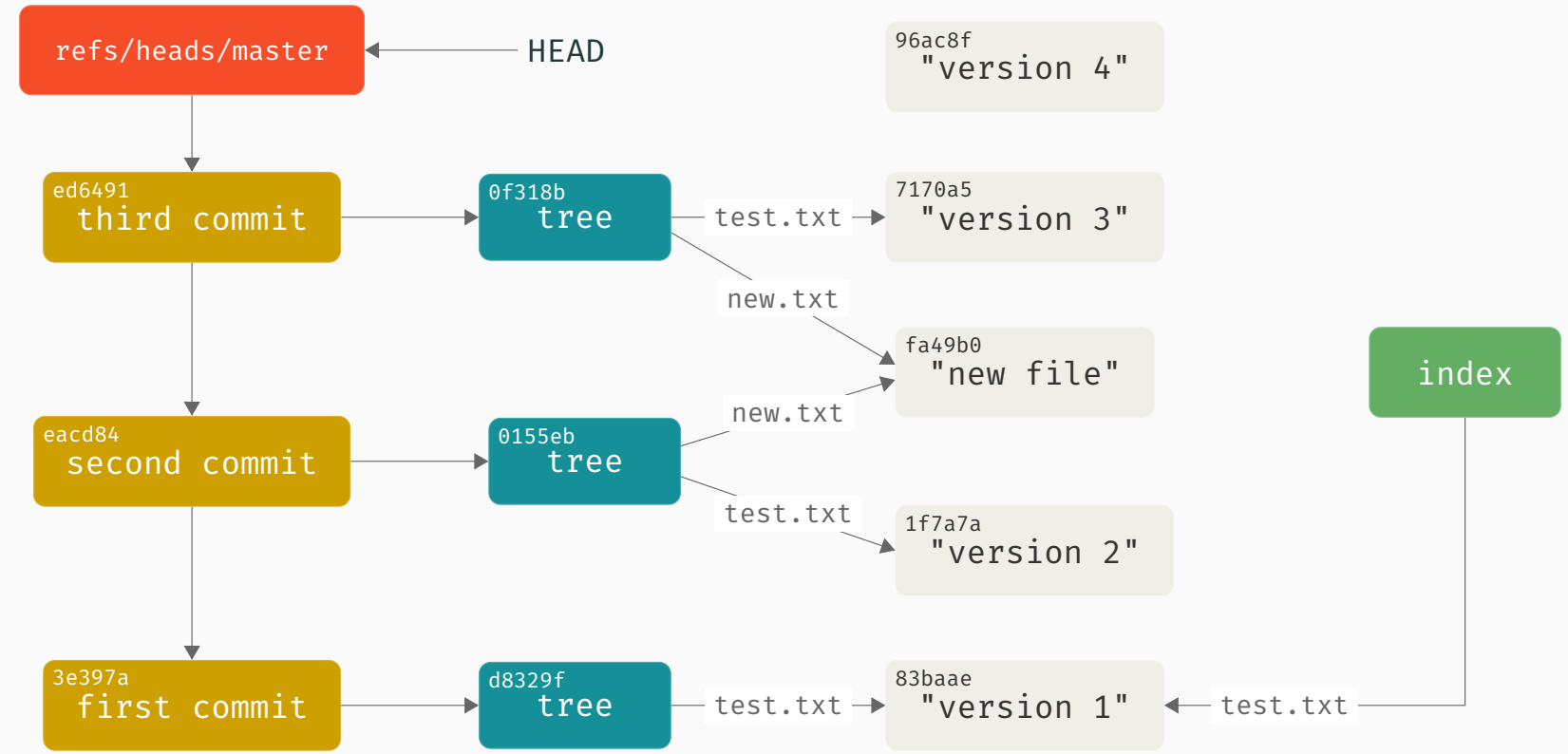
Git — Example



Working directory


```
git reset 3e397a -- test.txt
```

Git — Example



Working directory

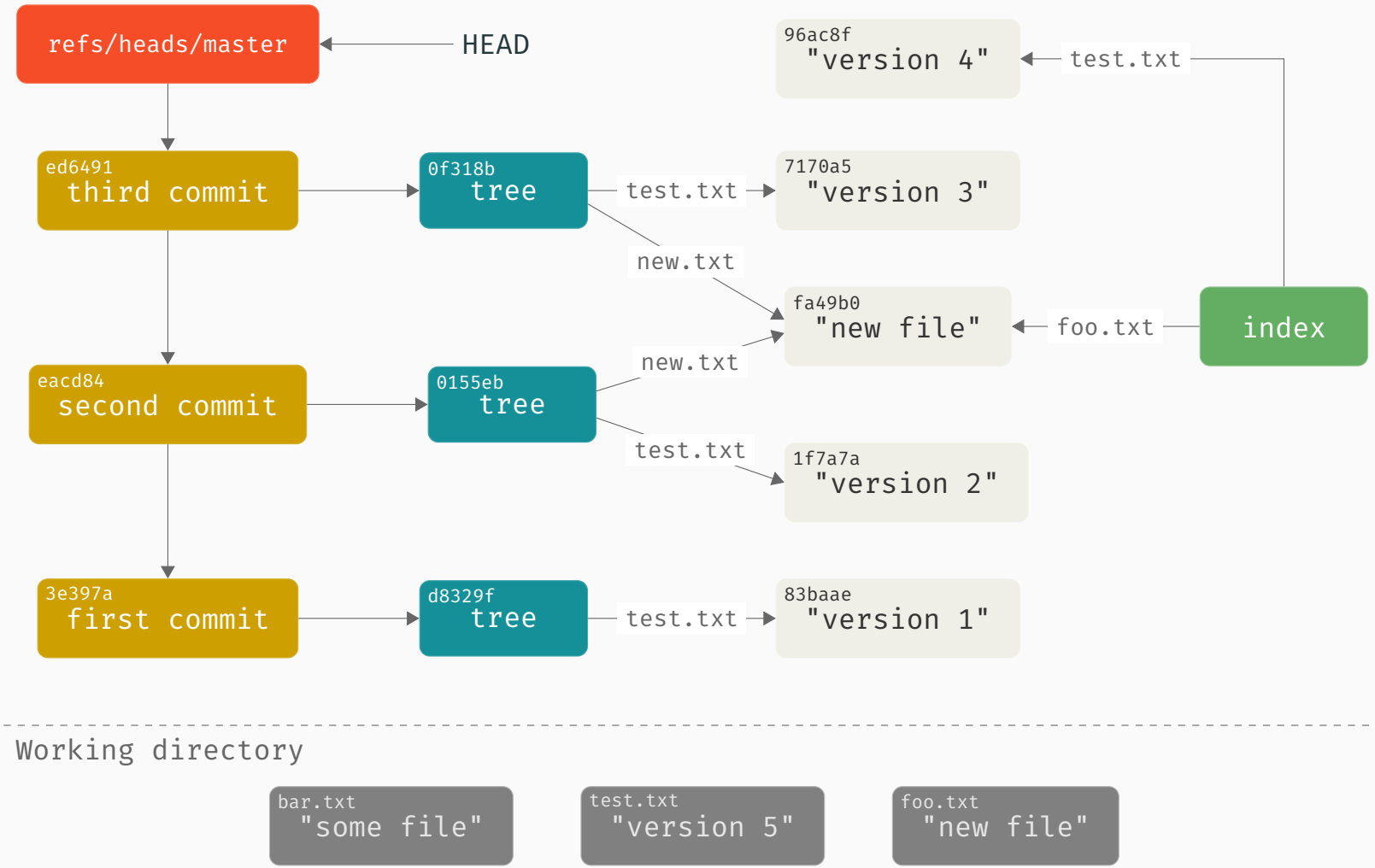

```
git reset 3e397a -- foo.txt
```

`git reset` — V2

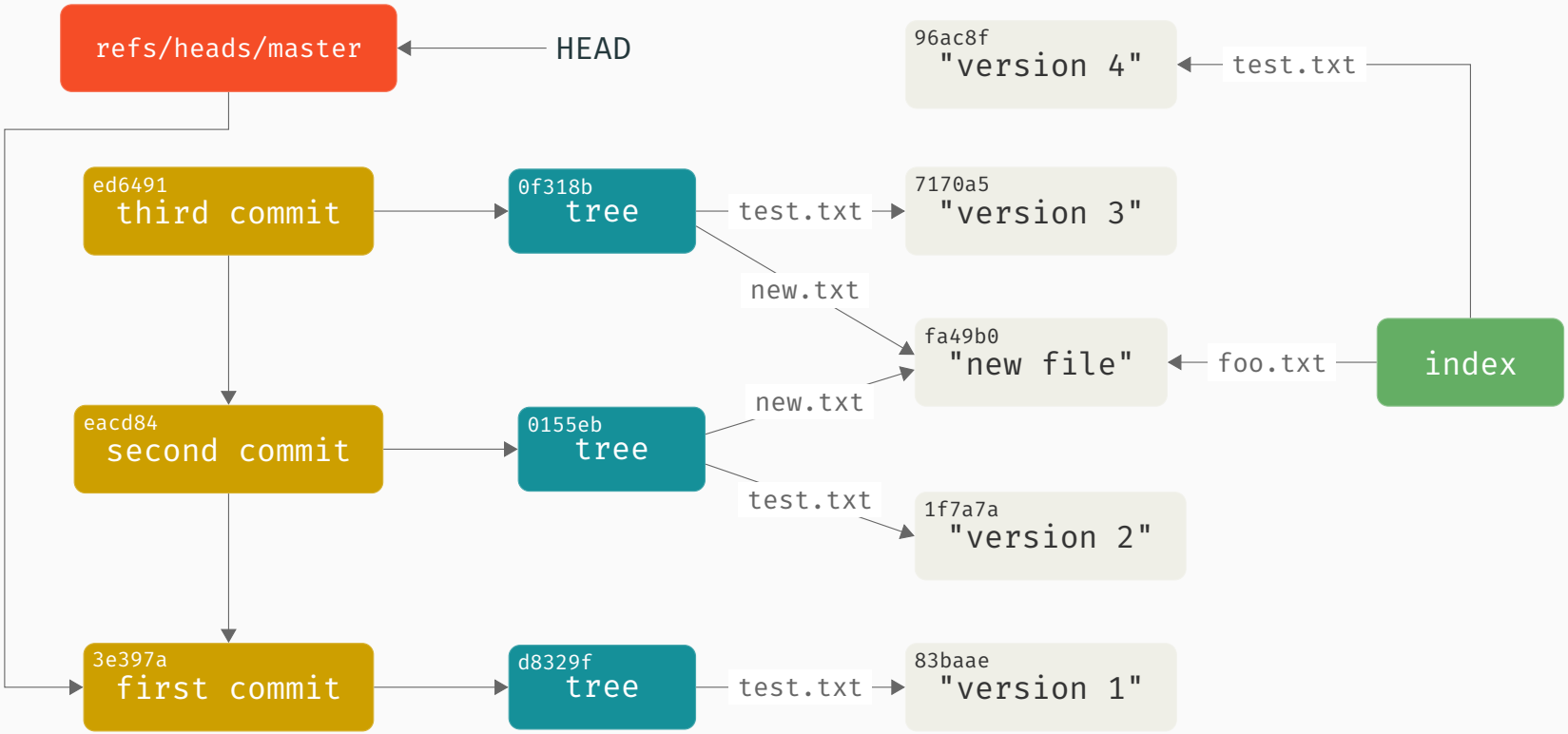
```
git reset [--soft | --mixed [-N] | --hard | --merge
| --keep] [-q] [<commit>]
```

- reset the current branch head to the specified `<commit>`, reset the index and reset files in the working tree:
  - `--soft` — reset the head but does not reset the index or files in the working tree;
  - `--mixed` (default) — reset the head and the index but does not reset files in the working tree;
  - `--hard` — reset the head, the index and all tracked files in the working tree (i.e., discard local changes for tracked files);
  - `--merge, --keep` — reset the head, the index, and some files in the working tree, depending on their states.

