

CSE306 Software Quality in Practice

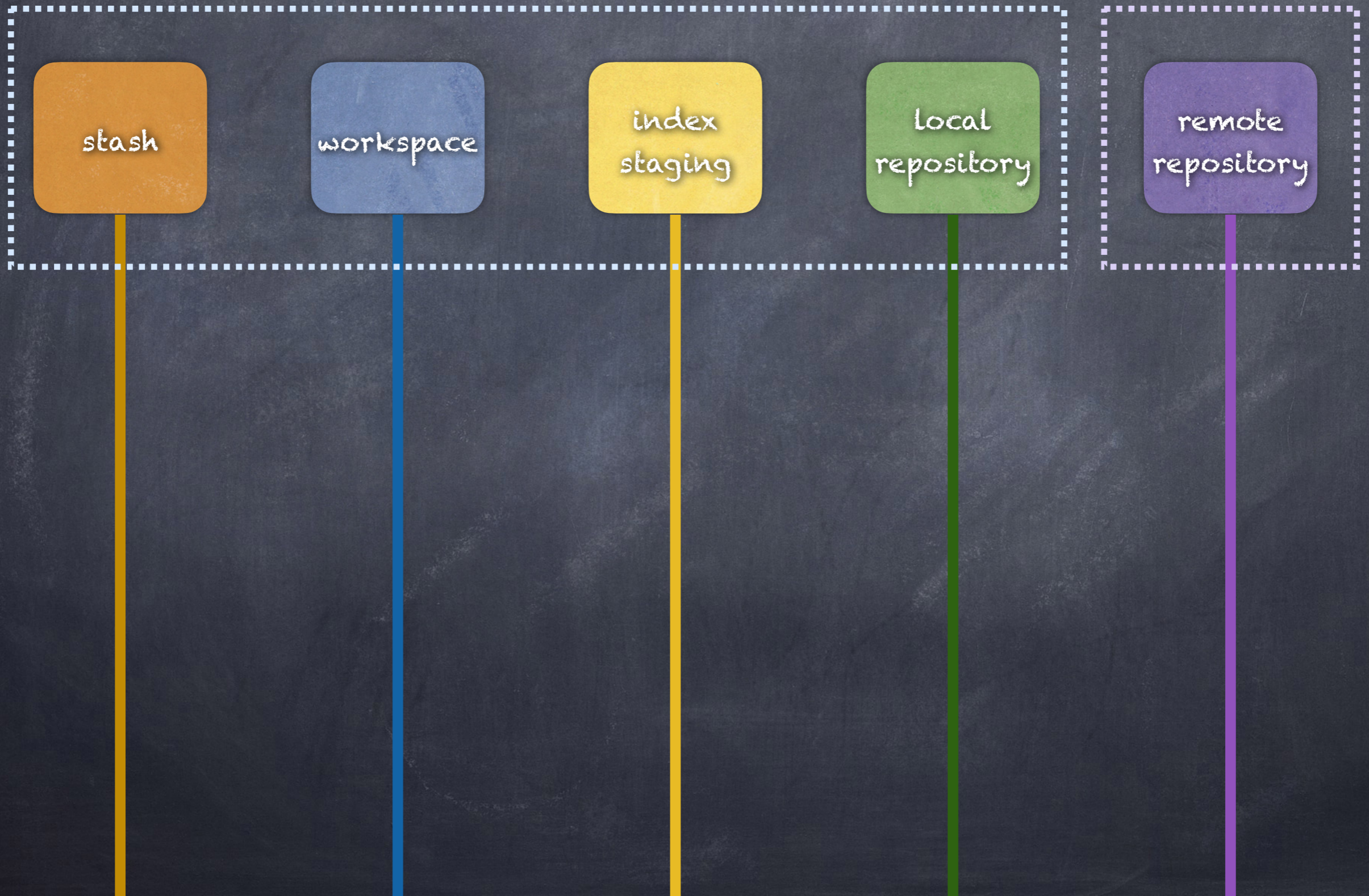
Dr. Carl Alphonse
alphonse@buffalo.edu
343 Davis Hall

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)



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

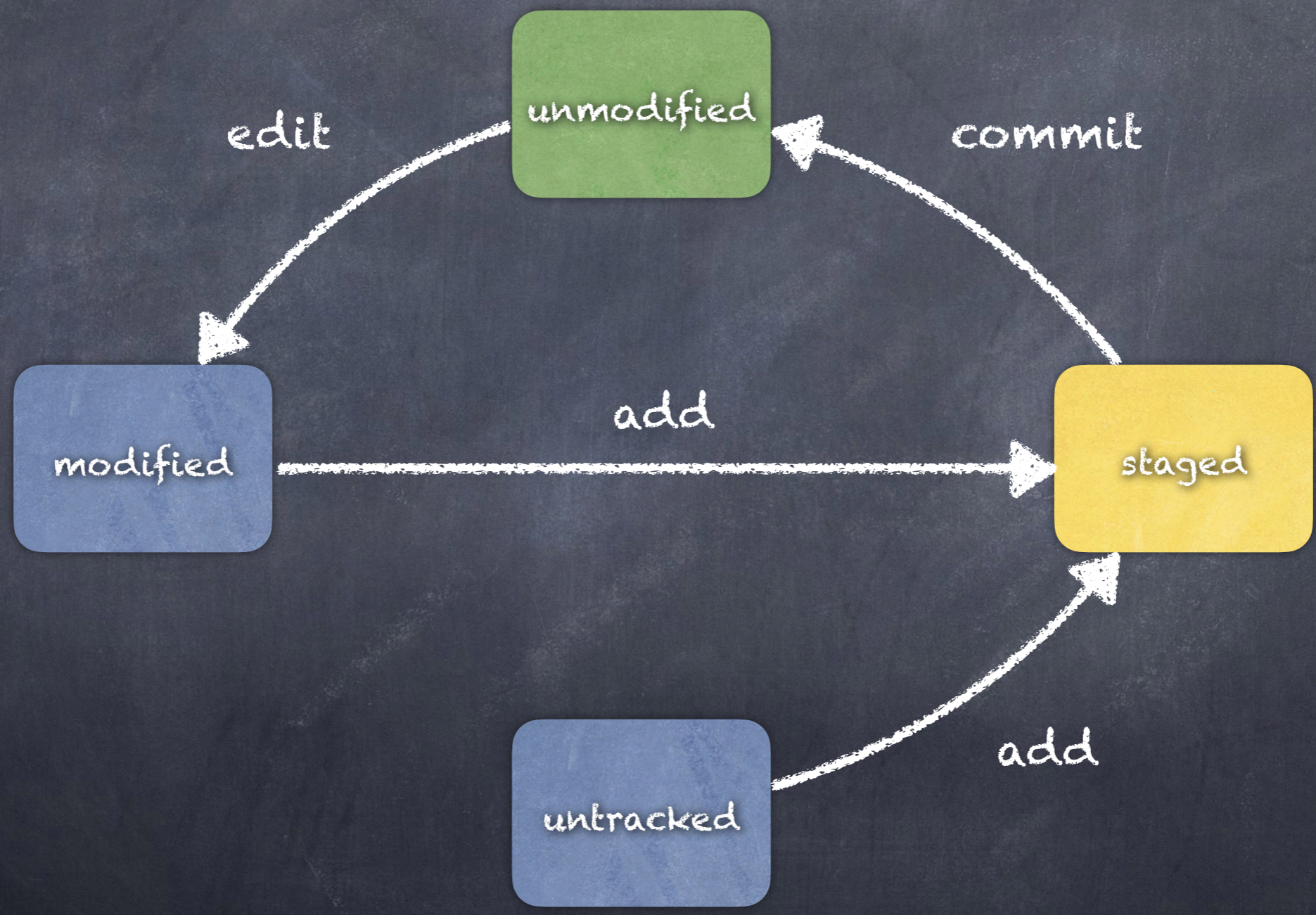
content
(blobs, trees, commits)

