Code Versioning

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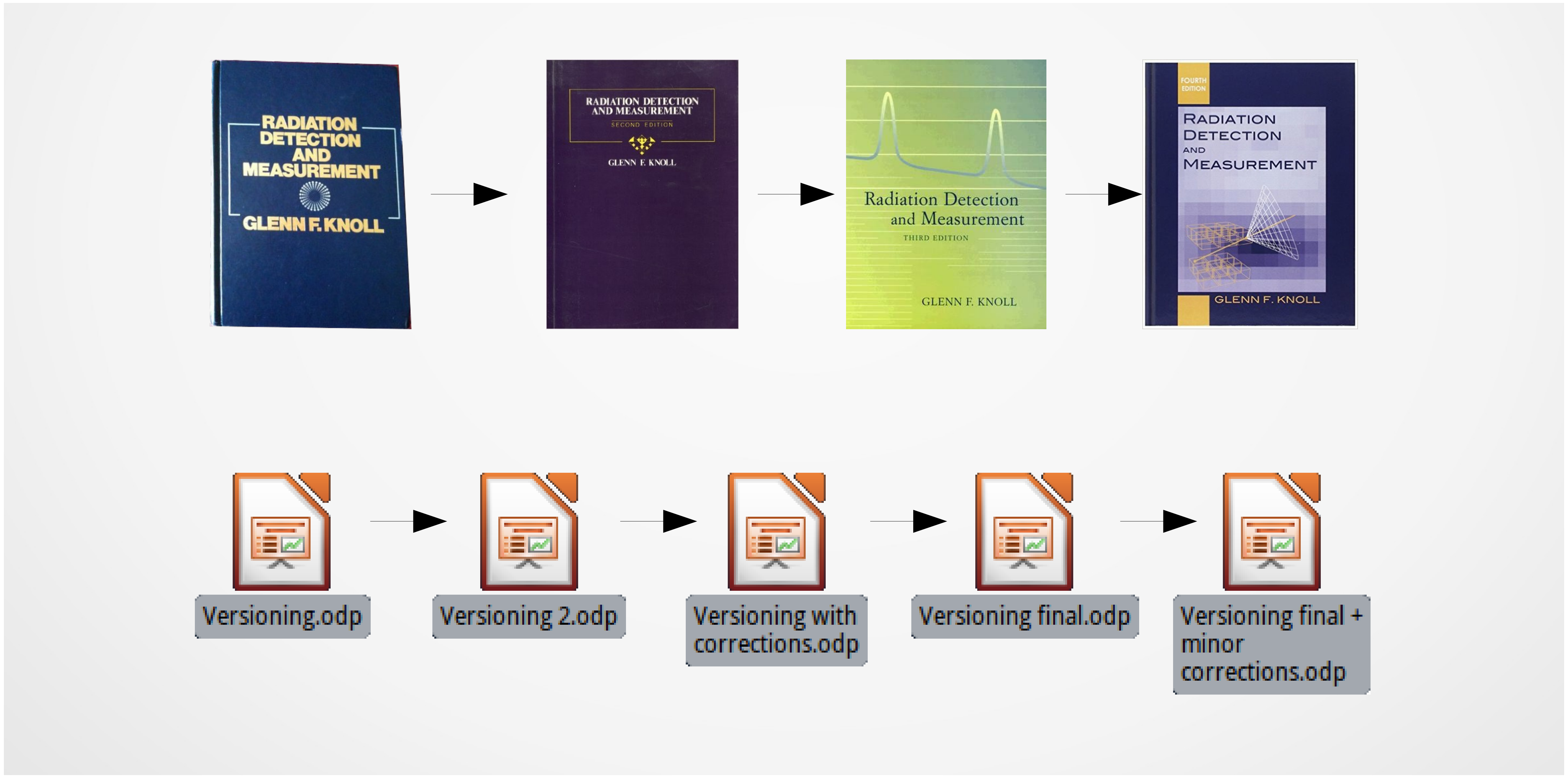
based on slides from
Damien Francois (CISM)
Juan Cabrera (NAMUR)
Jonathan Lambrechts (IMMC)
Scott Chalcon (git)

What is code versioning


RADIATION DETECTION AND MEASUREMENT
GLENN F. KNOLL
RADIATION DETECTION AND MEASUREMENT
SECOND EDITION
GLENN F. KNOLL
Radiation Detection and Measurement
THIRD EDITION
GLENN F. KNOLL
FOURTH EDITION
RADIATION DETECTION AND MEASUREMENT
GLENN F. KNOLL
Versioning.odp
Versioning 2.odp
Versioning with corrections.odp
Versioning final.odp
Versioning final + minor corrections.odp

Road Map

- Why using (code) versioning
- Basic of code versioning
    - revision, tracking file, …
- Branch/Workflow
    - Conflict, merging, …
- Online support
    - github/gitlab and similar

Goal of code versioning

1. History of modification
2. Team Work
3. WorkFlow

Goal of code versioning

1. **History of modification**

- Possibility to go back in time
    - Undo mistake / debugging /…
- Information about the modification
    - Who
    - When
    - Why

Goal of code versioning

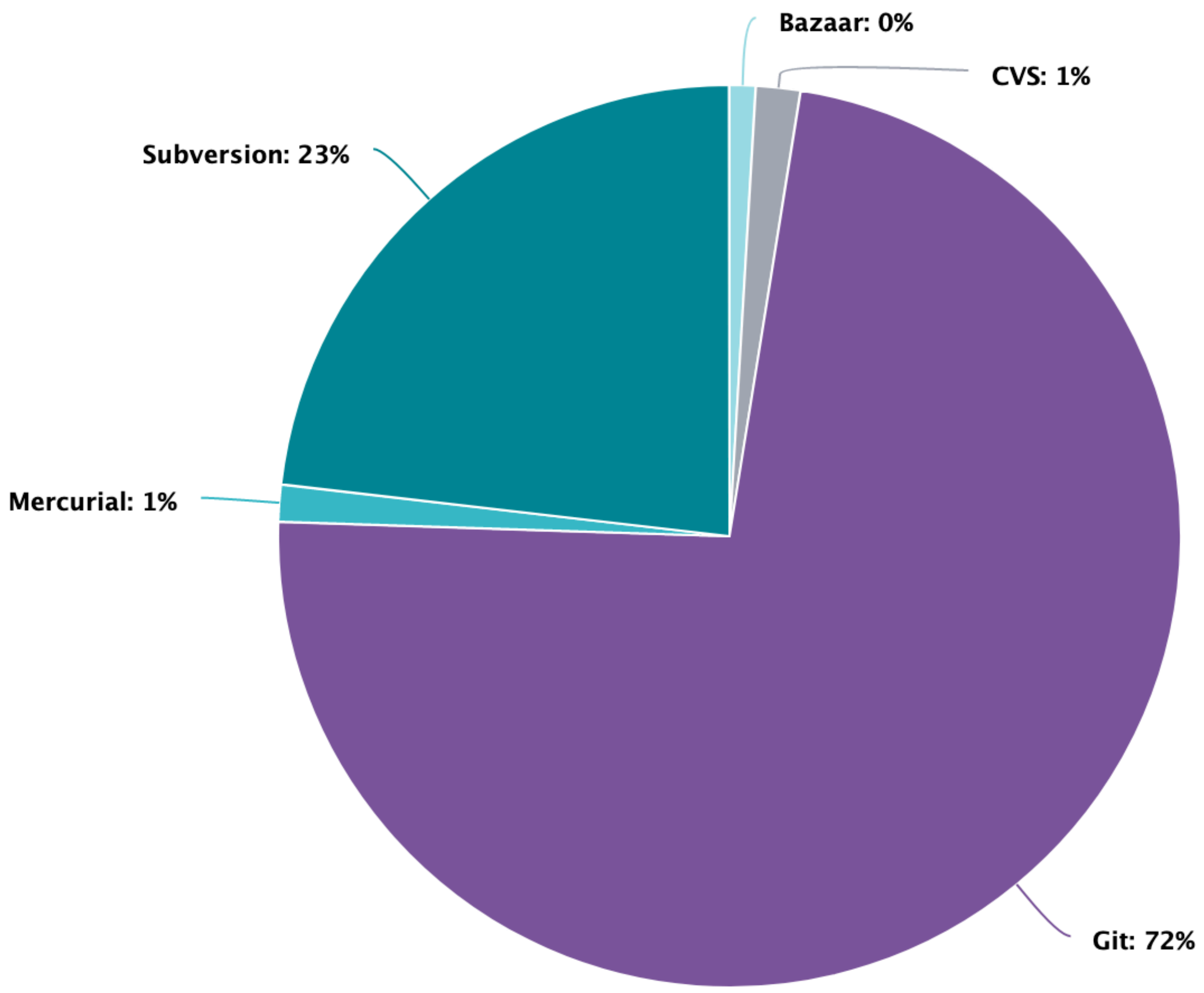
2. **Team Work**

- **Simultaneous** work on a project
  - No need to send email to say “I’m working on that file” (dropbox organization)
- **Asynchronous** synchronisation
  - Allow work Offline (opposite to overleaf project)
  - Need conflict resolution

Goal of code versioning

3. **Workflow**
   - **Testing new idea** (and easy way to throw them out)
   - **Multiple version** of the code
     - Stable (1.x.y)
     - Debug (1.x.y+1)
     - Next “feature” release (1.x+1.0)
     - Next “huge” release (2.0.0)
   - Need to pass modification from one version to next
     - Transfer of information between version