Git — Example


refs/heads/master
HEAD
96ac8f
"version 4"
test.txt
ed6491
third commit
0f318b
tree
test.txt
7170a5
"version 3"
new.txt
fa49b0
"new file"
foo.txt
index
eacd84
second commit
0155eb
tree
new.txt
test.txt
1f7a7a
"version 2"
3e397a
first commit
d8329f
tree
test.txt
83baae
"version 1"
Working directory
bar.txt
"some file"
test.txt
"version 5"
foo.txt
"new file"

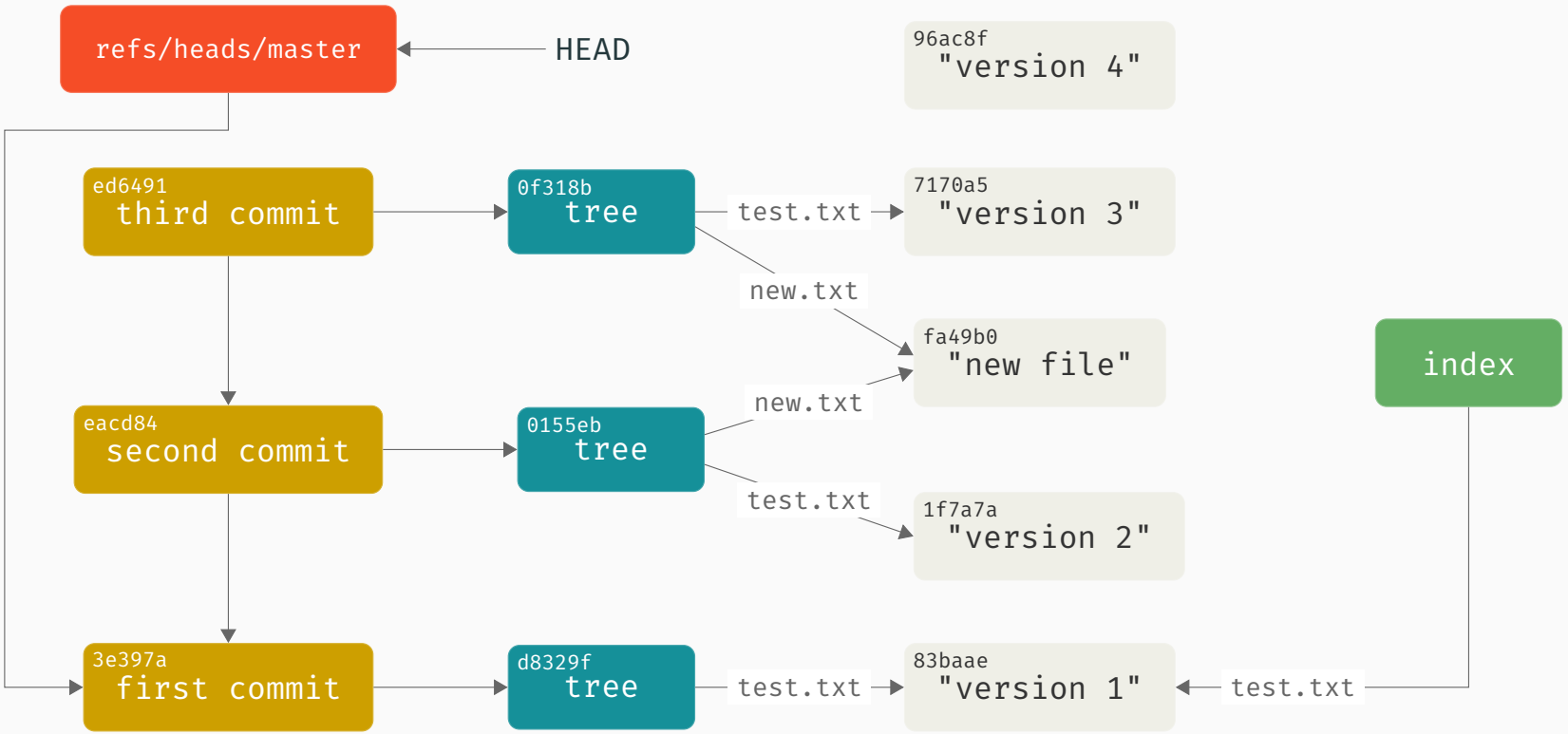
Git — Example



Working directory

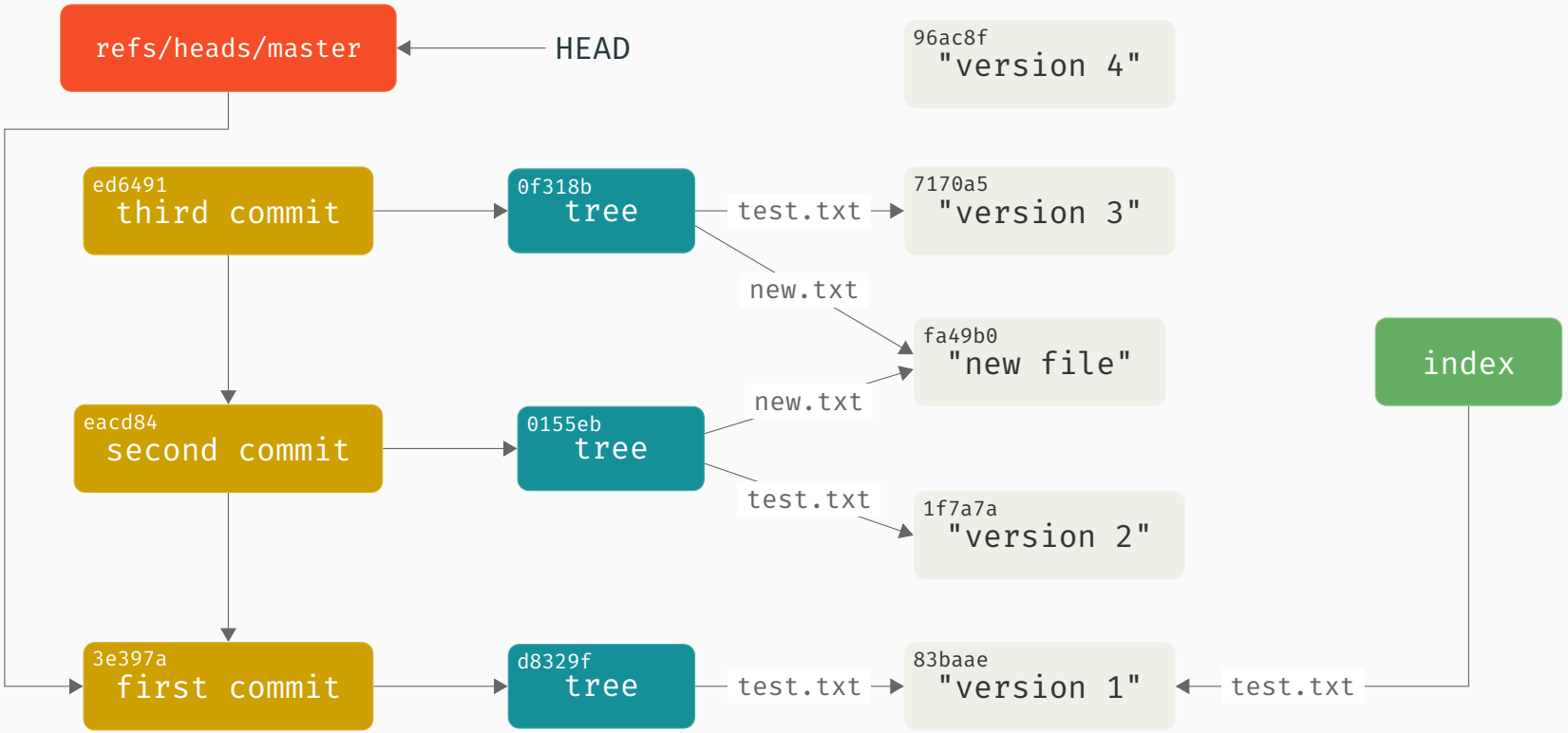

```
git reset --soft 3e397a
```

Git — Example




```
git reset [--mixed] 3e397a
```

Git — Example




```
git reset --hard 3e397a
```

`reset` vs. `checkout`

	HEAD[1]	Index	Workdir	"Safe"?[2]
Commit Level				
`reset --soft [commit]`	REF	✗	✗	✓
`reset [commit]`	REF	✓	✗	✓
`reset --hard [commit]`	REF	✓	✓	✗
`checkout [commit]`	HEAD	✓	✓	✓
File Level				
`reset [commit] <paths>`	—	✓	✗	✓
`checkout [commit] <paths>`	—	✓	✓	✗

[1] Indicates if the command moves the reference (branch), **REF**, or only the **HEAD**.
[2] Indicates if the command is safe for the working directory.