-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

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



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

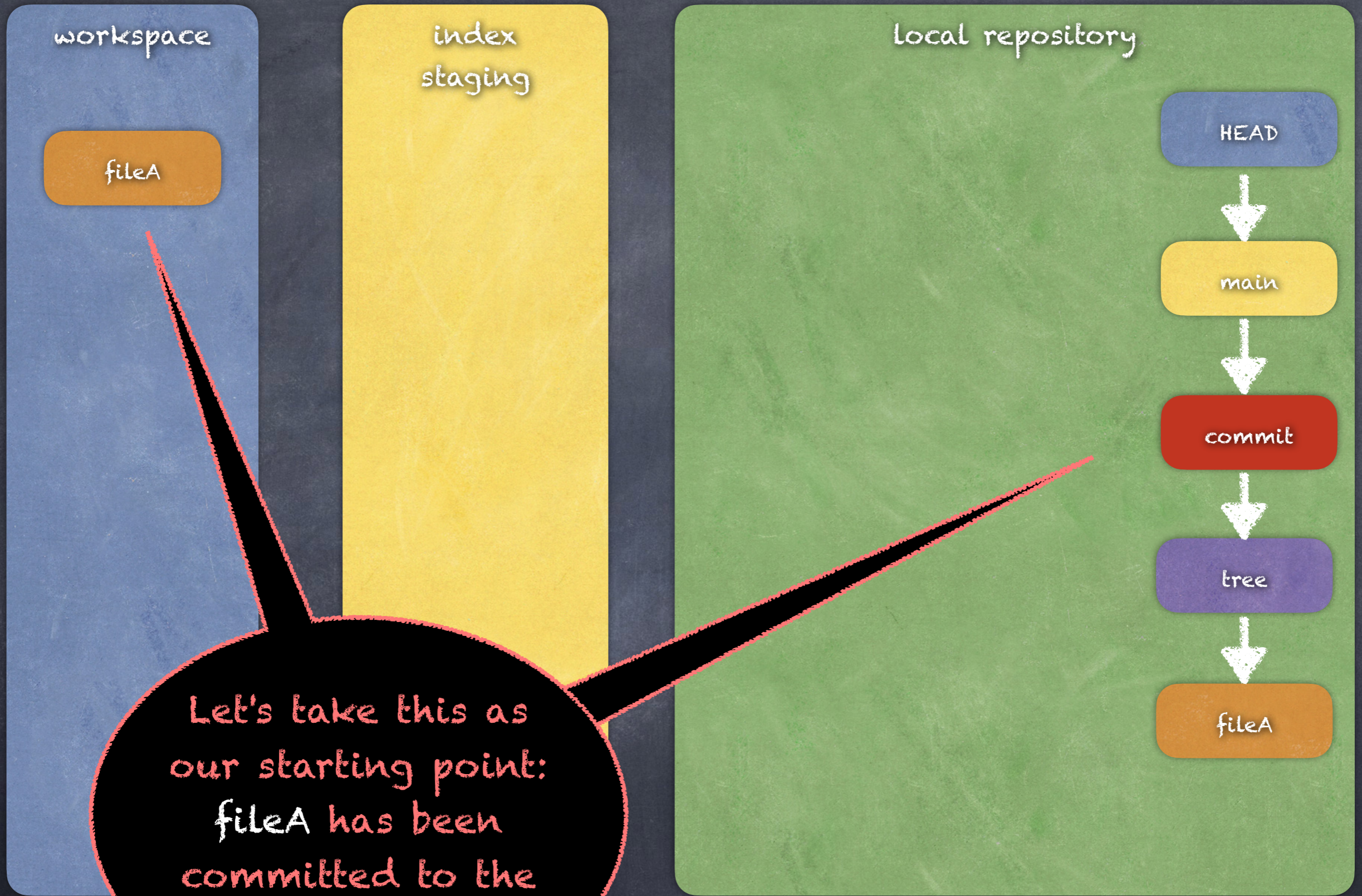
main

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

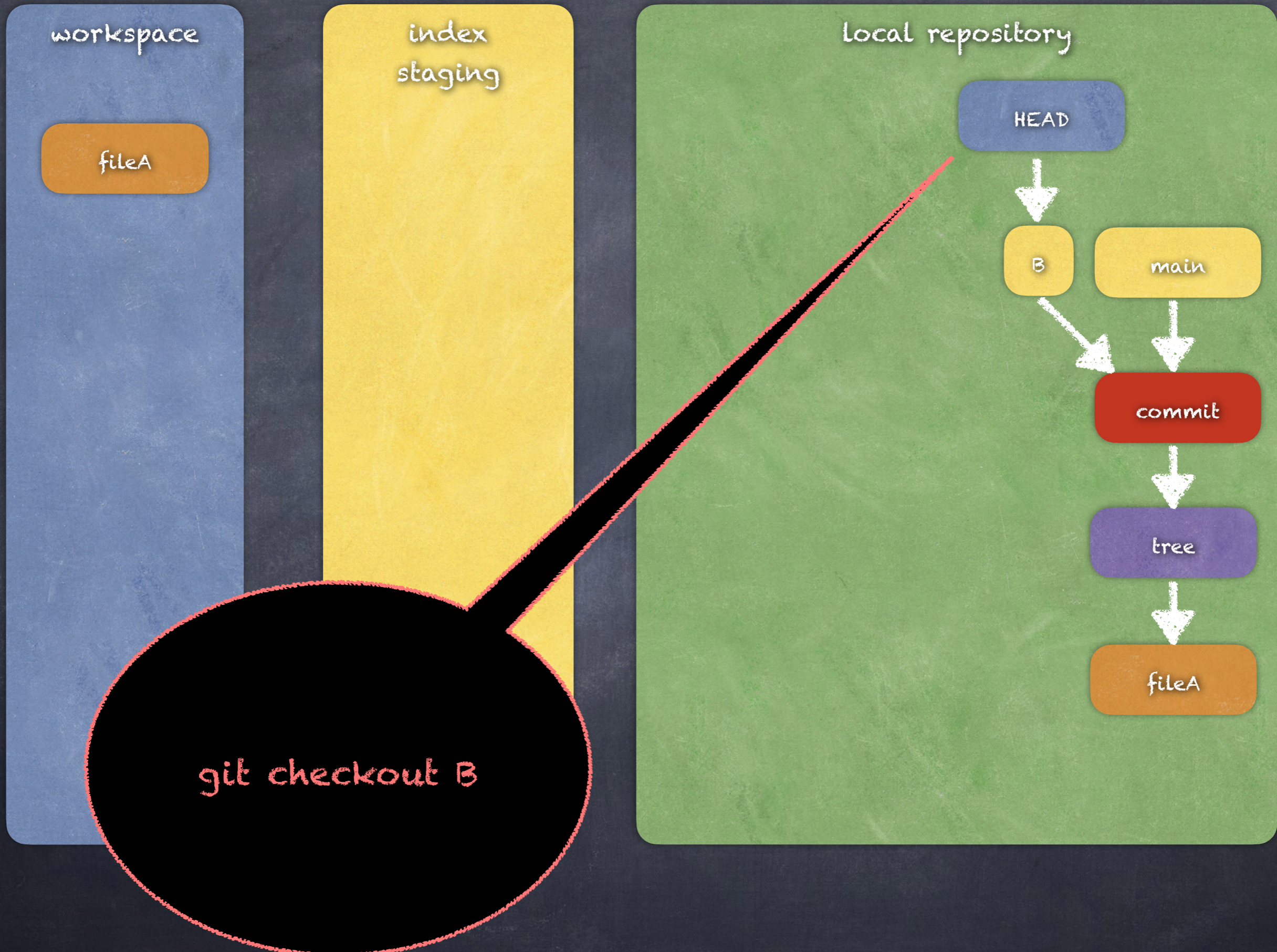
main

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

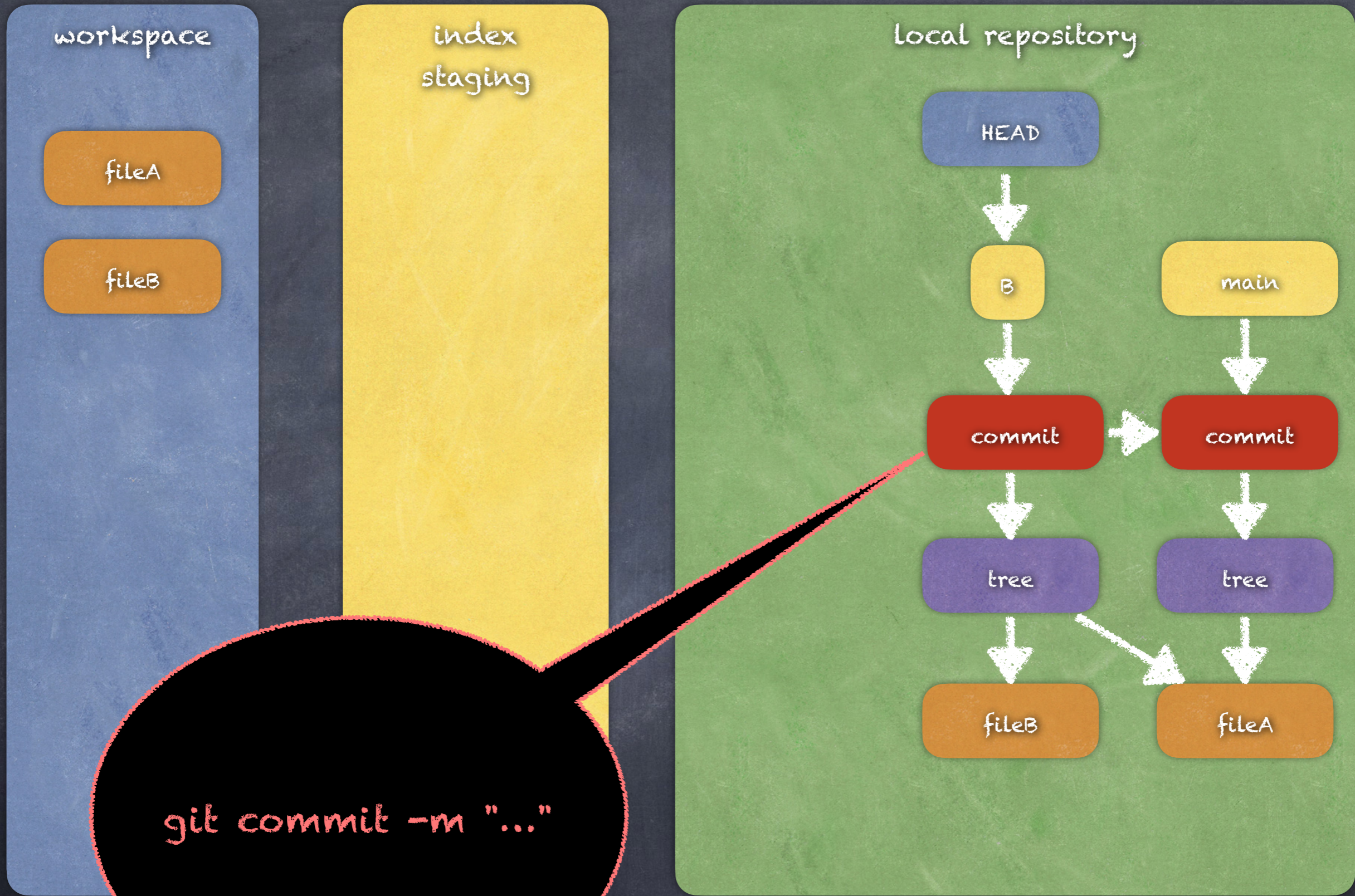
tree

tree

fileB

fileA

`git commit -m "..."`



workspace

fileA

index
staging

local repository

HEAD

main

B

commit

commit

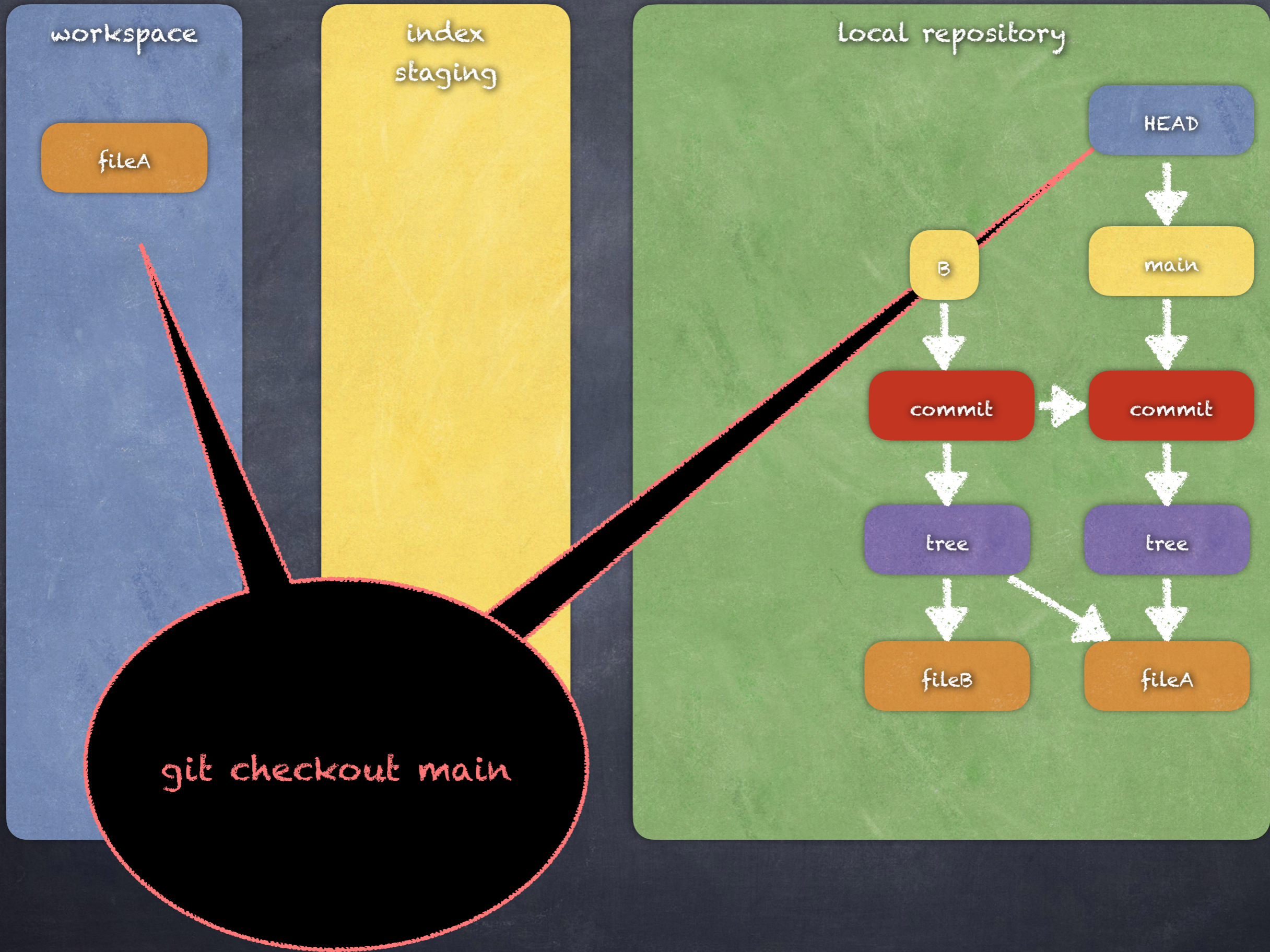
tree

tree

fileB

fileA

git checkout main



workspace

fileA

fileB

index
staging

local repository

HEAD

B

main

commit

commit

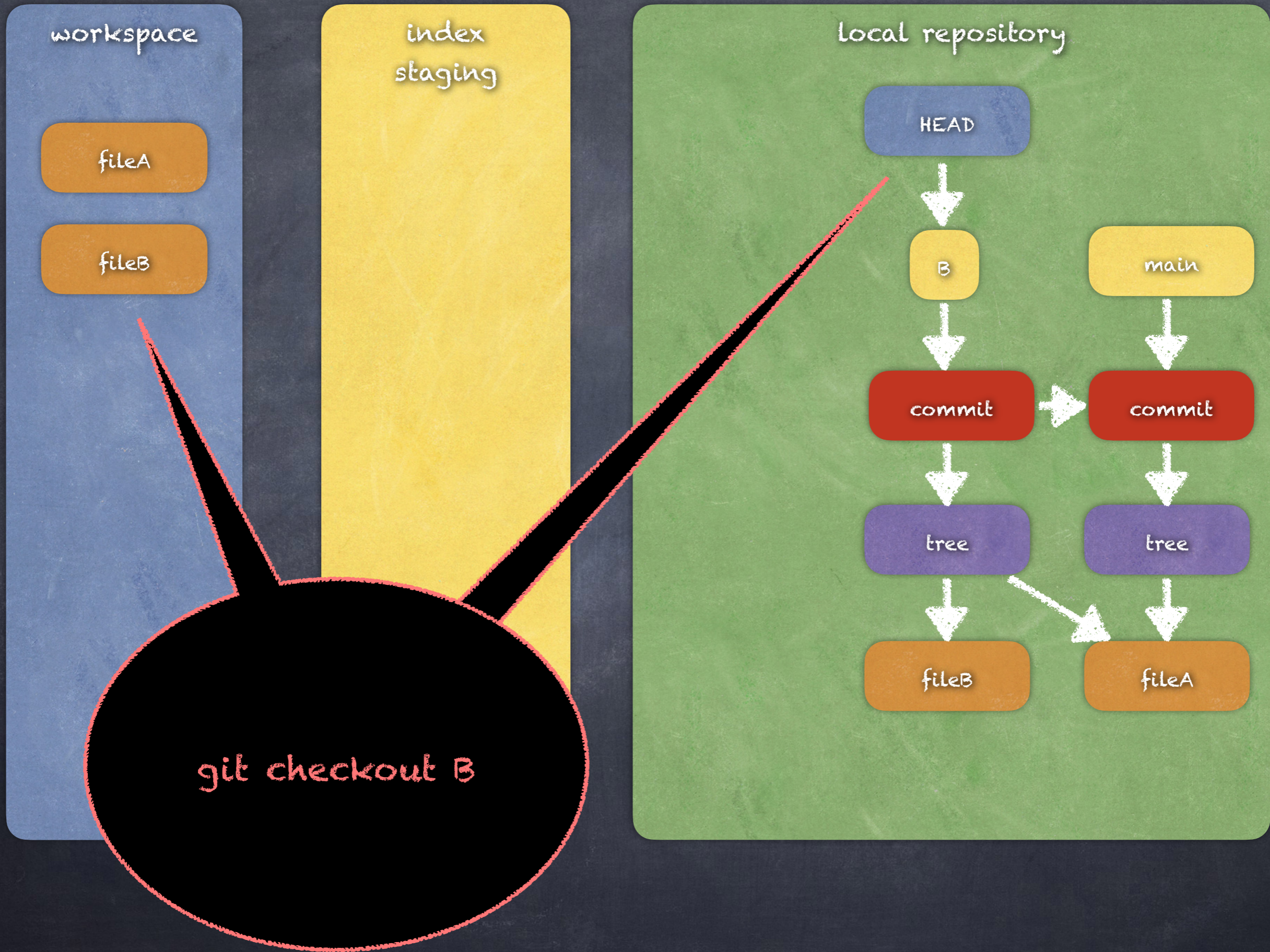
tree

tree

fileB

fileA

git checkout B