Open-Source Code

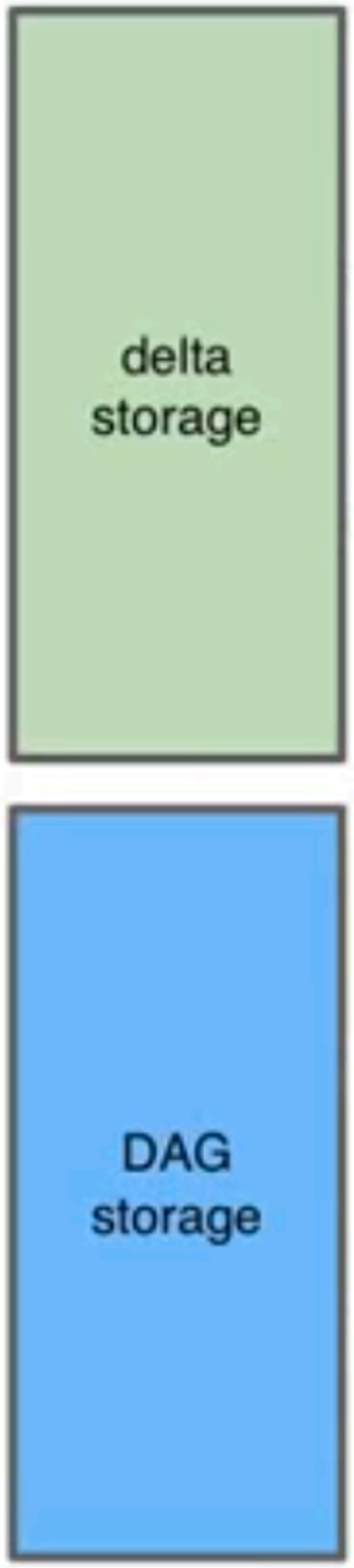


https://www.openhub.net/repositories/compare

Number for 2021 but no change anymore

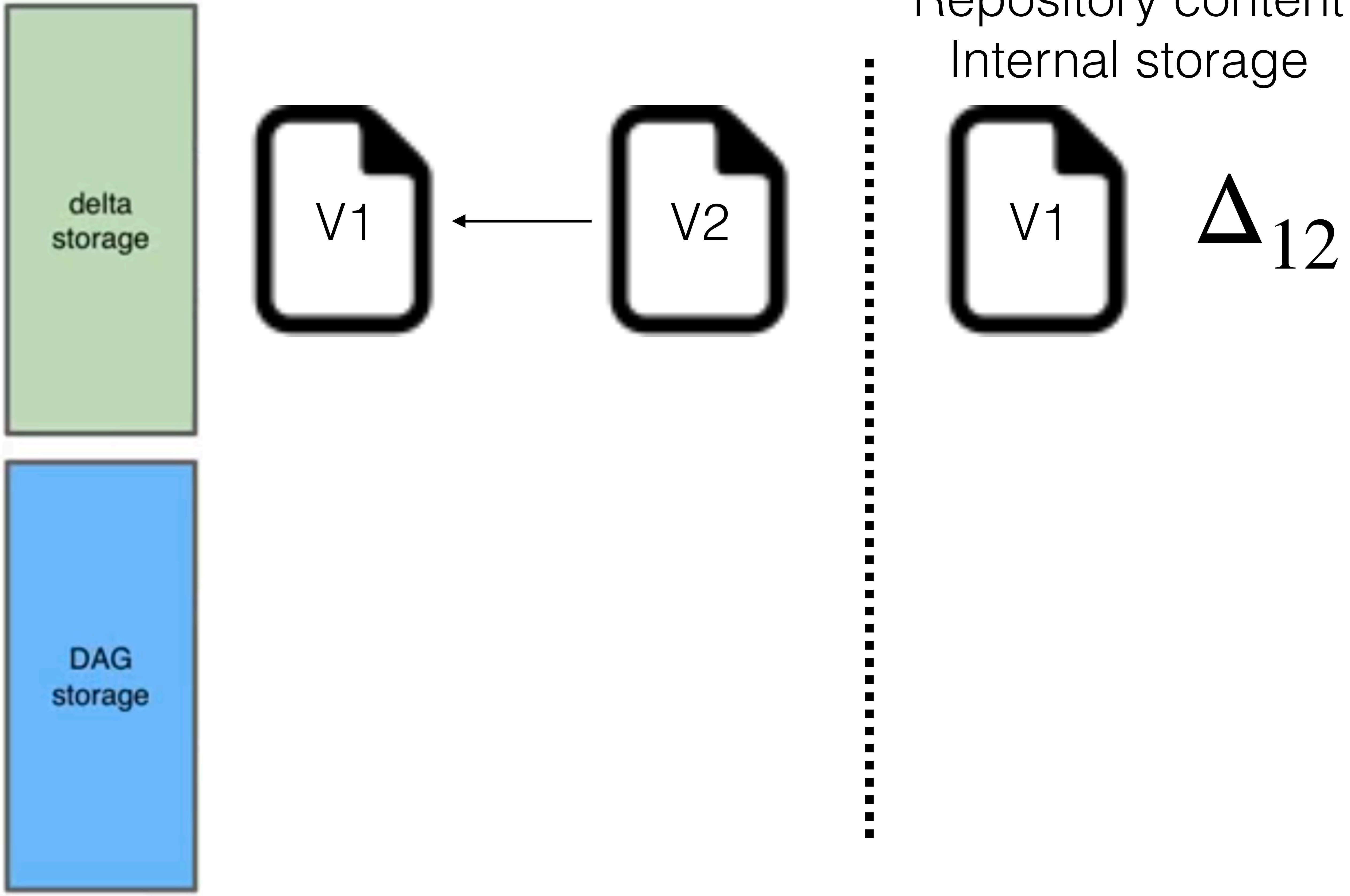
source control taxonomy

Repository content
Internal storage



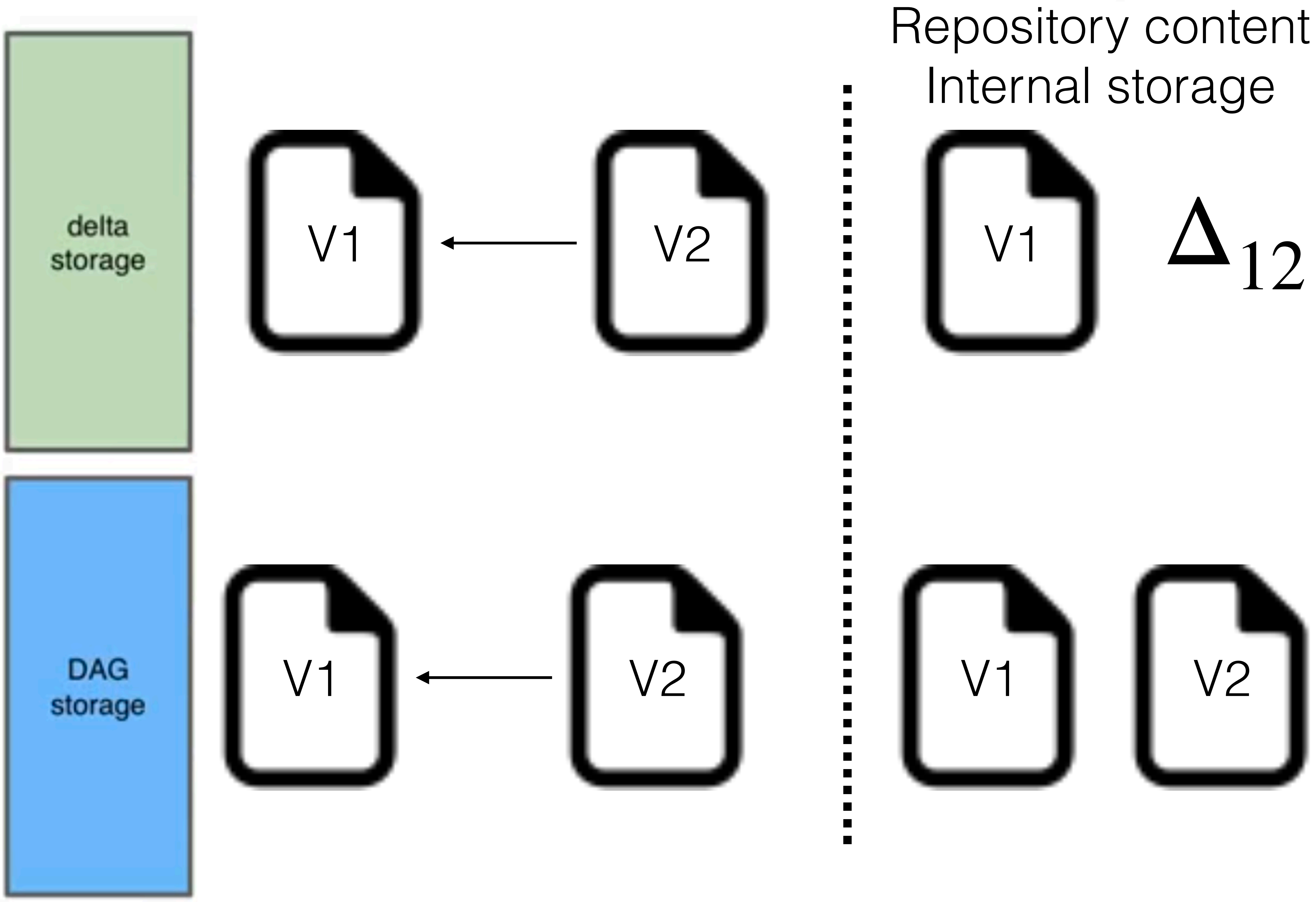
Slide from Scott Chalcon

source control taxonomy



Slide from Scott Chalcon

source control taxonomy



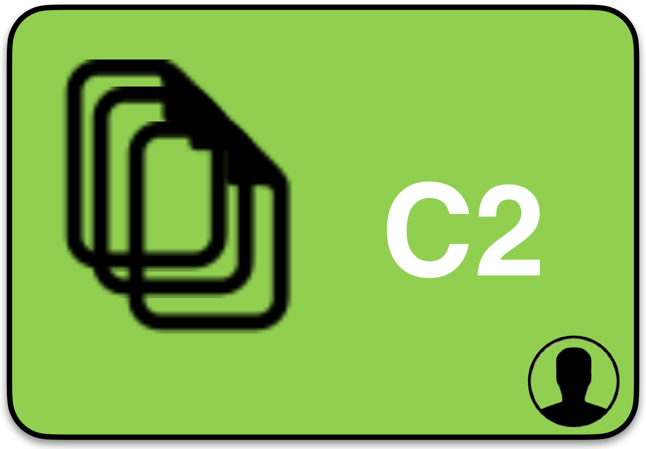
Slide from Scott Chalcon

Key Concept

1. History
    1. History and commit
2. Three phases of git
    1. Workspace
    2. Index
    3. Repository

1. Commit

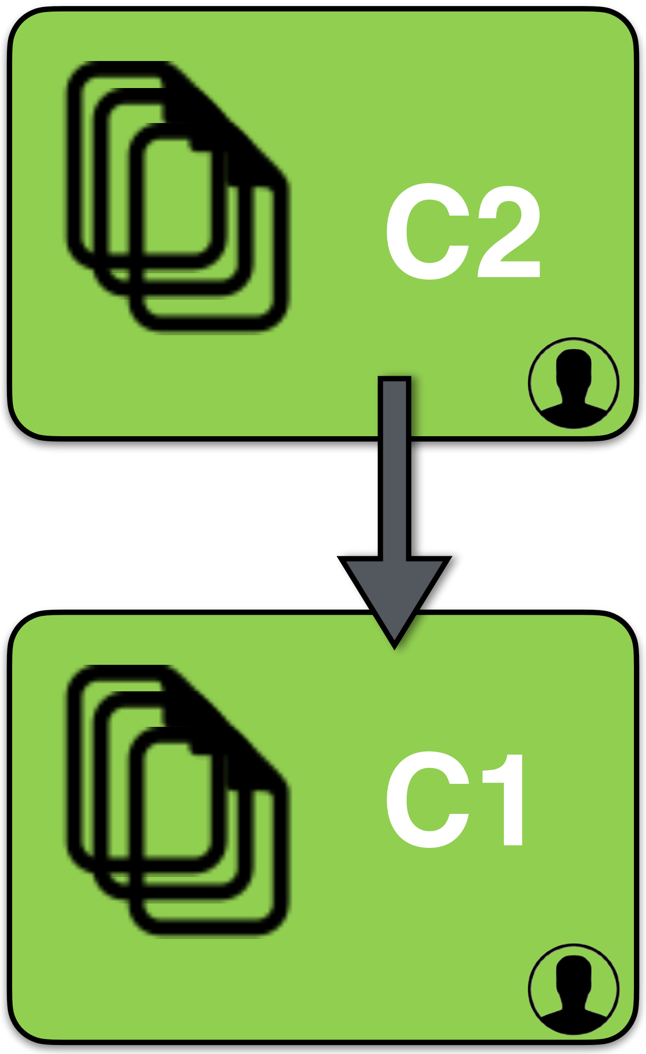
- An history: Is a **succession** of **snapshot** of your files at key time of their development
  - Each **snapshot** is called **COMMIT**



- Commit is
  - All the files at a given time
  - A unique name (SLHA1)
  - MetaData (who created/when/info)

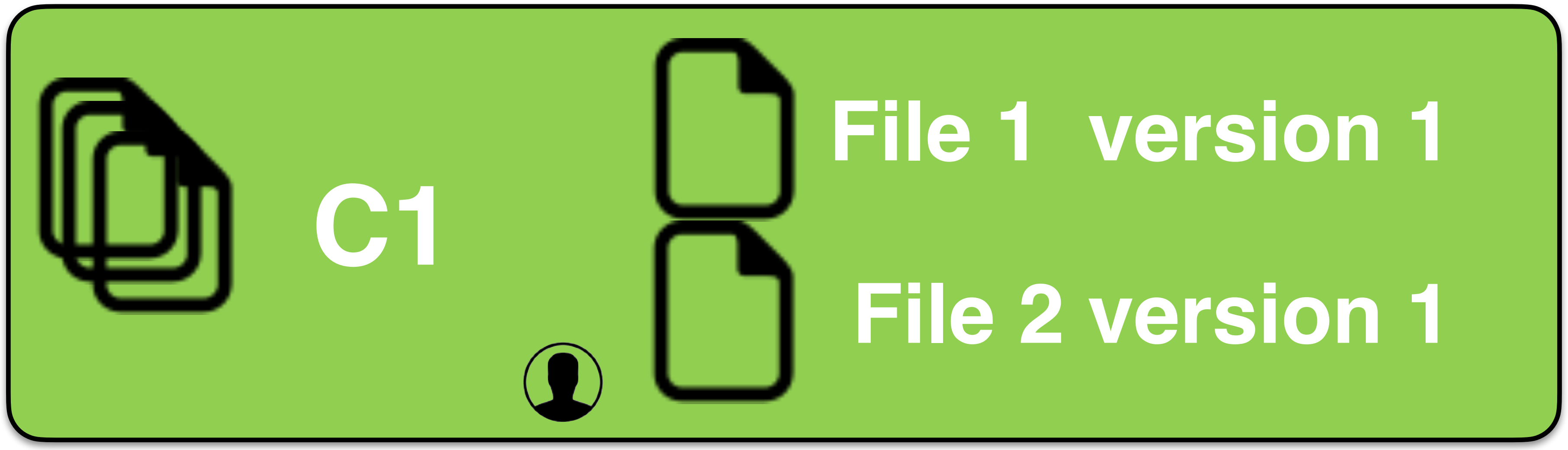
1. Commit

- An history: Is a **succession** of **snapshot** of your files at key time of their development
  - Each **snapshot** is called **COMMIT**

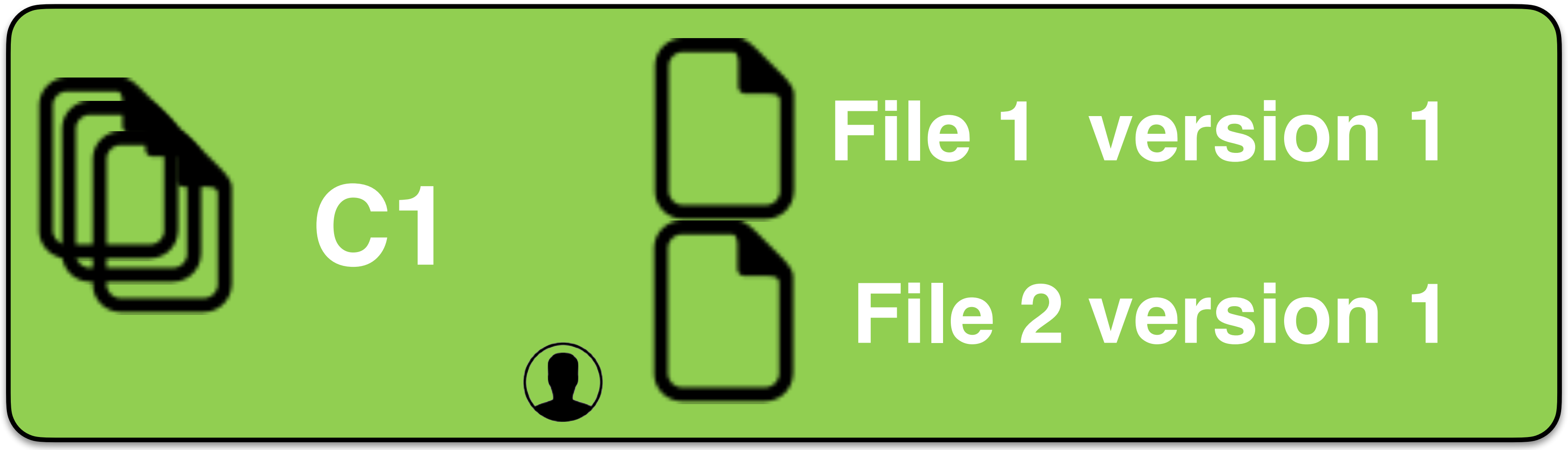


- Commit is
  - All the files at a given time
  - A unique name (SLHA1)
  - MetaData (who created/when/info)
  - Pointer to previous(es) commit

1. Commit

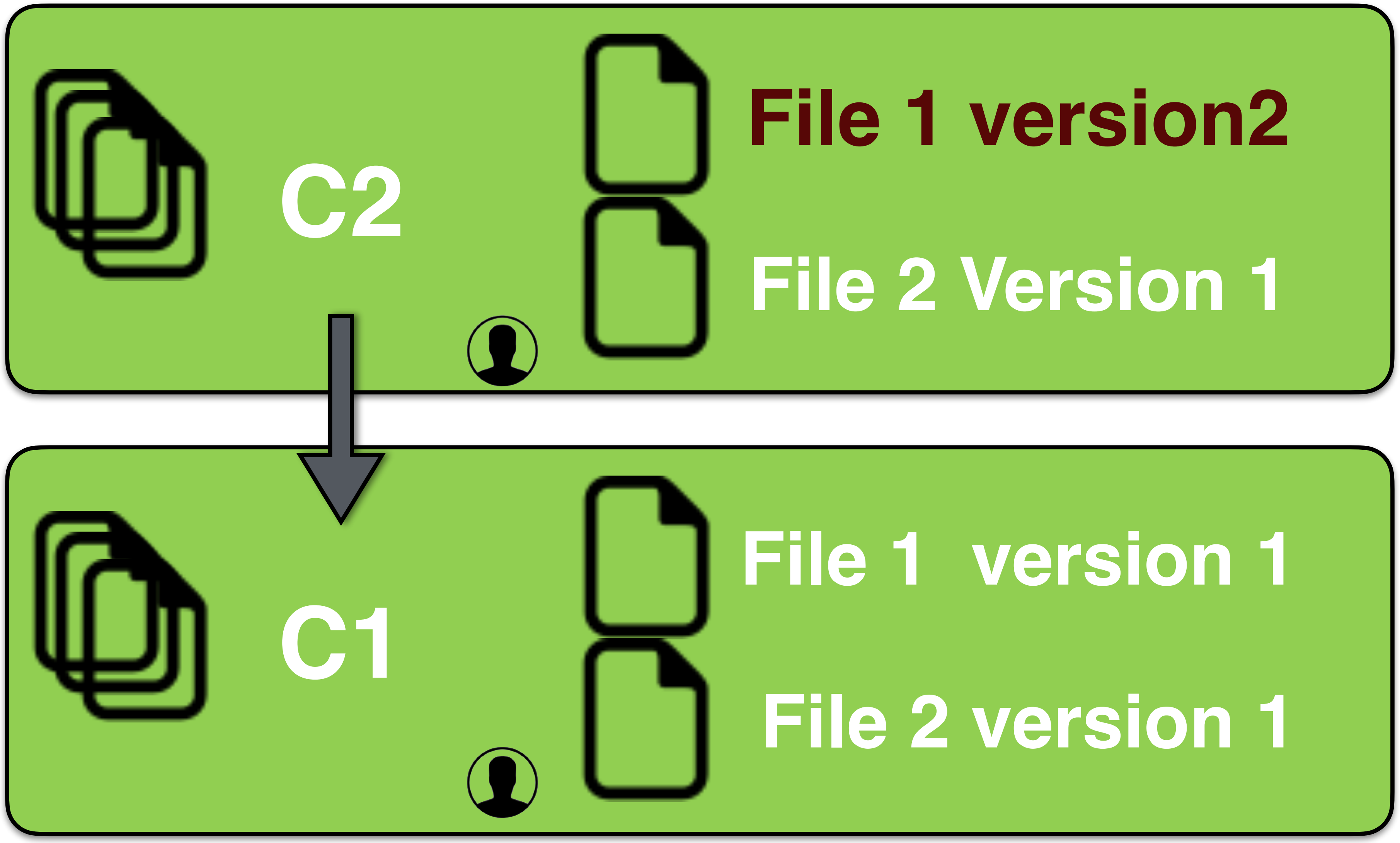


1. Commit



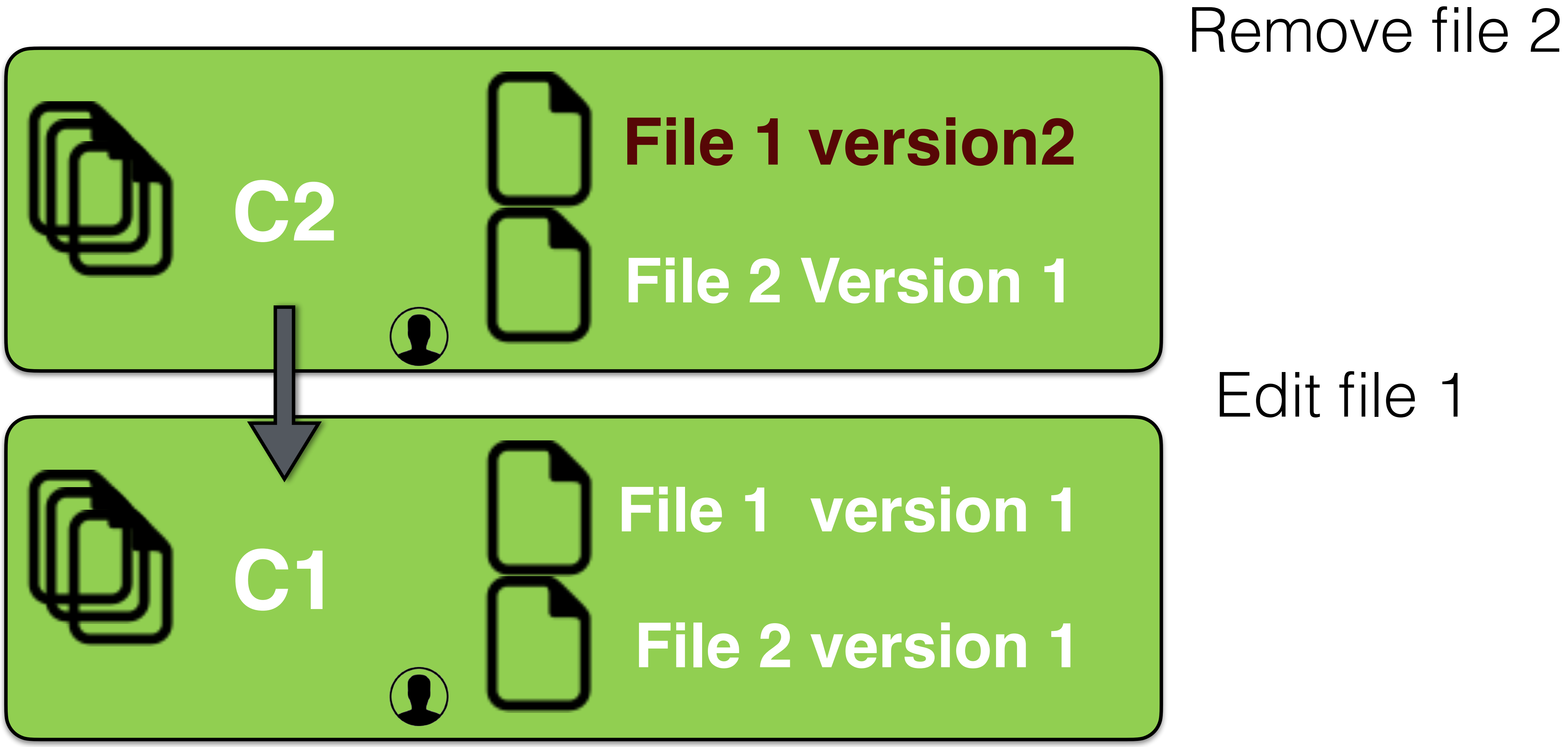
Edit file 1

1. Commit

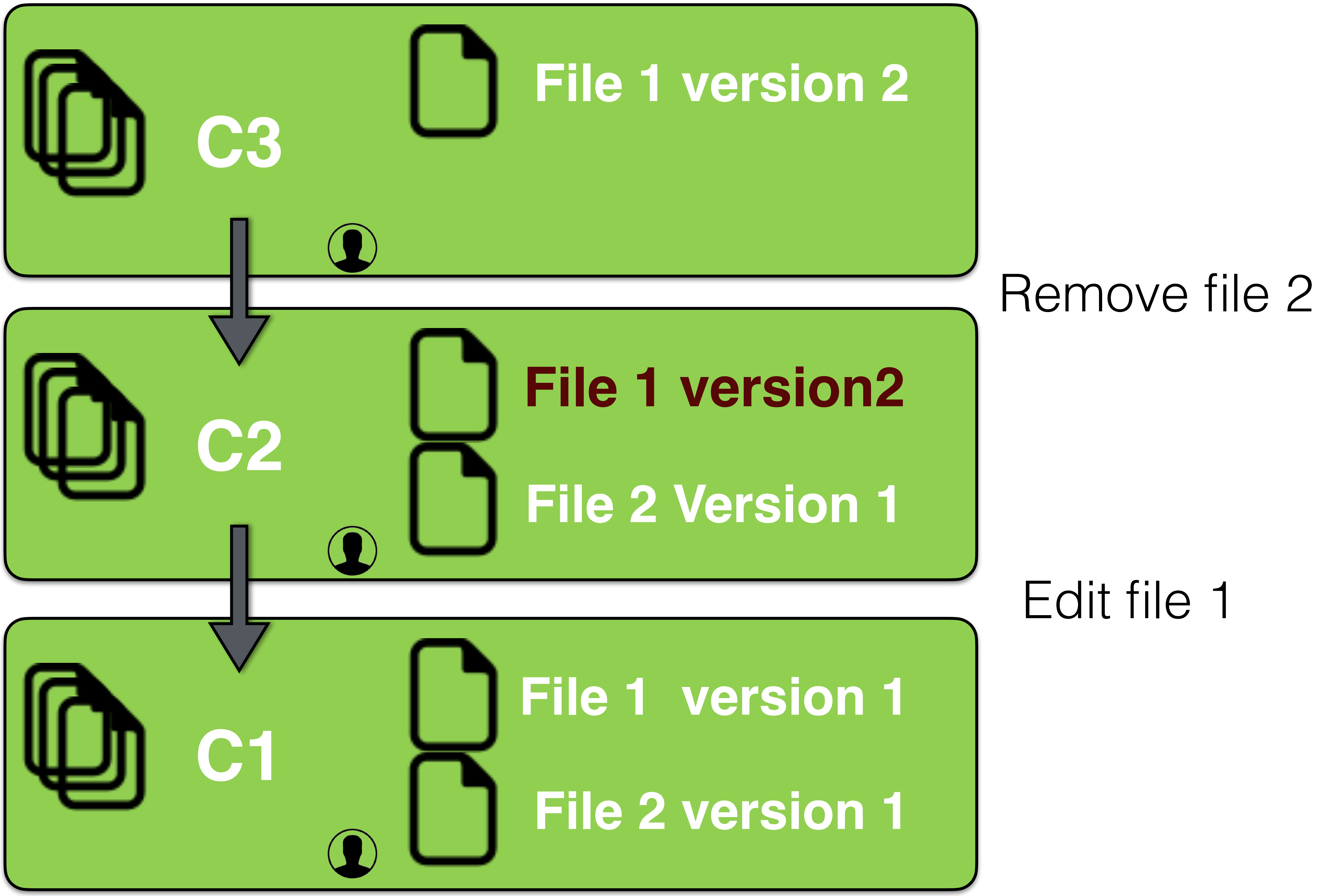


Edit file 1

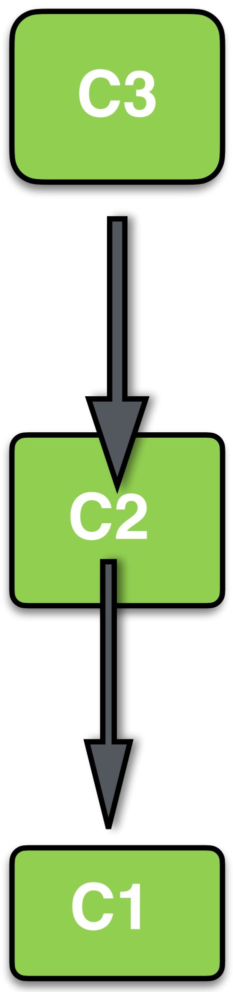
1. Commit


Remove file 2
C2
File 1 version2
File 2 Version 1
Edit file 1
C1
File 1 version 1
File 2 version 1

