

CSE306 Software Quality in Practice

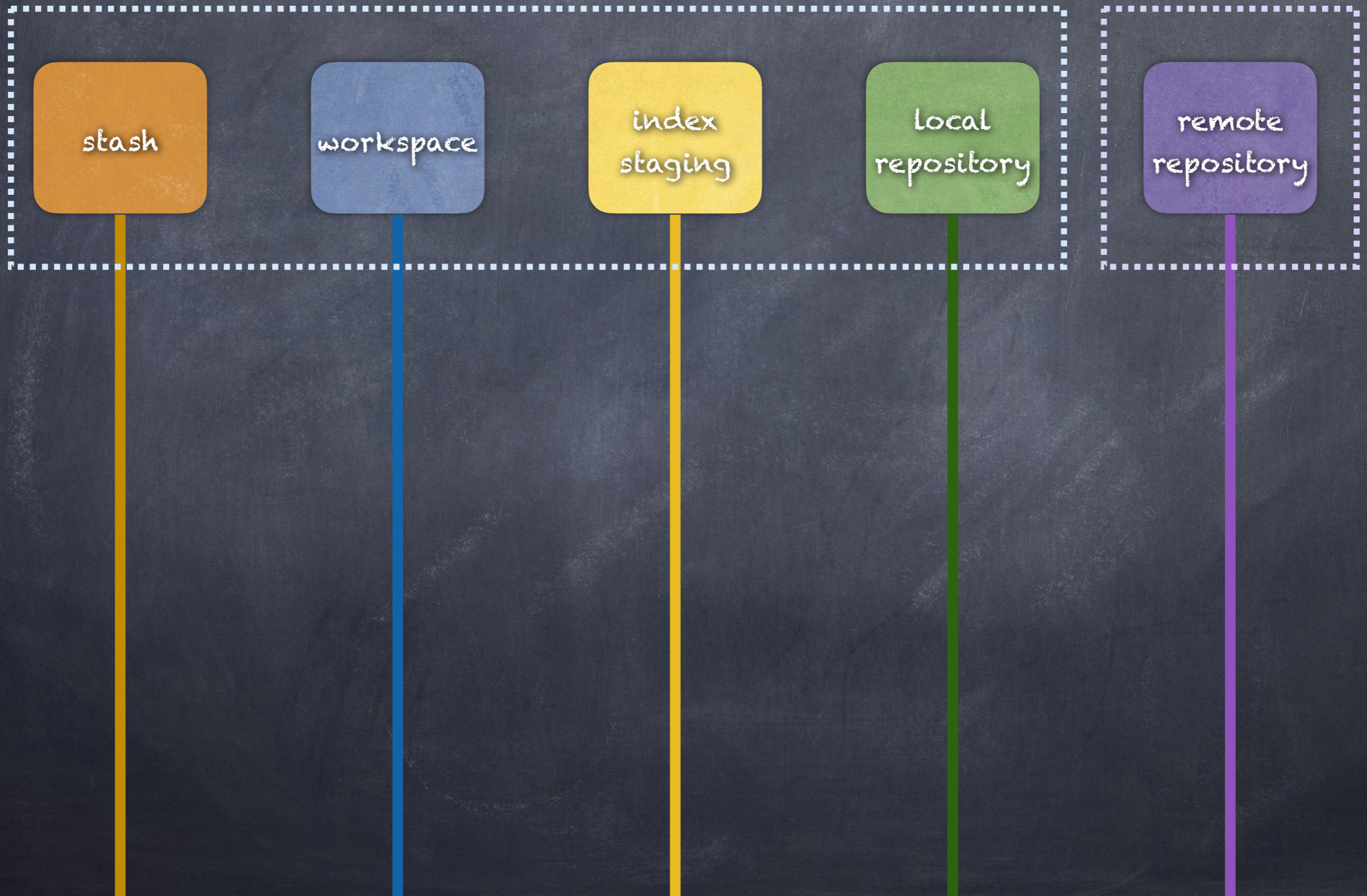
Dr. Carl Alphonse
alphonse@buffalo.edu
343 Davis Hall

Intermediate git

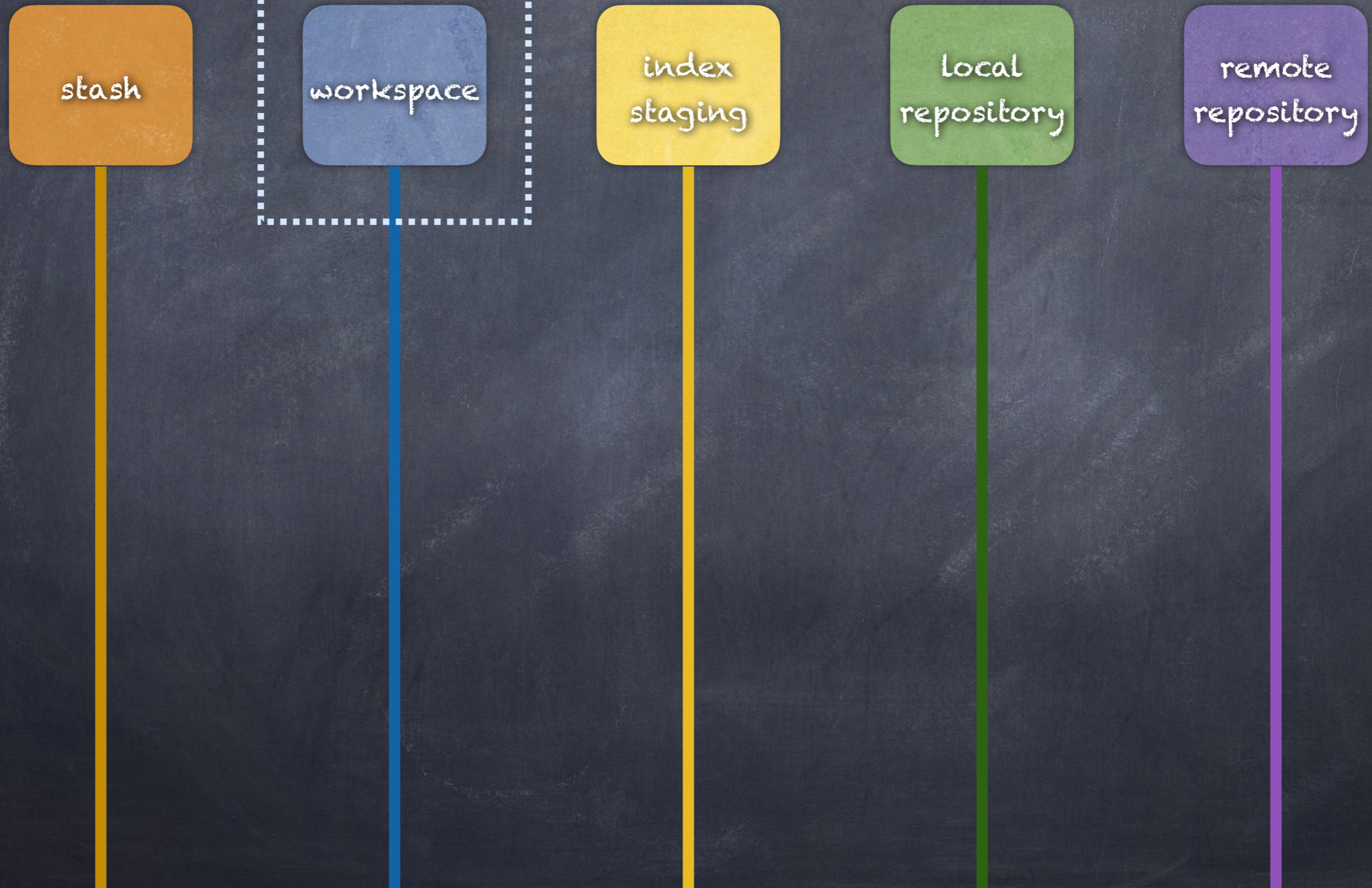
- Concepts to cover in more depth
 - Branch
 - Merge
- Additional resources
 - <http://think-like-a-git.net>
 - <https://github.com/pluralsight/git-internals-pdf/releases>

Local Machine
(e.g. your laptop, or
timberlake if you've ssh'ed in)

Remote
(e.g. bitbucket,
github,
CSE servers)

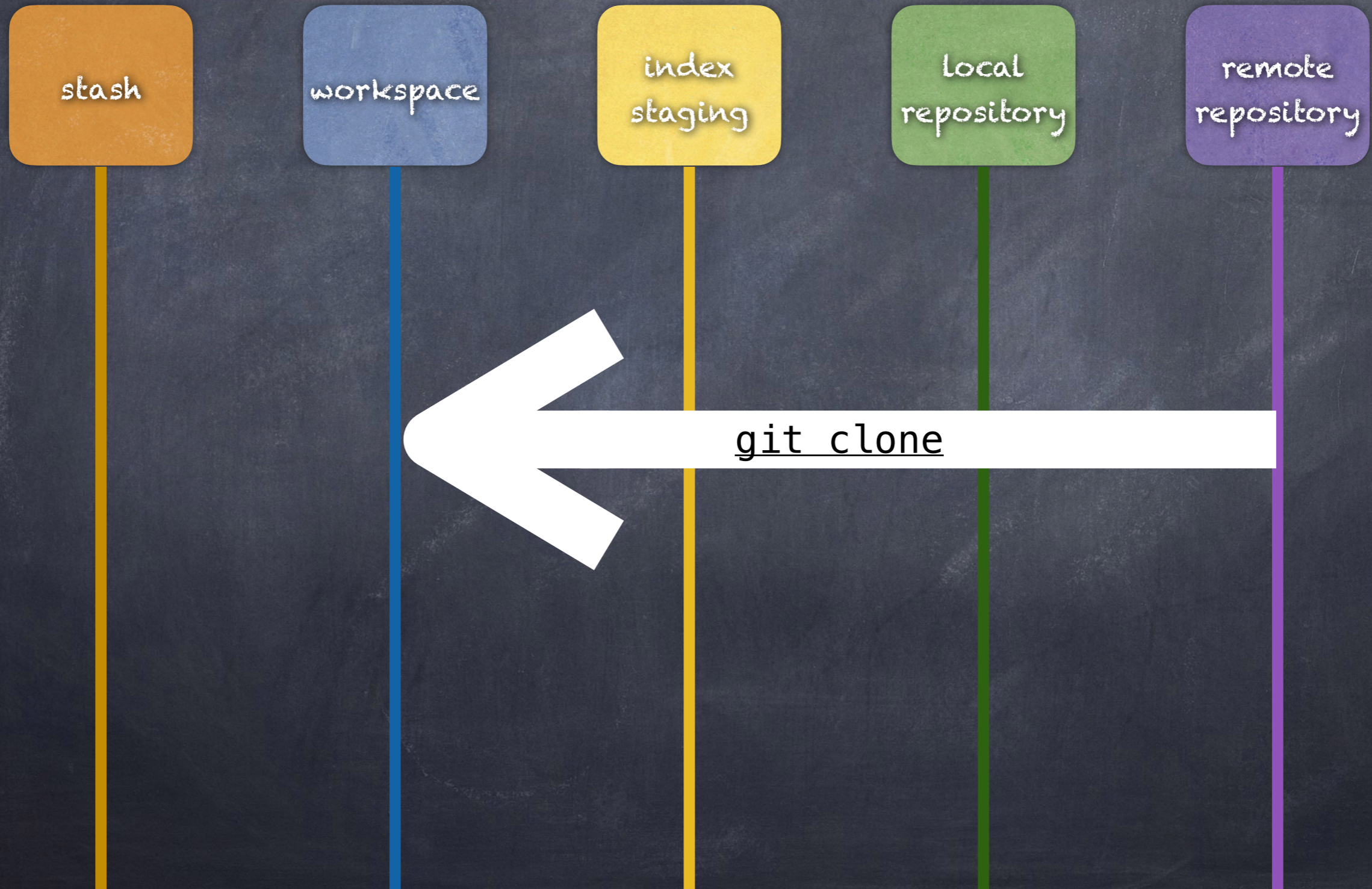


What you see
when working

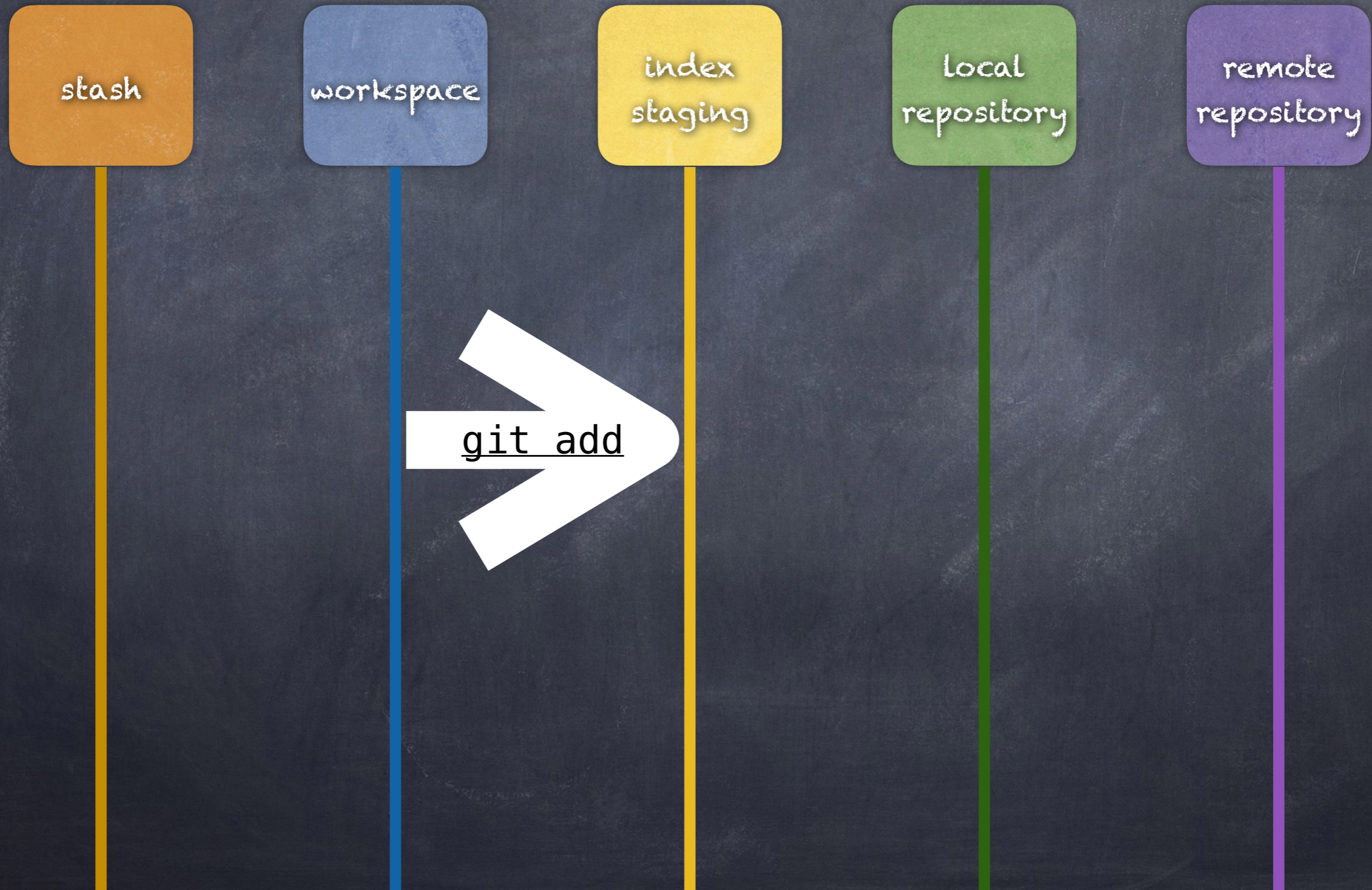


Cloning a remote

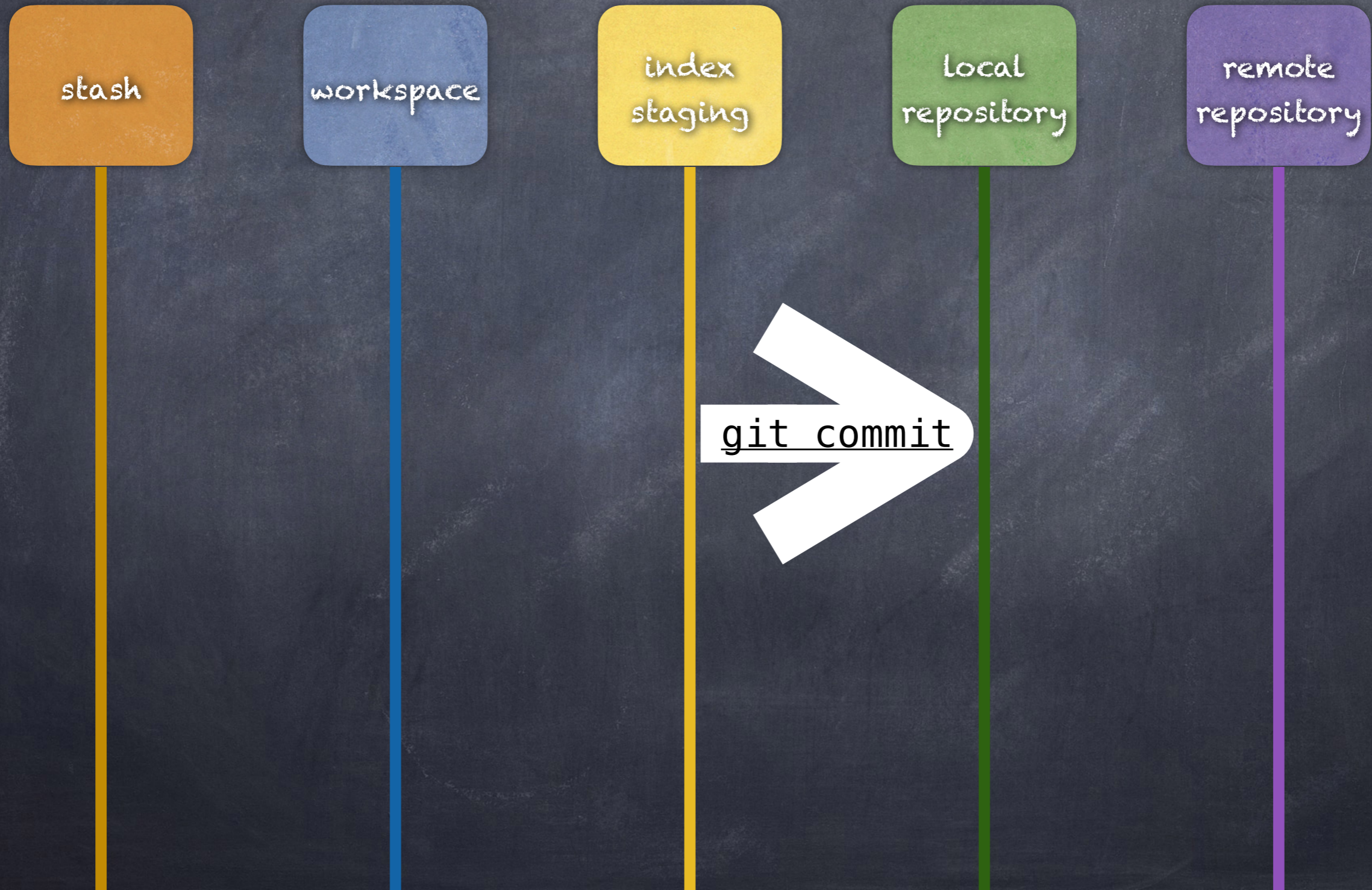
Makes a copy of remote repo in local repo
and checks out branch into workspace