TopHat Question

EXERCISE

workspace

README.md

F1

F2

F3

F4

index
staging

local repository

HEAD

b

a

main

commit

commit

commit

tree

tree

tree

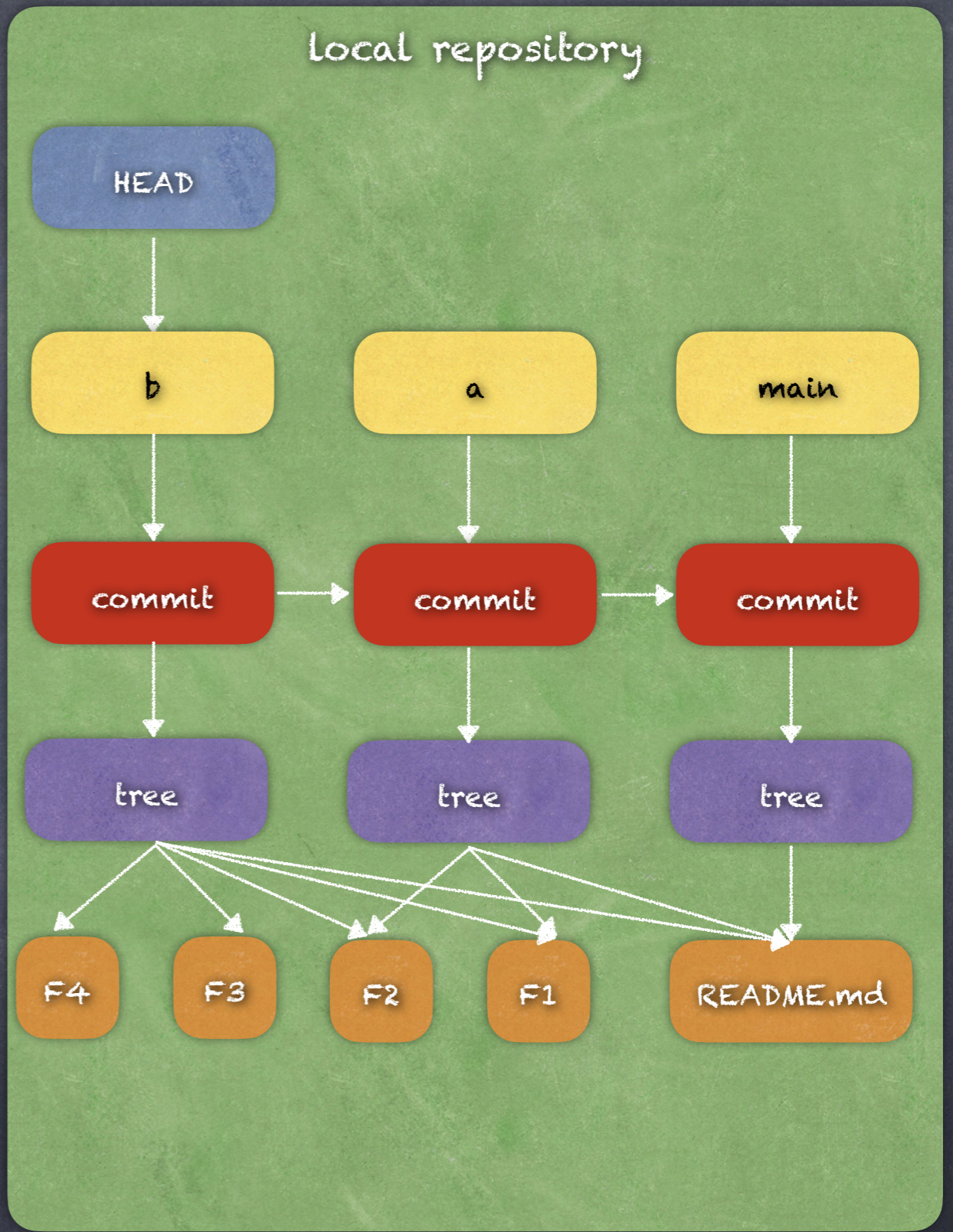
F4

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

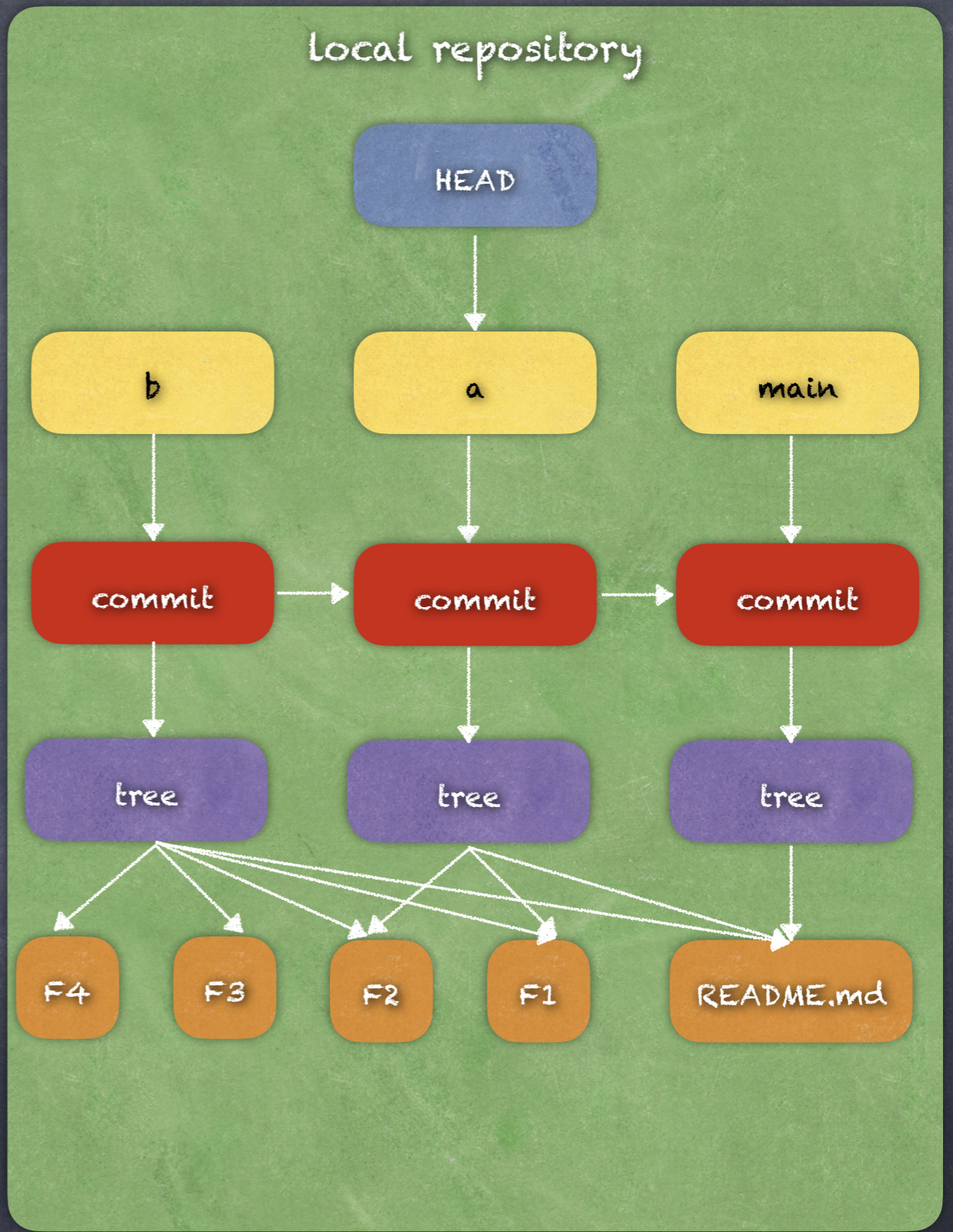
F4

F3

F2

F1

README.md



Now edit and commit F2.

emacs F2 (call edited version F2')

git add F2'

git commit -m "..."

workspace

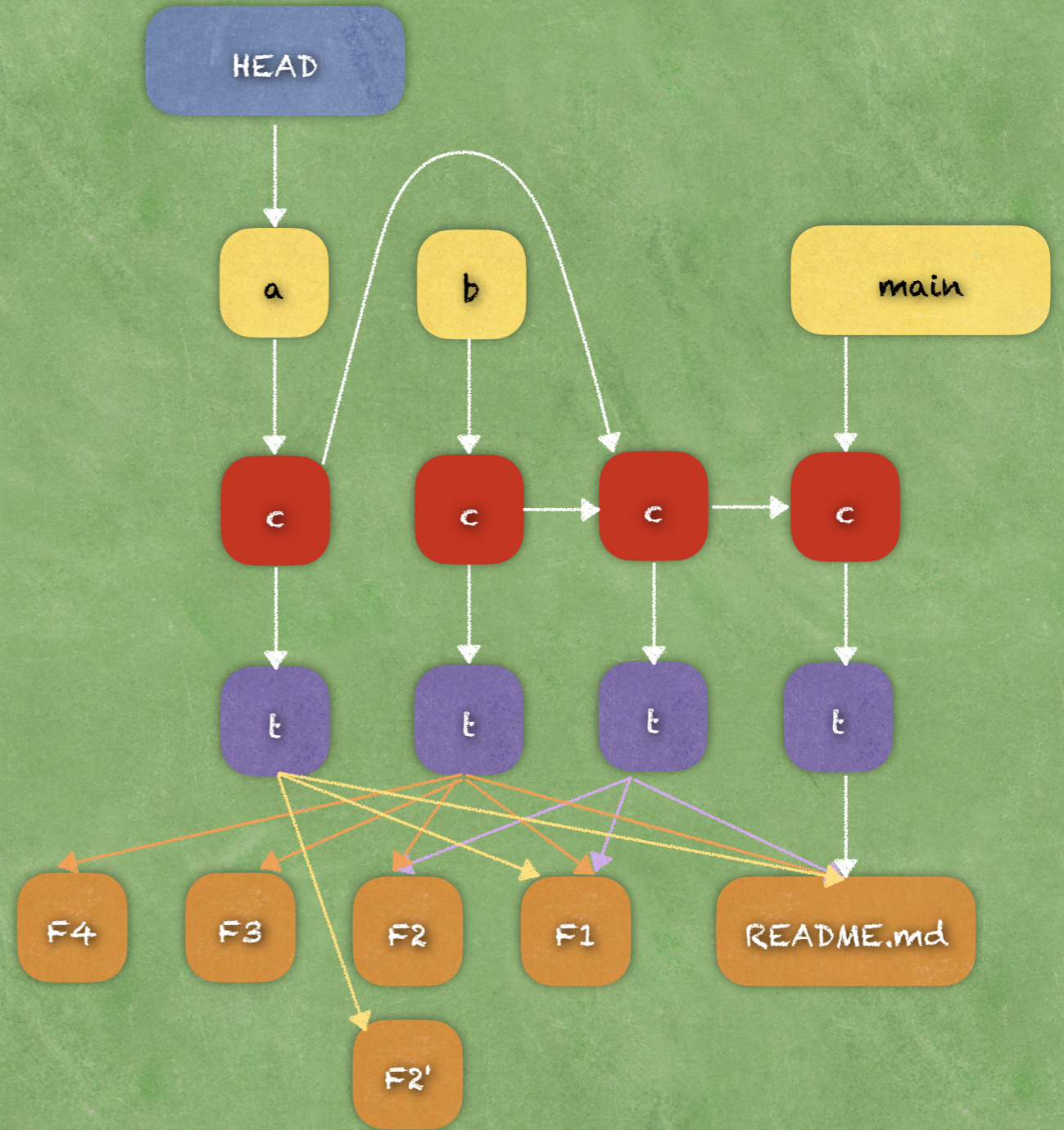
README.md

F1

F2'

index
staging

local repository



workspace

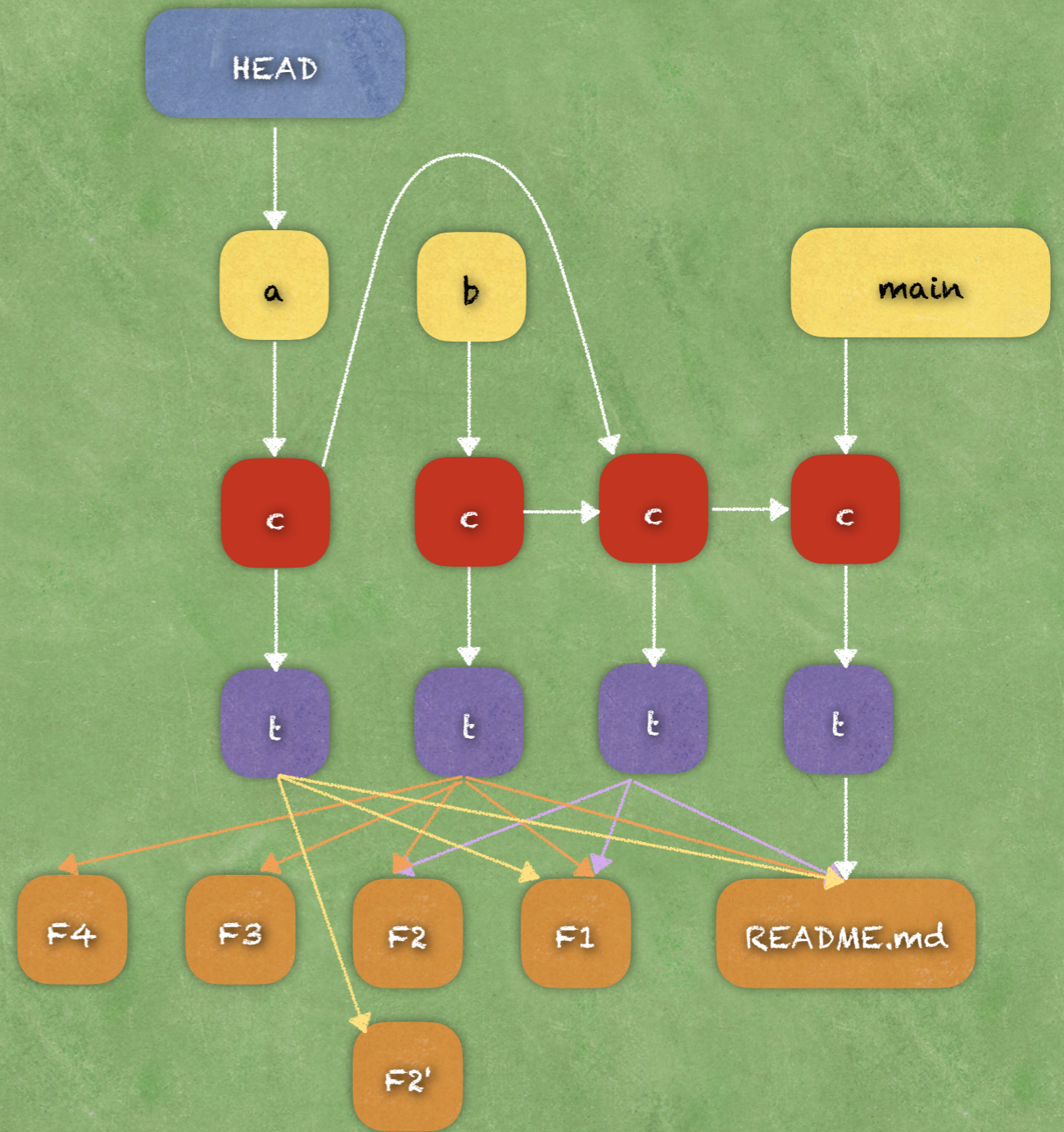
README.md

F1

F2'

index
staging

local repository



Create FS, add, and commit.

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

workspace

README.md

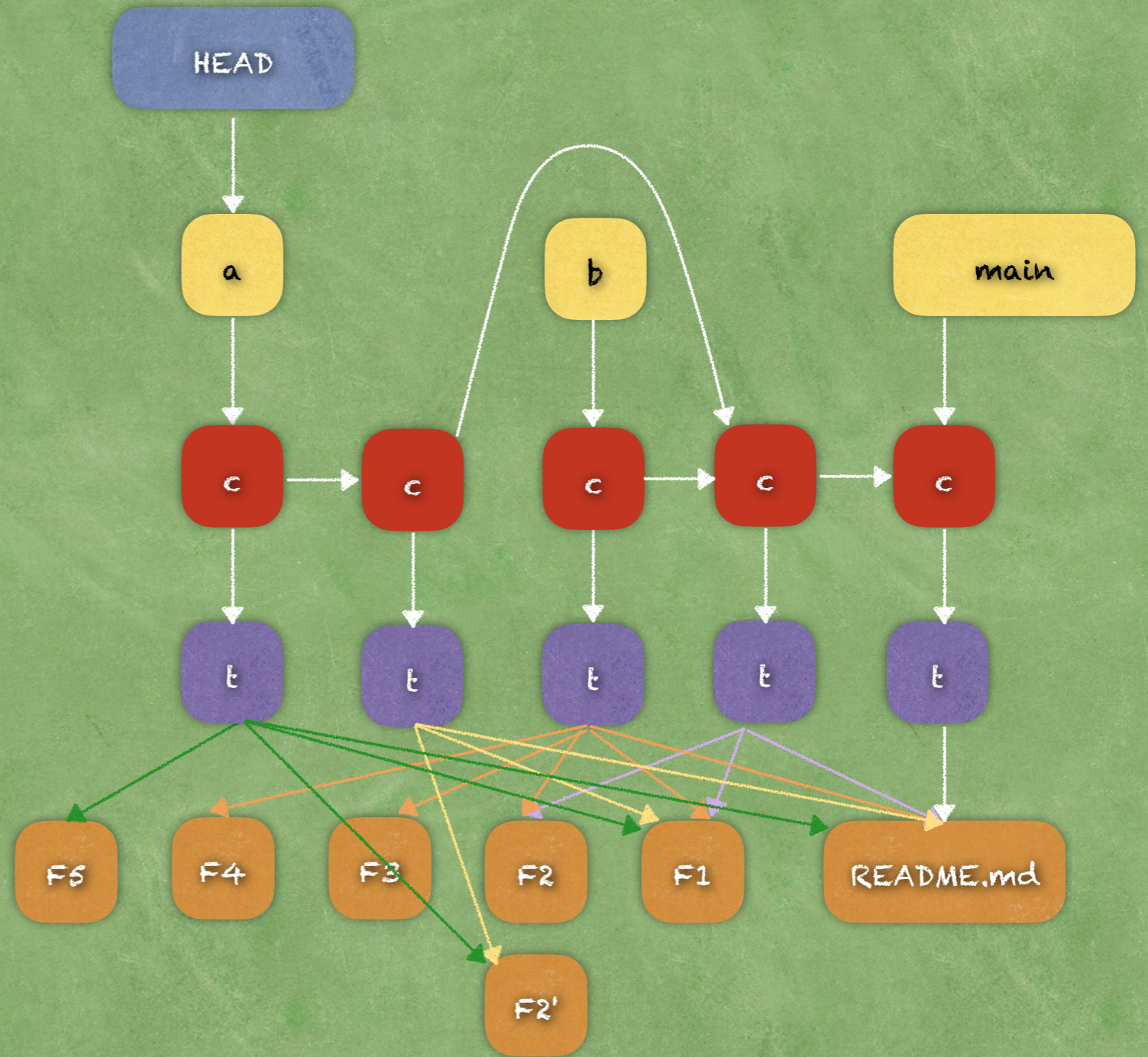
F1

F2'