1. Commit

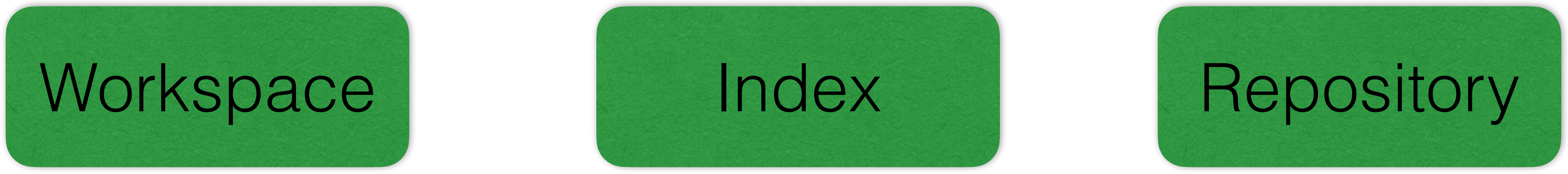

File 1 version 2
C3
Remove file 2
File 1 version2
C2
File 2 Version 1
Edit file 1
File 1 version 1
C1
File 2 version 1

1. Commit



1. Simplify representation of commit/history

Git Three area



Git Three area

Workspace

Index

Repository

./WORKDIR

Git Three area

Workspace

Index

Repository

./WORKDIR

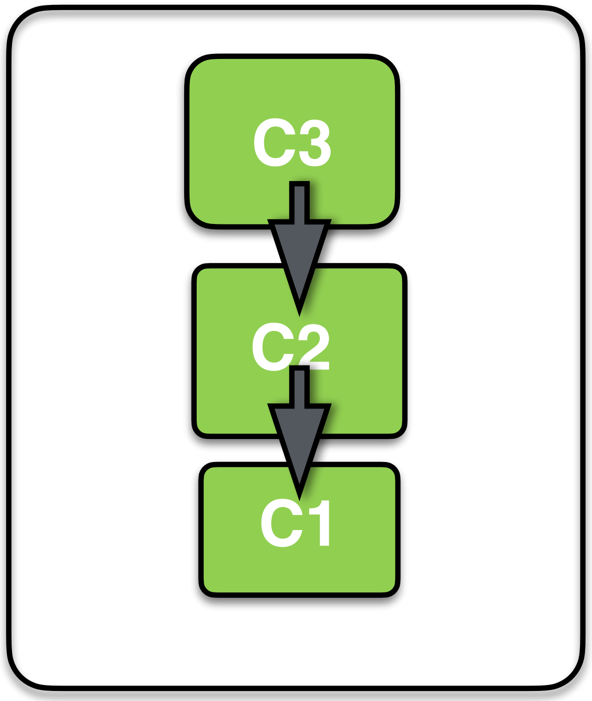
Git Three area

Workspace

Index

Repository

./WORKDIR



Git Three area

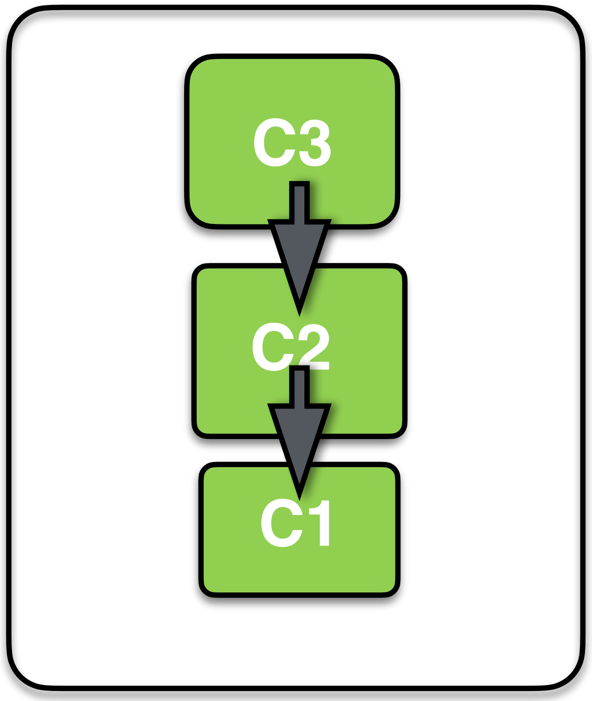
Workspace

Index

Repository

./WORKDIR

.git/



Git Three area

Workspace

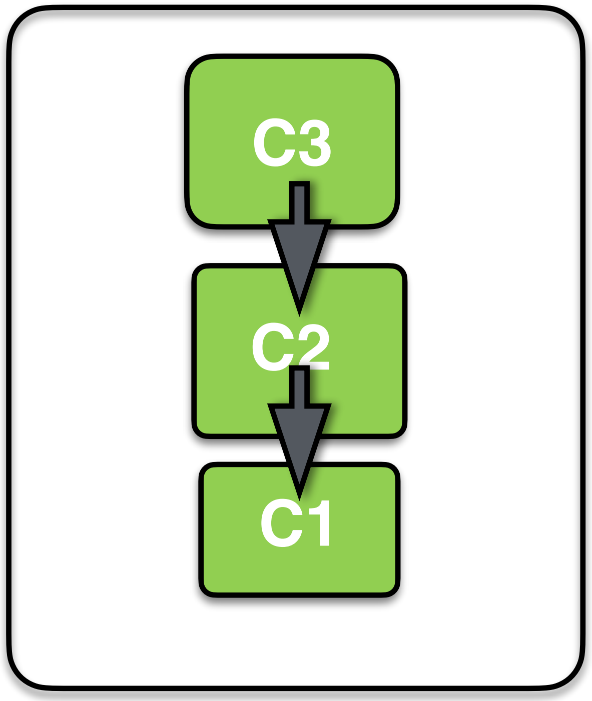
Index

Repository

./WORKDIR

Staging area

.git/



Git Three area

Workspace

Index

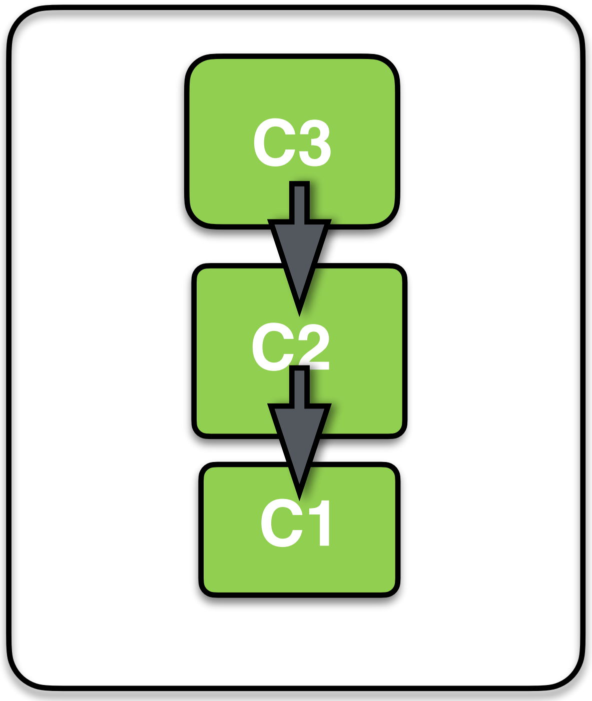
Repository

./WORKDIR

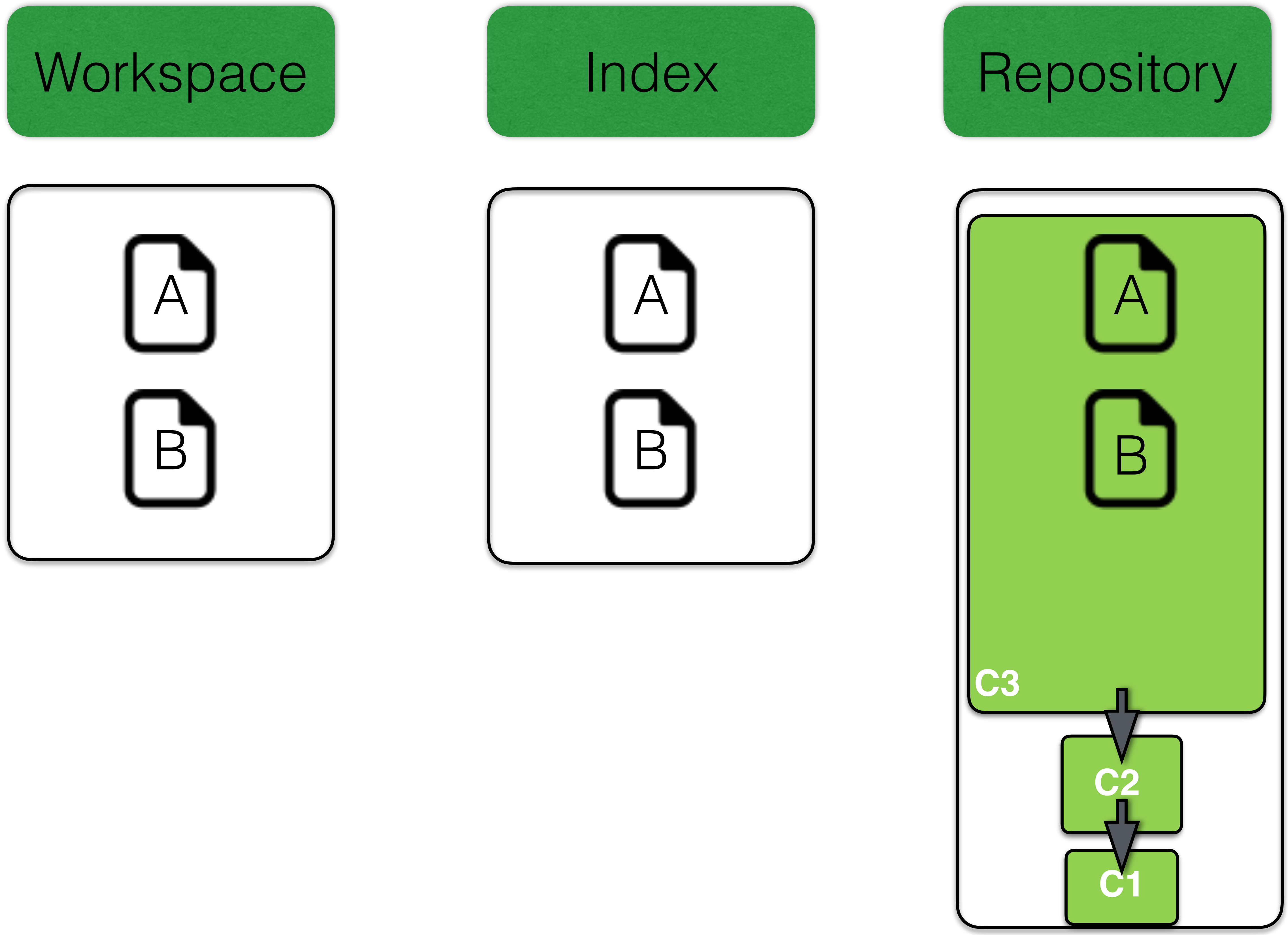
.git/index

Staging area

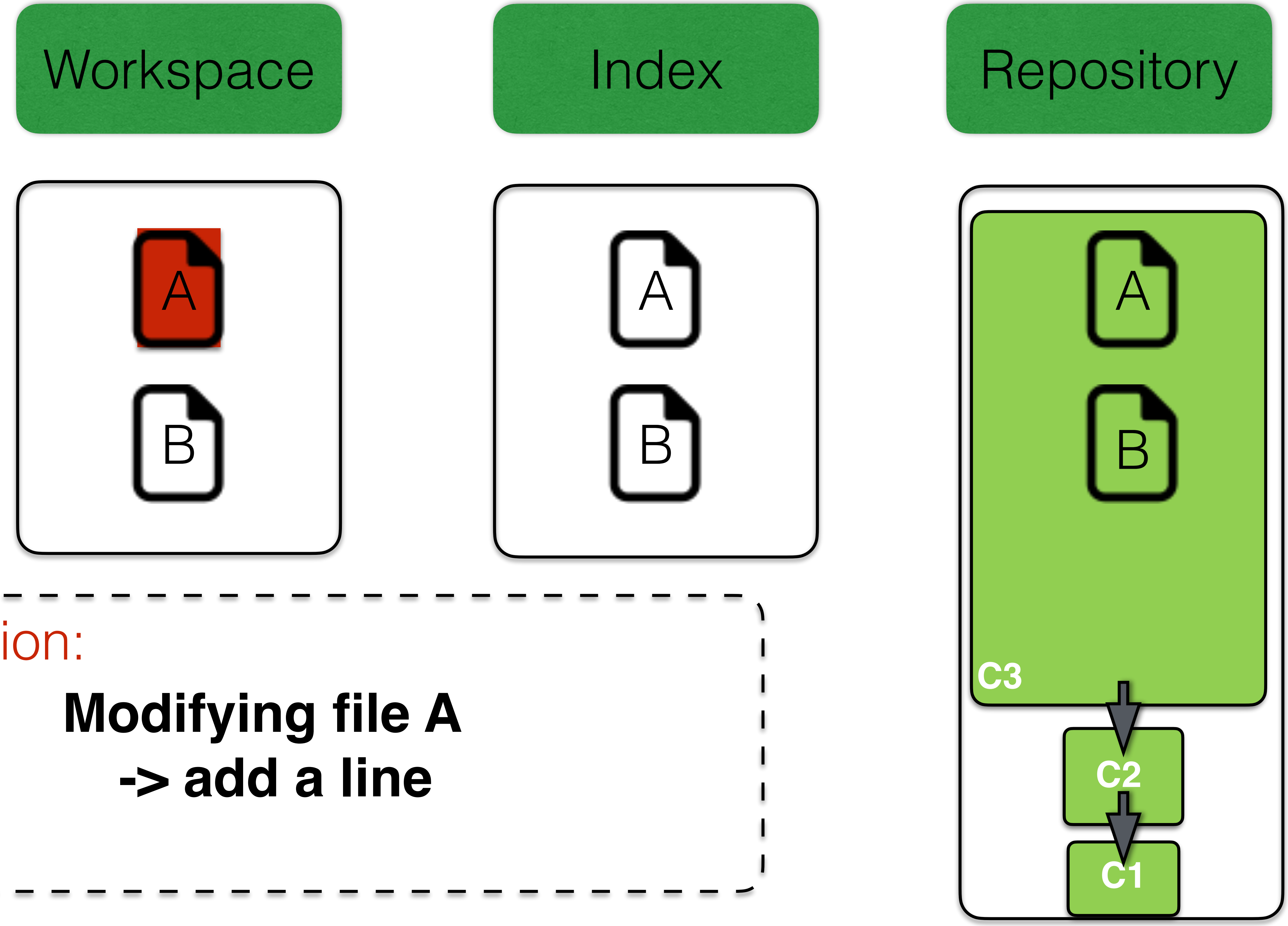
.git/



Git Three area



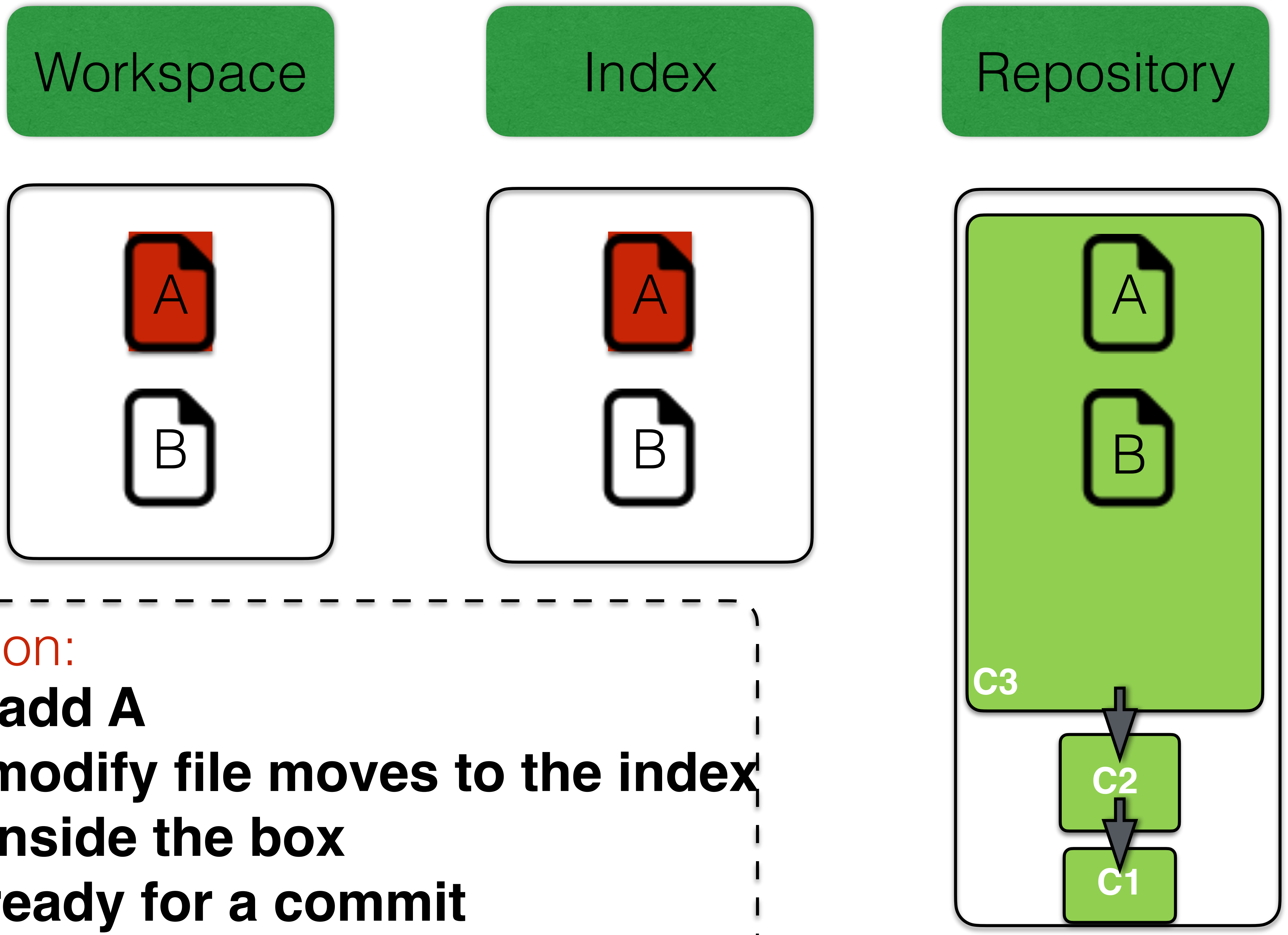
Git Three area



Action:

Modifying file A
-> add a line

Git Three area



Action:

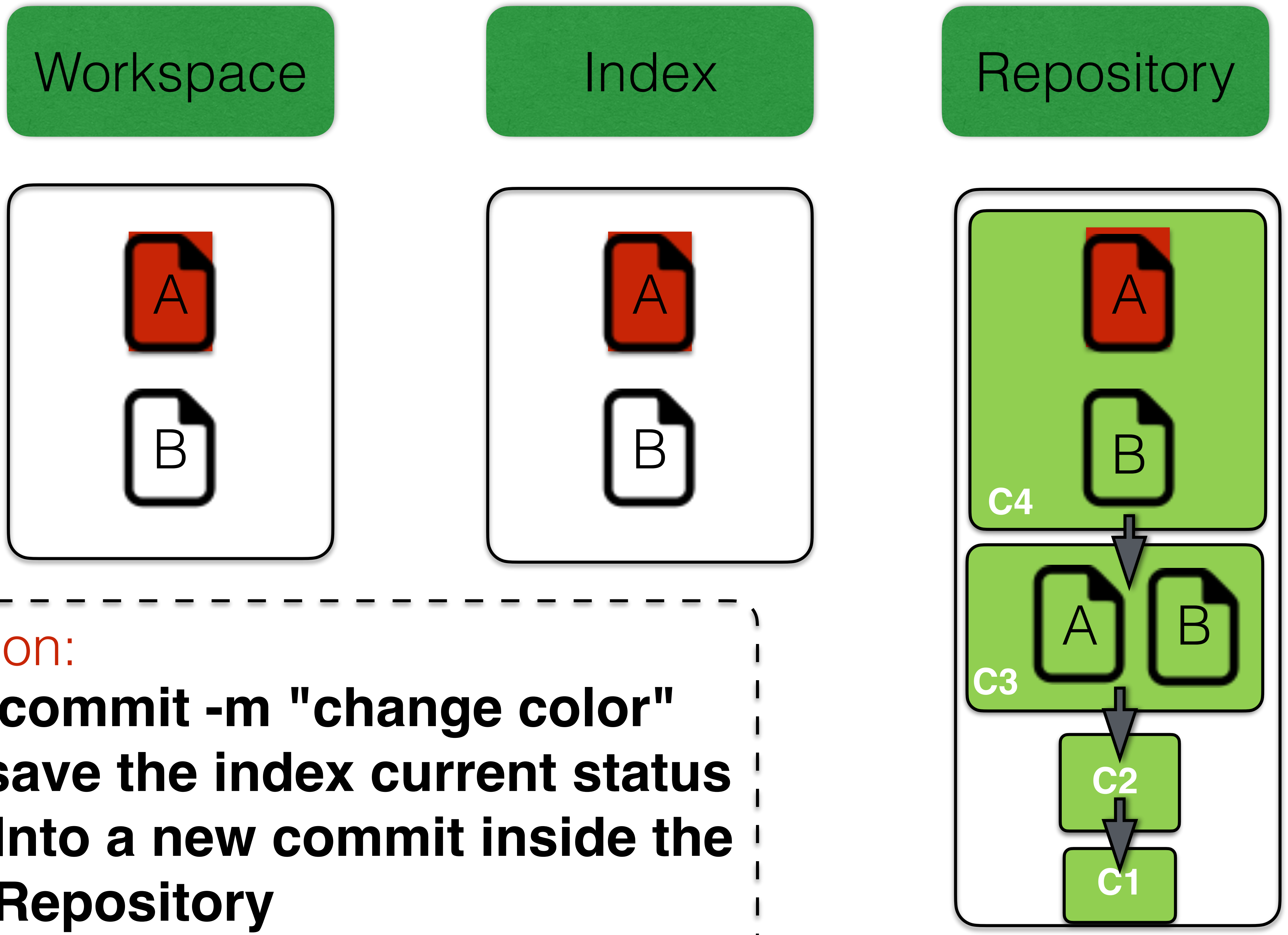
git add A

-> modify file moves to the index

-> inside the box

-> ready for a commit

Git Three area

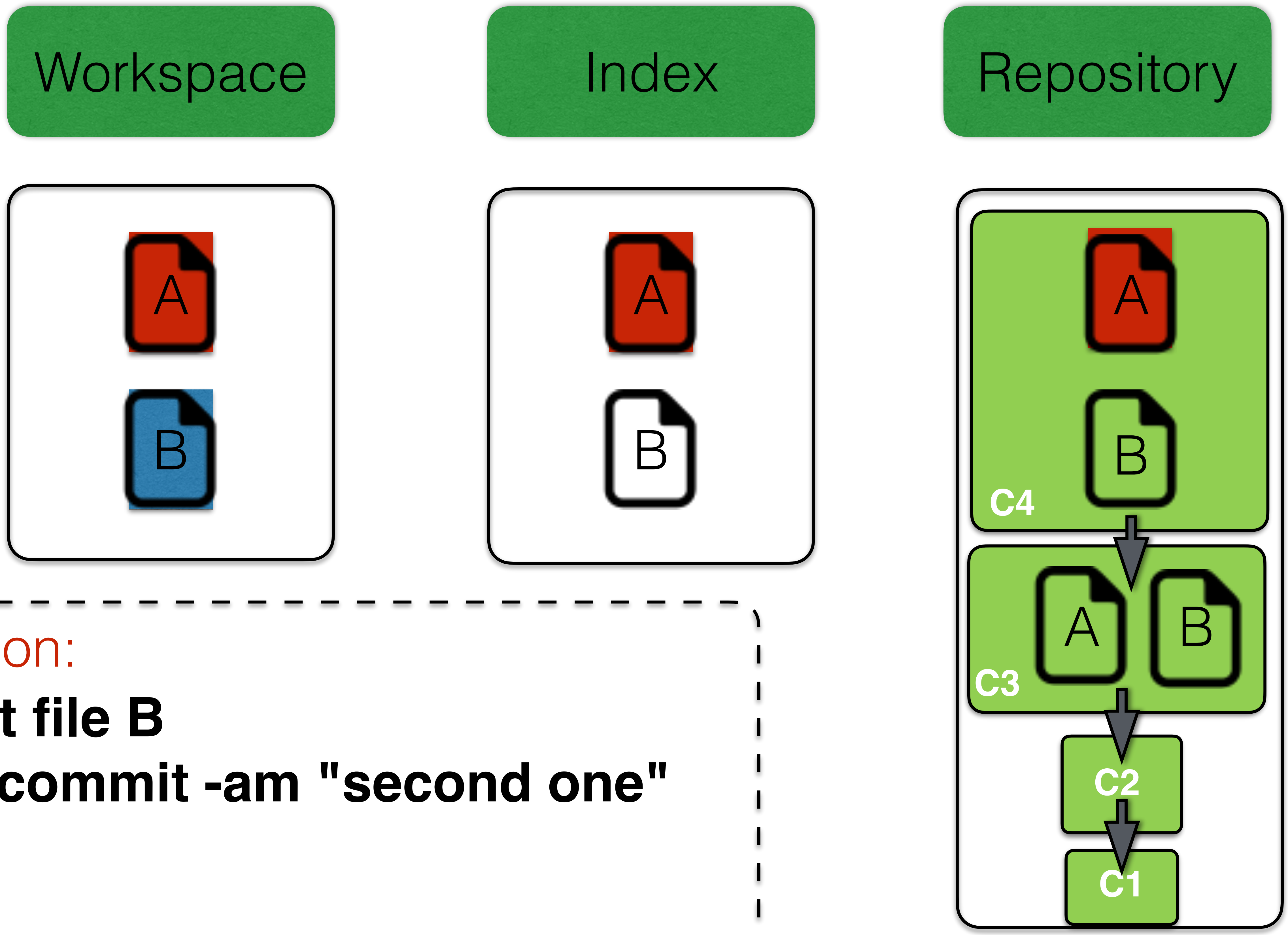


Action:

git commit -m "change color"

-> save the index current status
Into a new commit inside the
Repository

Git Three area

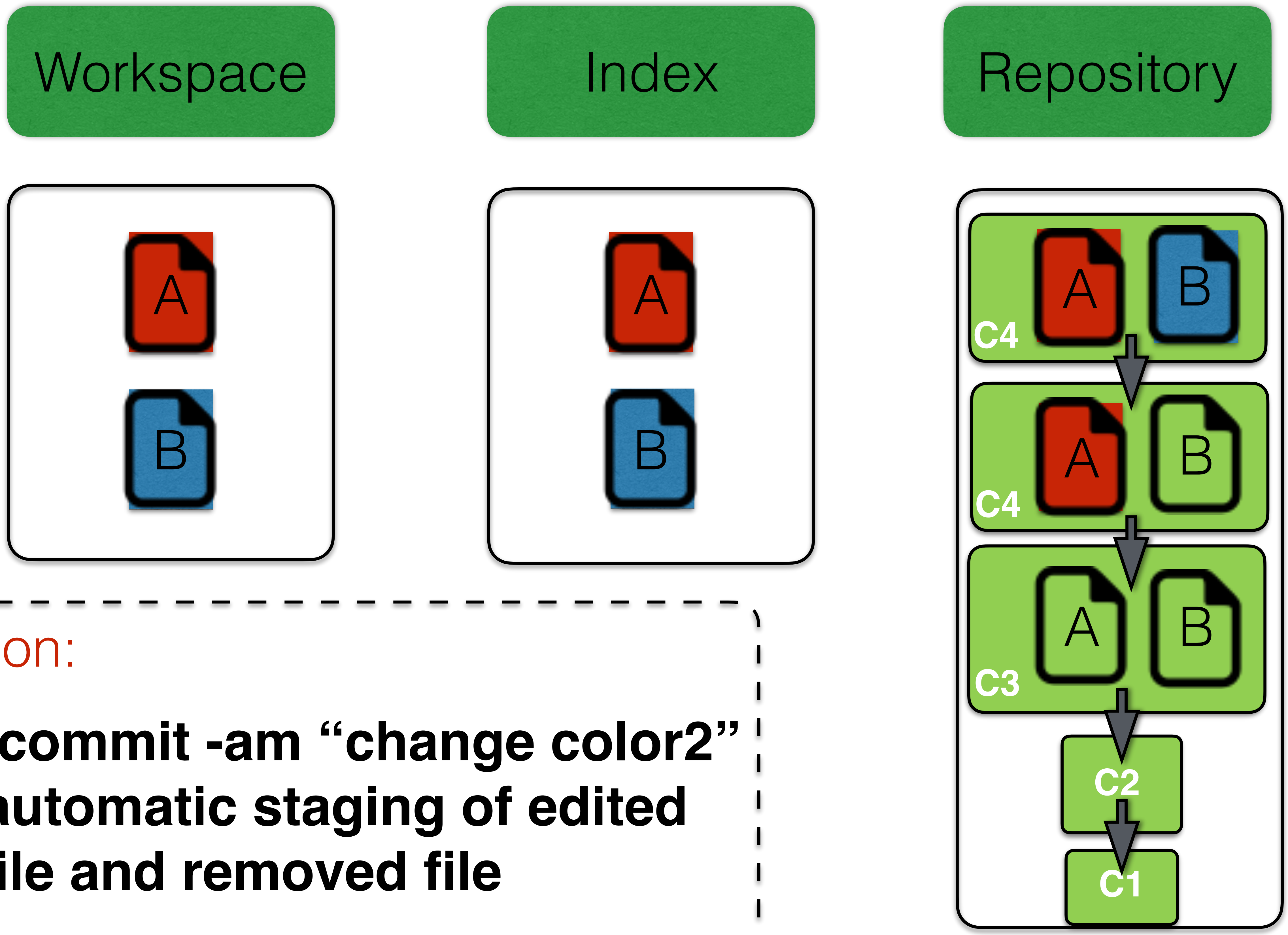


Action:

Edit file B

git commit -am "second one"

Git Three area



Action:

git commit -am "change color2"
-> automatic staging of edited file and removed file

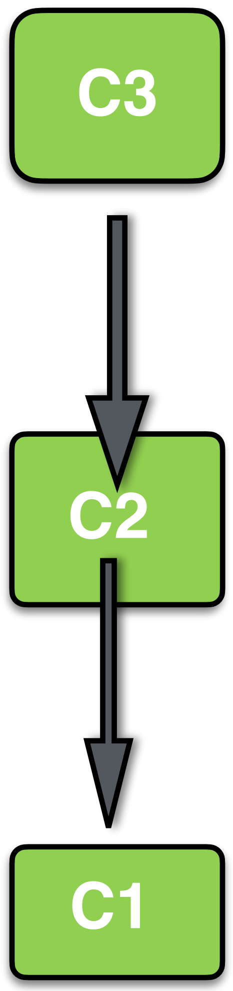
Demo #1

Initialisation
Git init
Git log
Git status
Git commit

Nice display: git log --oneline --graph

1. Commit

Head: place where the new commit will be attach

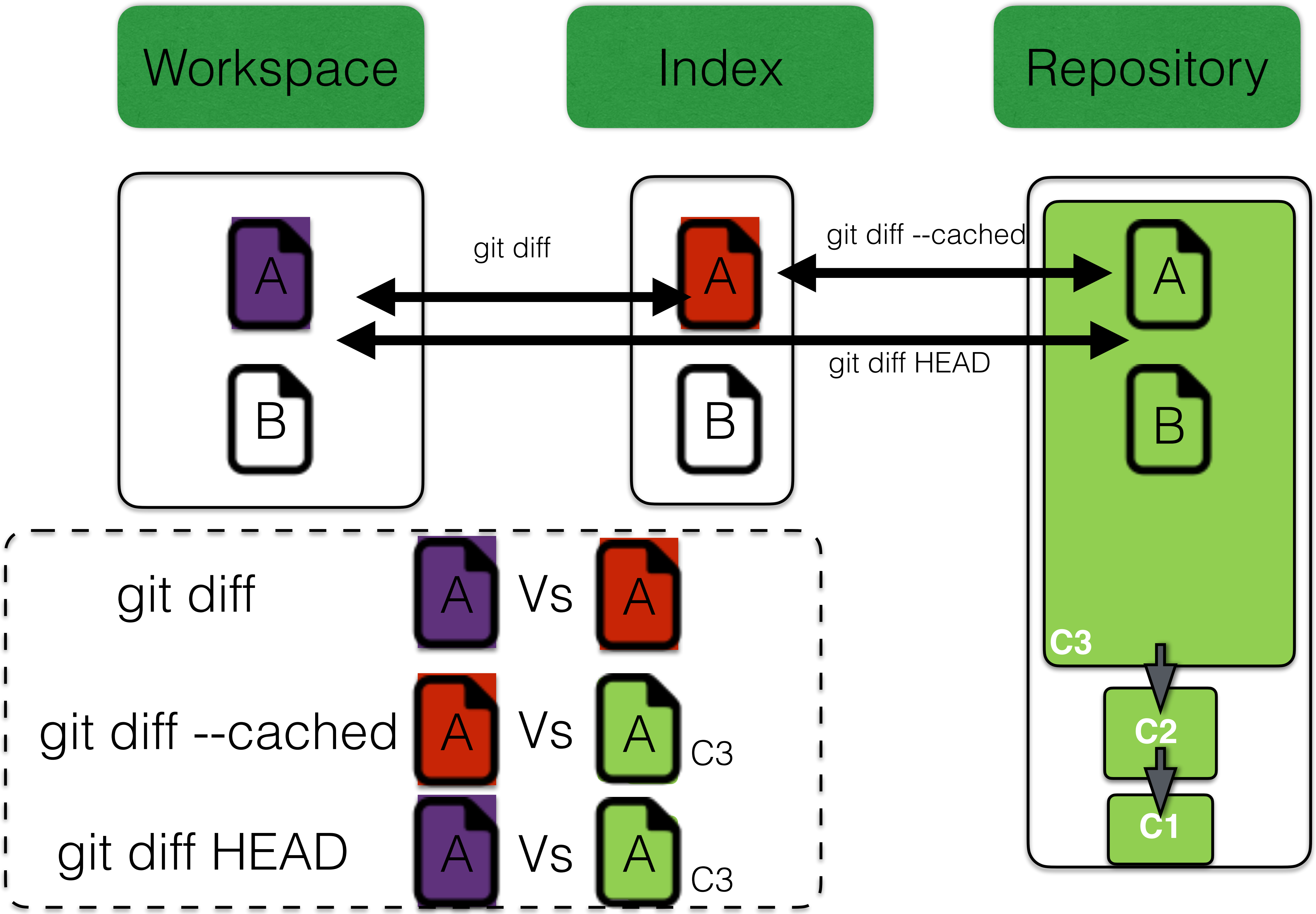


Head: latest committed version

Head~1

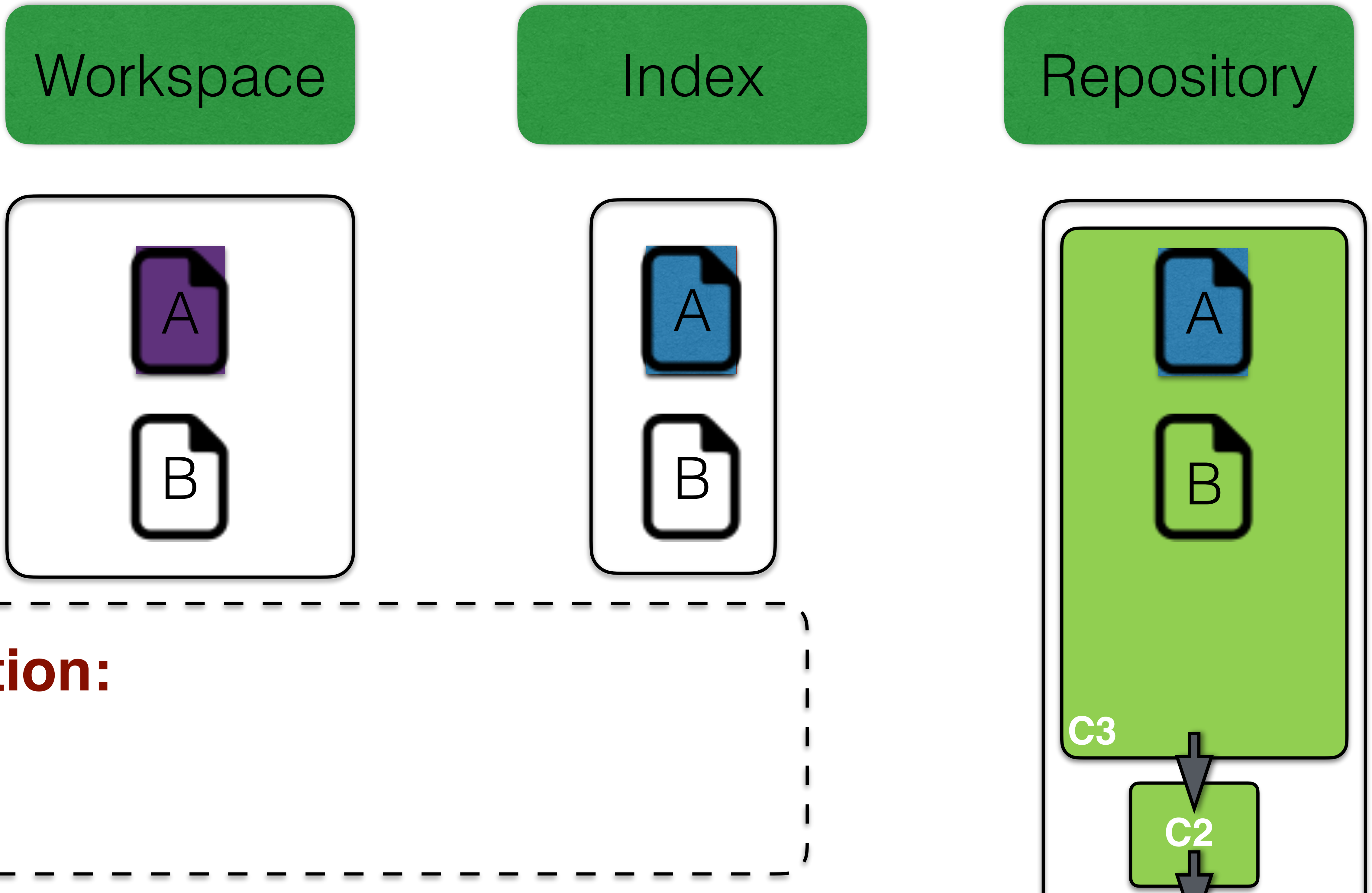
Head~2

Git diff


Workspace
Index
Repository
A
B
git diff
A
B
git diff --cached
git diff HEAD
A
B
C3
C2
C1
git diff
A
Vs
A
git diff --cached
A
Vs
A
C3
git diff HEAD
A
Vs
A
C3