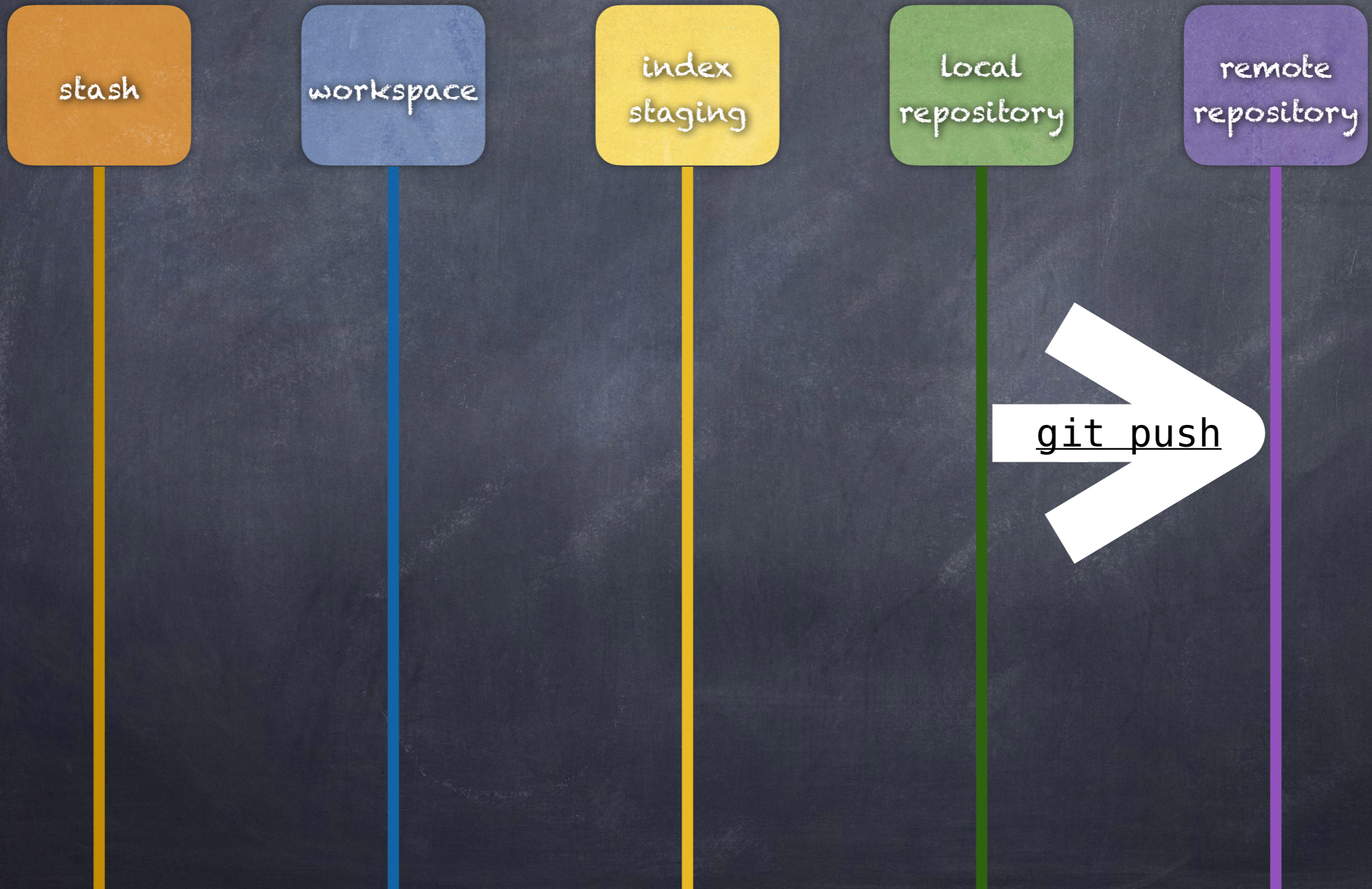
Add a file to the staging area
(add it to the index)



Create a new commit object with
the staged items from the index

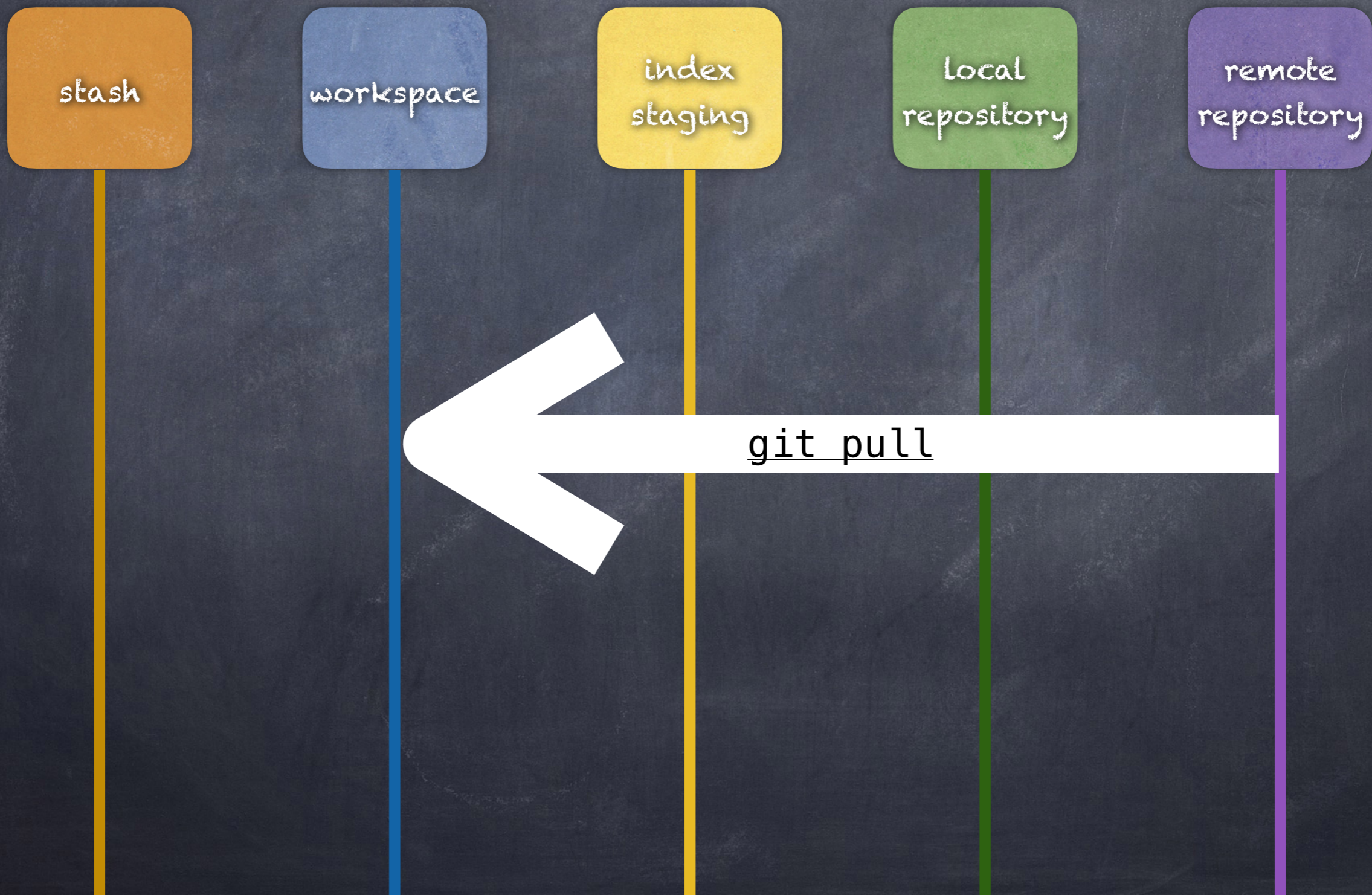


Push files from local repo to remote repo



Pulling files

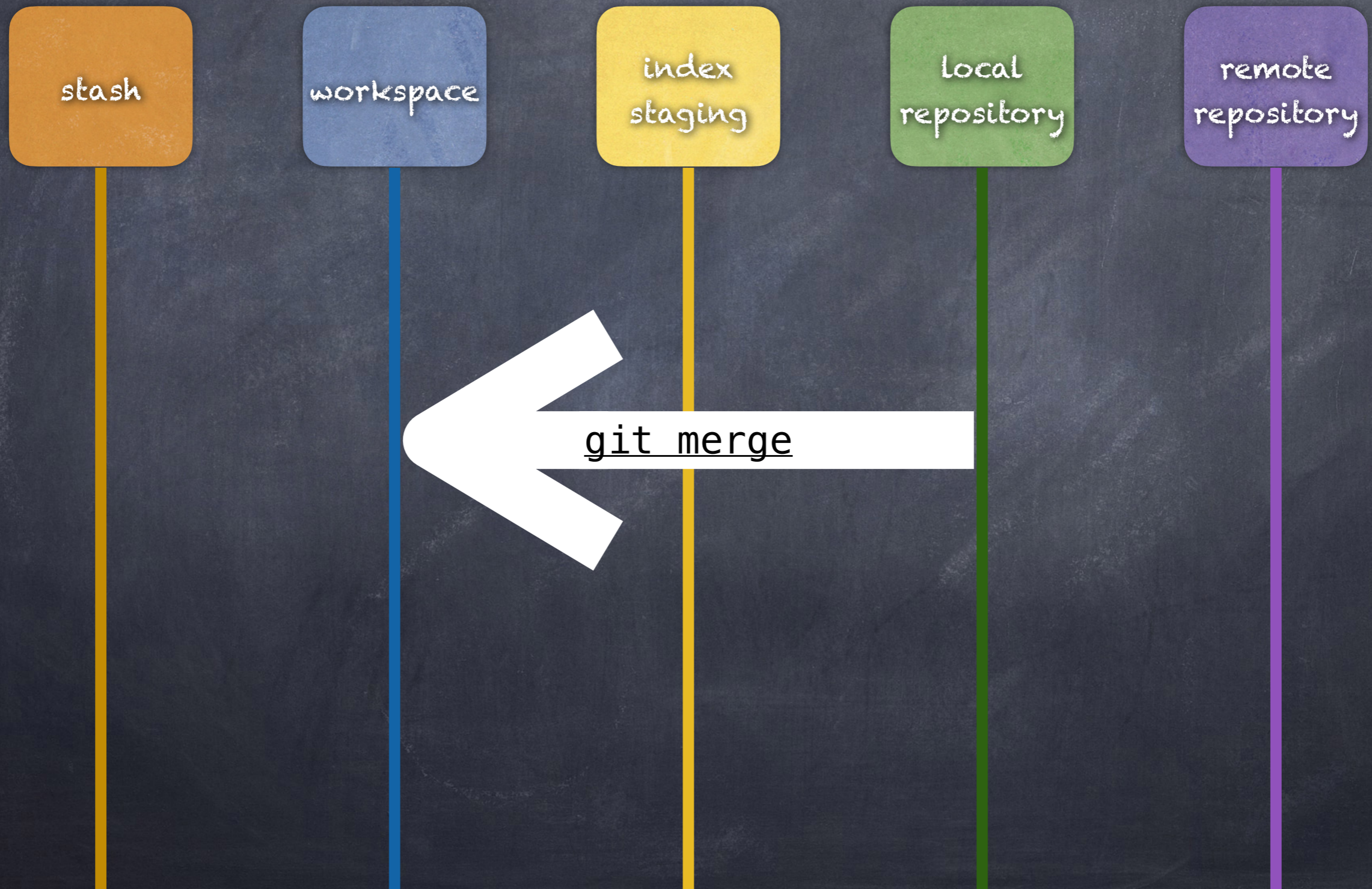
"git pull is shorthand for git fetch followed by git merge FETCH_HEAD"
[<https://git-scm.com/docs/git-pull>]



Grab files from remote



Create a commit combining
the contents of two branches



Recall the files in .git

```
-rw-r--r-- 1 alphonc staff 23 Apr 17 13:26 HEAD
drwxr-xr-x 2 alphonc staff 68 Apr 17 13:26 branches
-rw-r--r-- 1 alphonc staff 328 Apr 17 13:26 config
-rw-r--r-- 1 alphonc staff 73 Apr 17 13:26 description
drwxr-xr-x 12 alphonc staff 408 Apr 17 13:26 hooks
-rw-r--r-- 1 alphonc staff 137 Apr 17 13:26 index
drwxr-xr-x 3 alphonc staff 102 Apr 17 13:26 info
drwxr-xr-x 4 alphonc staff 136 Apr 17 13:26 logs
drwxr-xr-x 7 alphonc staff 238 Apr 17 13:26 objects
-rw-r--r-- 1 alphonc staff 107 Apr 17 13:26 packed-refs
drwxr-xr-x 5 alphonc staff 170 Apr 17 13:26 refs
```

pointer to the current branch

| | | | | | | | | |
|------------|----|---------|-------|-----|-----|----|-------|-------------|
| -rw-r--r-- | 1 | alphonc | staff | 23 | Apr | 17 | 13:26 | HEAD |
| drwxr-xr-x | 2 | alphonc | staff | 68 | Apr | 17 | 13:26 | branches |
| -rw-r--r-- | 1 | alphonc | staff | 328 | Apr | 17 | 13:26 | config |
| -rw-r--r-- | 1 | alphonc | staff | 73 | Apr | 17 | 13:26 | description |
| drwxr-xr-x | 12 | alphonc | staff | 408 | Apr | 17 | 13:26 | hooks |
| -rw-r--r-- | 1 | alphonc | staff | 137 | Apr | 17 | 13:26 | index |
| drwxr-xr-x | 3 | alphonc | staff | 102 | Apr | 17 | 13:26 | info |
| drwxr-xr-x | 4 | alphonc | staff | 136 | Apr | 17 | 13:26 | logs |
| drwxr-xr-x | 7 | alphonc | staff | 238 | Apr | 17 | 13:26 | objects |
| -rw-r--r-- | 1 | alphonc | staff | 107 | Apr | 17 | 13:26 | packed-refs |
| drwxr-xr-x | 5 | alphonc | staff | 170 | Apr | 17 | 13:26 | refs |