F5

index
staging

local repository



workspace

index
staging

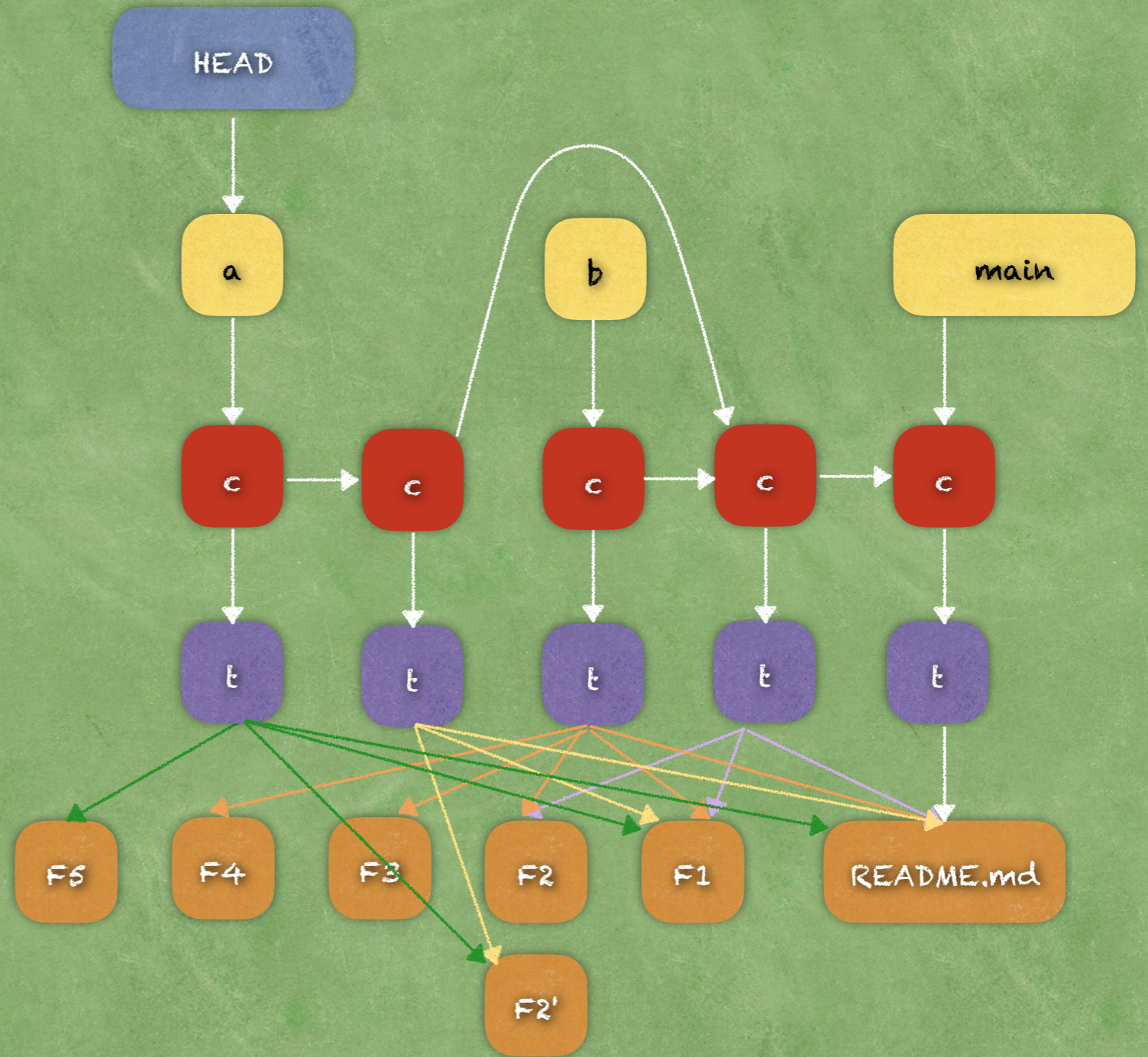
README.md

F1

F2'

F5

local repository



Switch to main.

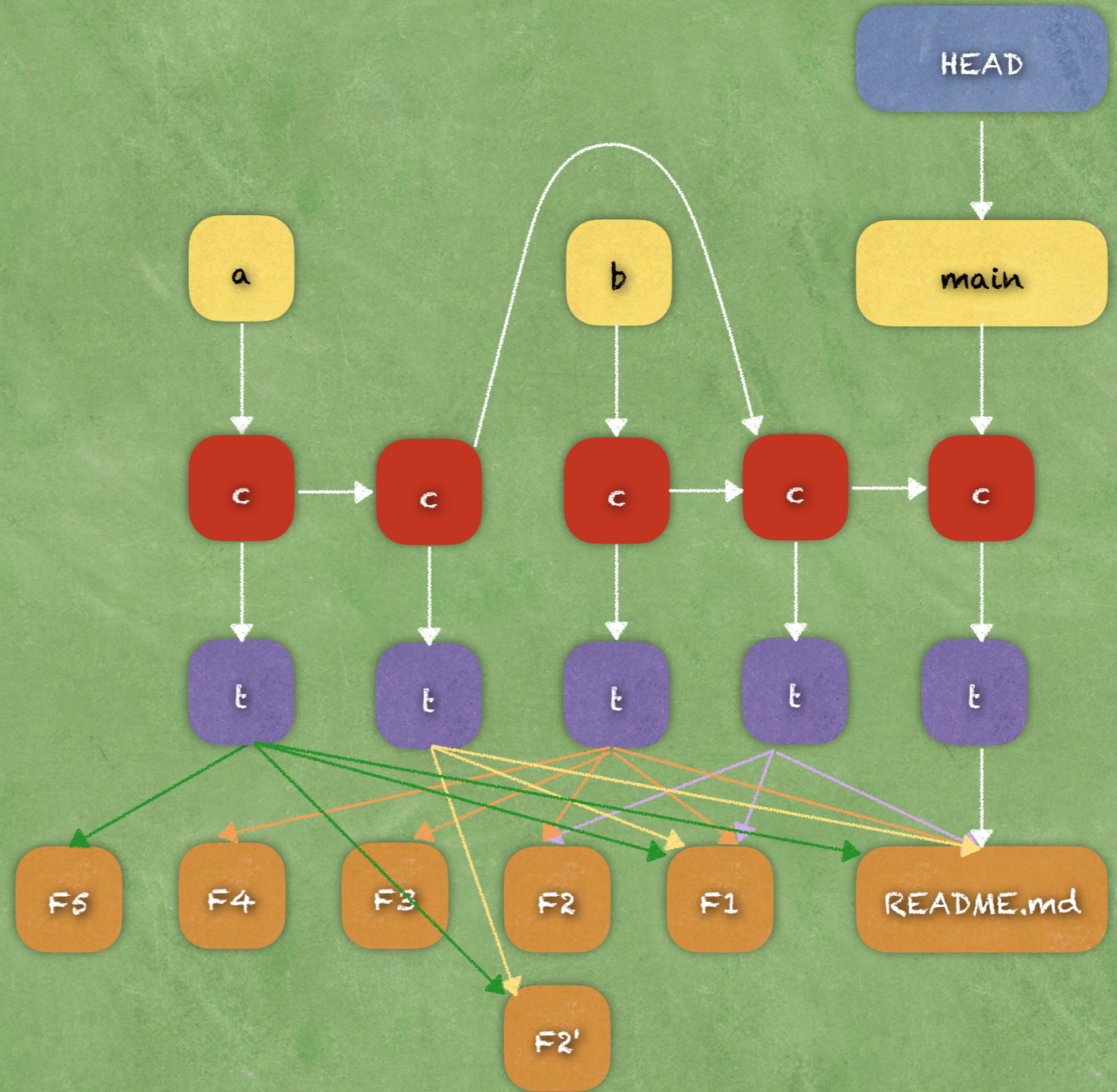
git checkout main

workspace

README.md

index
staging

local repository

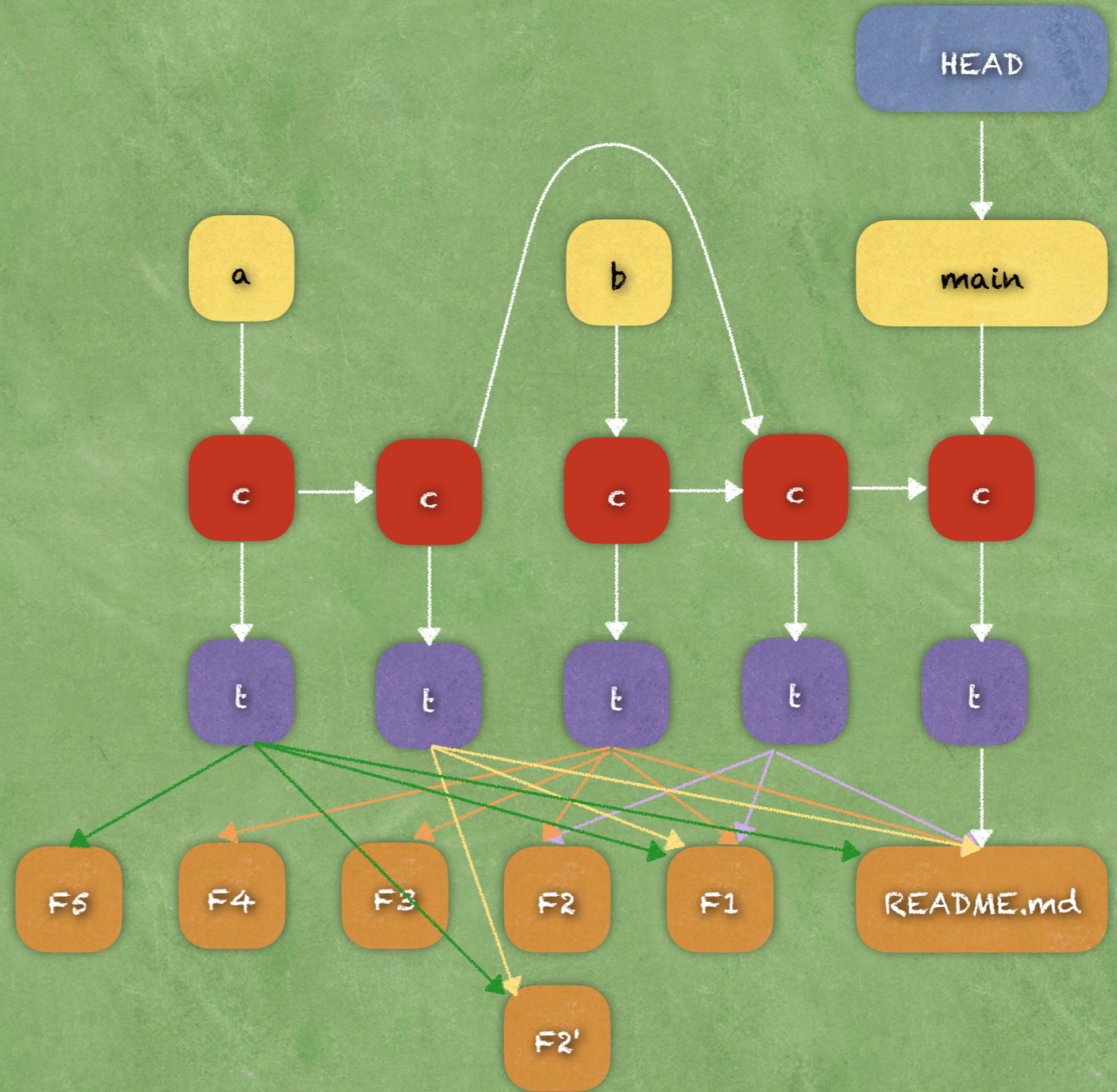


workspace

README.md

index
staging

local repository



Merge a into main.

git merge a

workspace

README.md

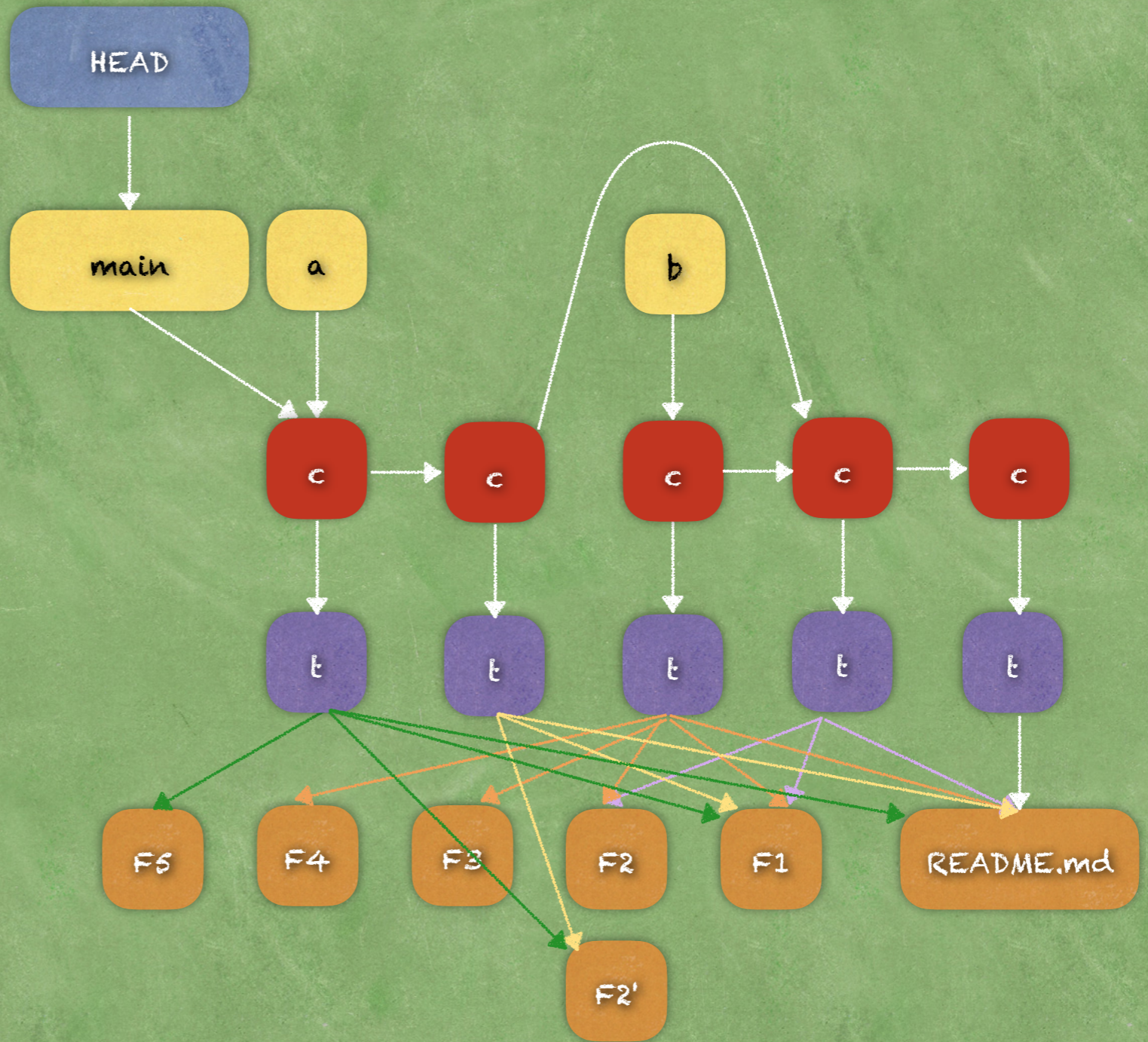
F1

F2'