Undo

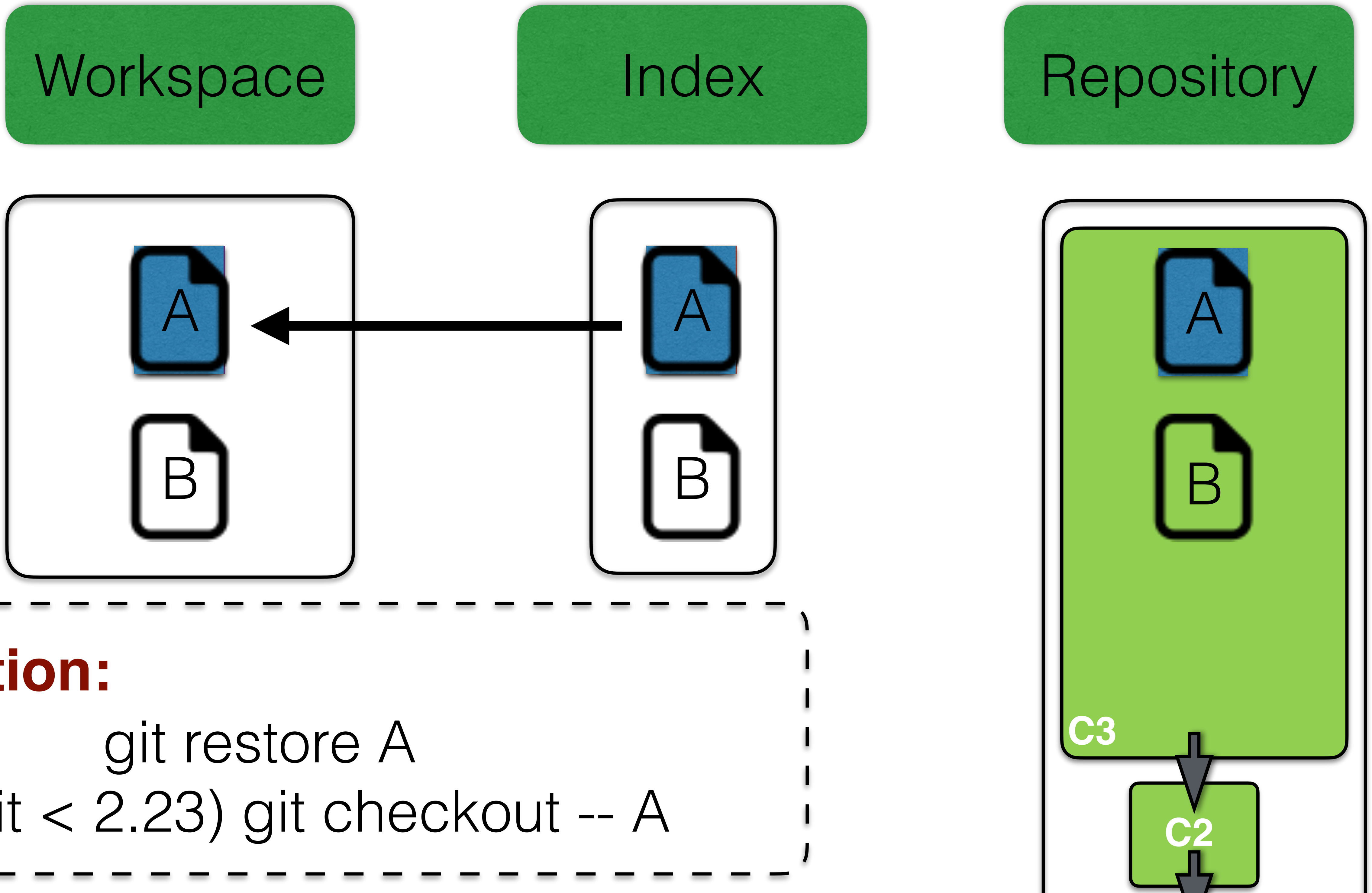
1: Wrong modification of a file in your workspace



Action:

Undo

1: Wrong modification of a file in your workspace

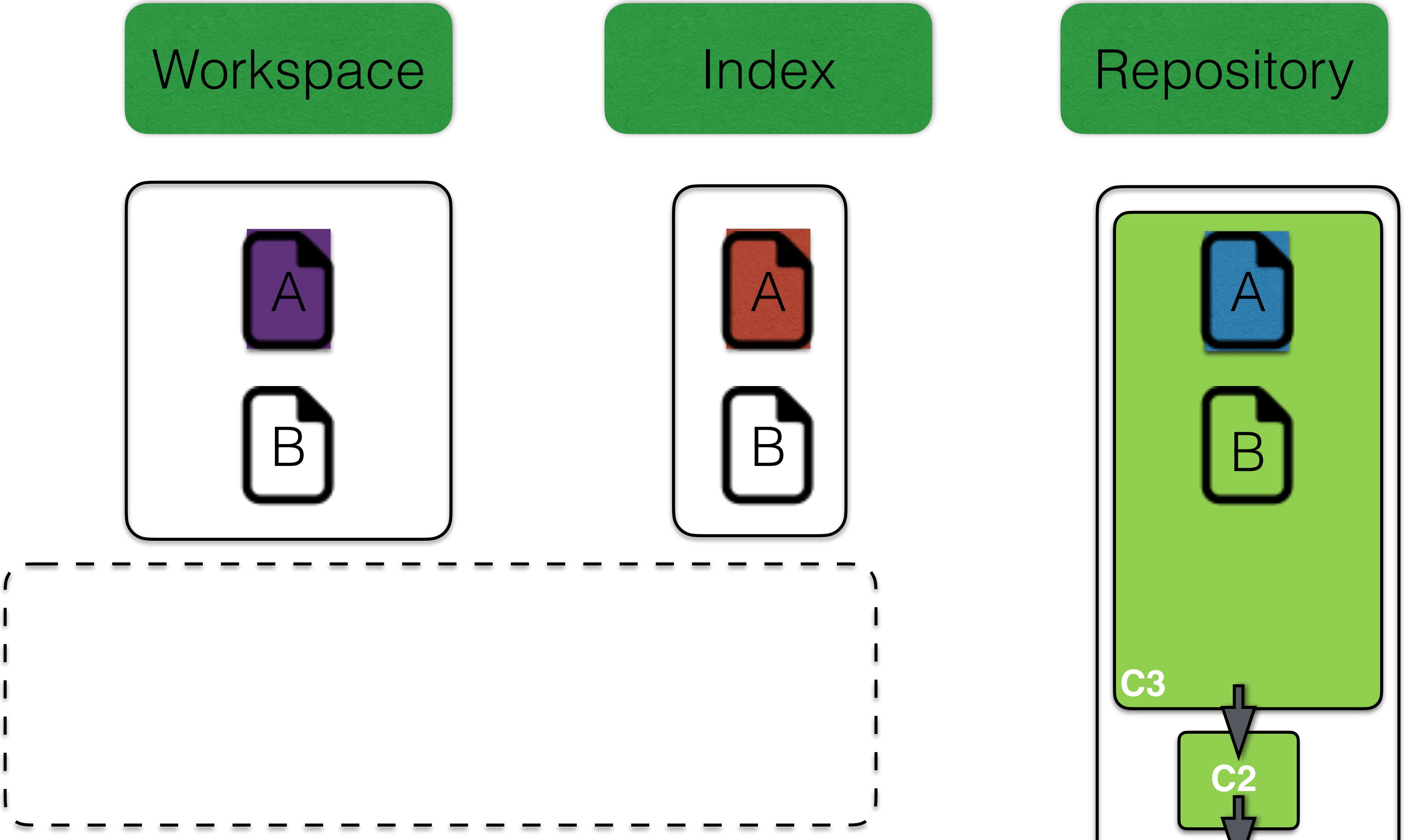


Action:

```
git restore A
(Git < 2.23) git checkout -- A
```

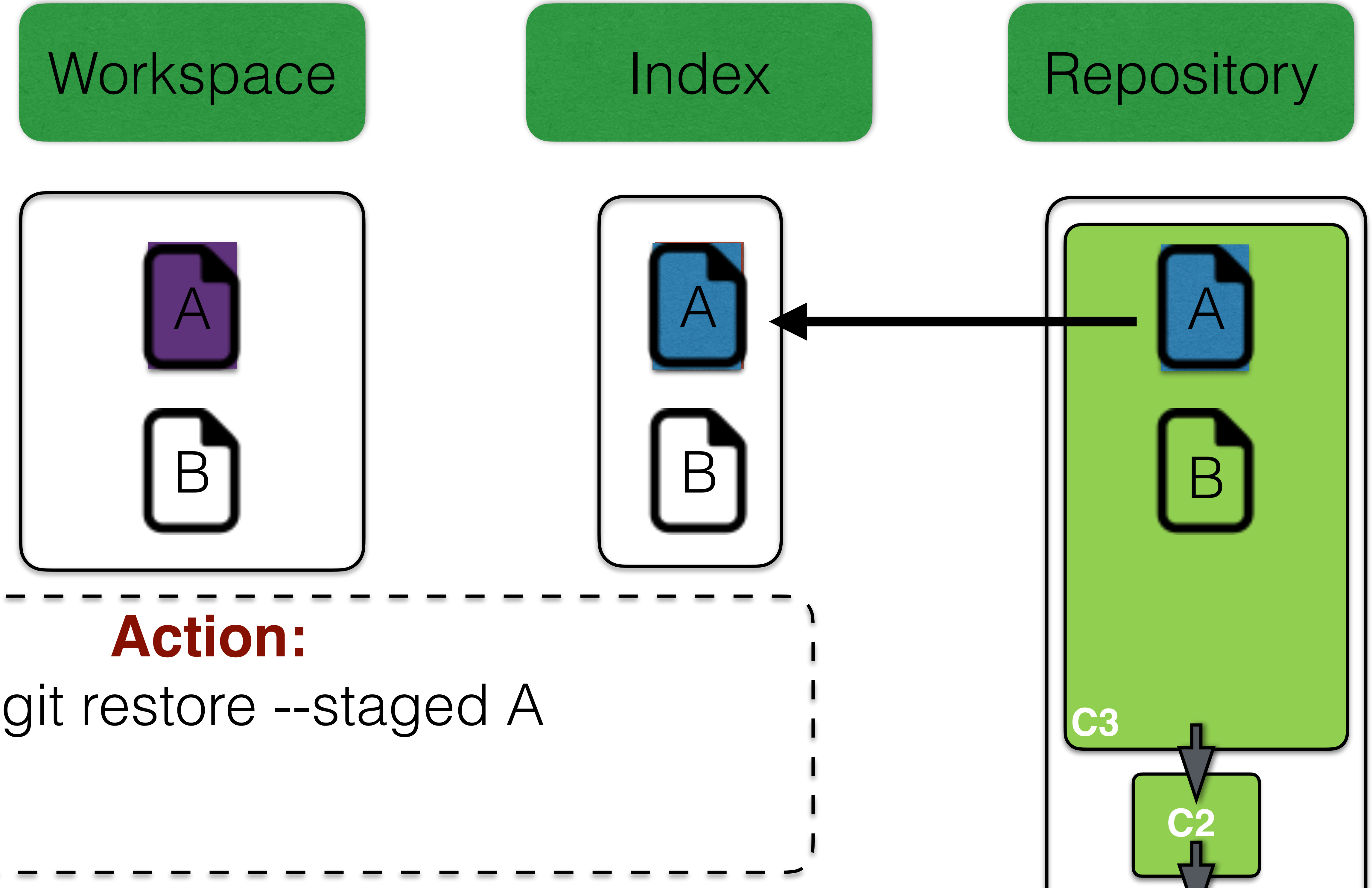
Undo

2: Wrong modification of a file that you put in your index



Undo

2: Wrong modification of a file that you put in your index

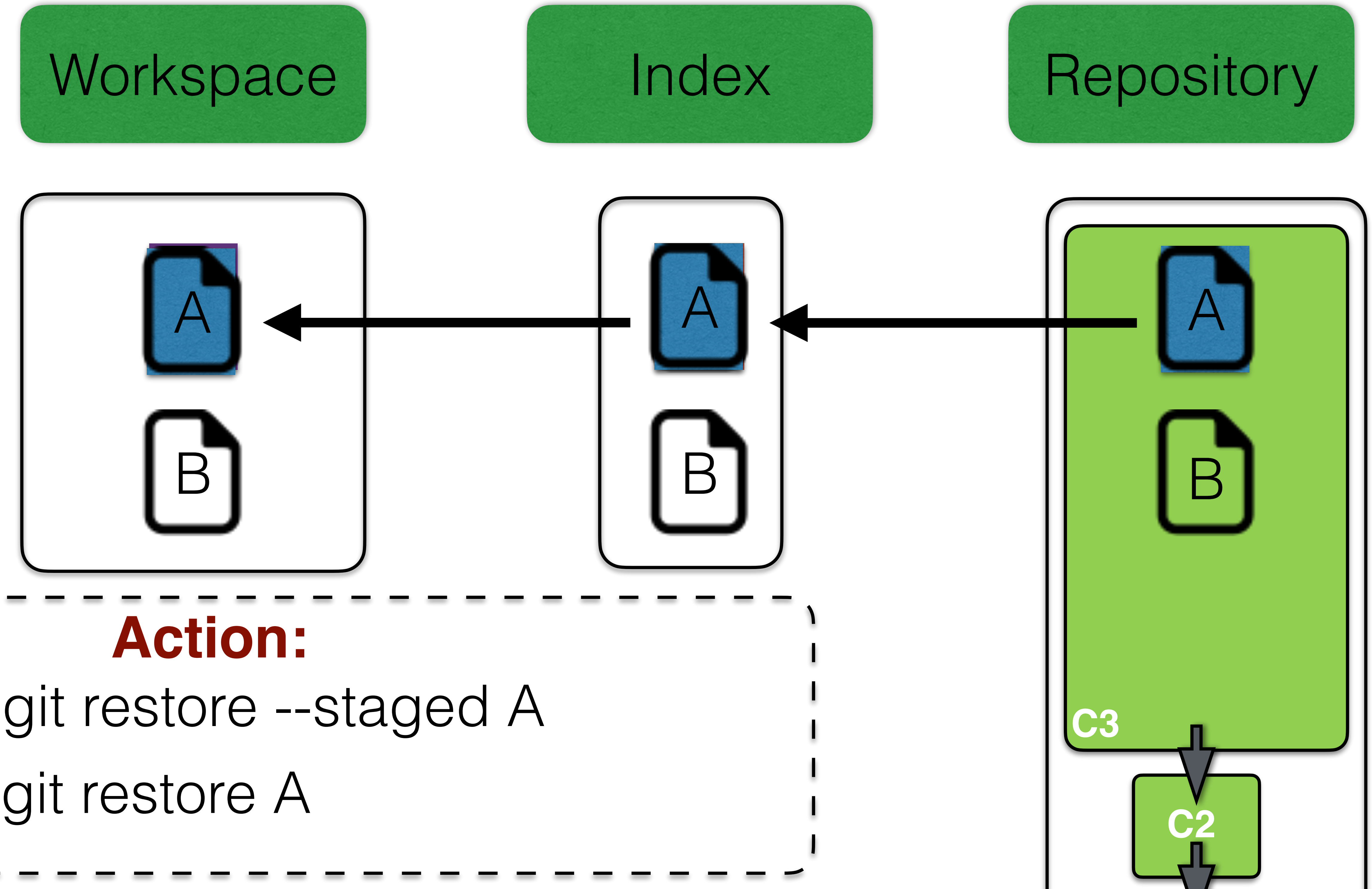


Action:

git restore --staged A

Undo

2: Wrong modification of a file that you put in your index

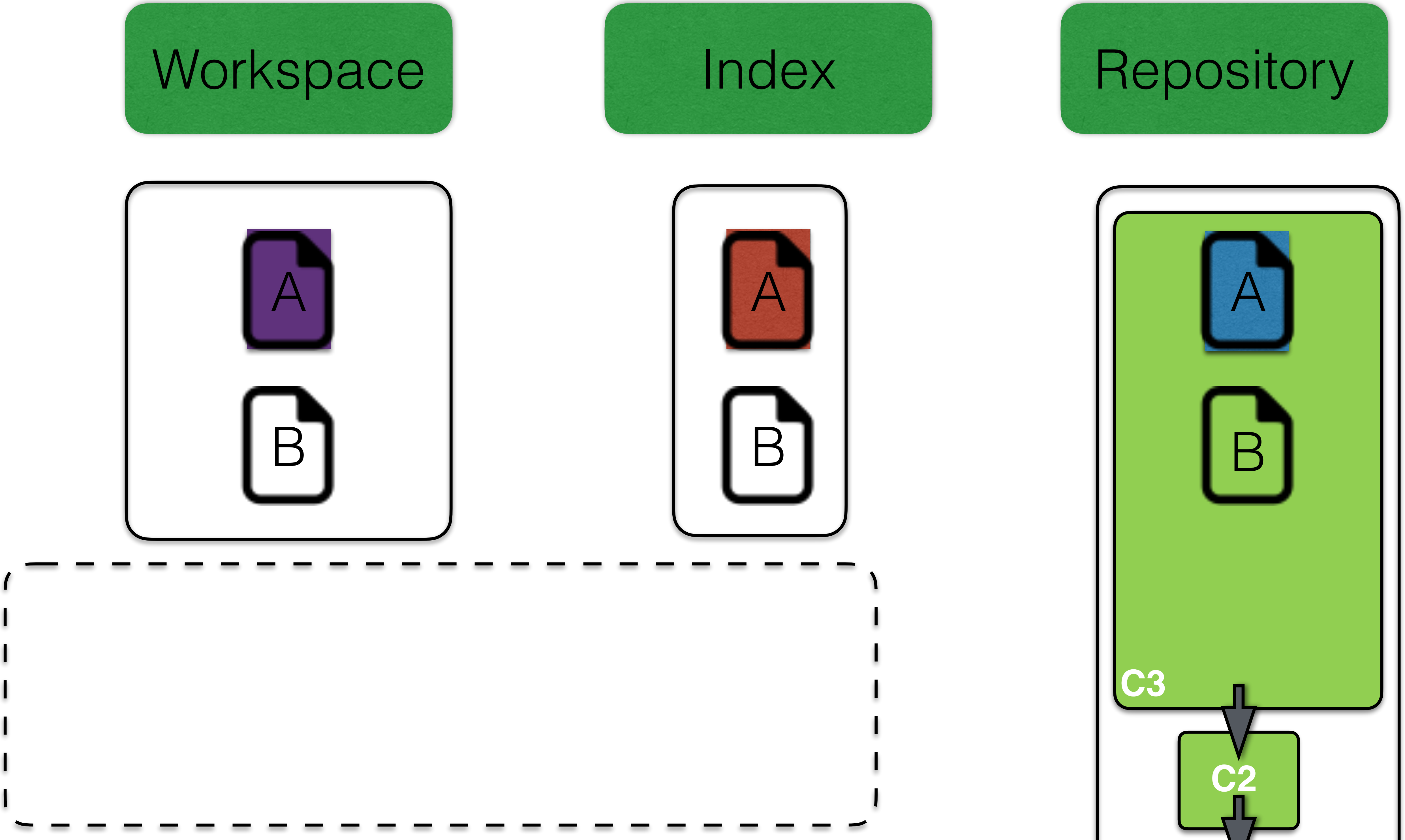


Action:

```
git restore --staged A
git restore A
```

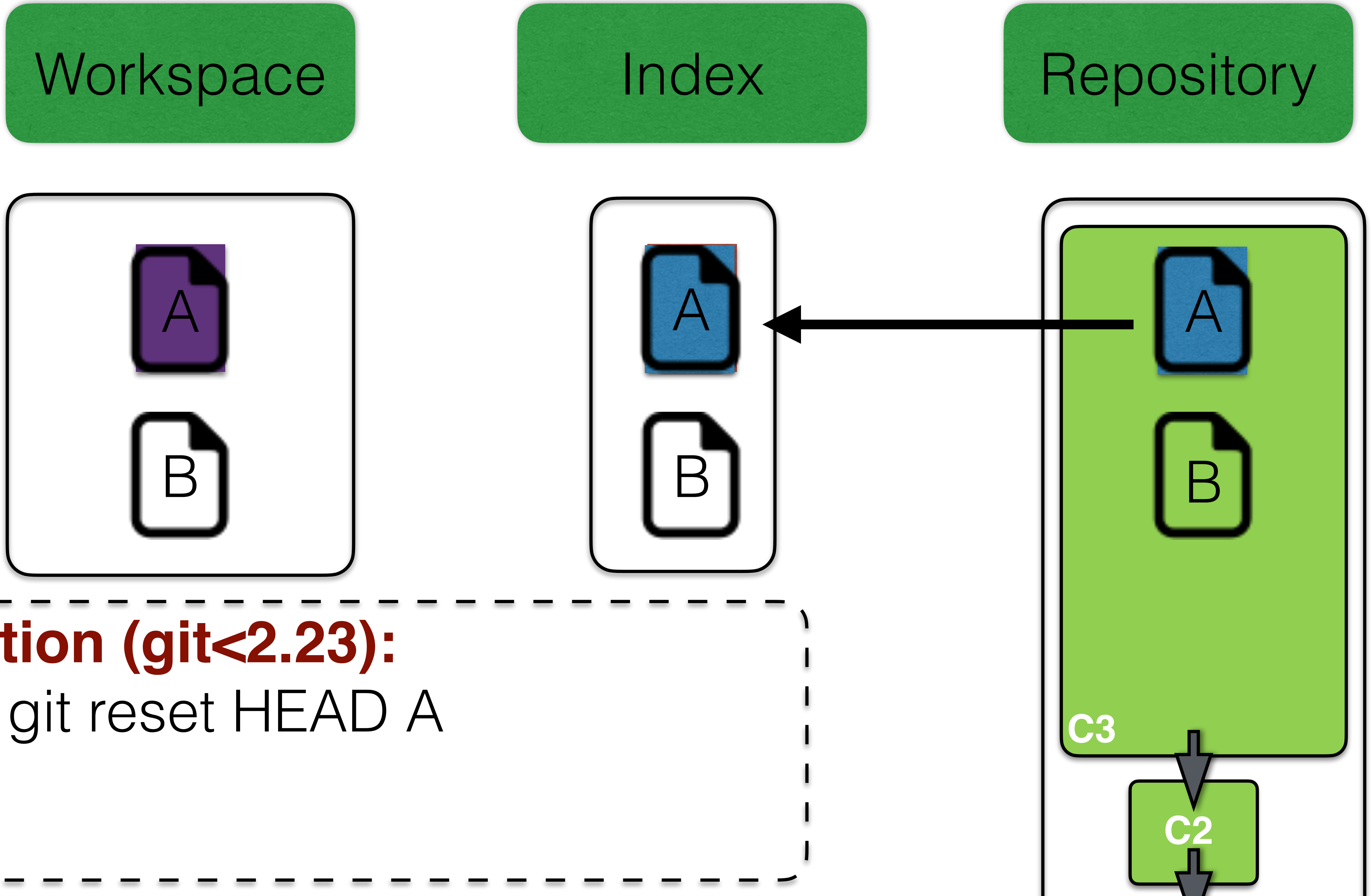
Undo

2: Wrong modification of a file that you put in your index



Undo

2: Wrong modification of a file that you put in your index

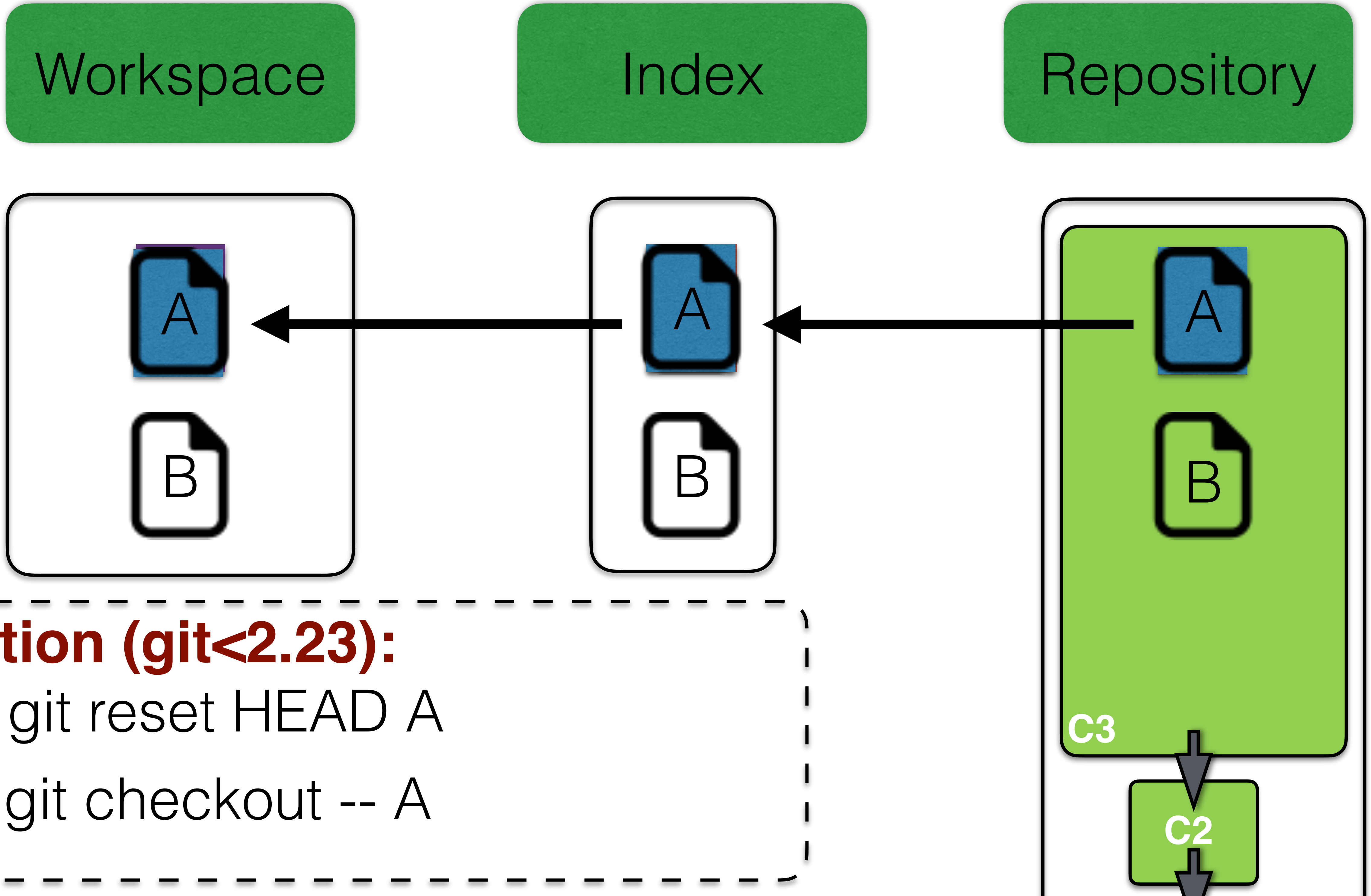


Action (git<2.23):

```
git reset HEAD A
```

Undo

2: Wrong modification of a file that you put in your index

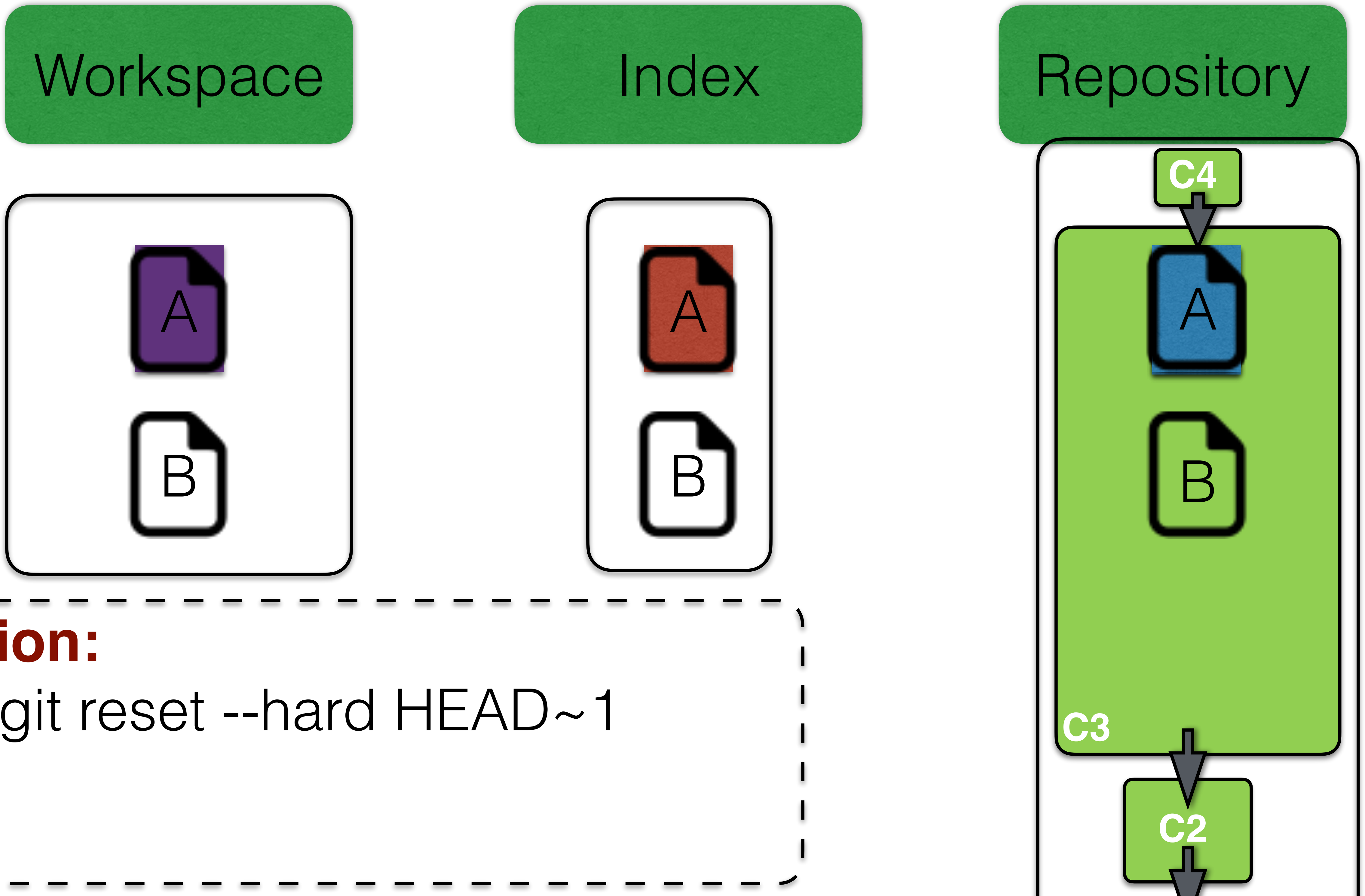


Action (git<2.23):

```
git reset HEAD A
git checkout -- A
```

Undo

3: Want to remove error from history

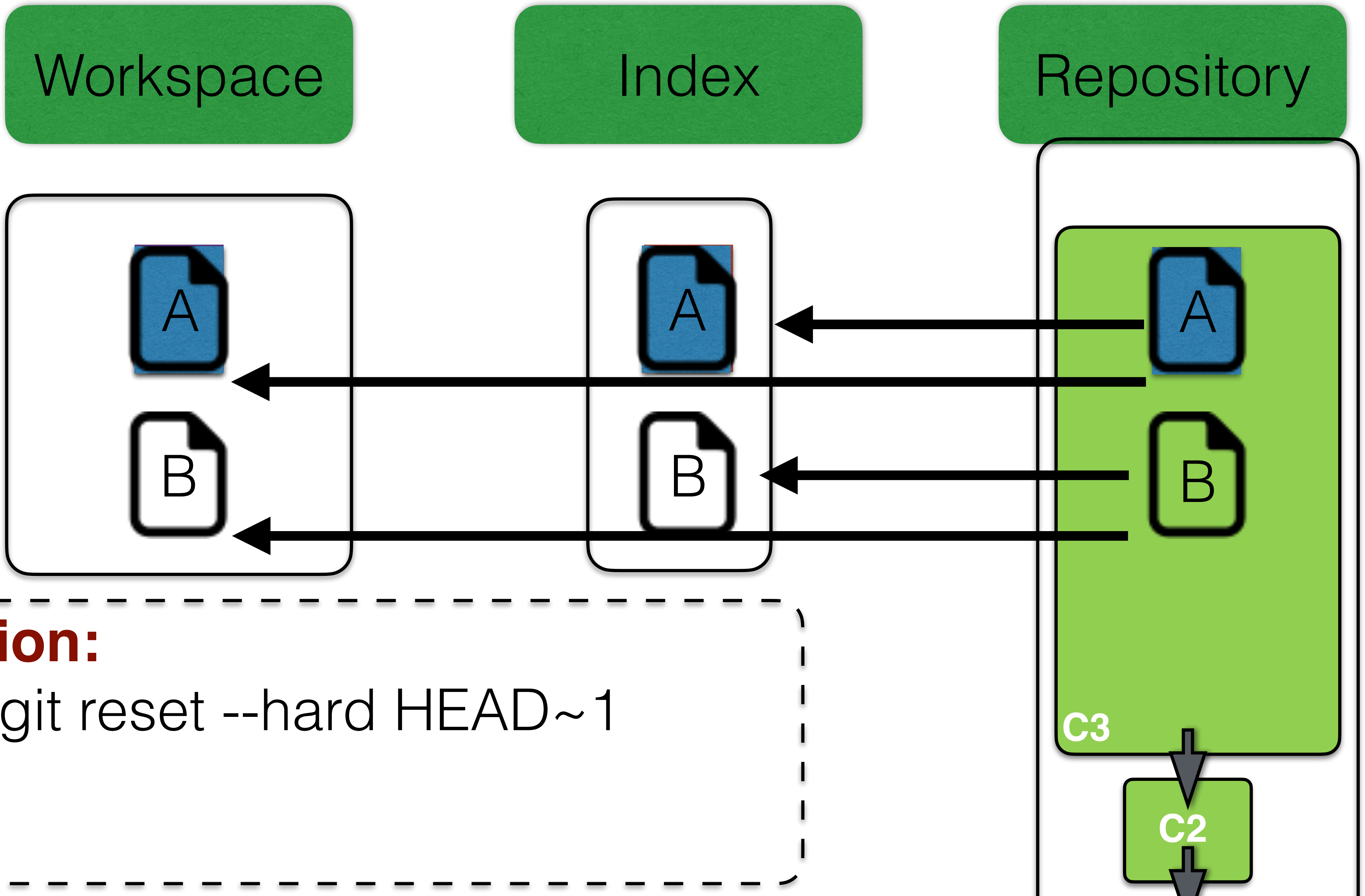


Action:

```
git reset --hard HEAD~1
```

Undo

3: Want to remove error from history

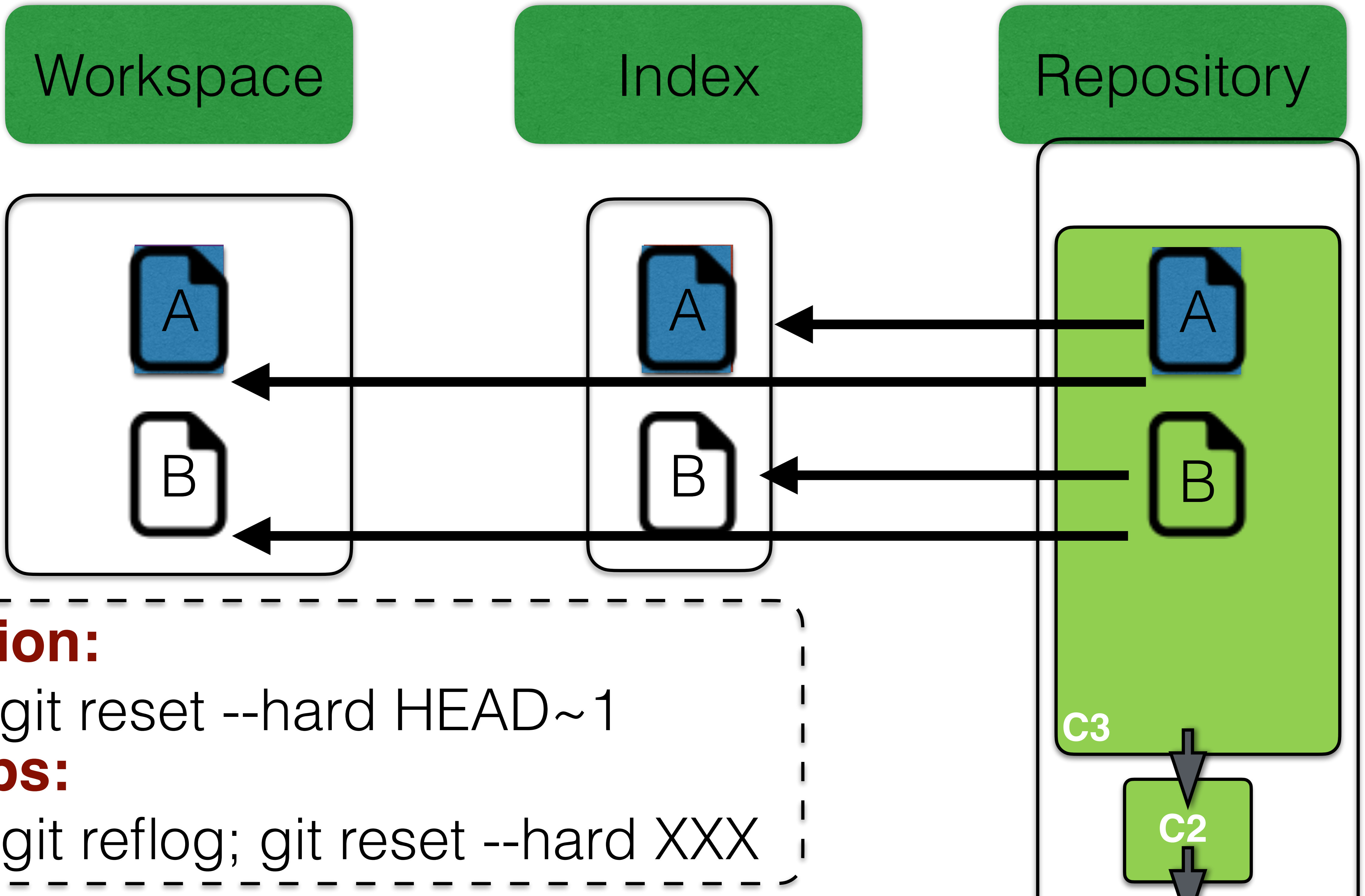


Action:

```
git reset --hard HEAD~1
```

Undo

3: Want to remove error from history



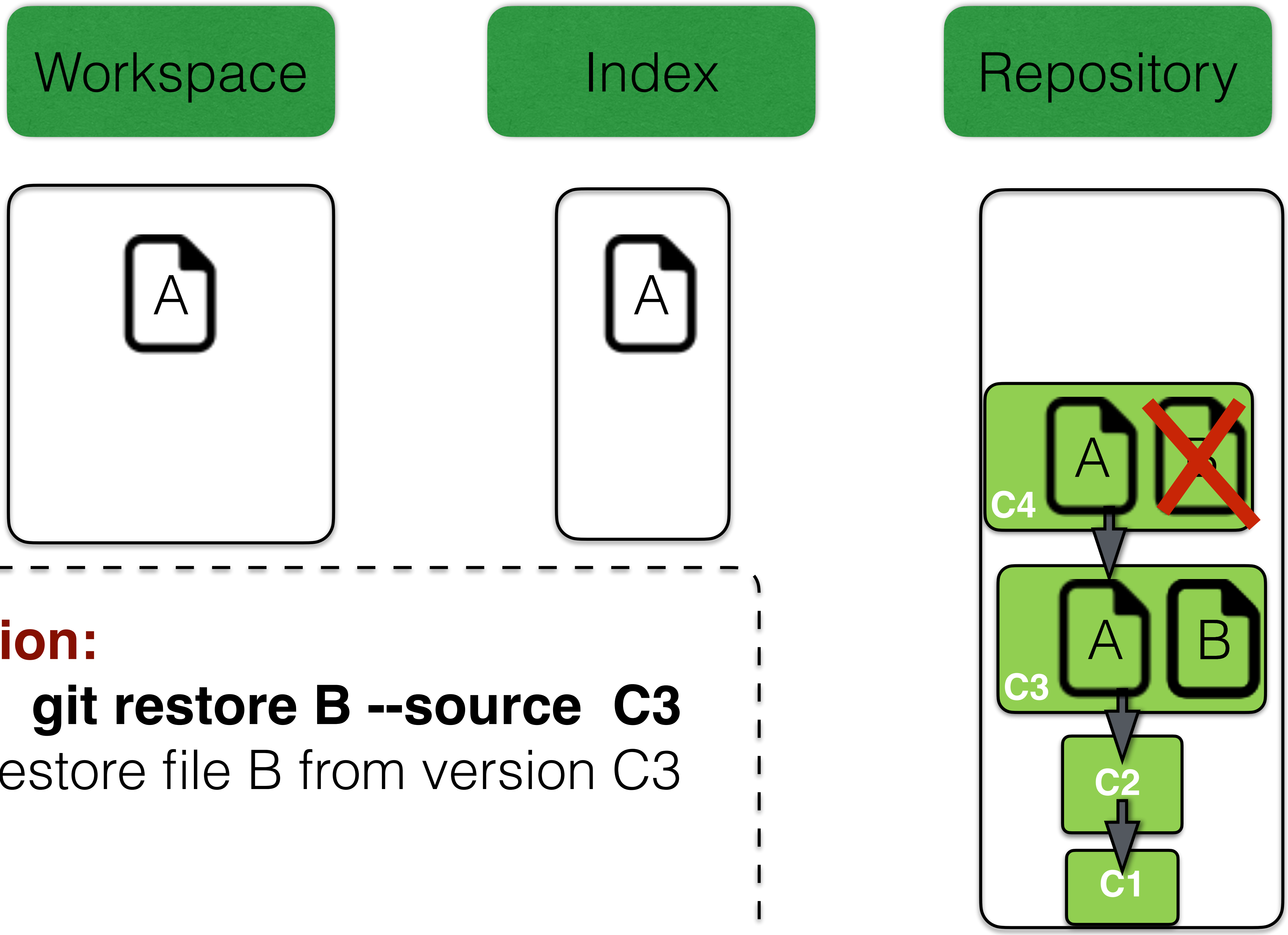
Action:

```