\$ more head
ref: refs/heads/main

| | | | | | | | | |
|------------|----|---------|-------|-----|-----|----|-------|-------------|
| -rw-r--r-- | 1 | alphonc | staff | 23 | Apr | 17 | 13:26 | HEAD |
| drwxr-xr-x | 2 | alphonc | staff | 68 | Apr | 17 | 13:26 | branches |
| -rw-r--r-- | 1 | alphonc | staff | 328 | Apr | 17 | 13:26 | config |
| -rw-r--r-- | 1 | alphonc | staff | 73 | Apr | 17 | 13:26 | description |
| drwxr-xr-x | 12 | alphonc | staff | 408 | Apr | 17 | 13:26 | hooks |
| -rw-r--r-- | 1 | alphonc | staff | 137 | Apr | 17 | 13:26 | index |
| drwxr-xr-x | 3 | alphonc | staff | 102 | Apr | 17 | 13:26 | info |
| drwxr-xr-x | 4 | alphonc | staff | 136 | Apr | 17 | 13:26 | logs |
| drwxr-xr-x | 7 | alphonc | staff | 238 | Apr | 17 | 13:26 | objects |
| -rw-r--r-- | 1 | alphonc | staff | 107 | Apr | 17 | 13:26 | packed-refs |
| drwxr-xr-x | 5 | alphonc | staff | 170 | Apr | 17 | 13:26 | refs |

staging area

| | | | | | | | |
|------------|----|---------|-------|-----|--------|-------|-------------|
| -rw-r--r-- | 1 | alphonc | staff | 23 | Apr 17 | 13:26 | HEAD |
| drwxr-xr-x | 2 | alphonc | staff | 68 | Apr 17 | 13:26 | branches |
| -rw-r--r-- | 1 | alphonc | staff | 328 | Apr 17 | 13:26 | config |
| -rw-r--r-- | 1 | alphonc | staff | 73 | Apr 17 | 13:26 | description |
| drwxr-xr-x | 12 | alphonc | staff | 408 | Apr 17 | 13:26 | hooks |
| -rw-r--r-- | 1 | alphonc | staff | 137 | Apr 17 | 13:26 | index |
| drwxr-xr-x | 3 | alphonc | staff | 102 | Apr 17 | 13:26 | info |
| drwxr-xr-x | 4 | alphonc | staff | 136 | Apr 17 | 13:26 | logs |
| drwxr-xr-x | 7 | alphonc | staff | 238 | Apr 17 | 13:26 | objects |
| -rw-r--r-- | 1 | alphonc | staff | 107 | Apr 17 | 13:26 | packed-refs |
| drwxr-xr-x | 5 | alphonc | staff | 170 | Apr 17 | 13:26 | refs |

content
(blobs, trees, commits)

| | | | | | | | |
|------------|----|---------|-------|-----|--------|-------|-------------|
| -rw-r--r-- | 1 | alphonc | staff | 23 | Apr 17 | 13:26 | HEAD |
| drwxr-xr-x | 2 | alphonc | staff | 68 | Apr 17 | 13:26 | branches |
| -rw-r--r-- | 1 | alphonc | staff | 328 | Apr 17 | 13:26 | config |
| -rw-r--r-- | 1 | alphonc | staff | 73 | Apr 17 | 13:26 | description |
| drwxr-xr-x | 12 | alphonc | staff | 408 | Apr 17 | 13:26 | hooks |
| -rw-r--r-- | 1 | alphonc | staff | 137 | Apr 17 | 13:26 | index |
| drwxr-xr-x | 3 | alphonc | staff | 102 | Apr 17 | 13:26 | info |
| drwxr-xr-x | 4 | alphonc | staff | 136 | Apr 17 | 13:26 | logs |
| drwxr-xr-x | 7 | alphonc | staff | 238 | Apr 17 | 13:26 | objects |
| -rw-r--r-- | 1 | alphonc | staff | 107 | Apr 17 | 13:26 | packed-refs |
| drwxr-xr-x | 5 | alphonc | staff | 170 | Apr 17 | 13:26 | refs |


```
$ ls -l objects
```

```
total 0
```

```
drwxr-xr-x  3 alphonc  staff  102 Apr 17 13:26 25  
drwxr-xr-x  3 alphonc  staff  102 Apr 17 13:26 39  
drwxr-xr-x  3 alphonc  staff  102 Apr 17 13:26 9c  
drwxr-xr-x  2 alphonc  staff   68 Apr 17 13:26 info  
drwxr-xr-x  2 alphonc  staff   68 Apr 17 13:26 pack
```

```
$ git cat-file -t 25b4
```

```
commit
```

```
$ git cat-file -t 9ce9
```

```
tree
```

```
$ git cat-file -t 39af
```

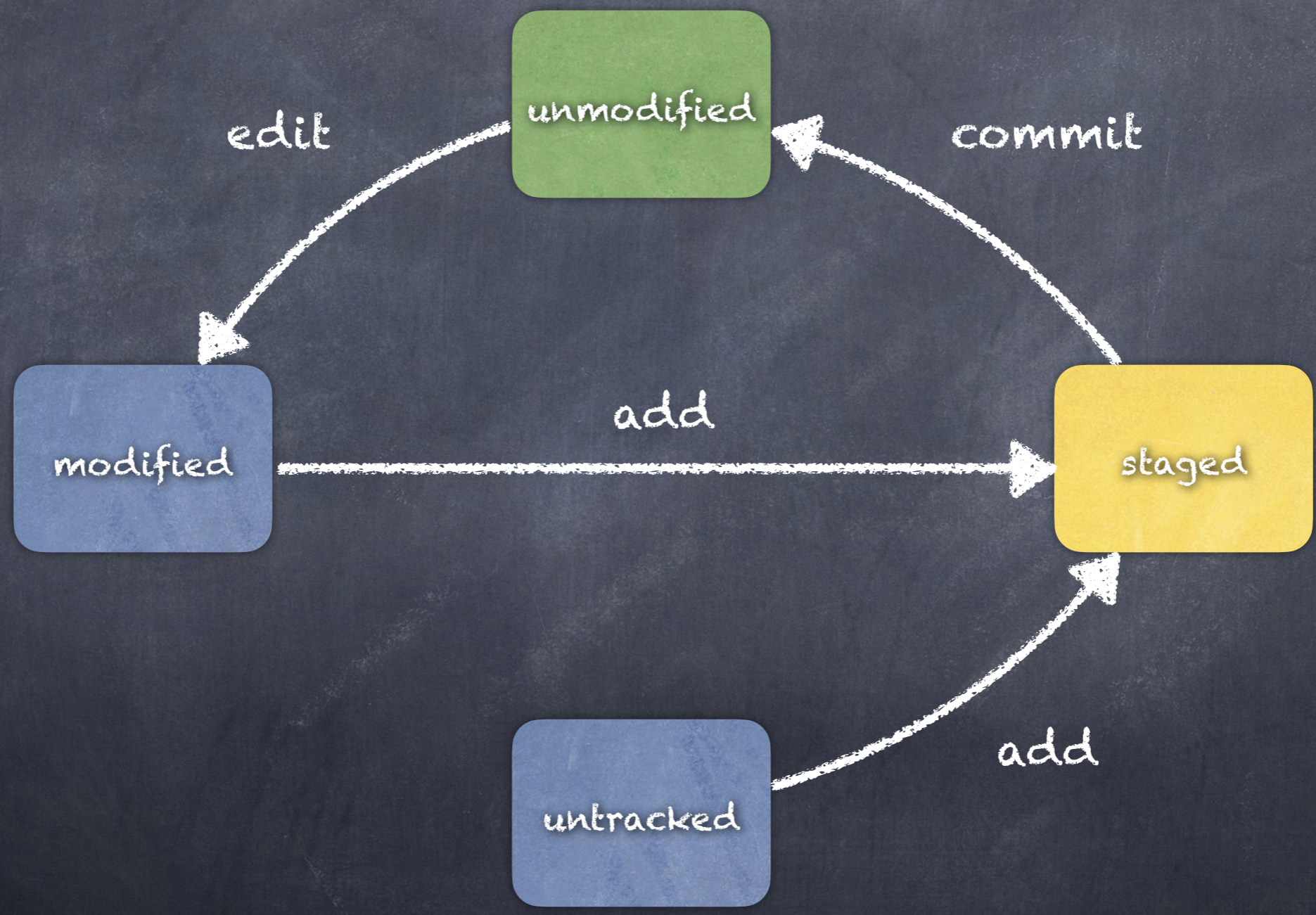
```
blob
```

```
drwxr-xr-x  4 alphonc  staff  156 Apr 17 13:26 log  
drwxr-xr-x  7 alphonc  staff  238 Apr 17 13:26 objects  
-rw-r--r--  1 alphonc  staff  107 Apr 17 13:26 packed-refs  
drwxr-xr-x  5 alphonc  staff  170 Apr 17 13:26 refs
```

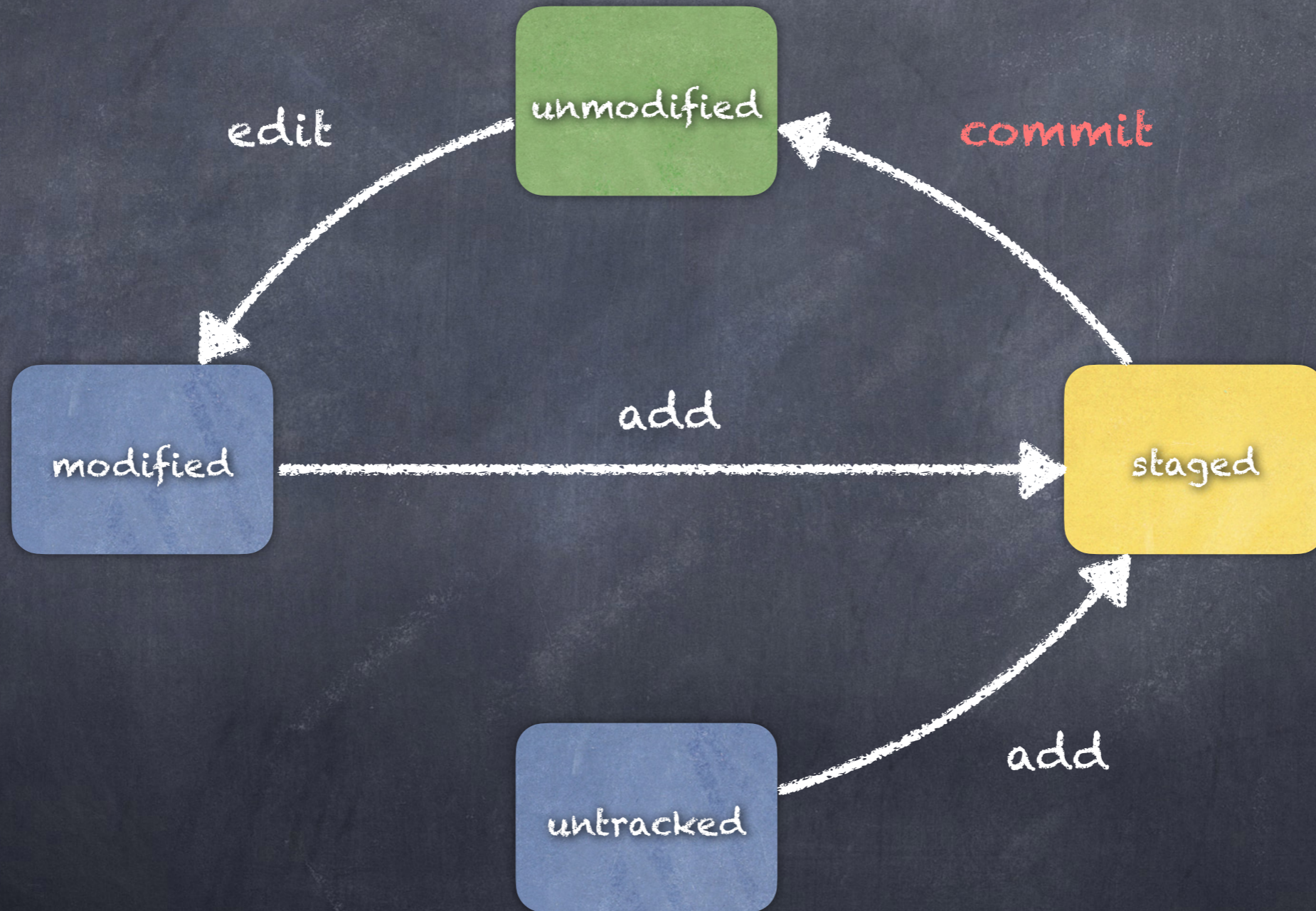
pointers to commits

| | | | | | | | |
|------------|----|---------|-------|-----|--------|-------|-------------|
| -rw-r--r-- | 1 | alphonc | staff | 23 | Apr 17 | 13:26 | HEAD |
| drwxr-xr-x | 2 | alphonc | staff | 68 | Apr 17 | 13:26 | branches |
| -rw-r--r-- | 1 | alphonc | staff | 328 | Apr 17 | 13:26 | config |
| -rw-r--r-- | 1 | alphonc | staff | 73 | Apr 17 | 13:26 | description |
| drwxr-xr-x | 12 | alphonc | staff | 408 | Apr 17 | 13:26 | hooks |
| -rw-r--r-- | 1 | alphonc | staff | 137 | Apr 17 | 13:26 | index |
| drwxr-xr-x | 3 | alphonc | staff | 102 | Apr 17 | 13:26 | info |
| drwxr-xr-x | 4 | alphonc | staff | 136 | Apr 17 | 13:26 | logs |
| drwxr-xr-x | 7 | alphonc | staff | 238 | Apr 17 | 13:26 | objects |
| -rw-r--r-- | 1 | alphonc | staff | 107 | Apr 17 | 13:26 | packed-refs |
| drwxr-xr-x | 5 | alphonc | staff | 170 | Apr 17 | 13:26 | refs |

Possible states of a file



commit preserves contents
(accidental removals can be recovered from)



understanding branching

<https://www.git-scm.com/book/en/v2/Git-Branching-Branched-in-a-Nutshell>

- `git branch <name>` creates a new pointer

workspace

fileA

index
staging

local repository

HEAD

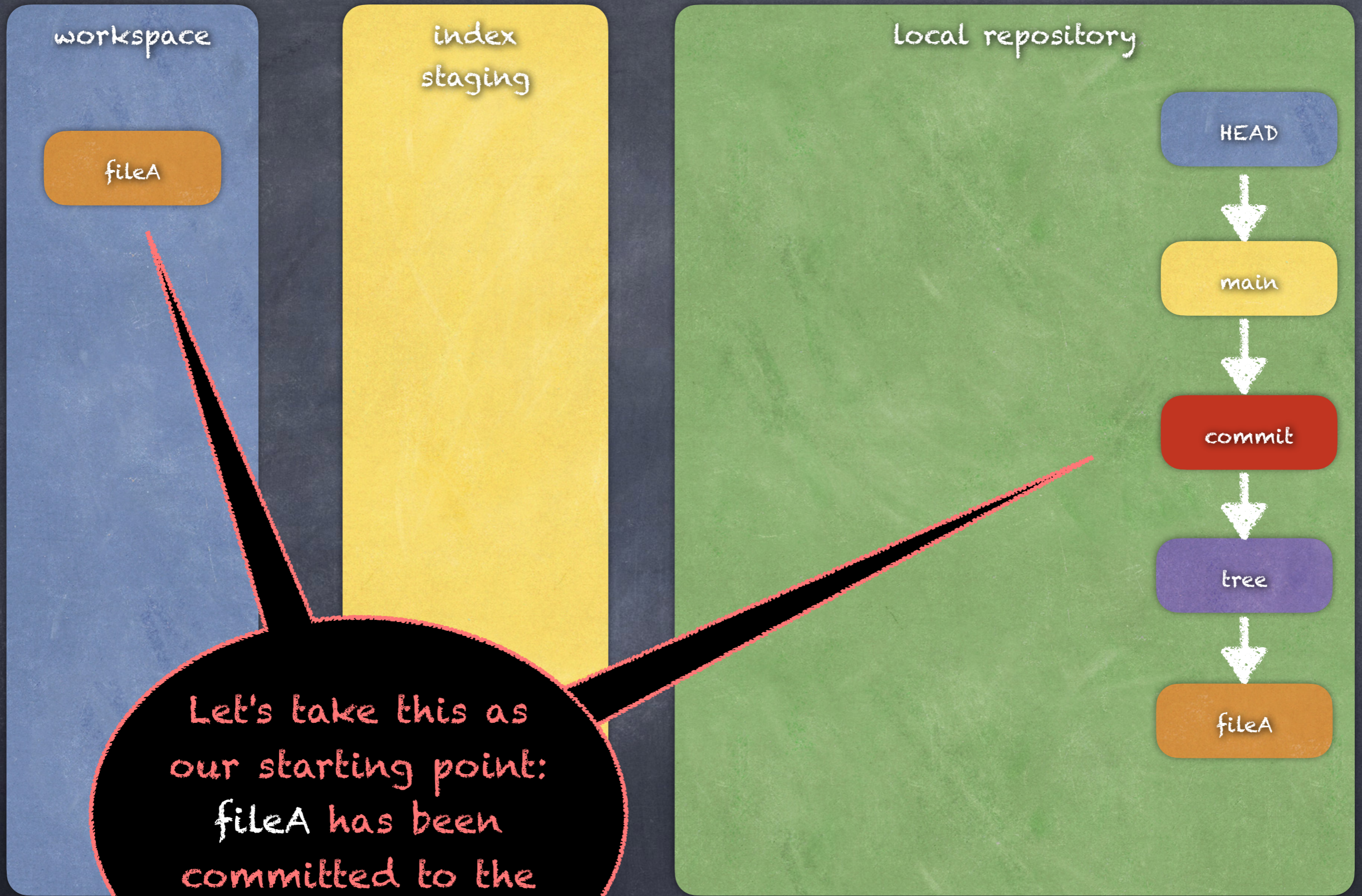
main

commit

tree

fileA

Let's take this as
our starting point:
fileA has been
committed to the
local repo.