F5

index
staging

local repository



workspace

README.md

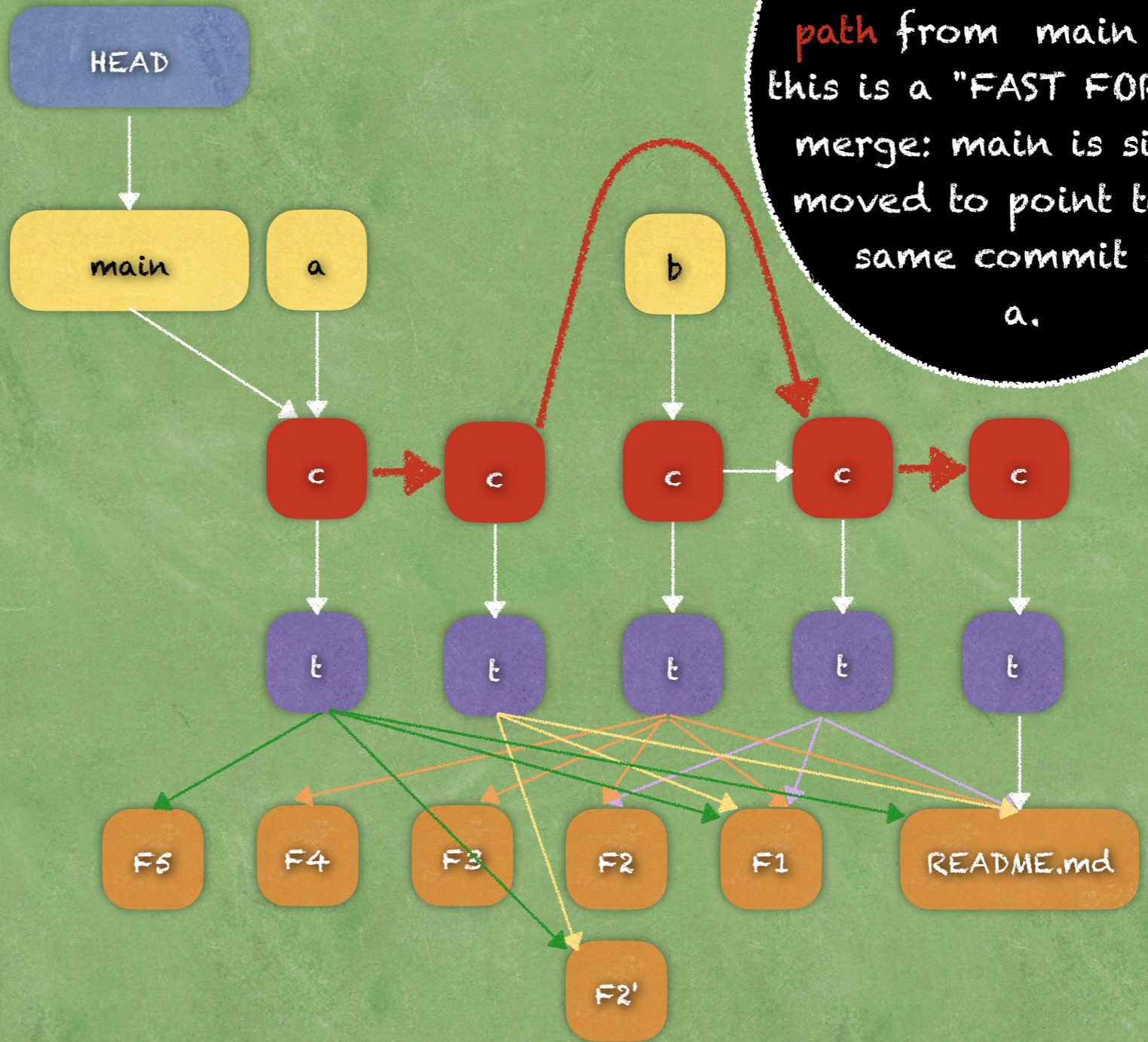
F1

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

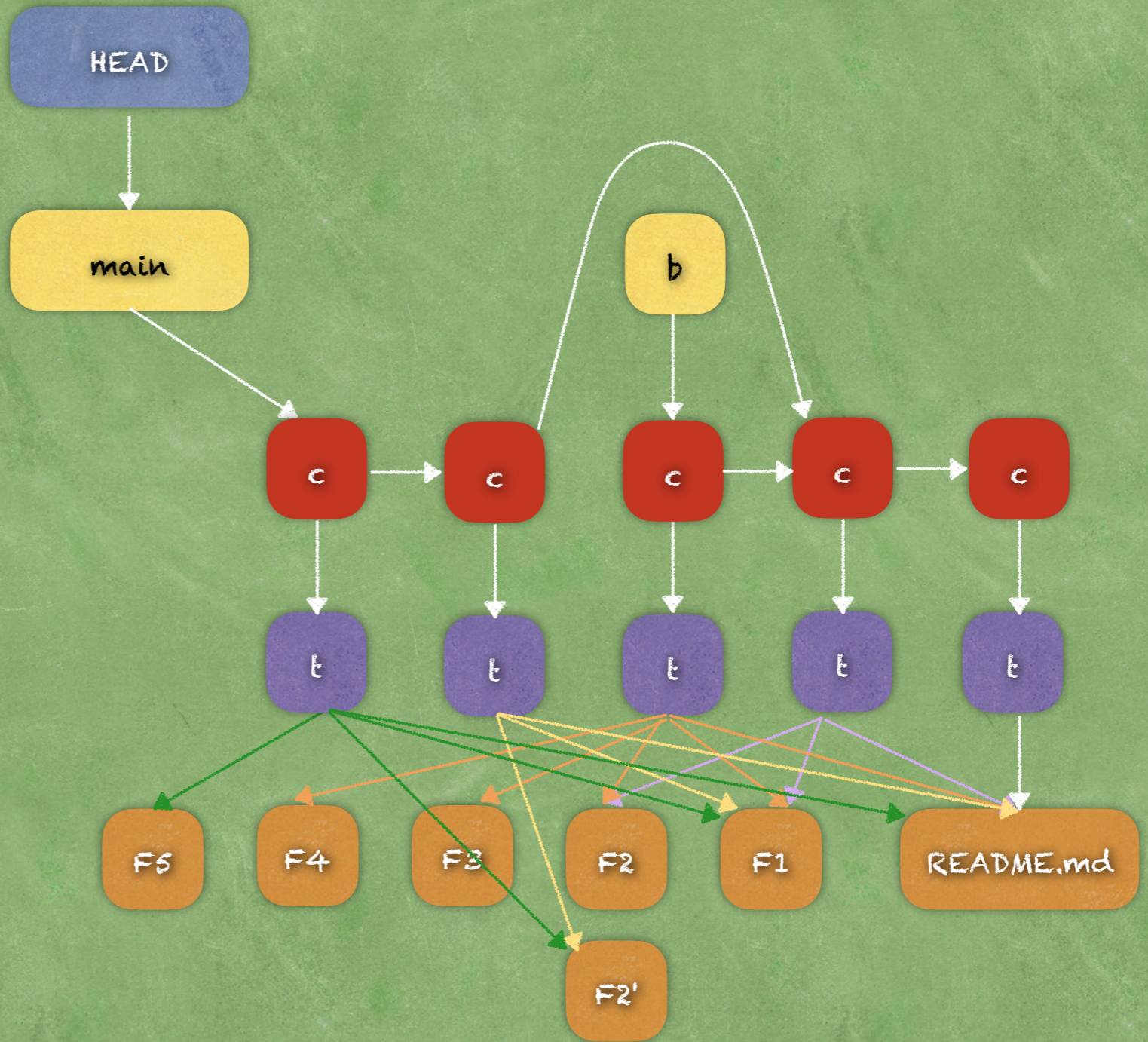
F1

F2'

F5

index
staging

local repository



EXERCISE

workspace

README.md

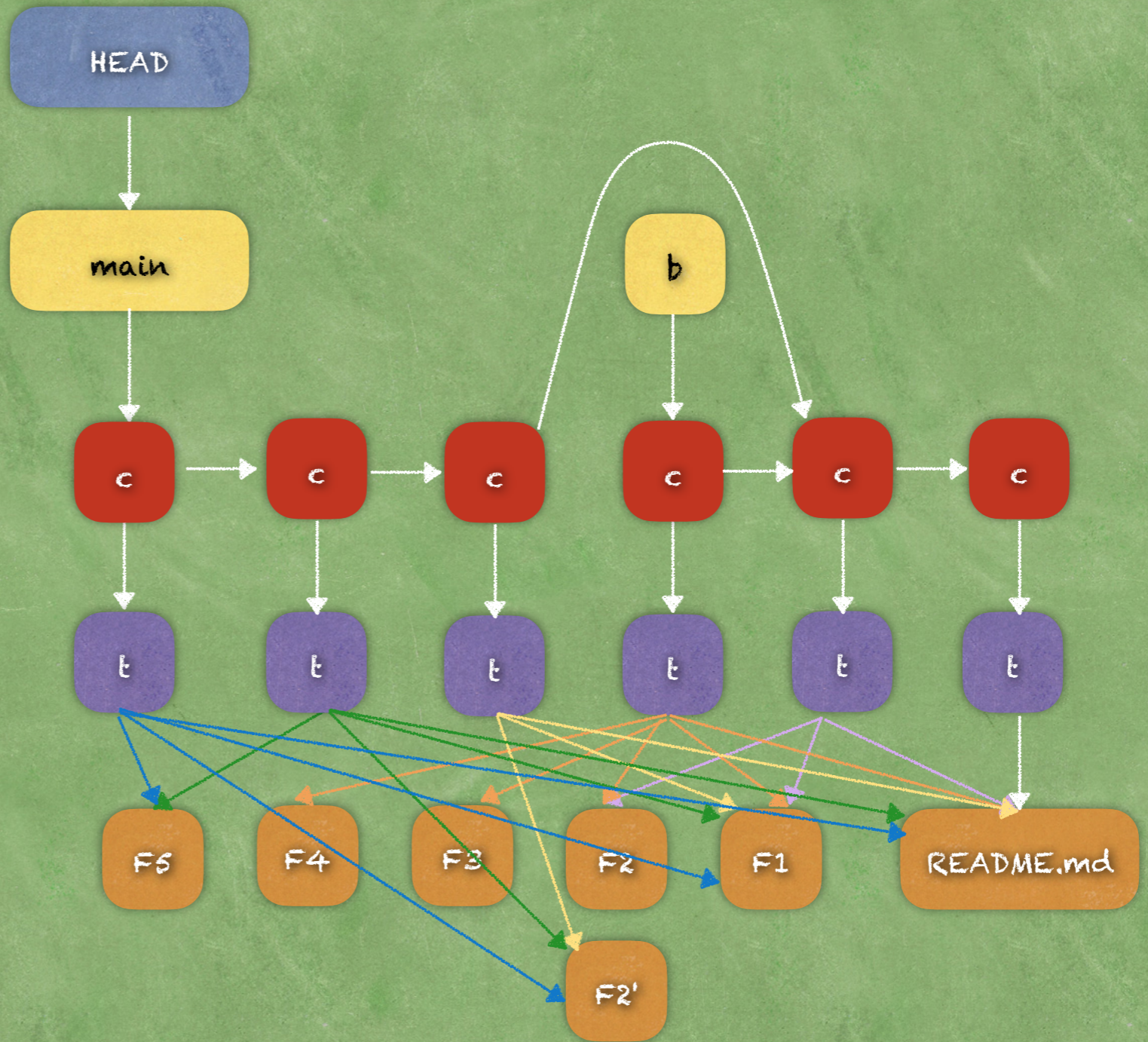
F1

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

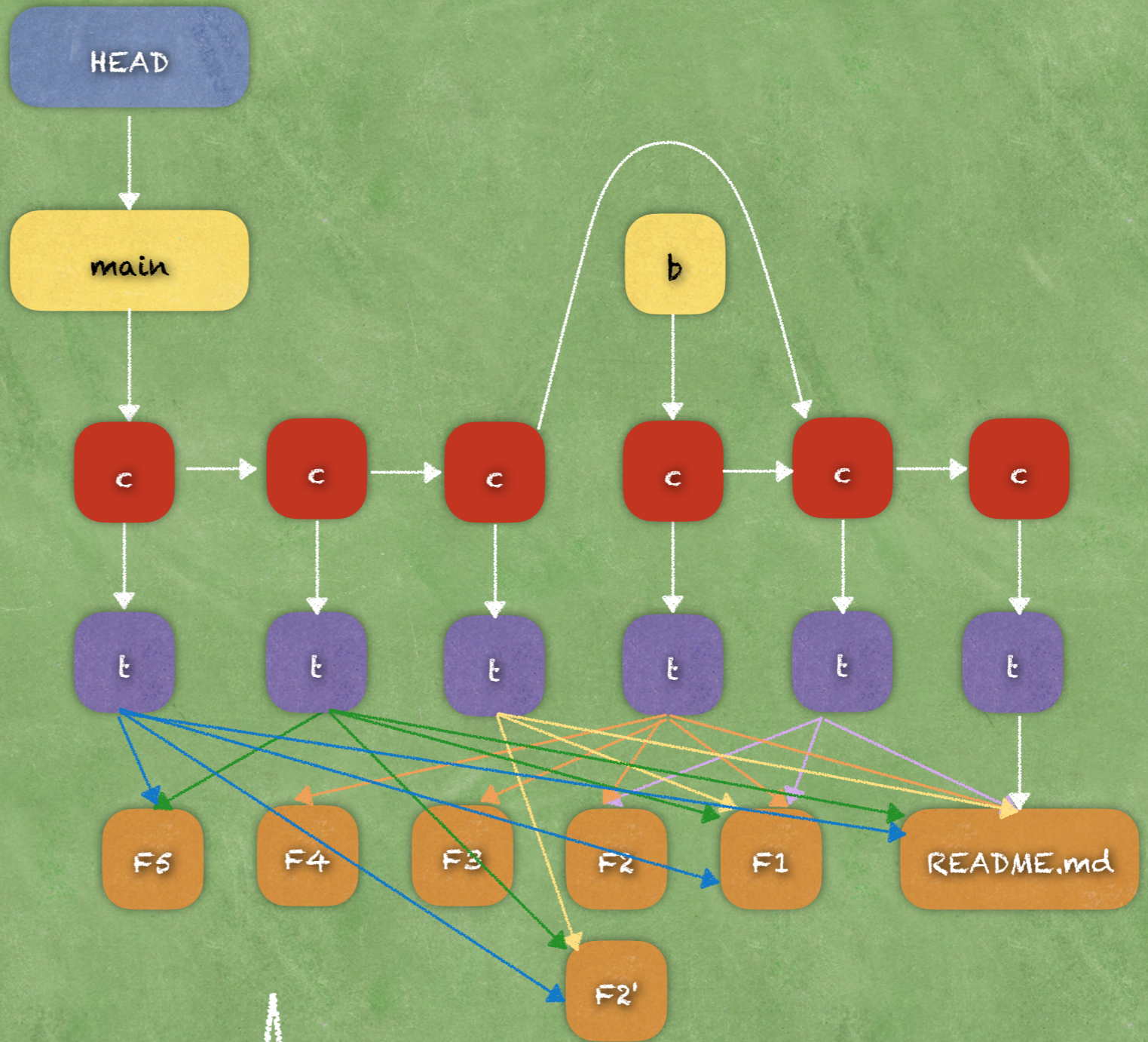
README.md

F1

F2'