git reset --hard HEAD~1
```

Oops:

```
git reflog; git reset --hard XXX
```

Keep history: Restore file

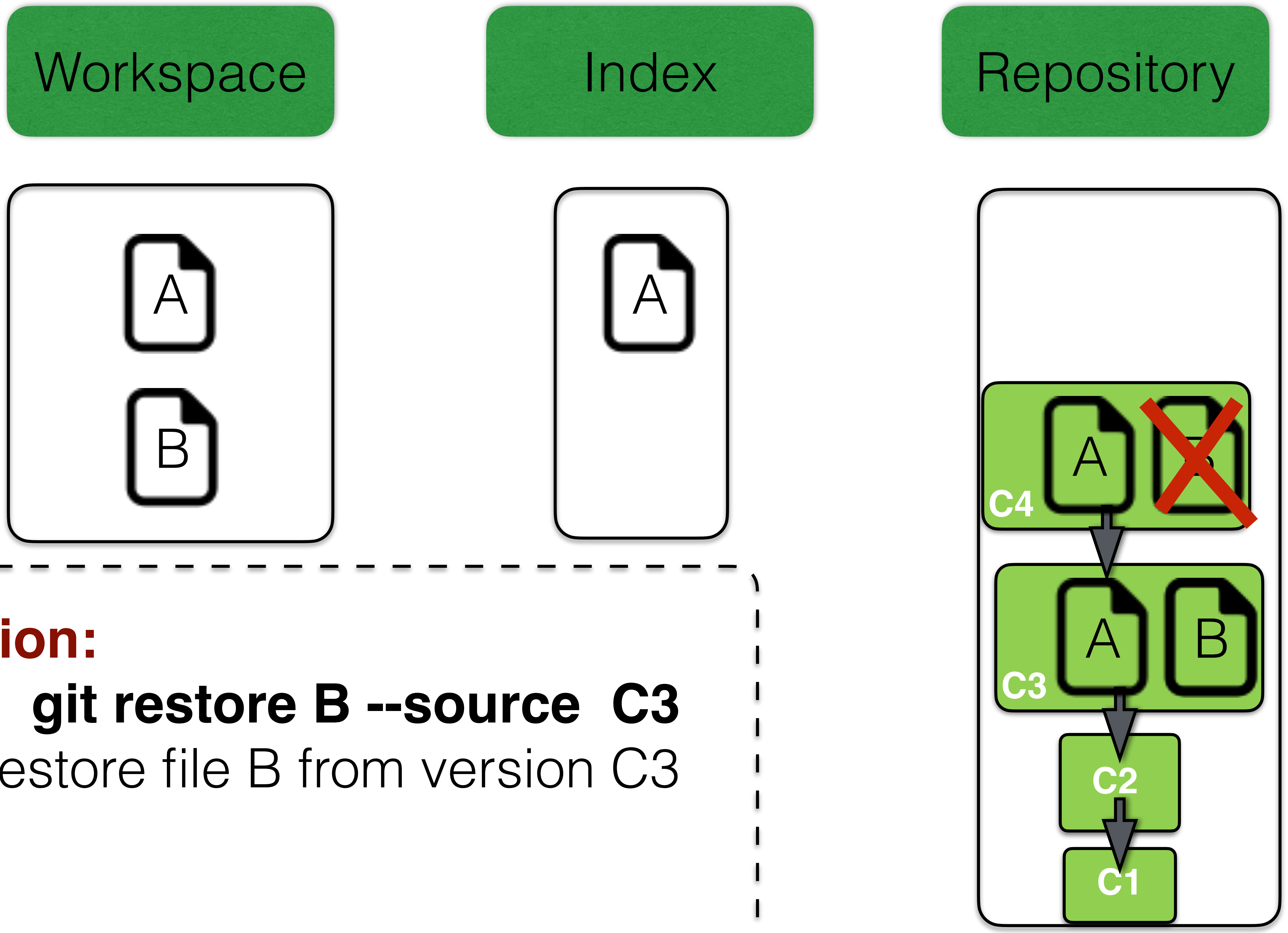


Action:

git restore B --source C3

-> restore file B from version C3

Keep history: Restore file

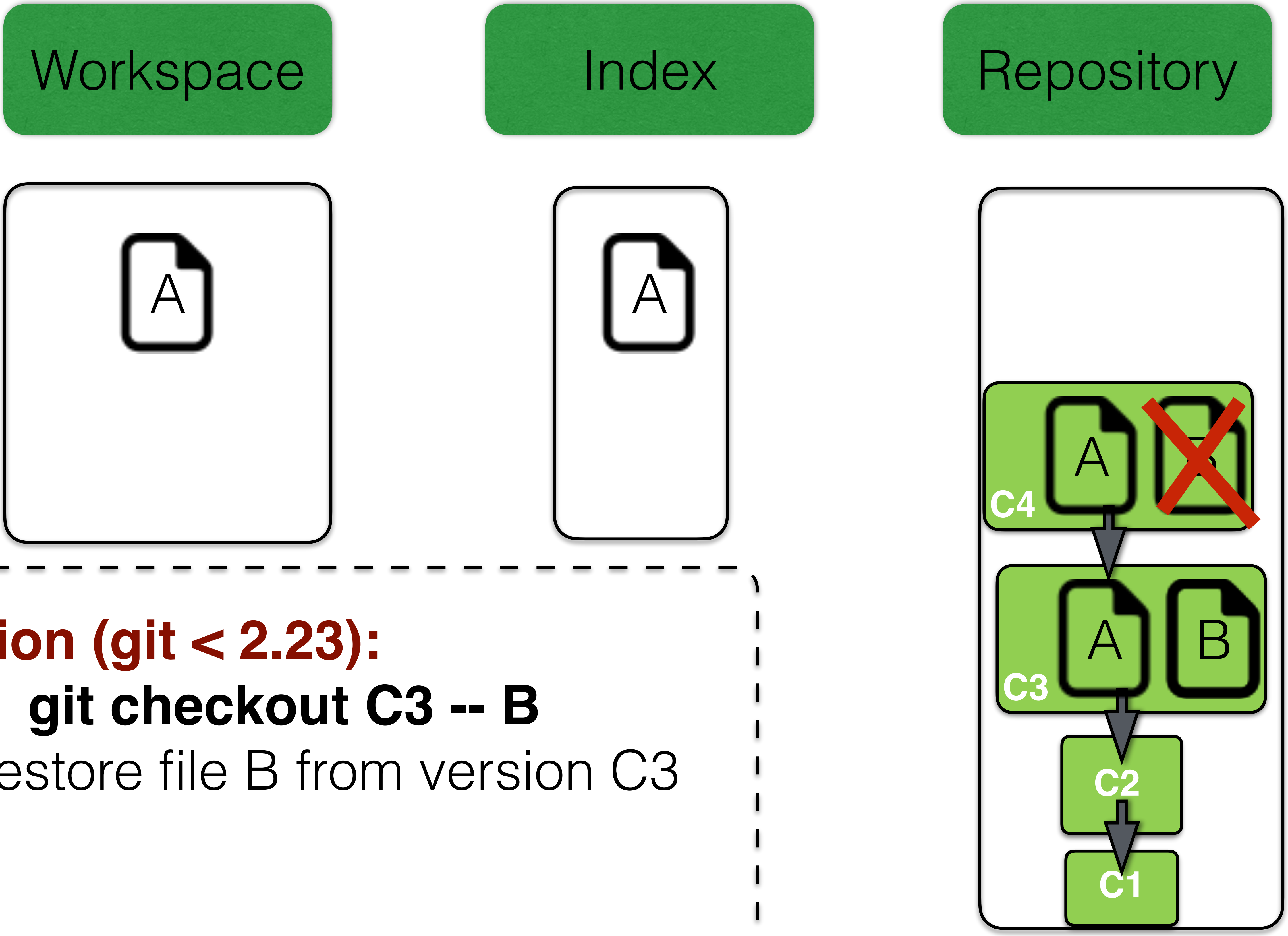


Action:

git restore B --source C3

-> restore file B from version C3

Keep history: Restore file

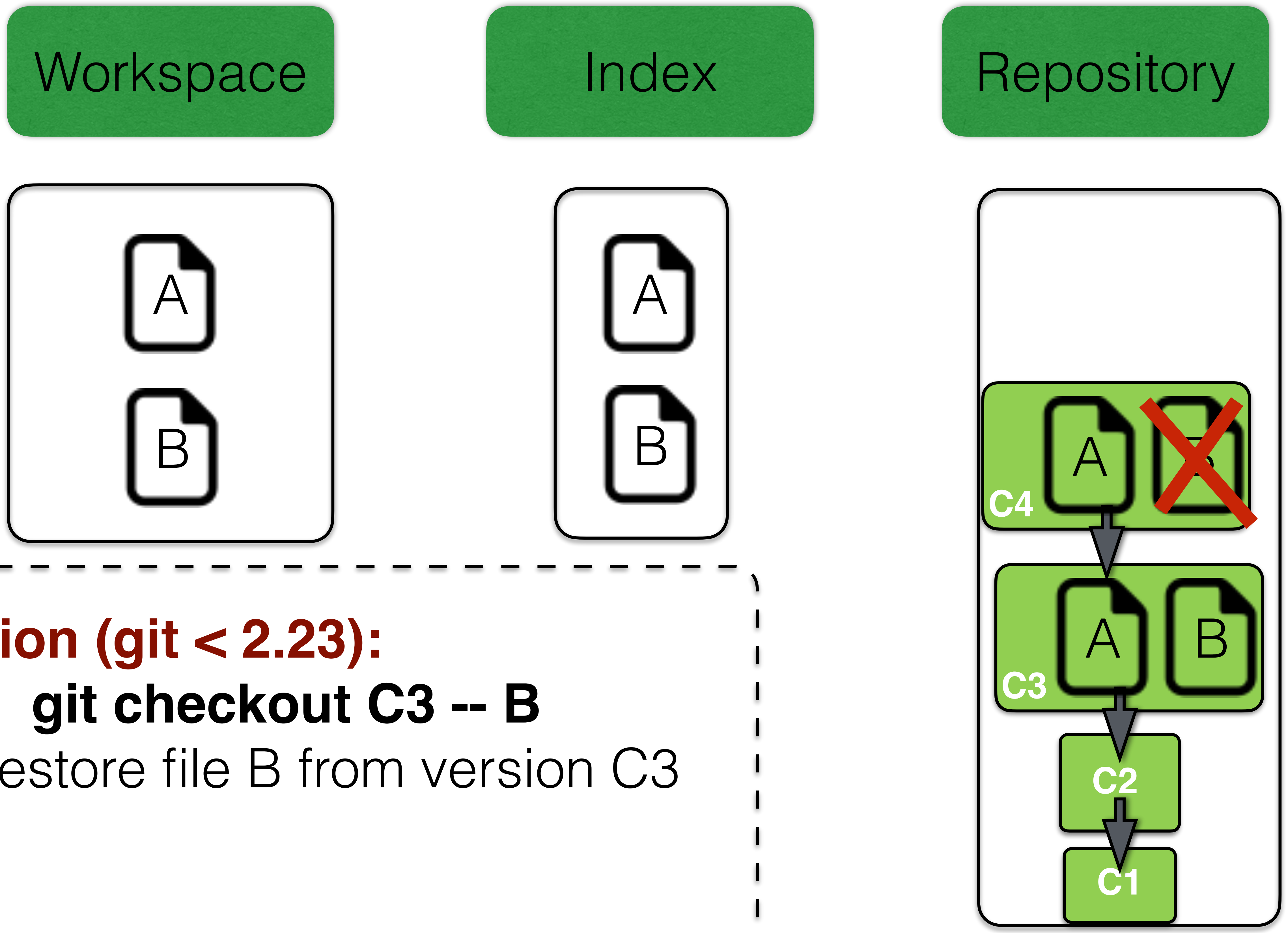


Action (git < 2.23):

```
git checkout C3 -- B
```

-> restore file B from version C3

Keep history: Restore file



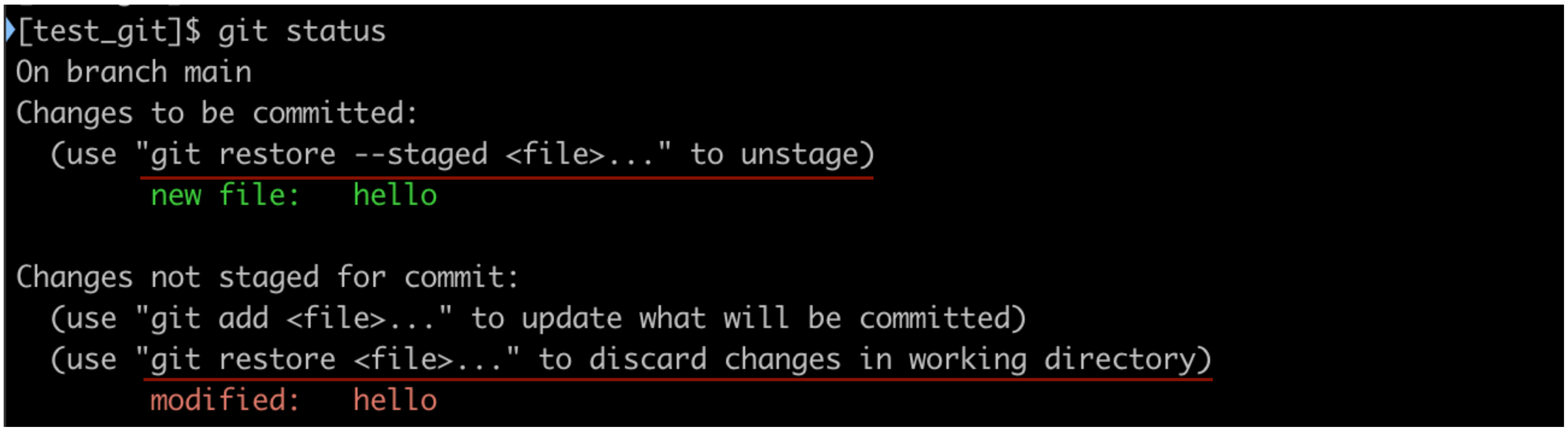
Action (git < 2.23):

git checkout C3 -- B

-> restore file B from version C3

Useful trick

Git status does indicates which restore command to use for most common situation



```
[test_git]$ git status
On branch main
Changes to be committed:
  (use "git restore --staged <file>..." to unstage)
        new file:   hello

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:   hello
```