workspace

fileA

index
staging

local repository

HEAD

main

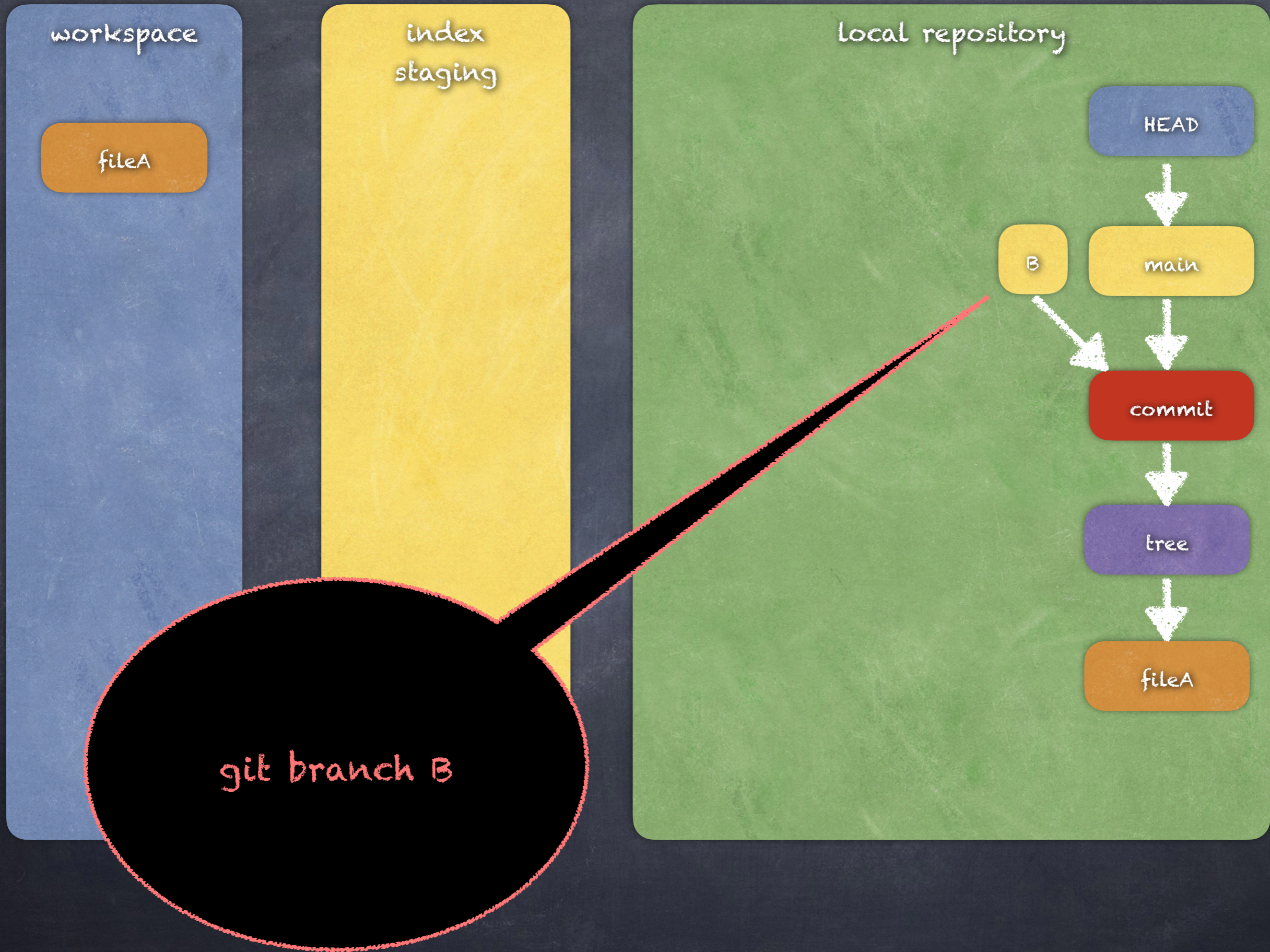
commit

tree

fileA

B

git branch B



workspace

fileA

index
staging

local repository

HEAD

B

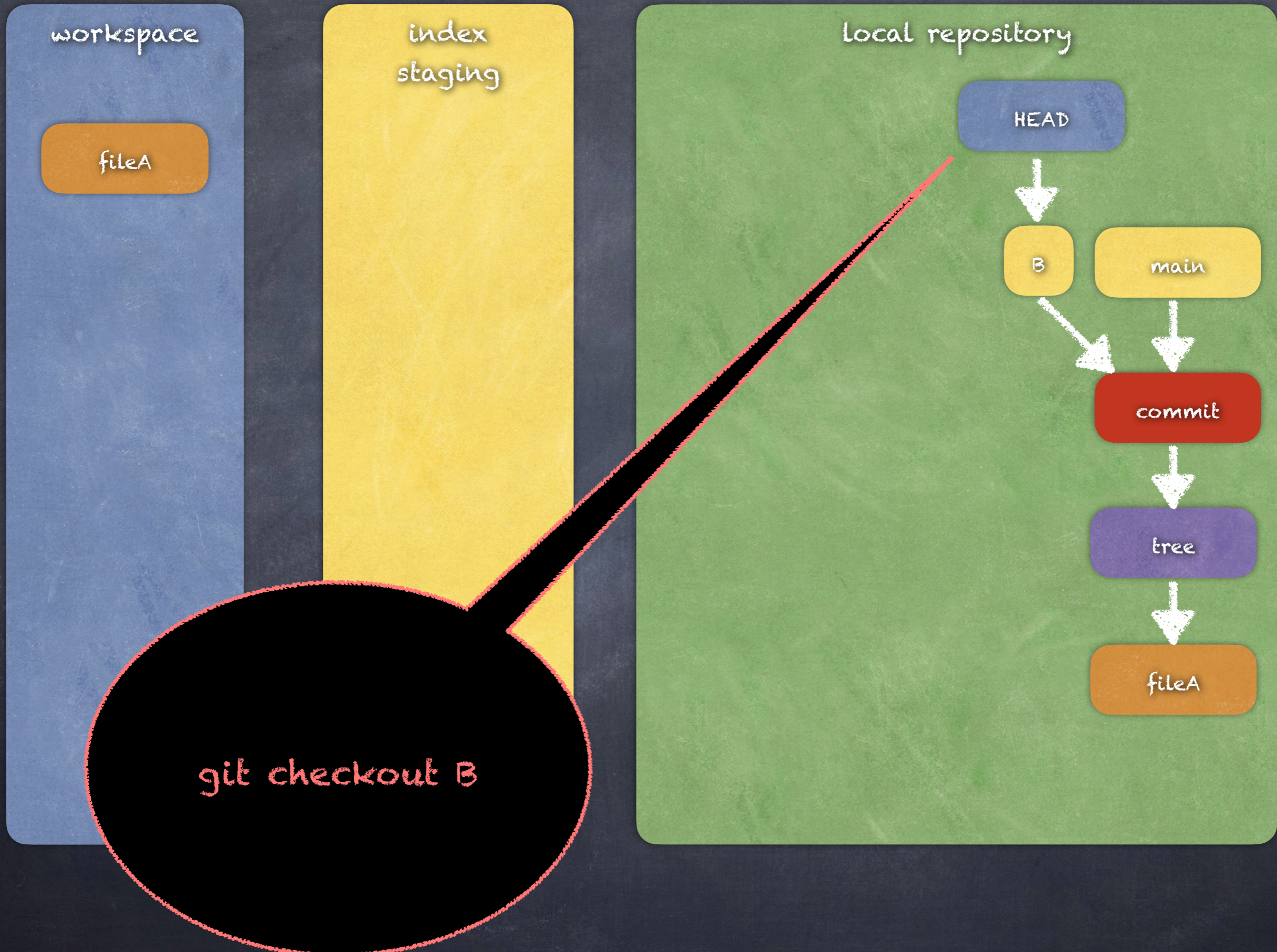
main

commit

tree

fileA

git checkout B



workspace

fileA

fileB

create fileB
(in workspace)