F5

local repository



STARTING POINT

workspace

index
staging

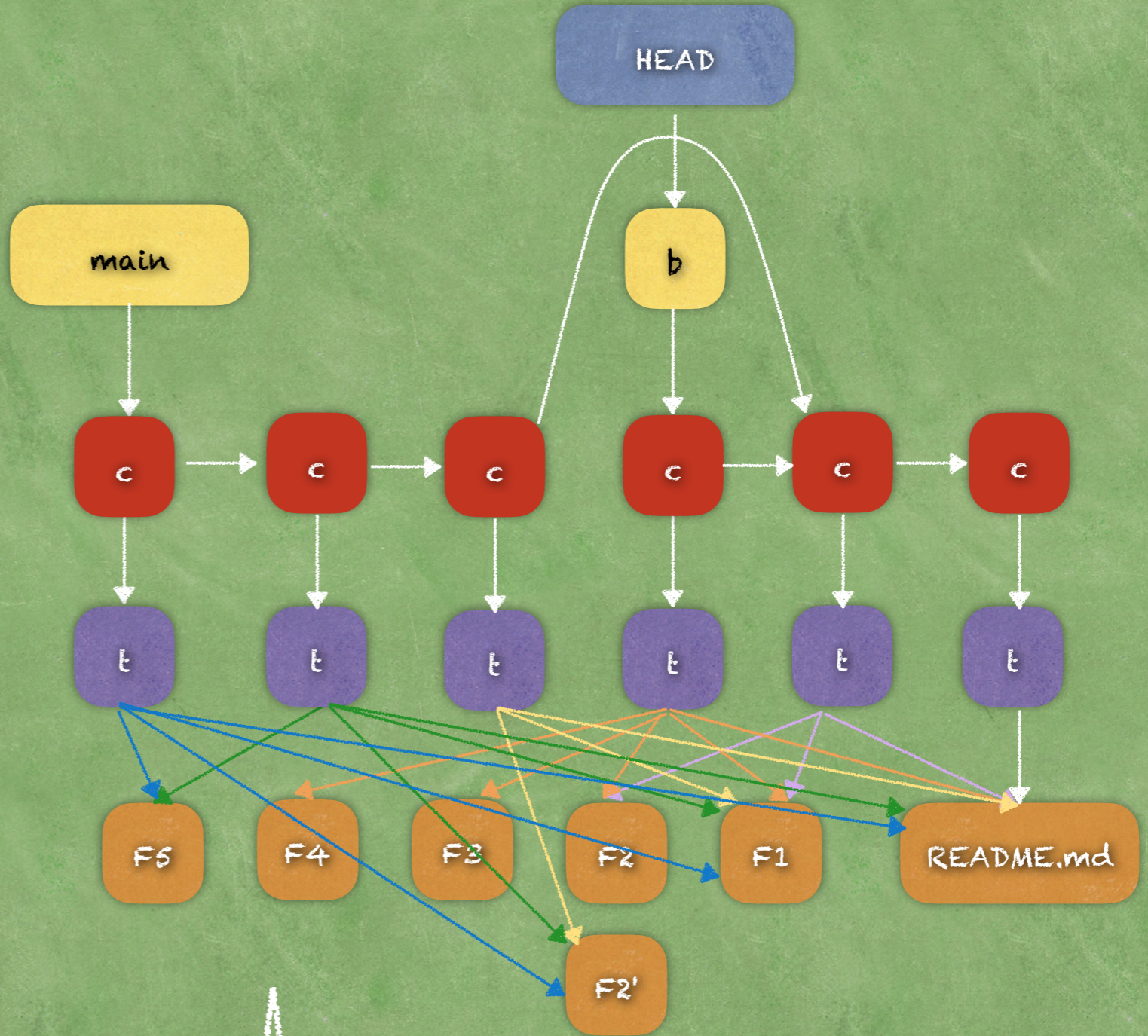
README.md

F1

F2''

F3

F4



edit F2 to create conflict with F2''

workspace

index
staging

README.md

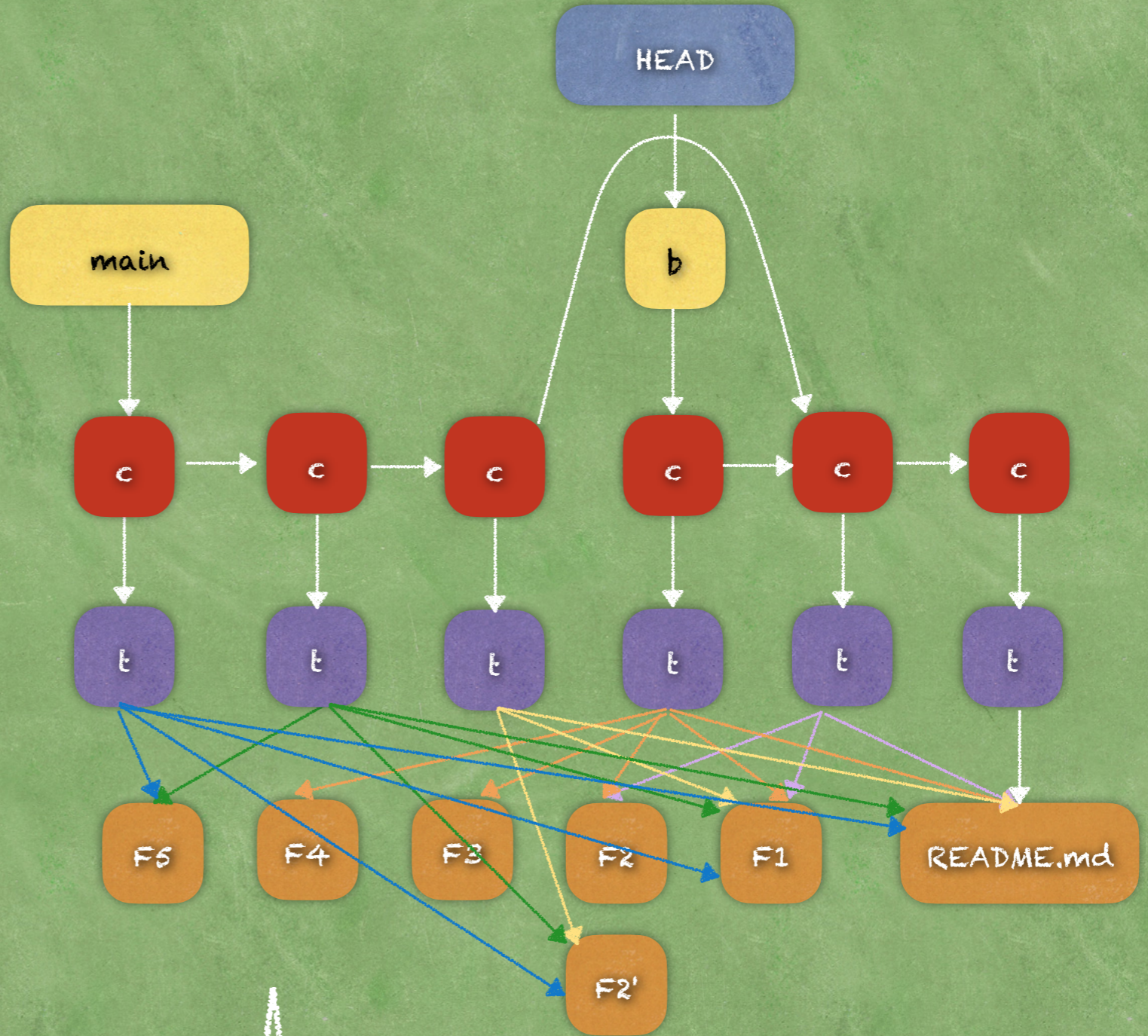
F1

F2''

F3

F4

F2''



git add F2''

workspace

index
staging

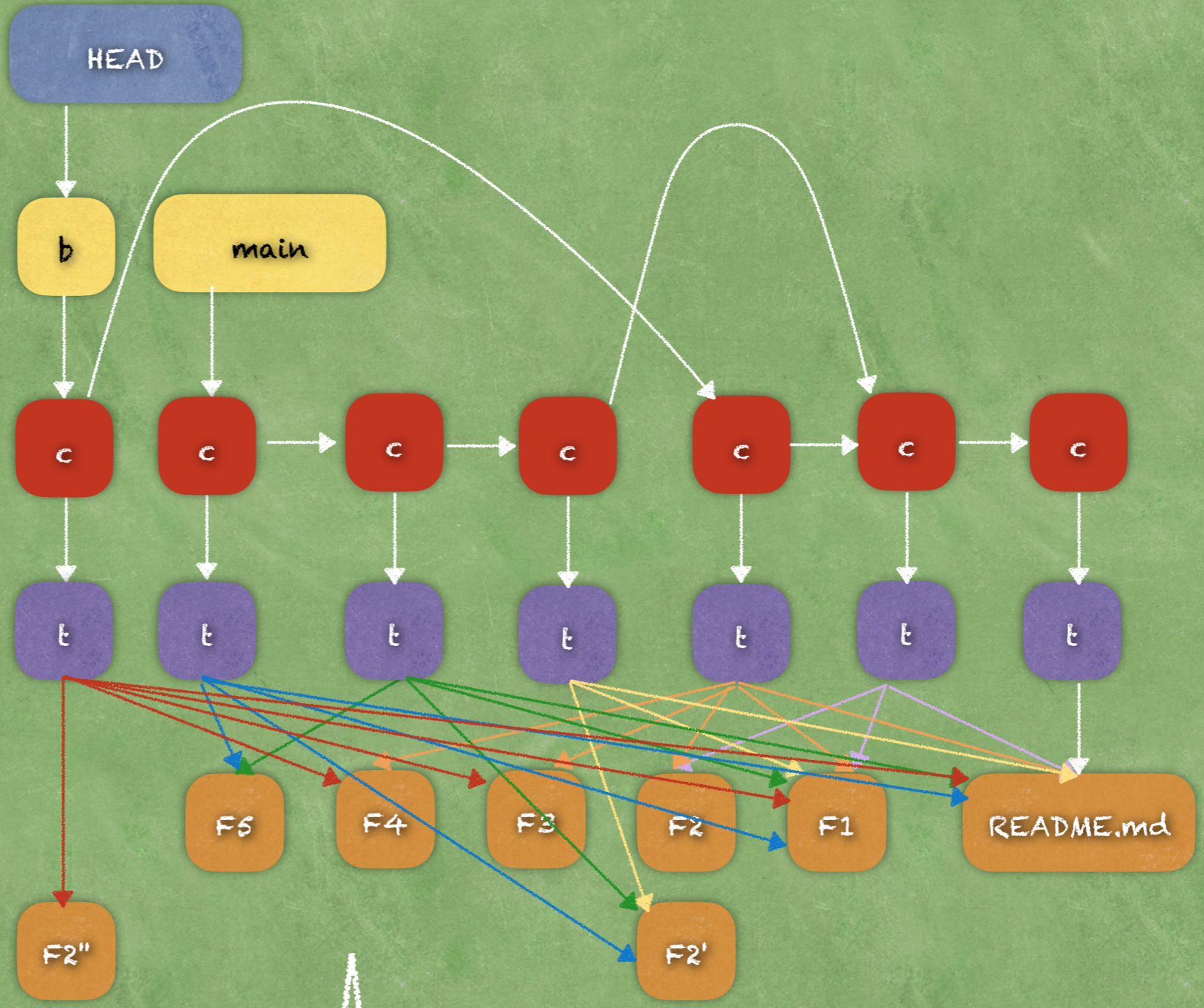
README.md

F1

F2''

F3

F4



git commit -m "..."

workspace

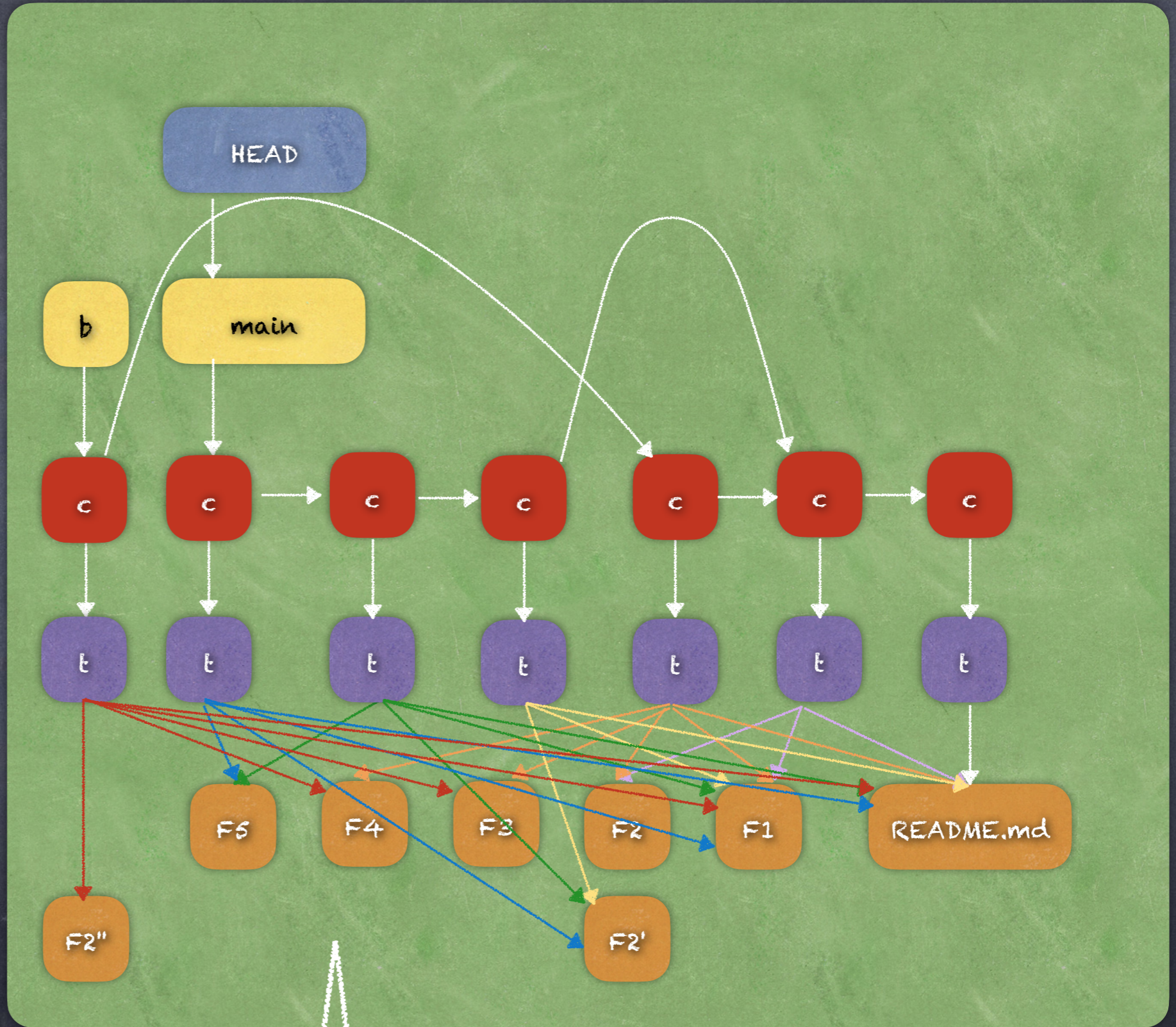
index
staging

README.md

F1

F2'

F5



git checkout main

workspace

index
staging

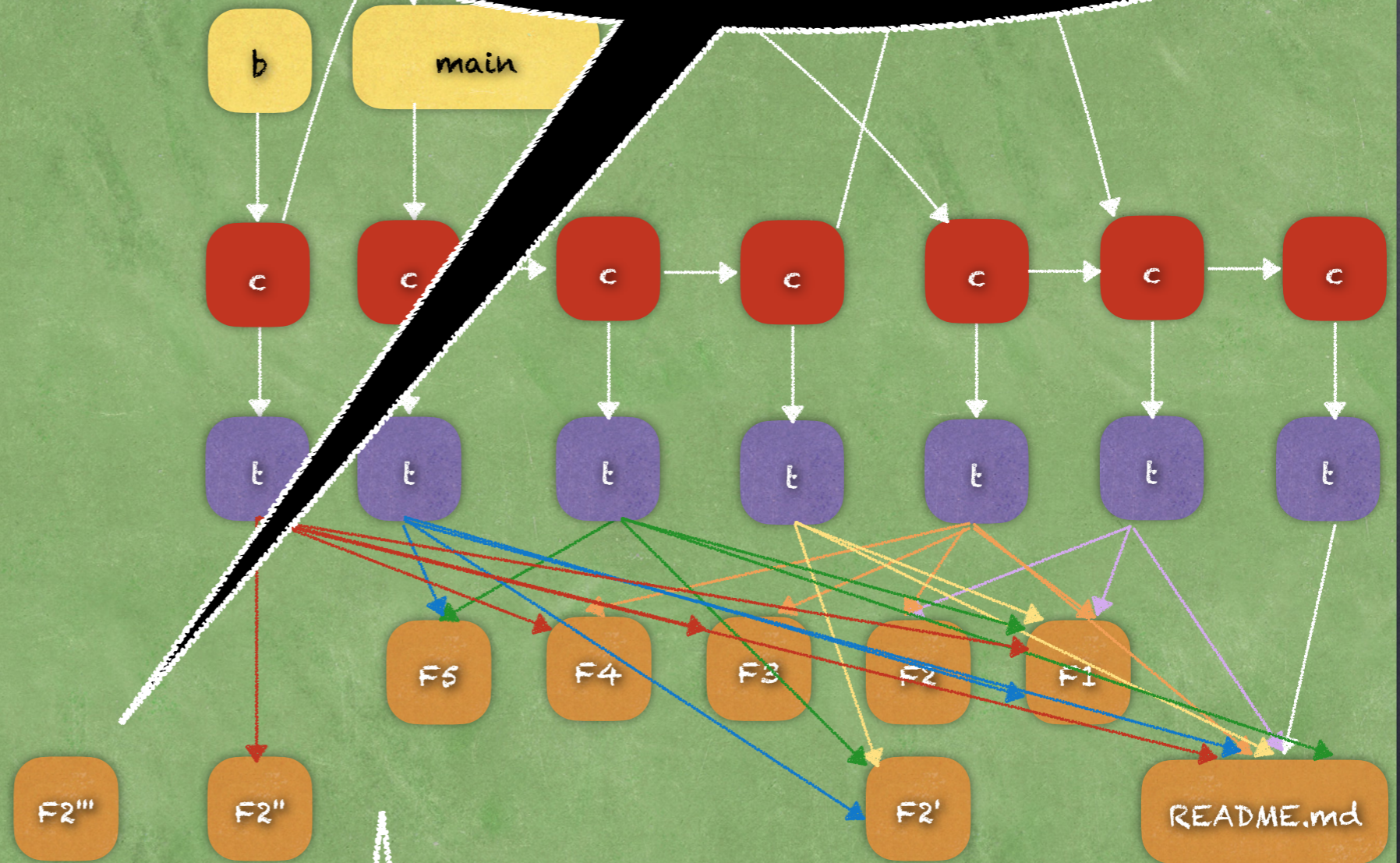
README.md

F1

F2'''

F5

Blob created with
conflict markings.



git merge b

workspace

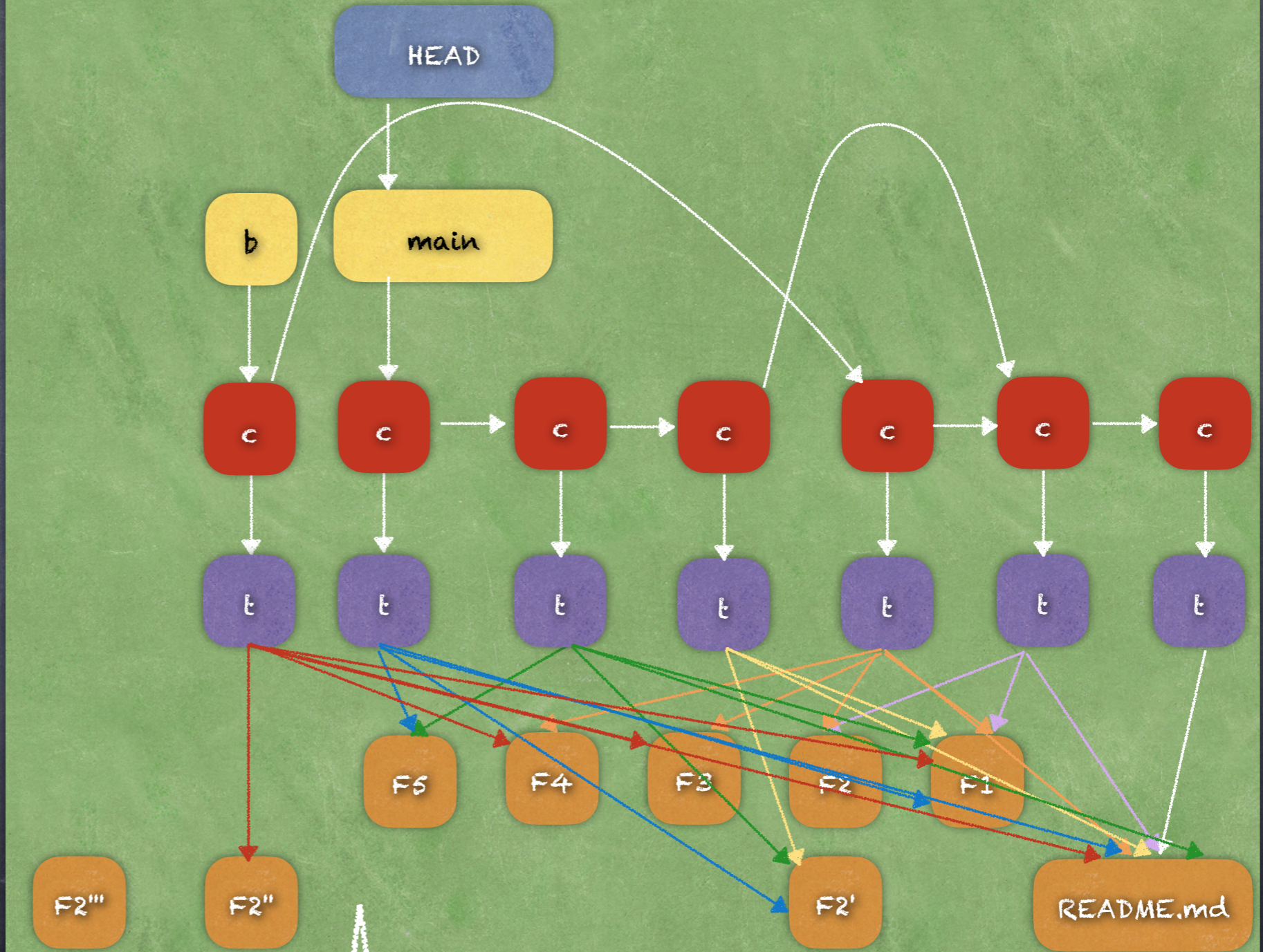
index
staging

README.md

F1

F2+

F5



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

workspace

index
staging

README.md

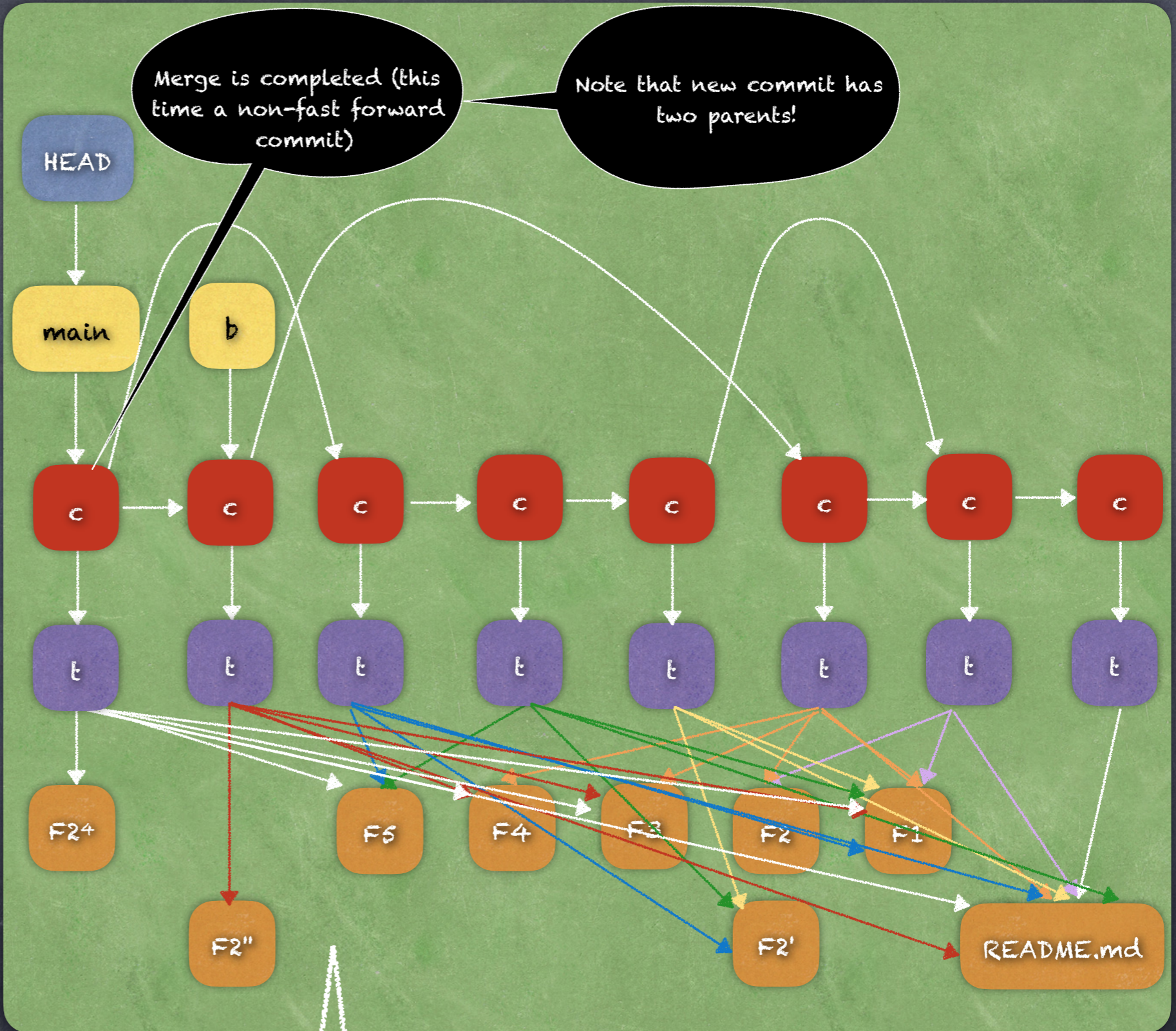
F1

F2+

F3

F4

F5



`git commit -m "..."`

Question

- Is there a difference between
 - merging a into b
 - merging b into a

Question



YES!