index
staging

fileB

... then
git add fileB

local repository

HEAD

B

main

commit

tree

fileA



workspace

fileA

fileB

index
staging

local repository

HEAD

B

main

commit

commit

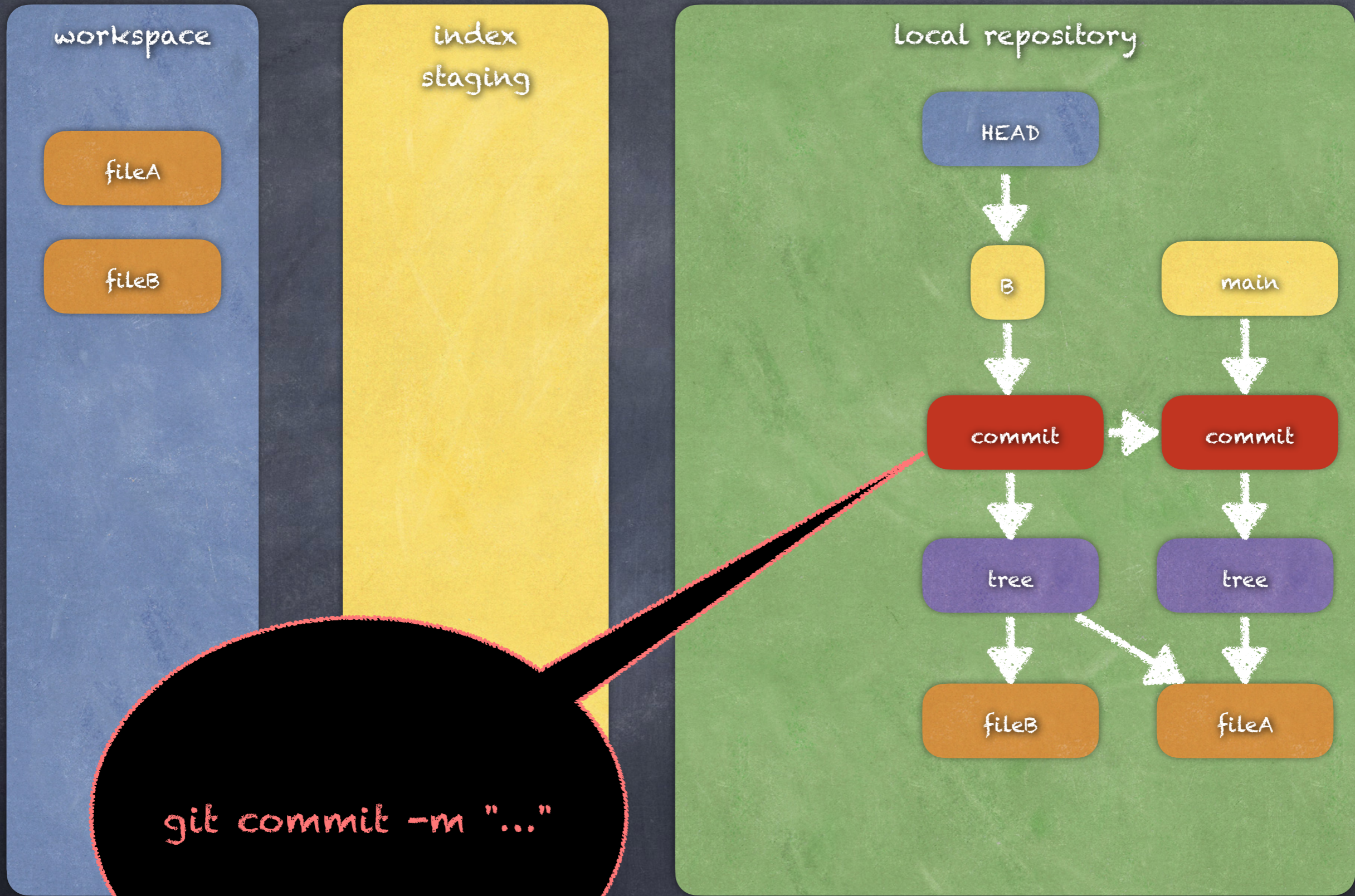
tree

tree

fileB

fileA

`git commit -m "..."`



workspace

fileA

index
staging

local repository

HEAD

main

B

commit

commit

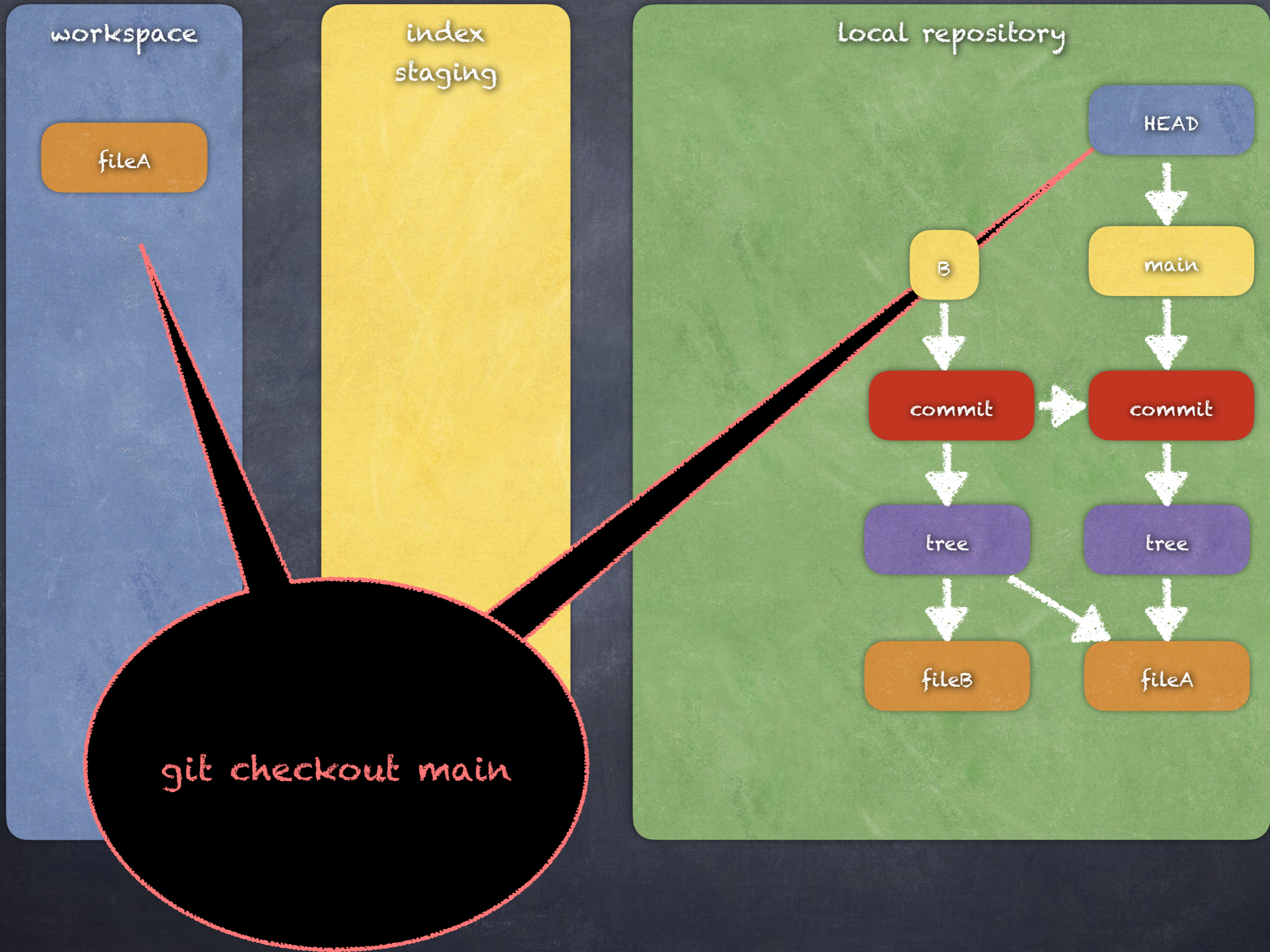
tree

tree

fileB

fileA

git checkout main



workspace

fileA

fileB

index
staging

local repository

HEAD

B

main

commit

commit

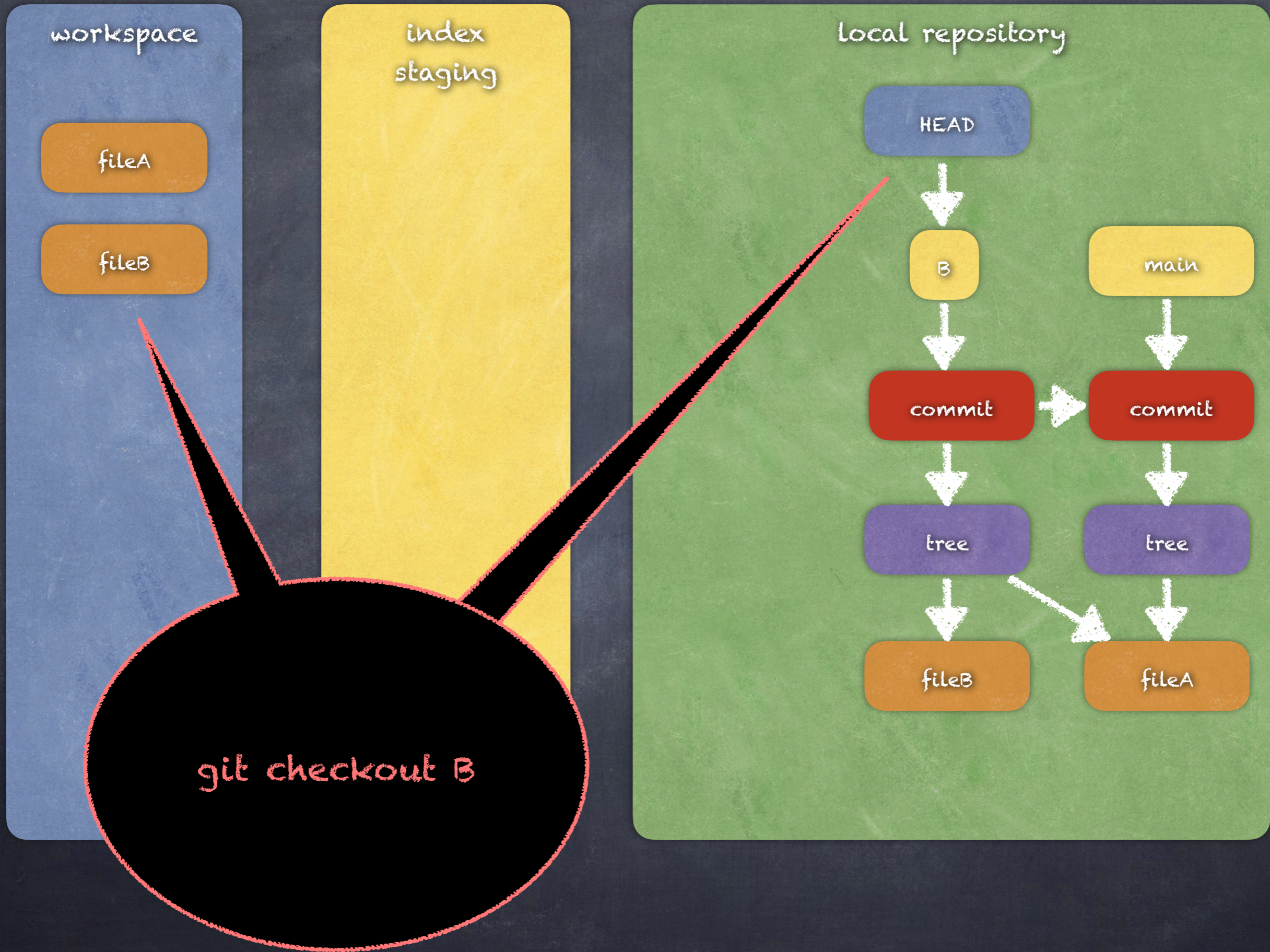
tree

tree

fileB

fileA

git checkout B



EXERCISE

workspace

README.md

F1

F2

F3

F4

index
staging

local repository

HEAD

b

a

main

commit

commit

commit

tree

tree

tree

F4

F3

F2

F1

README.md

Let us first switch to branch 'a':

```
git checkout a
```

workspace

README.md

F1

F2

index
staging

local repository

HEAD

b

a

main

commit

commit

commit

tree

tree

tree

F4

F3

F2

F1

README.md

Now edit and commit F2.

```
emacs F2 (call edited version F2')
```

```
git add F2'
```

```
git commit -m "..."
```

workspace

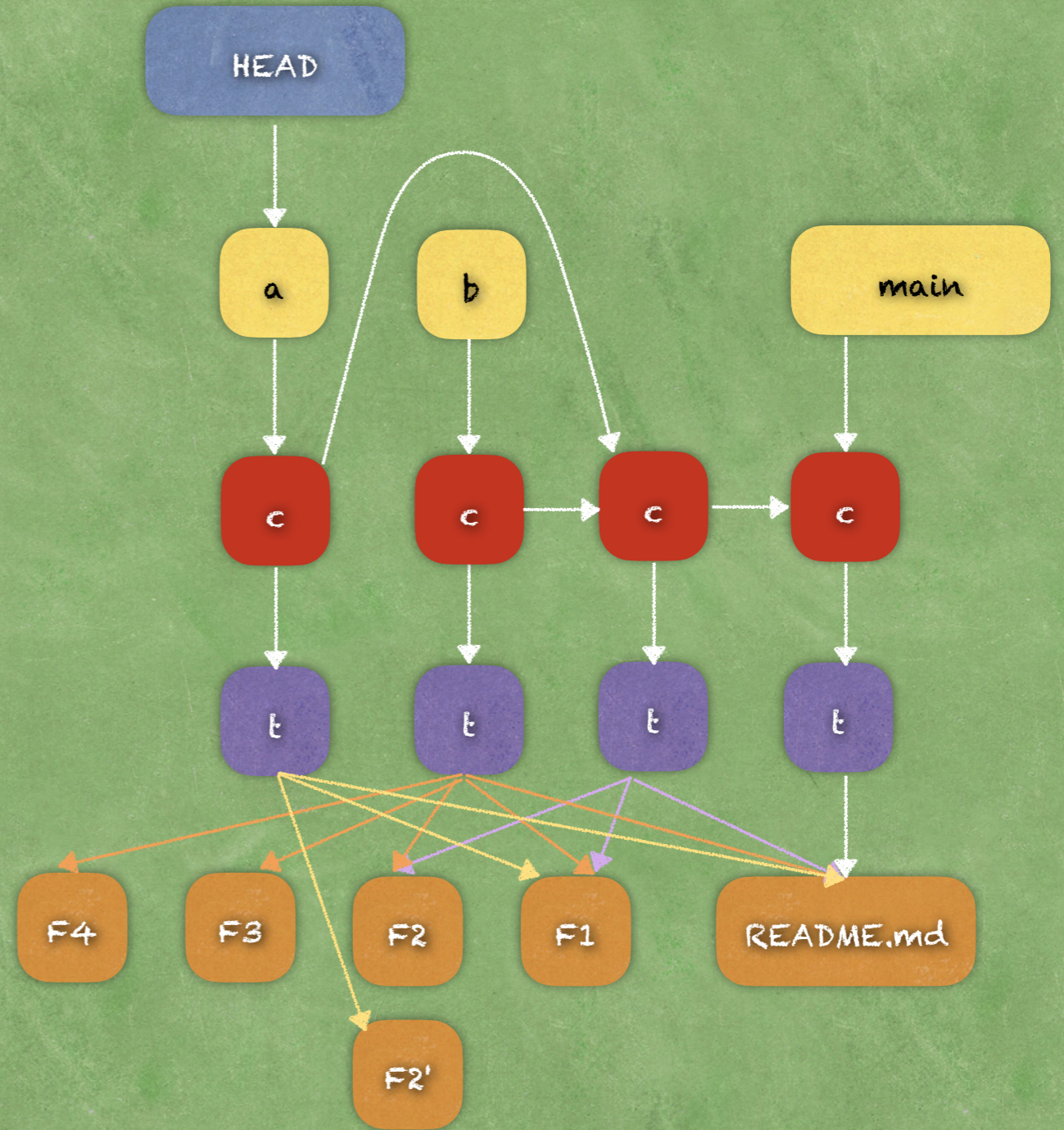
README.md

F1

F2'

index
staging

local repository



Create FS, add, and commit.

```
emacs FS  
git add FS  
git commit -m "..."
```

workspace

README.md

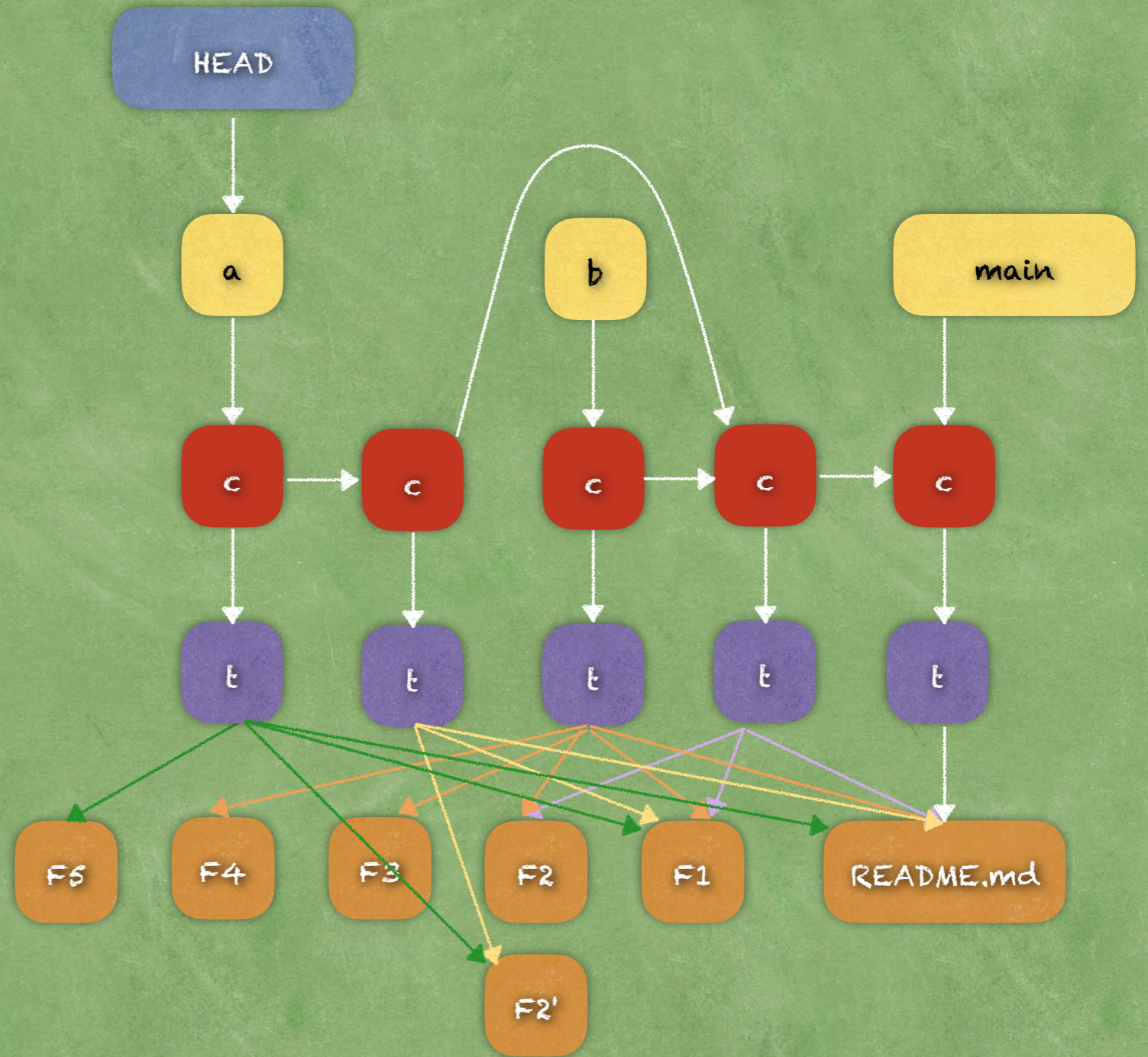
F1

F2'

F5

index
staging

local repository



Switch to main.

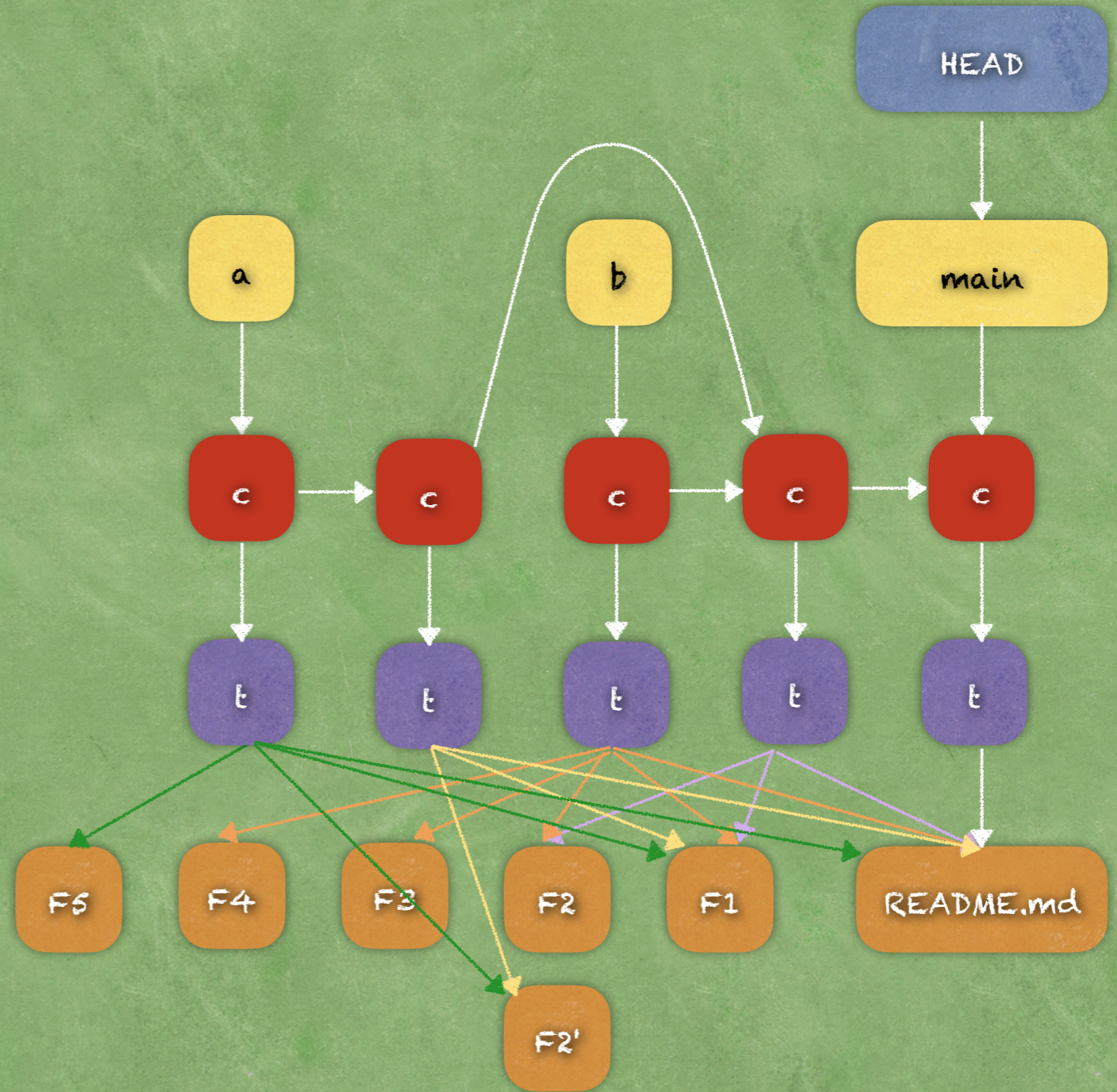
```
git checkout main
```

workspace

README.md

index
staging

local repository



Merge a into main.

```
git merge a
```

workspace

README.md

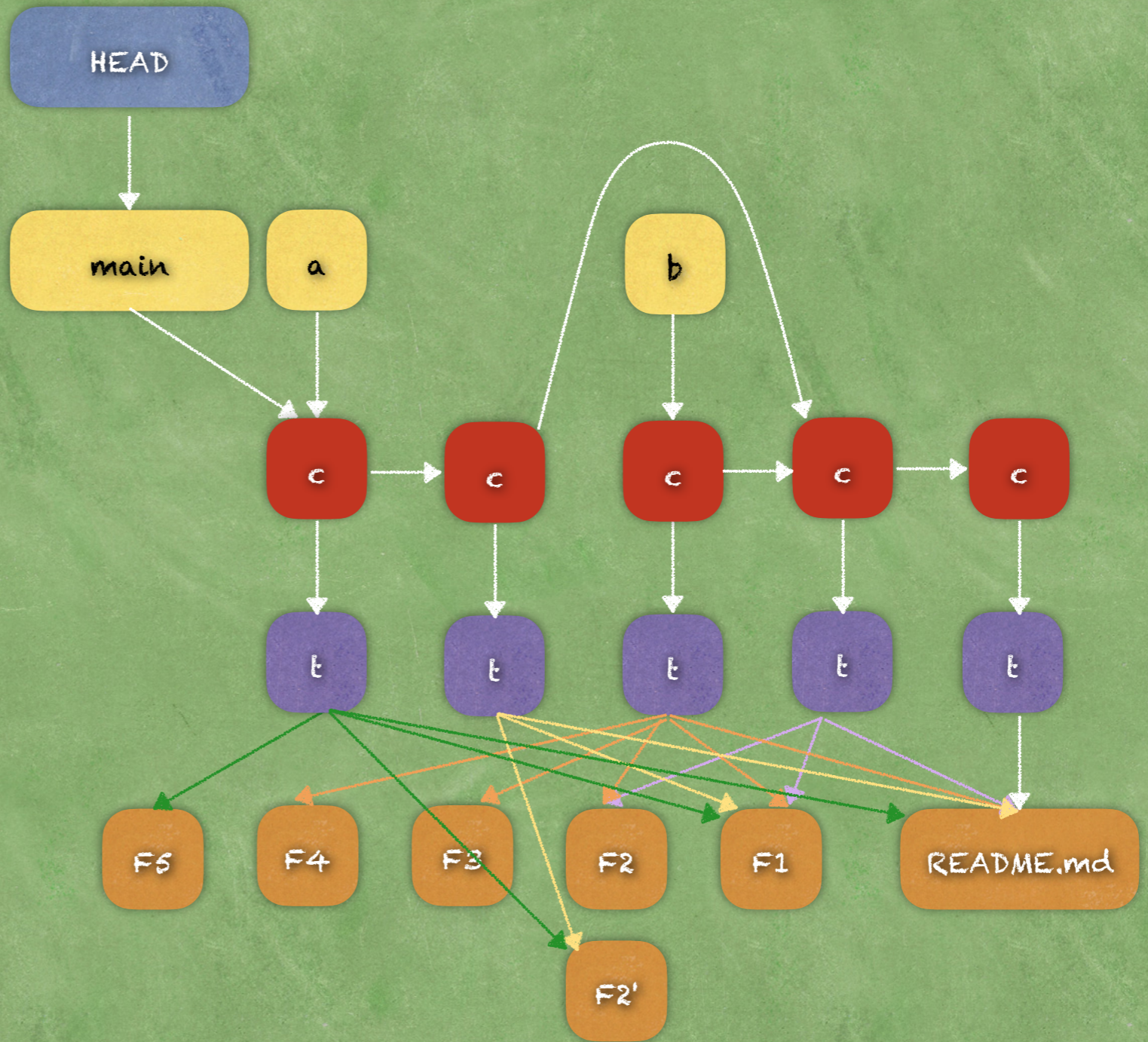
F1

F2'

F5

index
staging

local repository



workspace

README.md

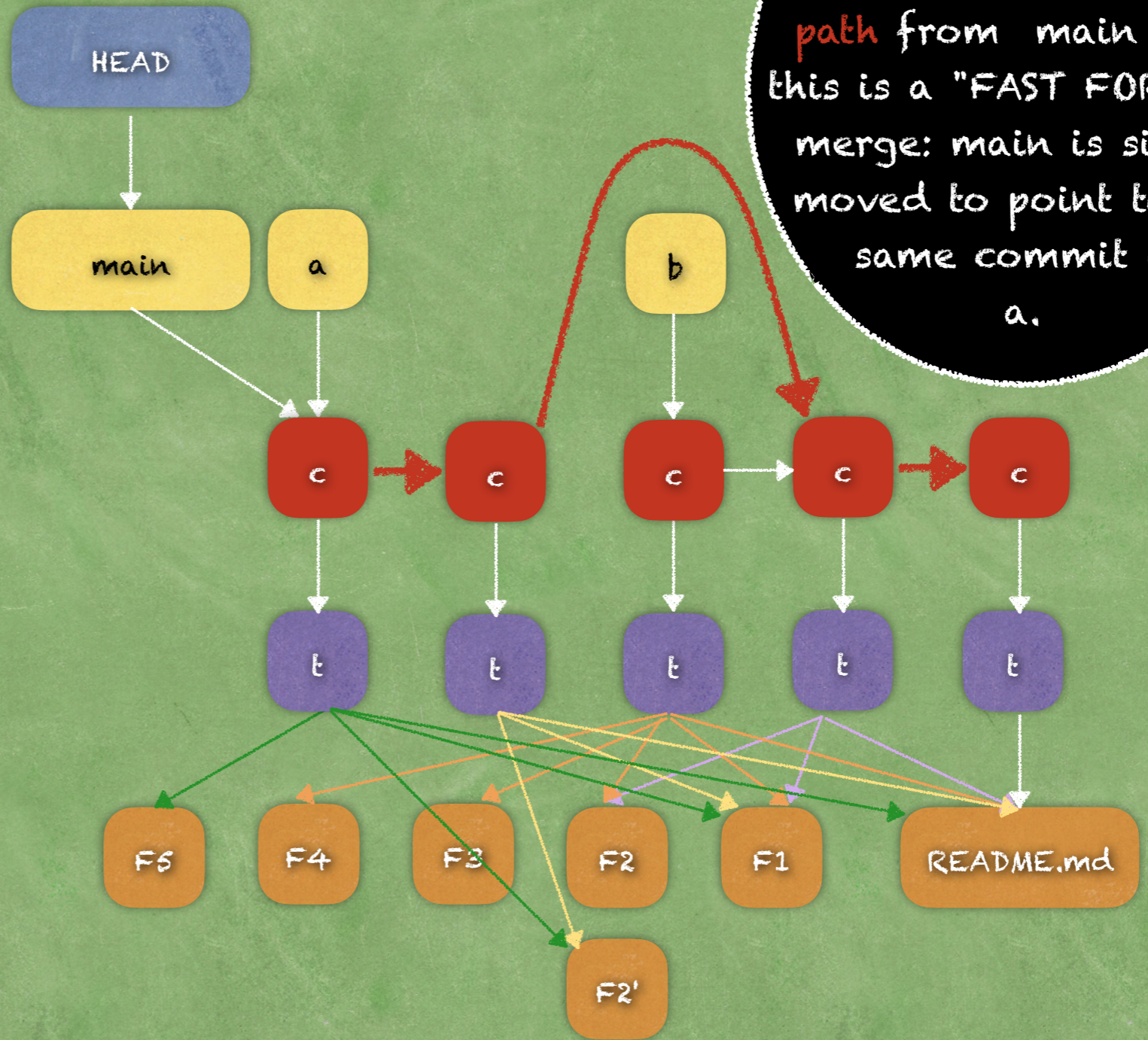
F1

F2'

F5

index
staging

local repository



Because there was a **straight line path** from main to a, this is a "FAST FORWARD merge: main is simply moved to point to the same commit as a."

Deleting a branch

- `git branch -d a`

workspace

README.md

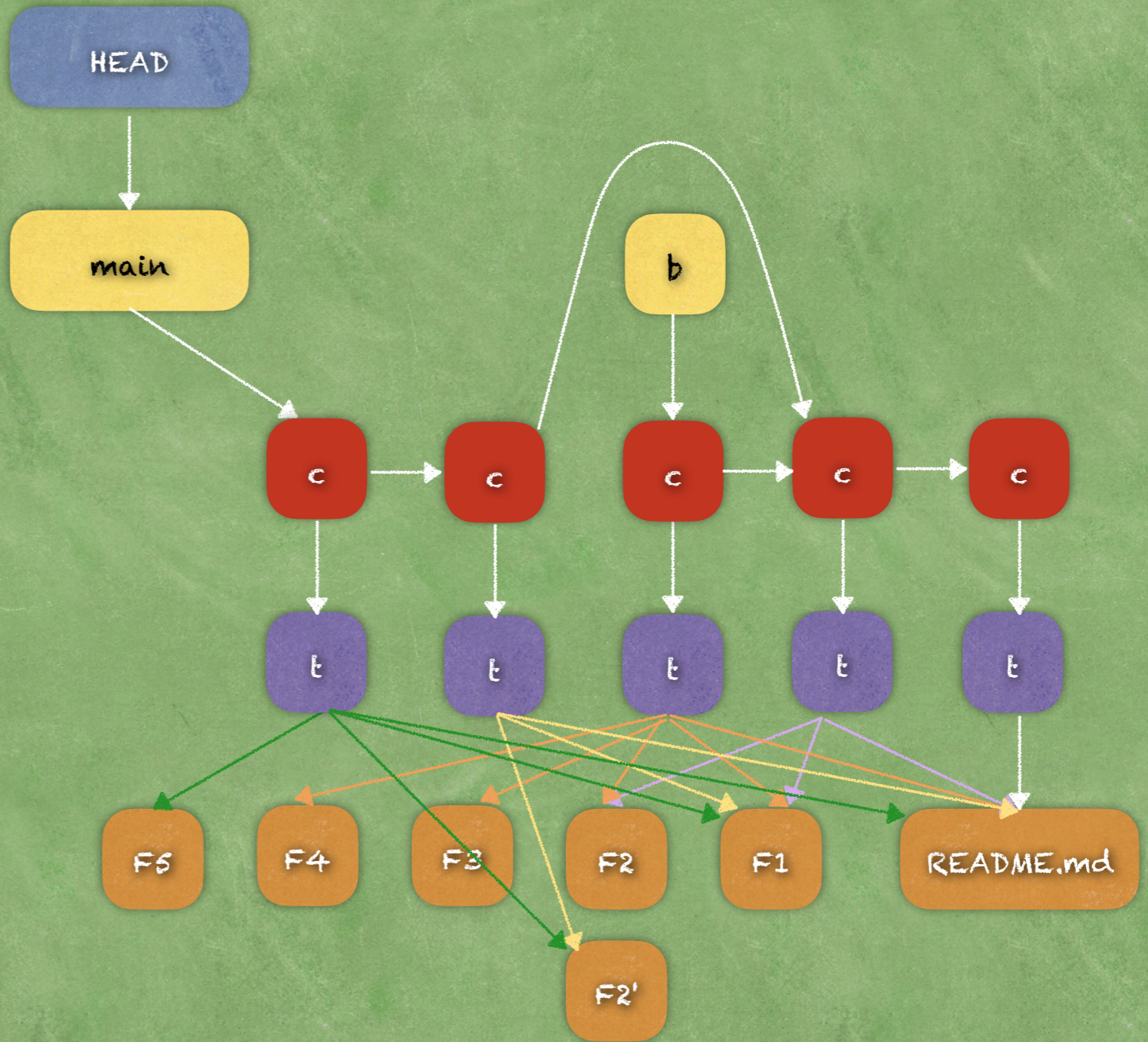
F1

F2'

F5

index
staging

local repository



(natural breakpoint)

EXERCISE

workspace

README.md

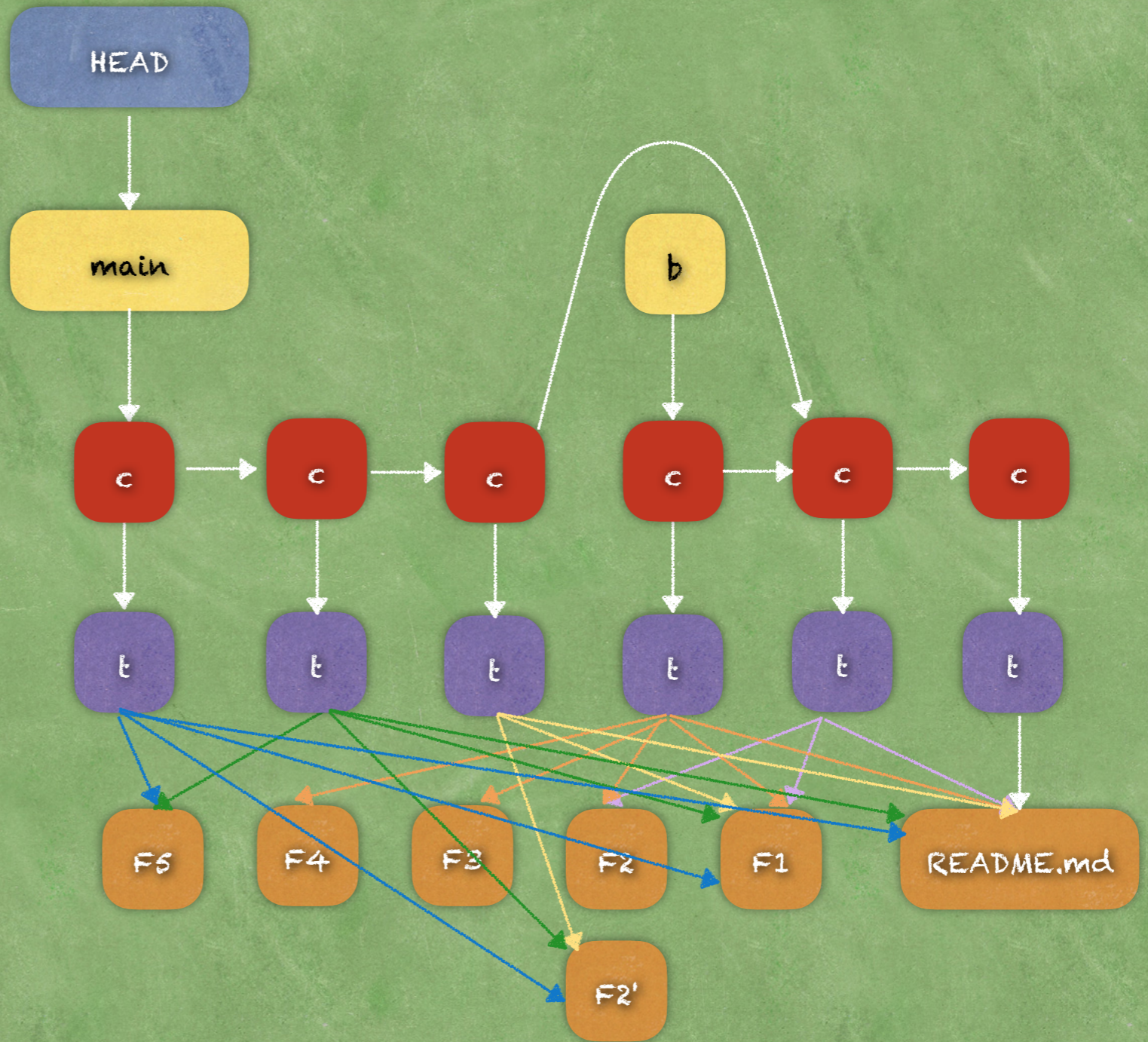
F1

F2'

F5

index
staging

local repository



Switch to b, edit F2 to create conflict (edit same part of F2 as you did on branch a, but change it in a different way), merge b into main (switch to main, then 'git merge b').

workspace

index
staging

README.md

F1

F2'

F5

local repository

HEAD

main

b

c

c

c

c

c

c

t

t

t

t

t

t

F5

F4

F3

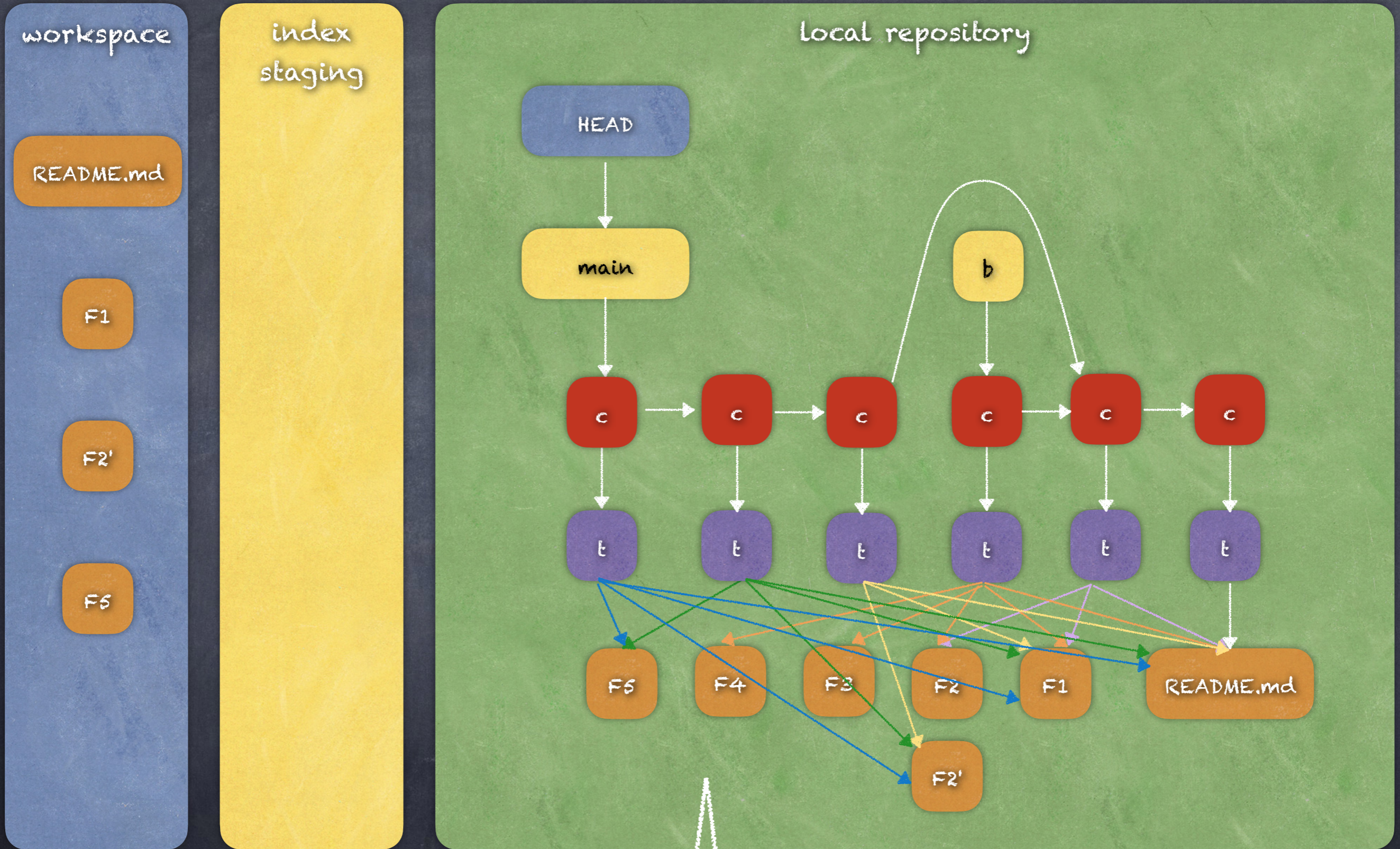
F2

F1

README.md

F2'