- Is there a difference between
 - merging a into b
 - merging b into a

workspace

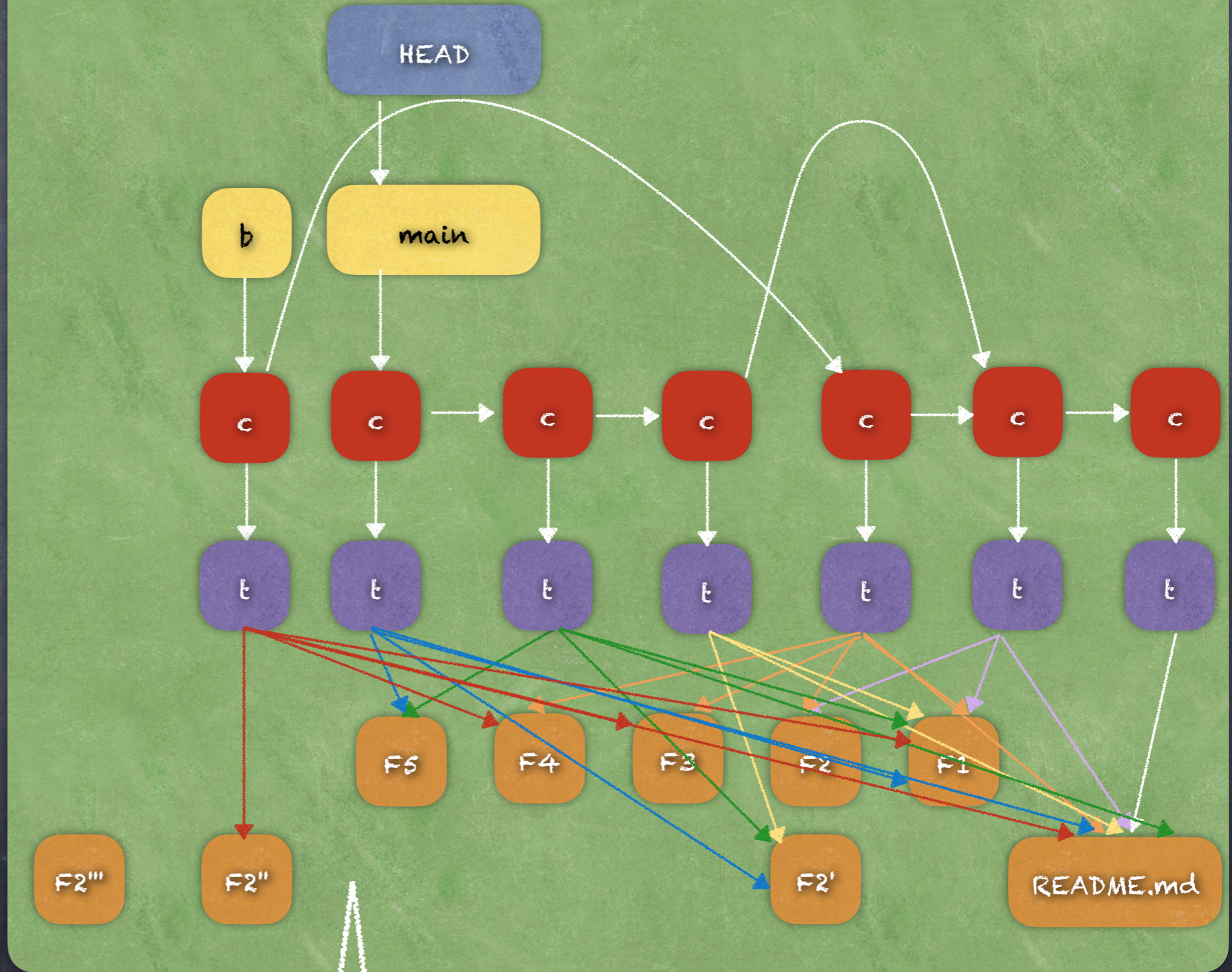
index
staging

README.md

F1

F2+

F5



STARTING POINT

workspace

index
staging

README.md

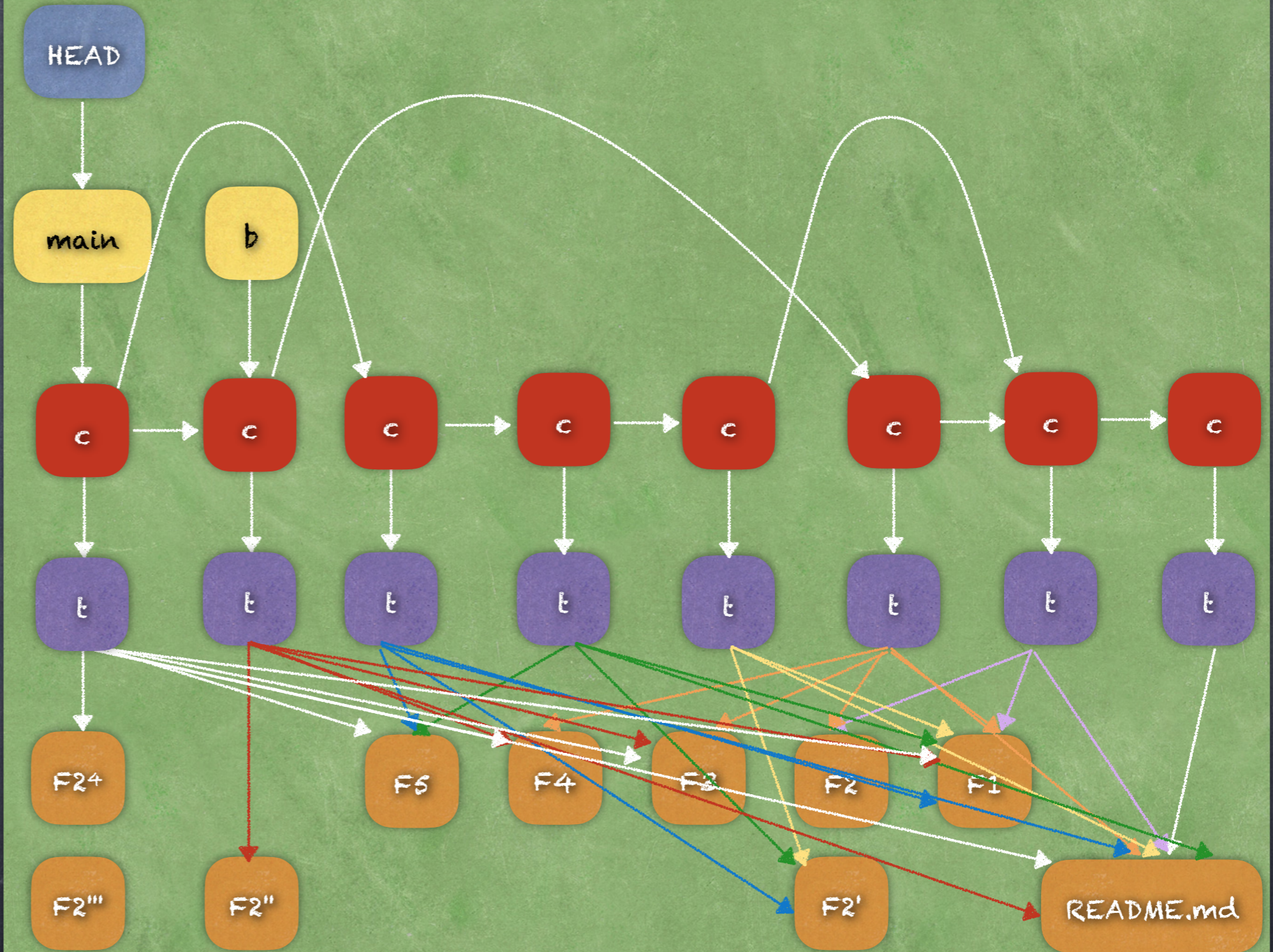
F1

F2+

F3

F4

F5



merging b into main
main moves, b does not

vs

workspace

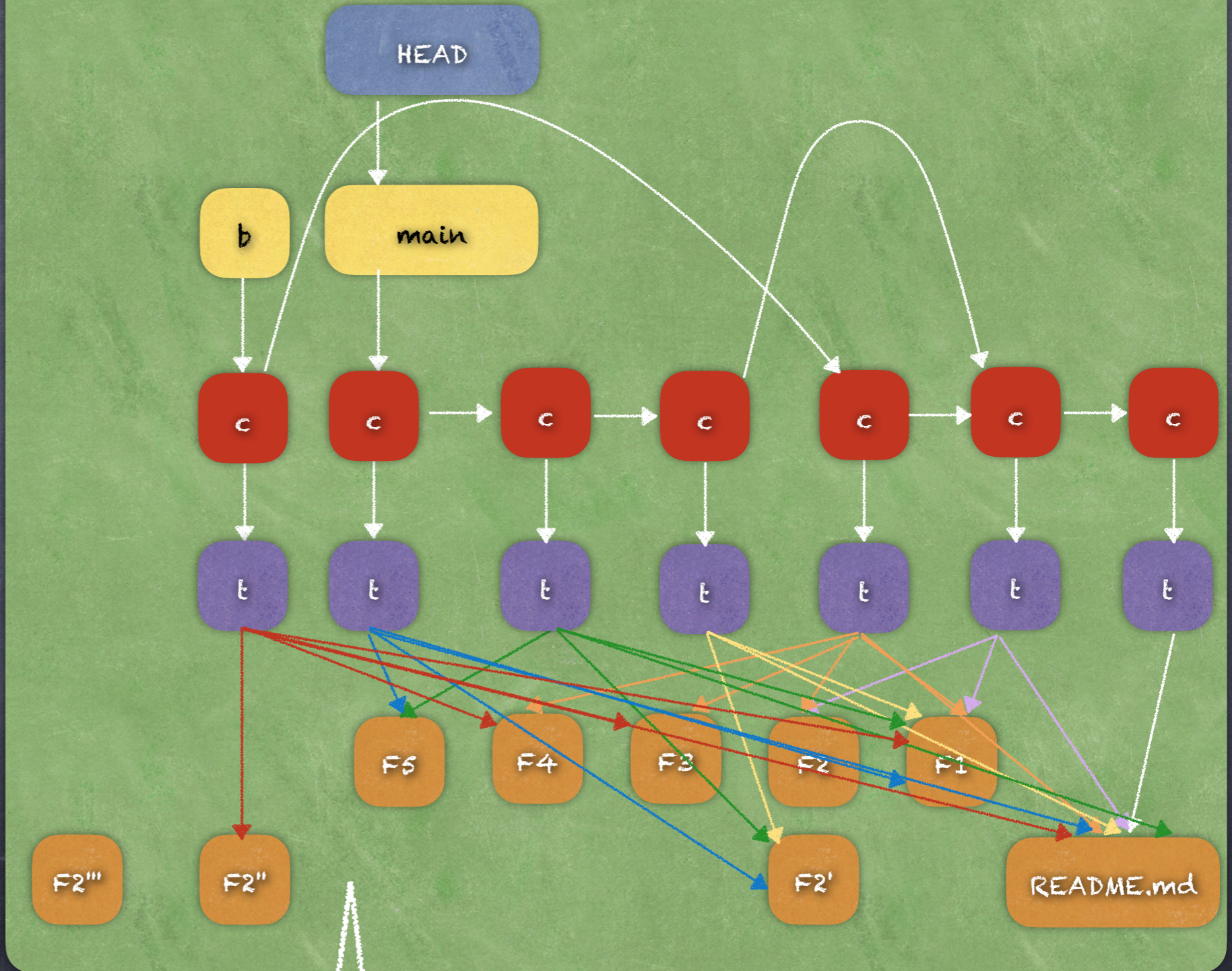
index
staging

README.md

F1

F2+

F5



STARTING POINT

workspace

index
staging

README.md

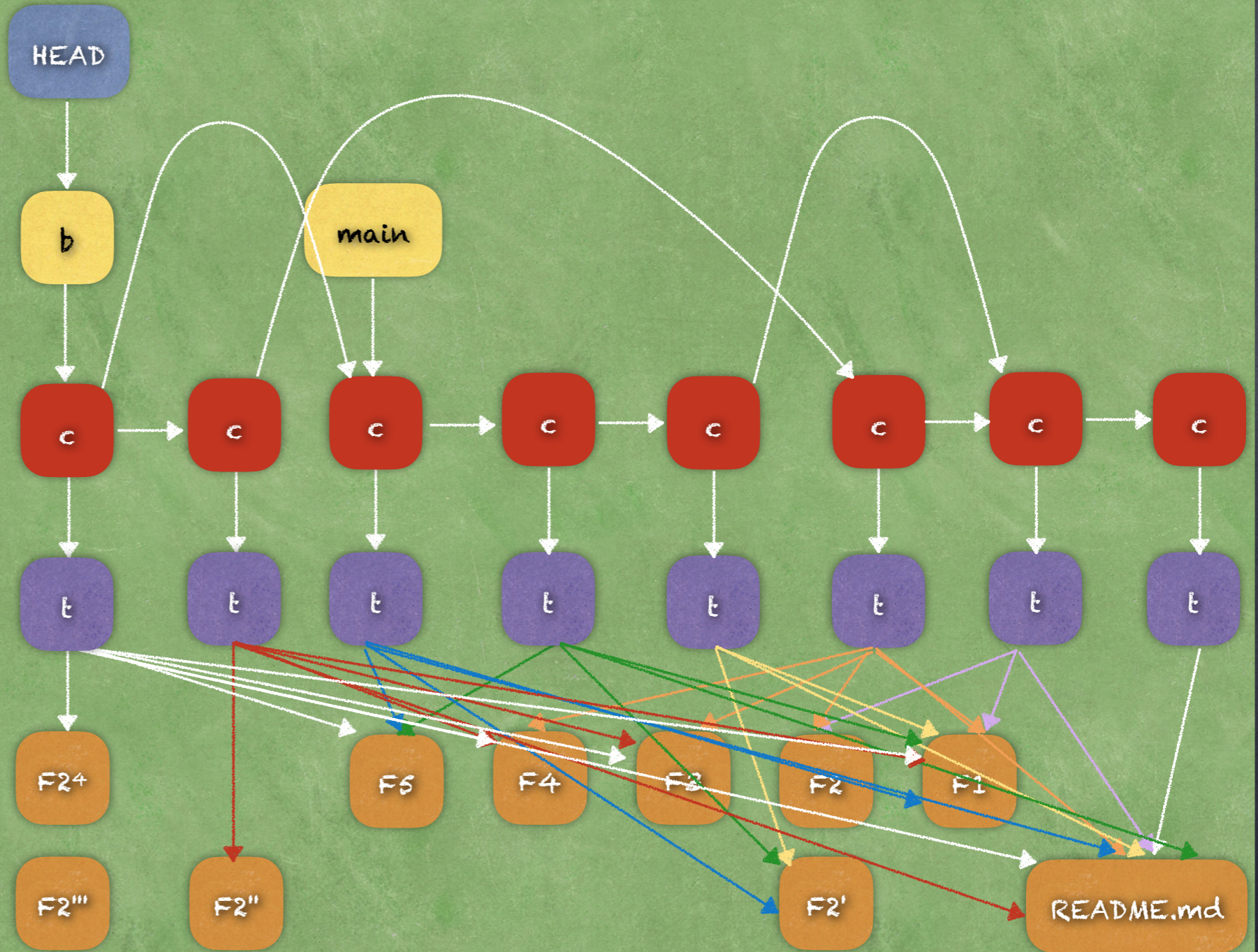
F1

F2+

F3

F4

F5



merging main into b
b moves, main does not

also:
parent order
differs

<https://www.kernel.org/pub/software/scm/git/docs/git-rev-parse.html>

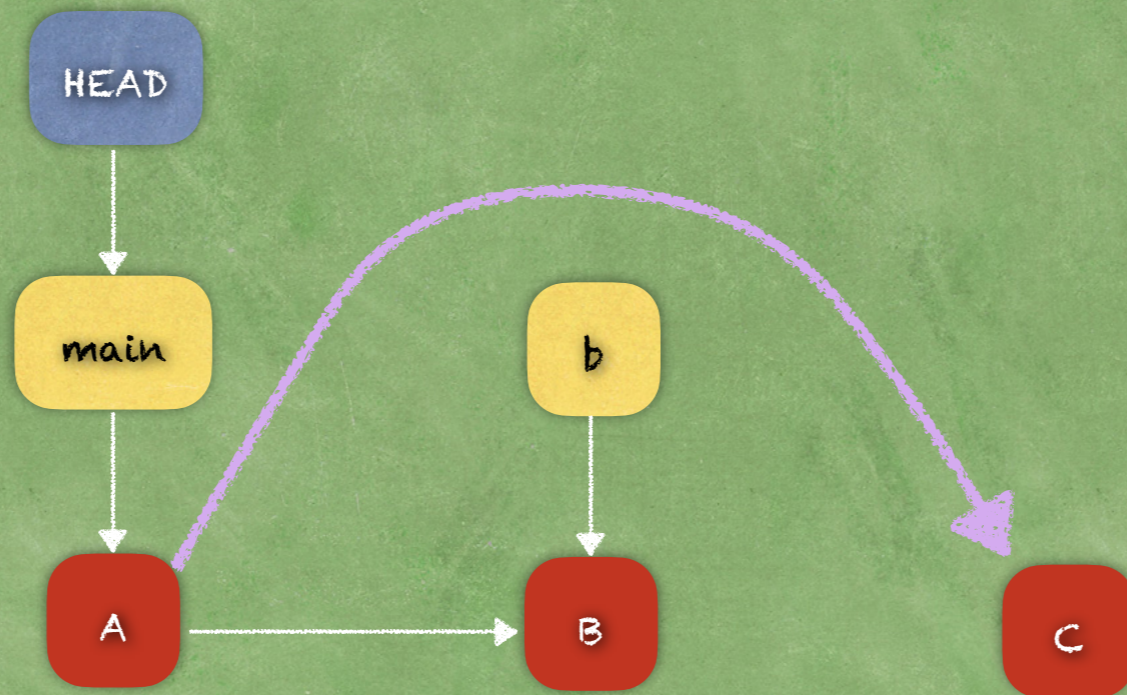


A = A^0
B = A^1 = A^1 = $A^{\sim 1}$
C = A^2 = A^2
D = A^{1^1} = A^{1^1} = $A^{\sim 2}$
E = B^2 = A^{1^2}
F = B^3 = A^{1^3}
G = $A^{1^1^1}$ = $A^{1^1^1}$ = $A^{\sim 3}$
H = D^2 = B^{1^2} = $A^{1^1^2}$ = $A^{\sim 2^2}$
I = F^1 = B^{3^1} = $A^{1^3^1}$
J = F^2 = B^{3^2} = $A^{1^3^2}$

The parents of a commit are ordered.

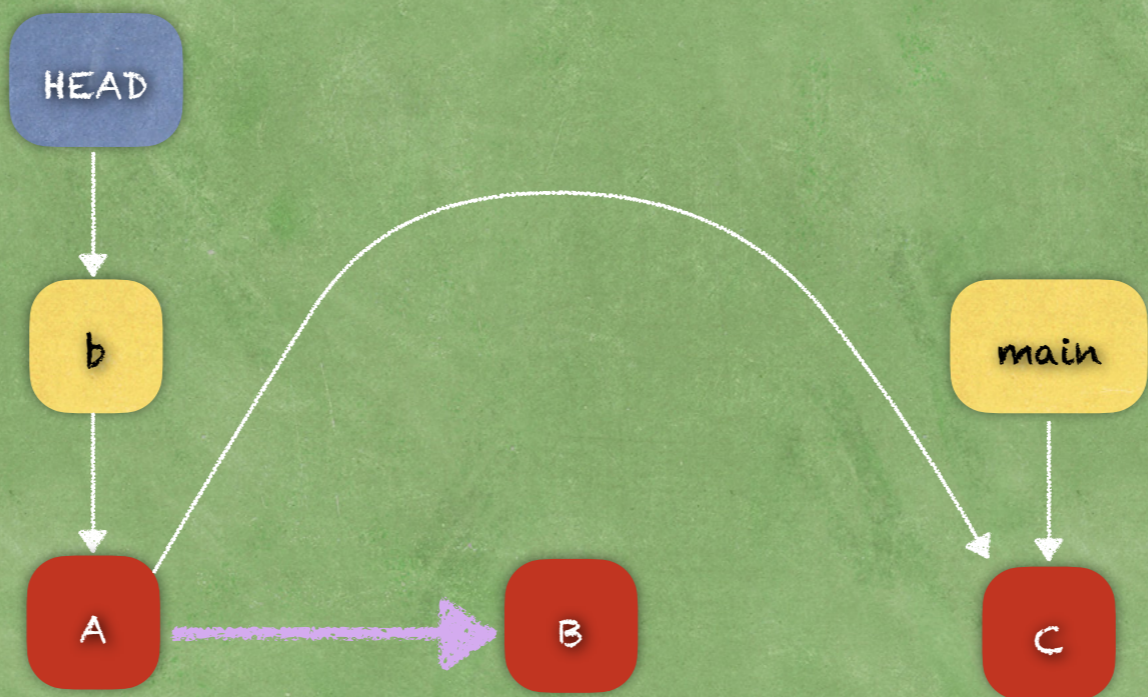
<http://stackoverflow.com/questions/26384166/what-is-the-difference-between-merging-main-into-branch-and-merging-branch-int>

<https://stackoverflow.com/questions/2221658/whats-the-difference-between-head-and-head-in-git>



merging b into main

$HEAD^1 \rightarrow C, HEAD^2 \rightarrow B$



merging main into b
HEAD¹ → B, HEAD² → C