STARTING POINT



workspace

README.md

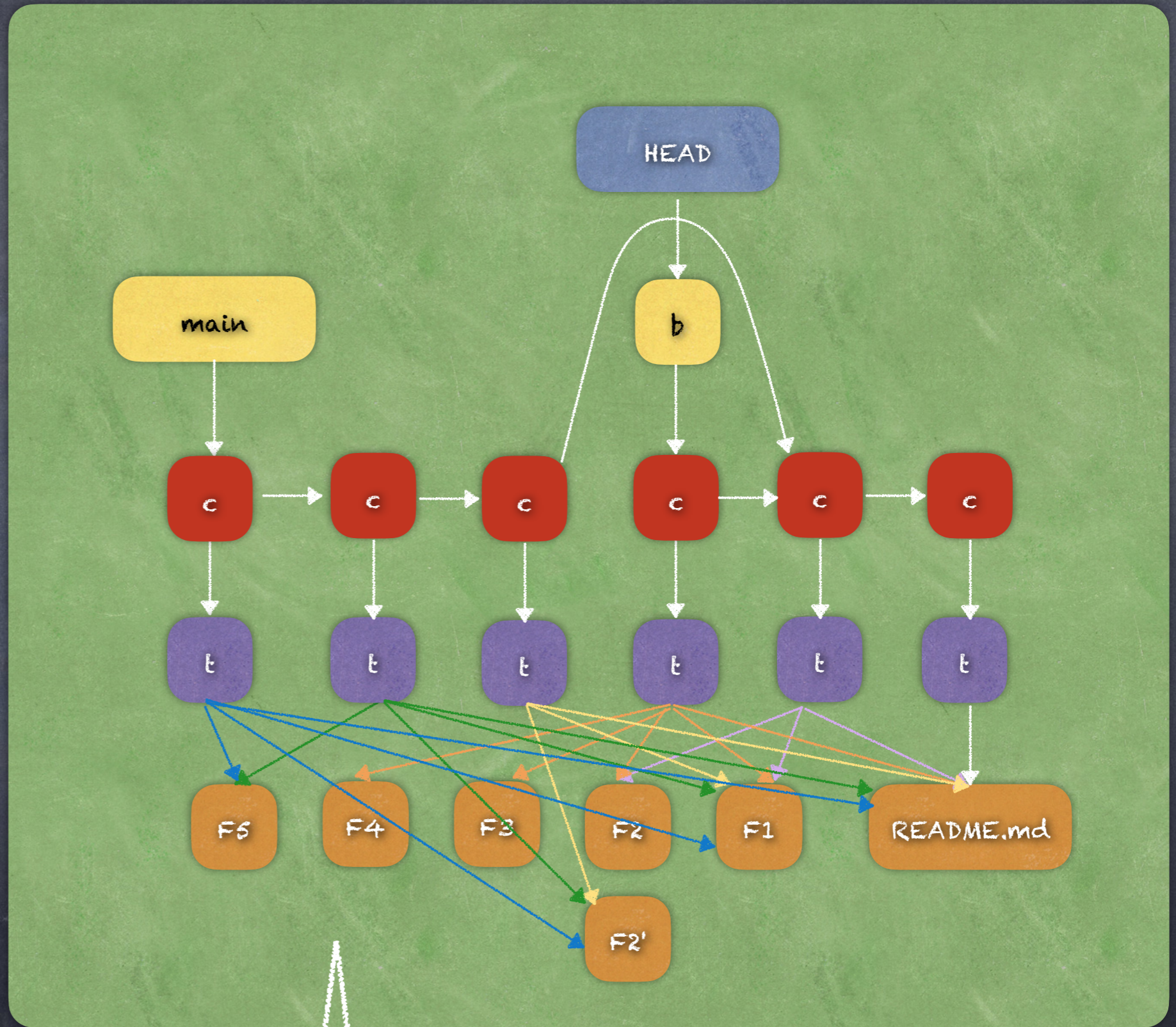
F1

F2

F3

F4

index
staging



git checkout b

workspace

index
staging

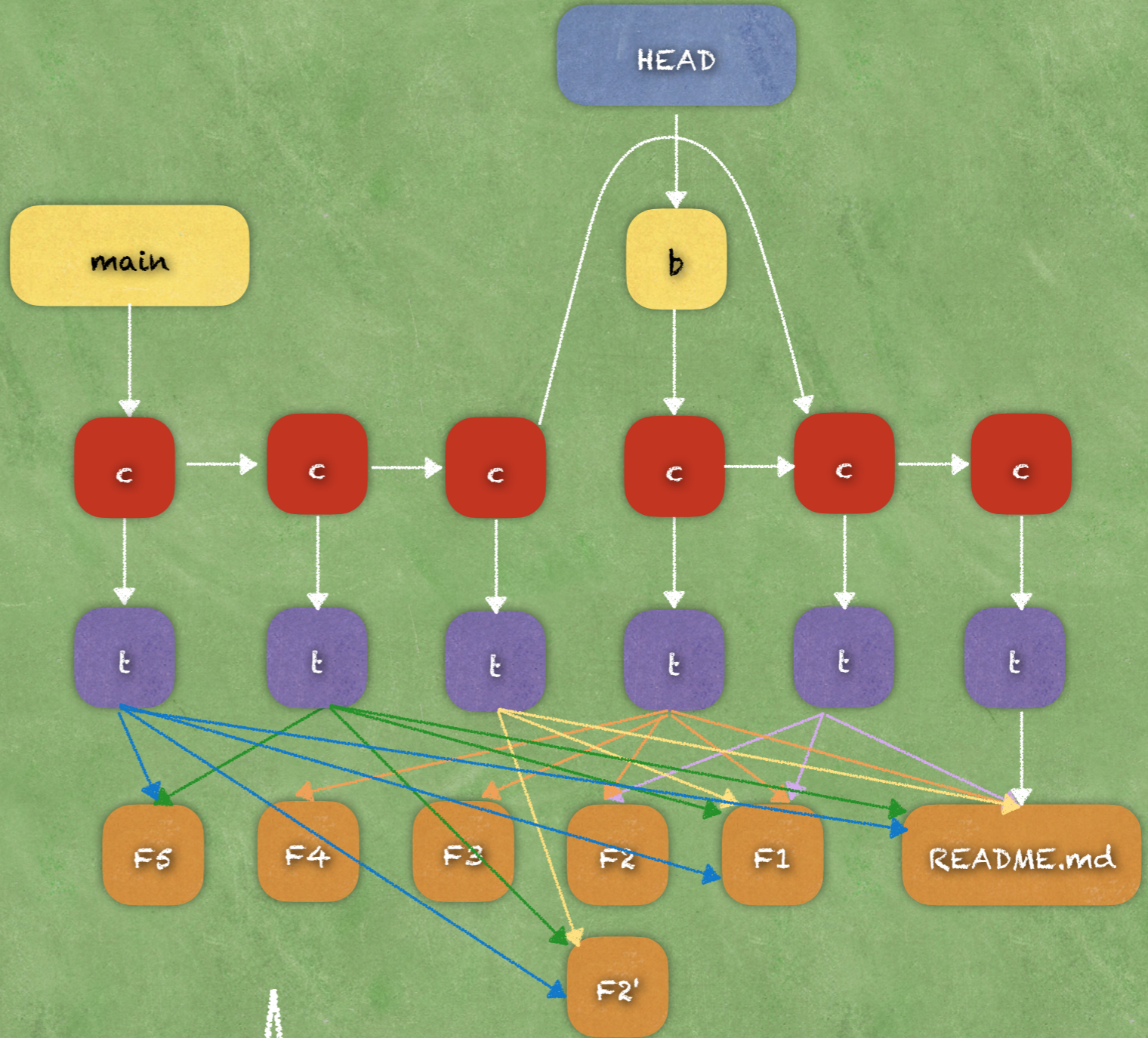
README.md

F1

F2''

F3

F4



workspace

index
staging

README.md

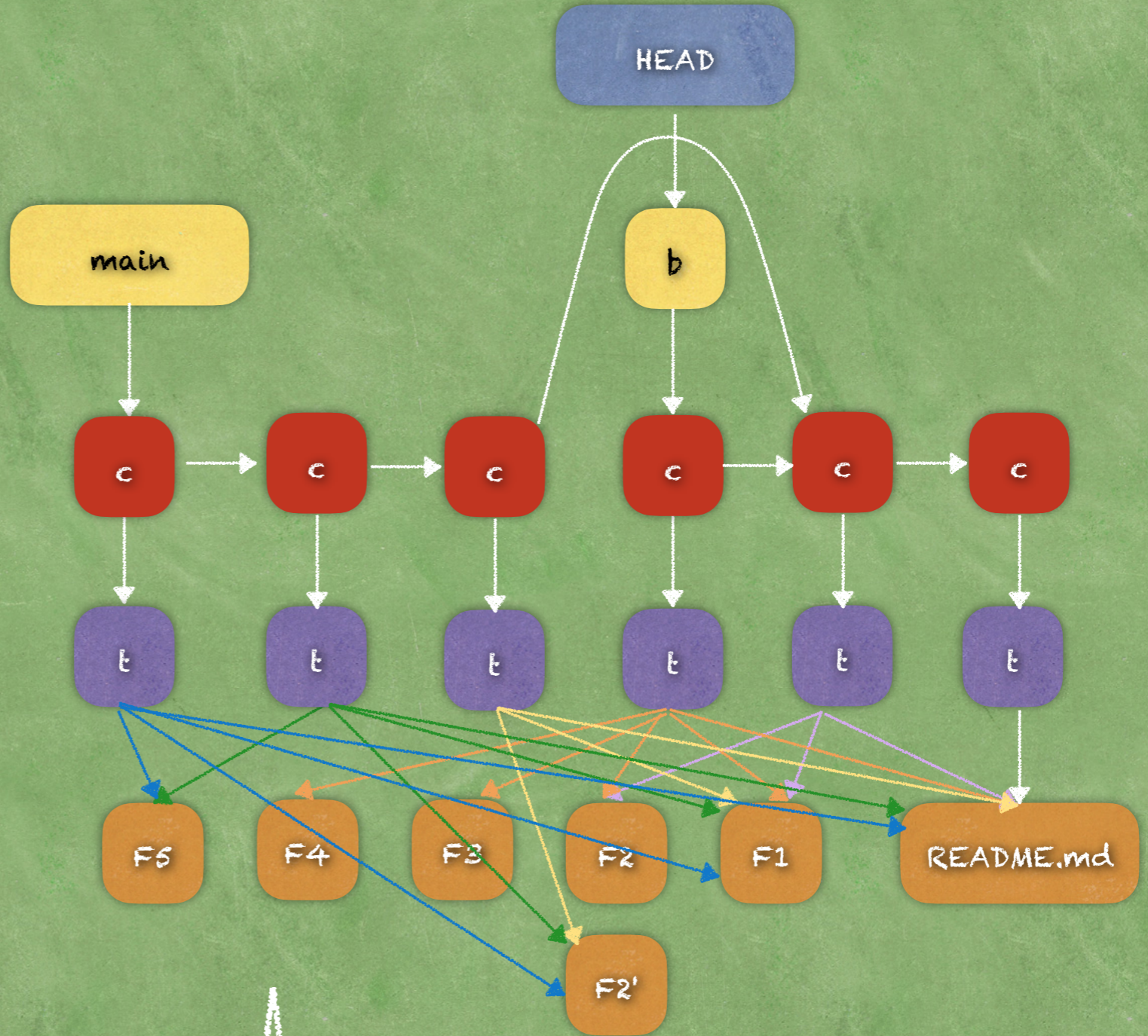
F1

F2''

F3

F4

F2''



git add F2''

workspace

index
staging

README.md

F1

F2''

F3

F4

HEAD

b

main

c

c

c

c

c

c

c

t

t

t

t

t

t

t

F5

F4

F3

F2

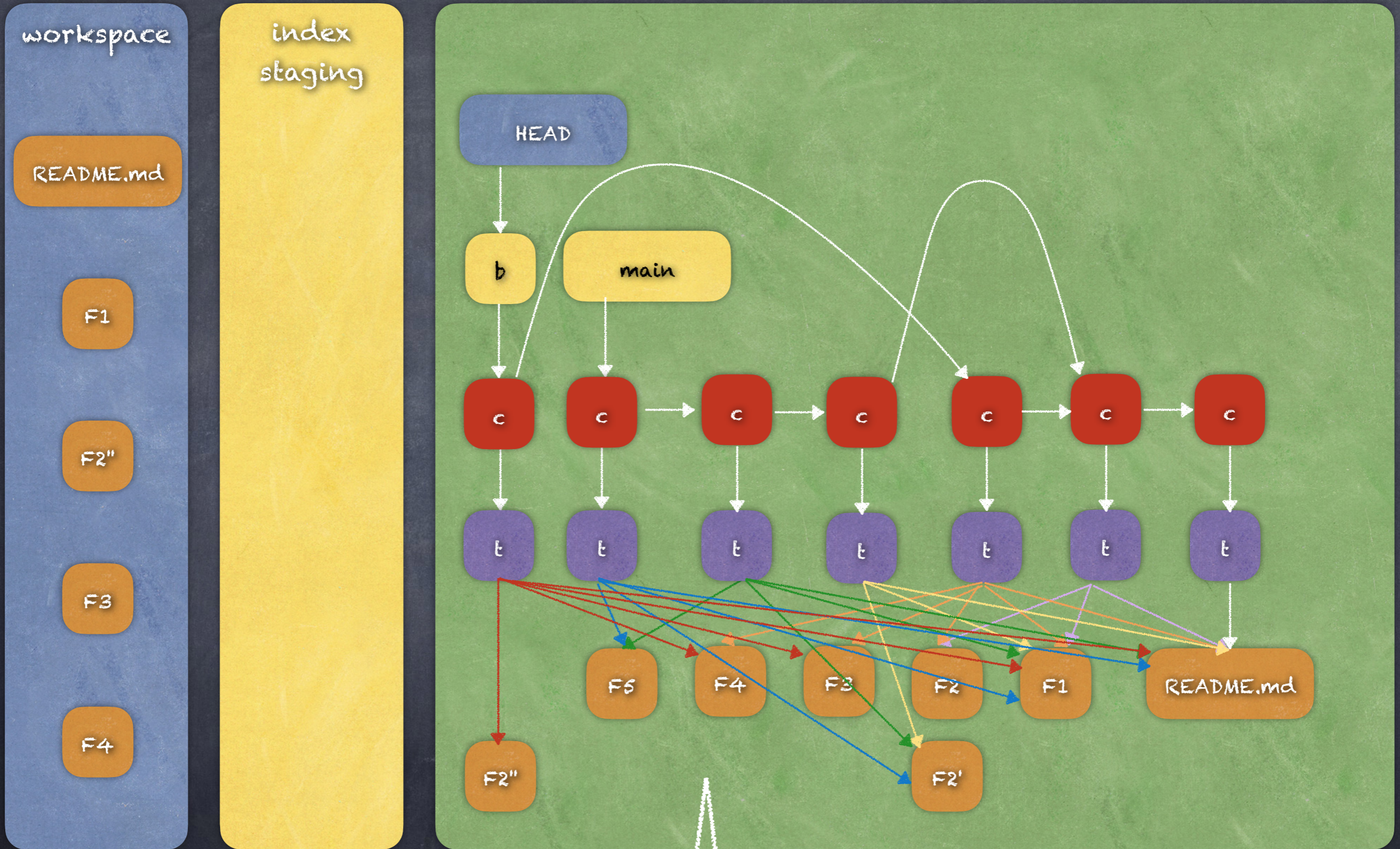
F1

README.md

F2''

F2'

git commit -m "..."



workspace

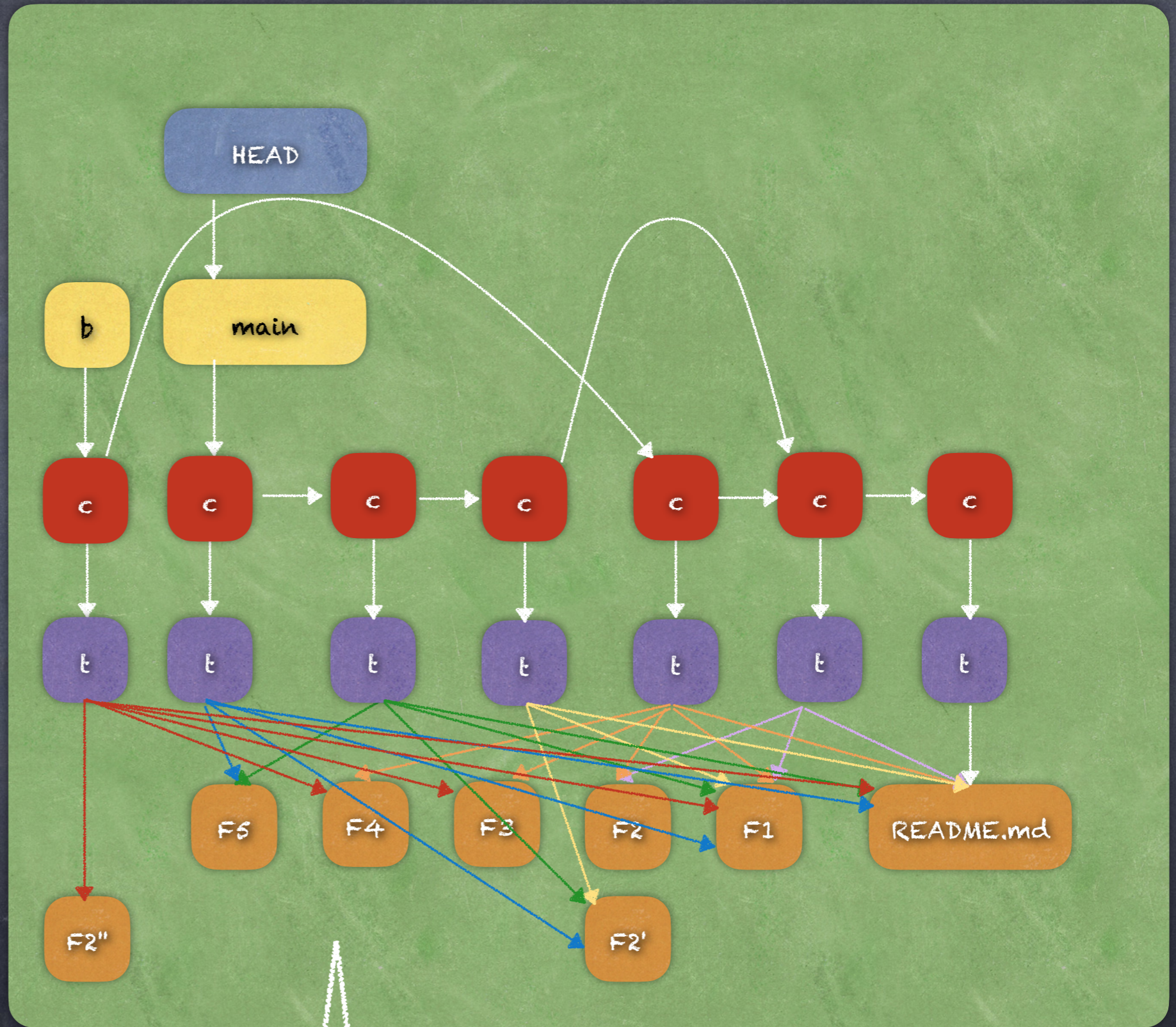
index
staging

README.md

F1

F2'

F5



git checkout main

workspace

index
staging

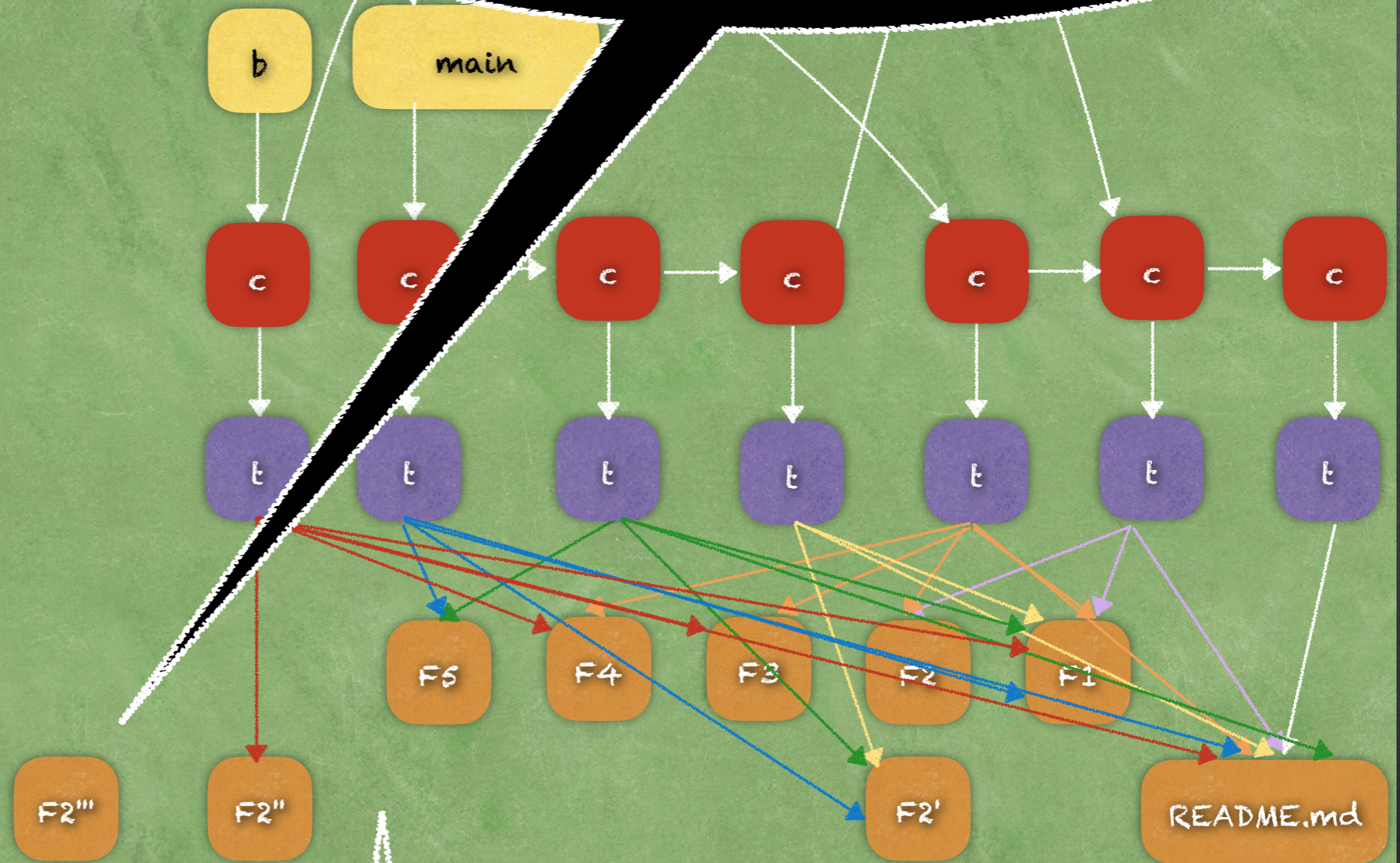
README.md

F1

F2'''

F5

Blob created with
conflict markings.



git merge b

workspace

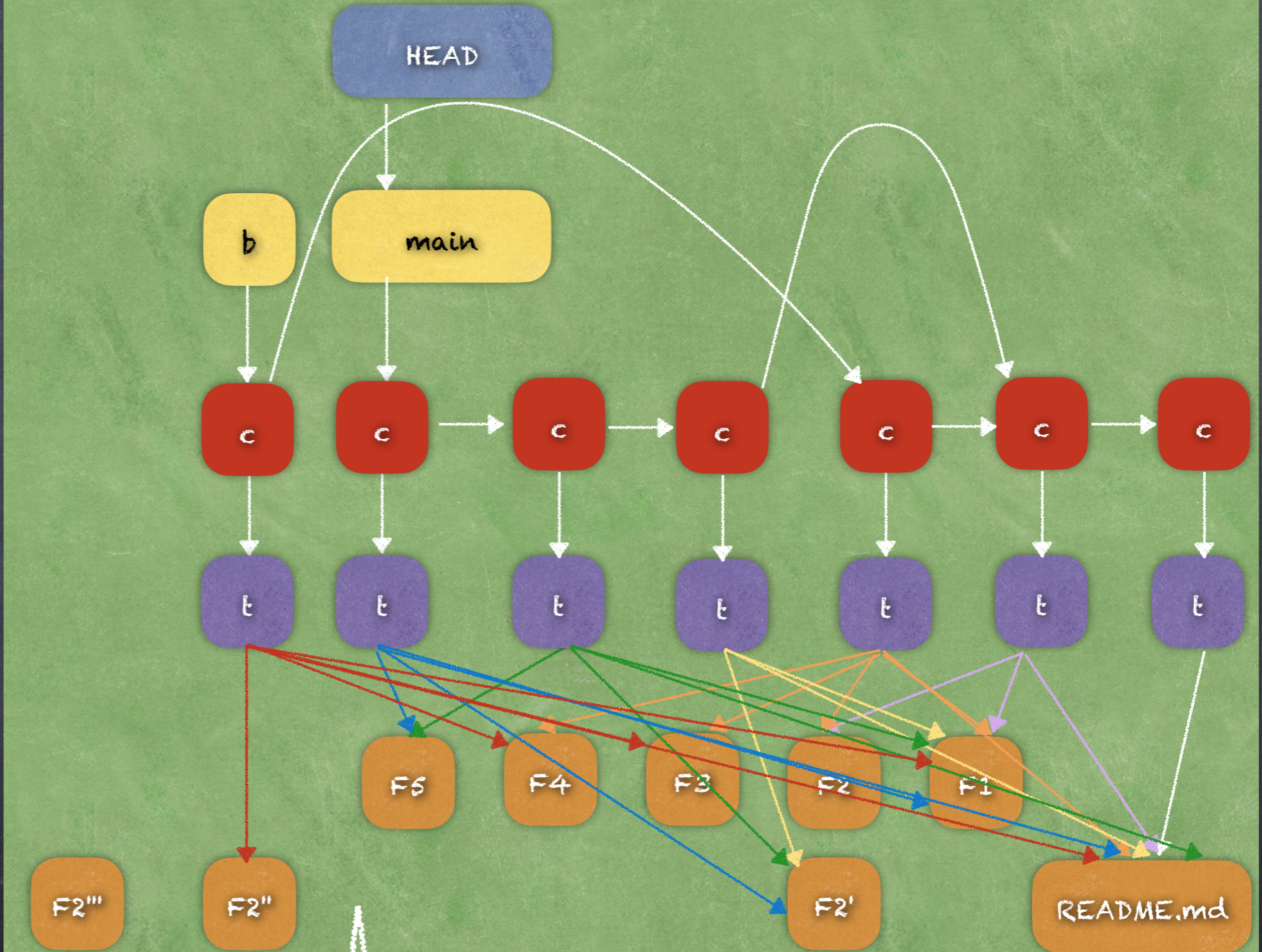
index
staging

README.md

F1

F2+

F5



edit F''' to resolve conflict, creating F2+

workspace

index
staging

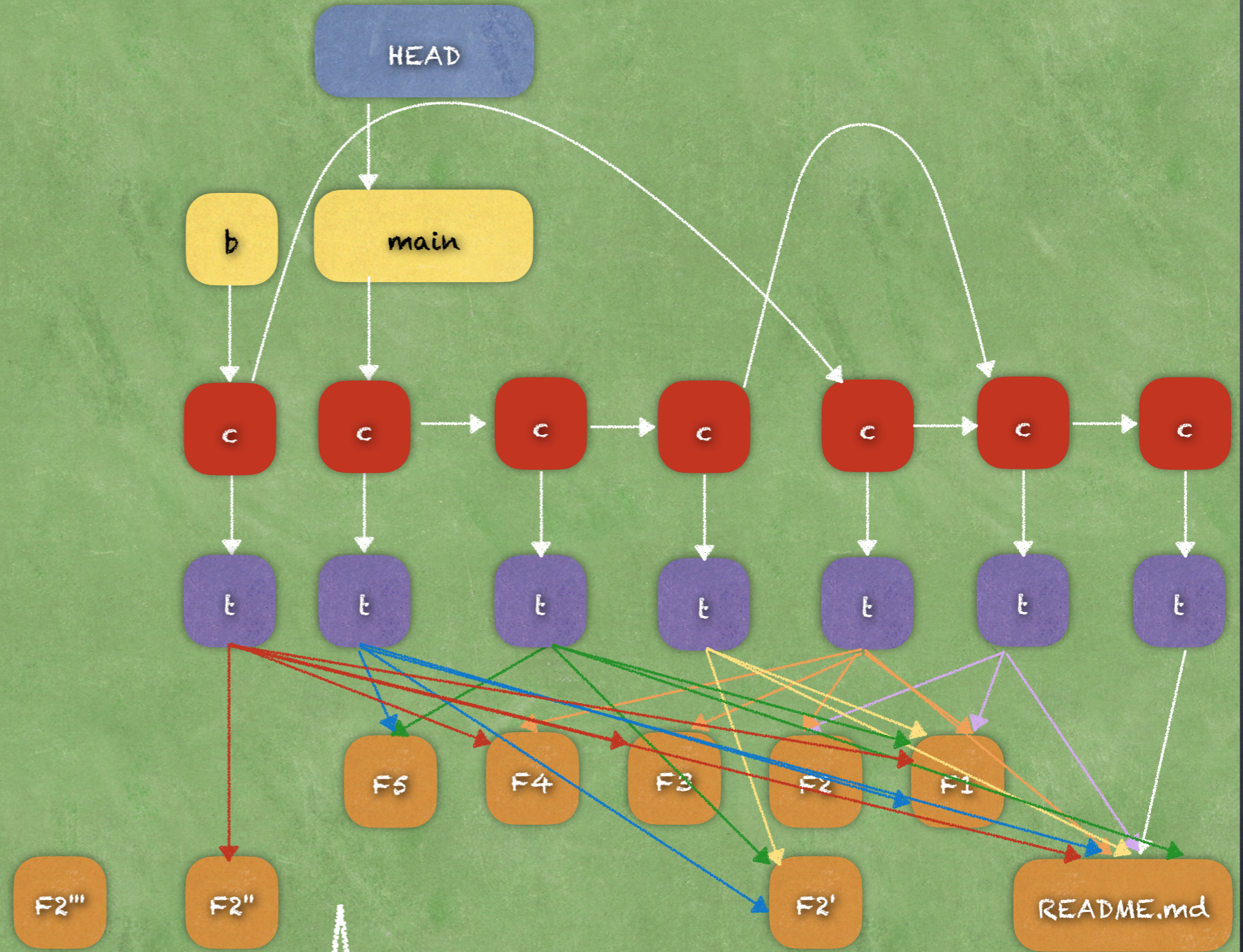
README.md

F1

F2+

F5

F2+



add to staging

workspace

index
staging

README.md

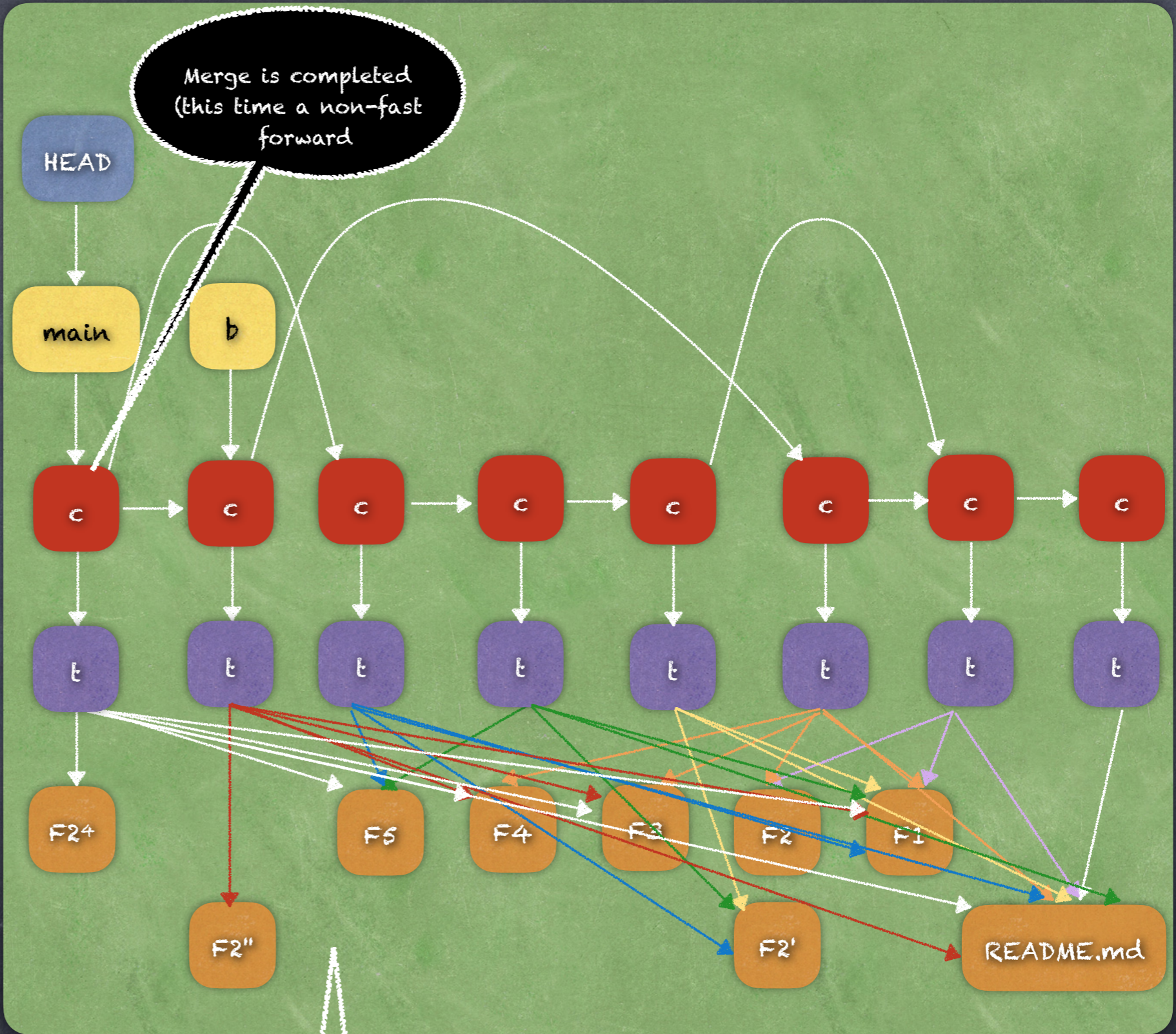
F1

F2+

F3

F4

F5



`git commit -m "..."`