Local project

Exercise #1

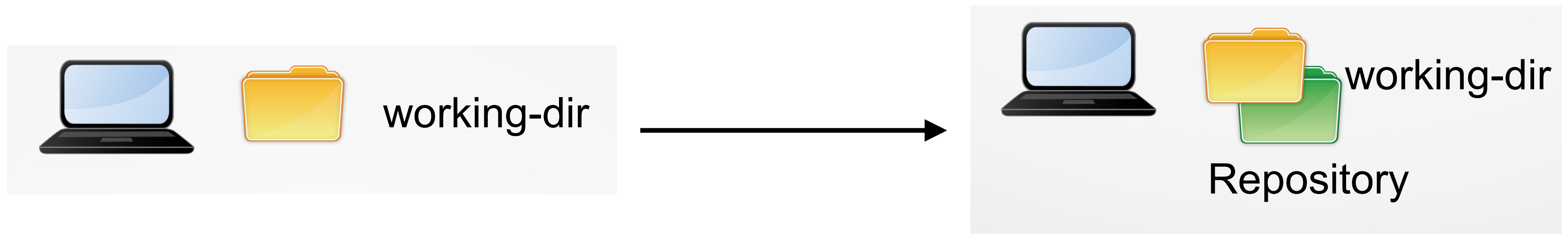
Starting with git

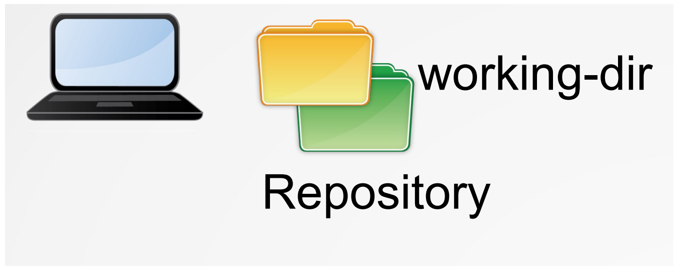
```
$ git config --global user.name "John Doe"
$ git config --global user.email johndoe@example.com
```

.config/git/ignore, .gitignore

```
# Backup files left behind by the Emacs and vim editor.
*~
# Temporary files used by the vim editor.
.*.swp
# compiled objects
*.pyc
*.o
# directory fileter example (case sensitive)
# ignore log dir
Logs/
```

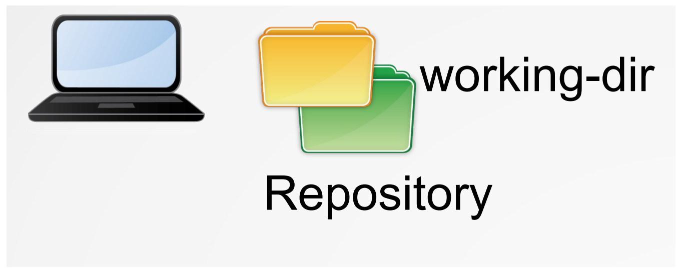
```
$ git init
```





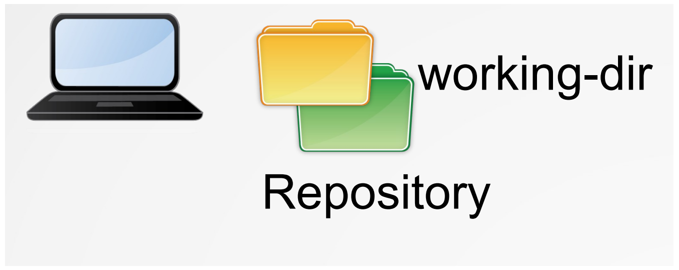
single user/project

```
$ vim test.c
$ vim test.h
$ git status
On branch master

Initial commit

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

        test.c
        test.h

nothing added to commit but untracked files present (use "git add" to track)
```



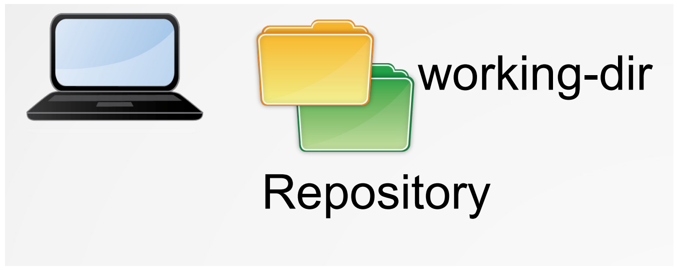
adding file (for next commit)

```
$ git add test.c
$ git status
On branch master

Initial commit

Changes to be committed:
  (use "git rm --cached <file>..." to unstage)

        new file:   test.c

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

        test.h
```



Commit

```
$ git commit -m'Add test.c'
[master (root-commit) 46ef322] Add test.c
 1 file changed, 0 insertions(+), 0 deletions(-)
 create mode 100644 test.c
$ git status
On branch master
Untracked files:
  (use "git add <file>..." to include in what will be committed)

        test.h

nothing added to commit but untracked files present (use "git add" to track)
```



checking modif

```
$ vim test.c
$ git diff
diff --git a/test.c b/test.c
index 0197793..0c7f097 100644
--- a/test.c
+++ b/test.c
@@ -1,4 +1,4 @@
 int main()
 {
-    int a=5;
+    int a=6;
 }
$
```

Do it yourself

- install git
- configure the tools (name + email)
- create a local repository
  - commit one file then modify it and re-commit
- check “diff”, “log”, “status” functionality

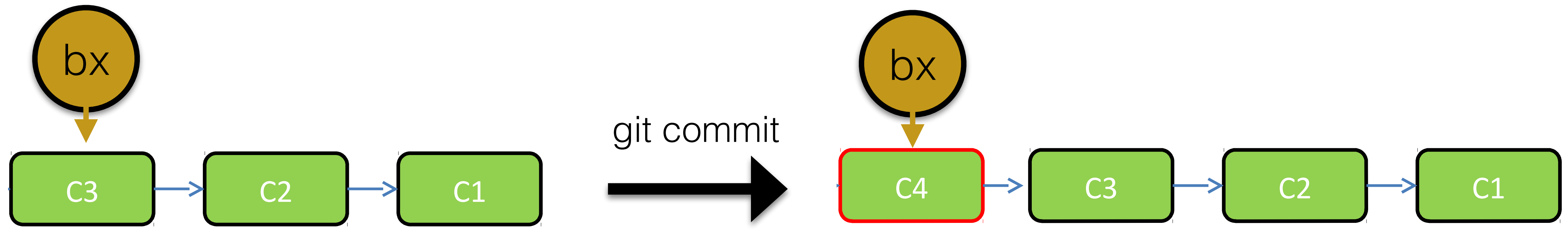
Workflow

branch in git

- Branch is **pointer** to a commit (represent an history)
- A branch can point at other commit, it can move!
- A branch is a way to organize your work and working histories
- Since commit know which commits they are based on, branch represents a commit and what came before it
- a branch is **cheap**, you can have multiple branch in the same repository and switch your working dir from one branch state to another

branches

- default branch: master
- When doing a commit, the branch moves to the new commit



branches

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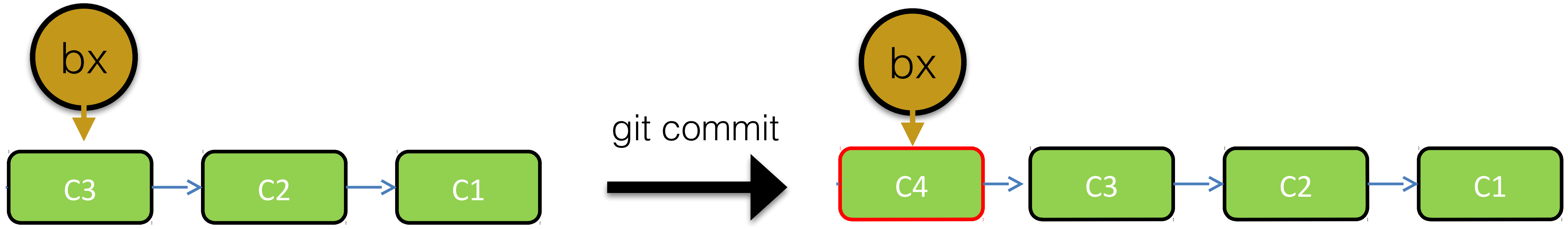
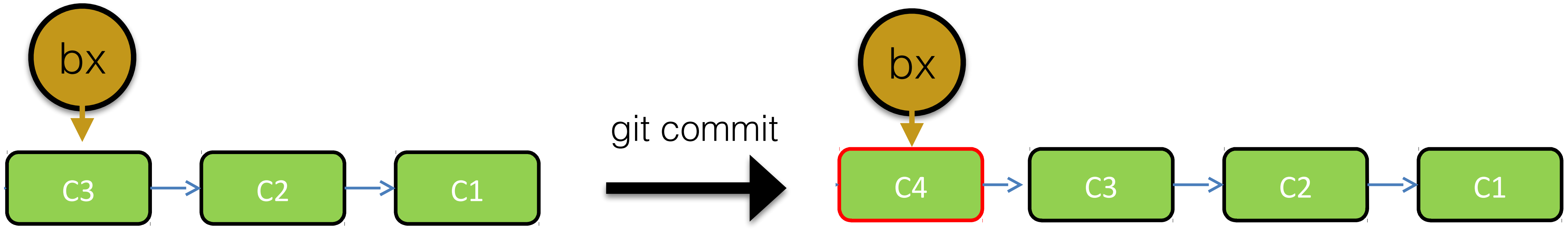


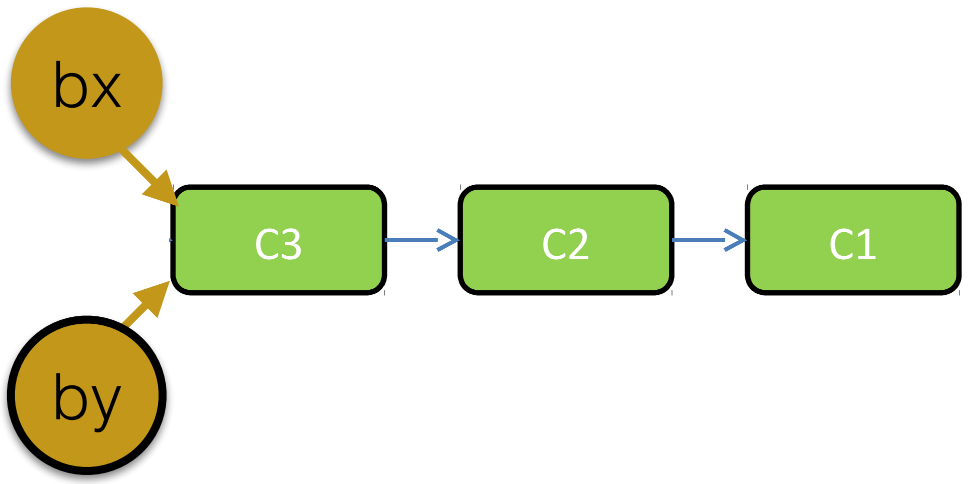
- creating a new branch: add a pointer (git switch -c by)

branches

- default branch: master
- When doing a commit, the branch moves to the new commit

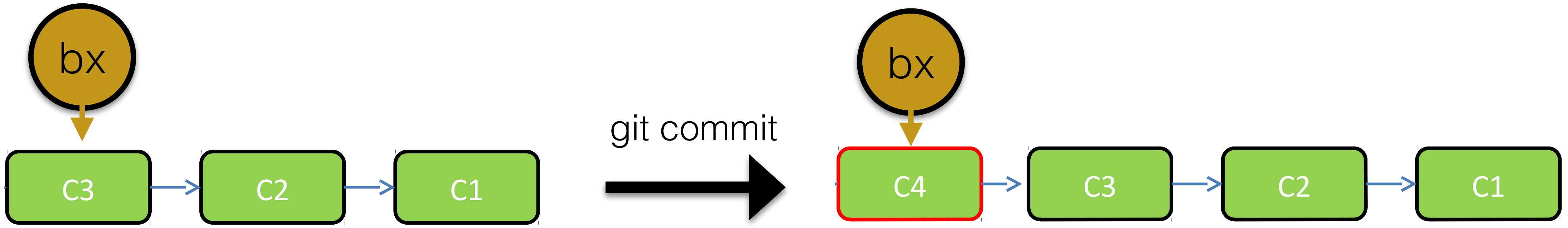


- creating a new branch: add a pointer (git switch -c by)

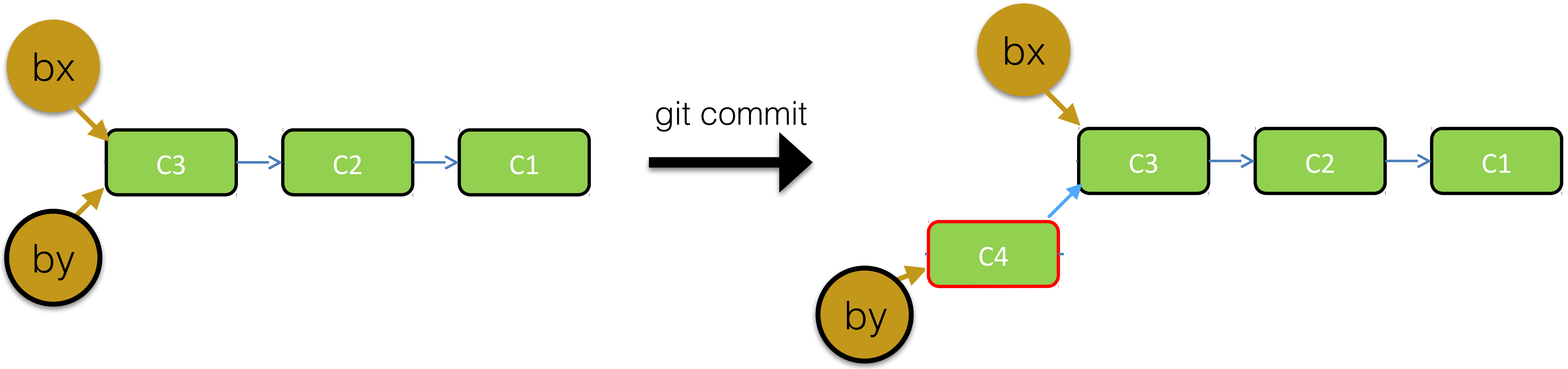


branches

- default branch: master
- When doing a commit, the branch moves to the new commit



- creating a new branch: add a pointer (git switch -c by)
  - only selected branch affected by commit!



branches

create a new branch	git branch NAME
create a new branch	git switch -c NAME
switch to a branch	git switch NAME
delete a branch	`git branch -d bx`
rename a branch	`git branch -m bx`
move a branch	`git branch -f bx rev`
List all branches	**git branch**

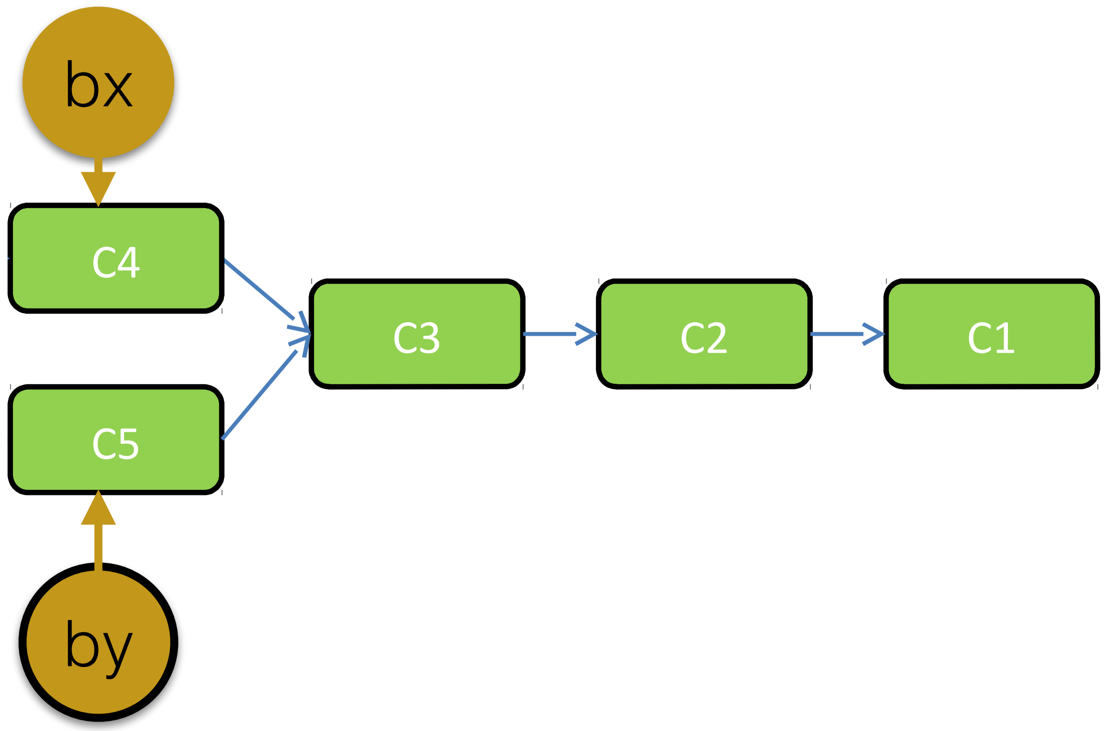
- **master :** default created branch
- branch is cheap -> do it often
- branch allow to have short/long term parallel development

Git<2.23

create a new branch	`git checkout -b bx`
switch to a branch	`git checkout bx`

merging

- The interest of branch is that you can **merge** them
  - Include in one (branch) file the modification done somewhere else



merging

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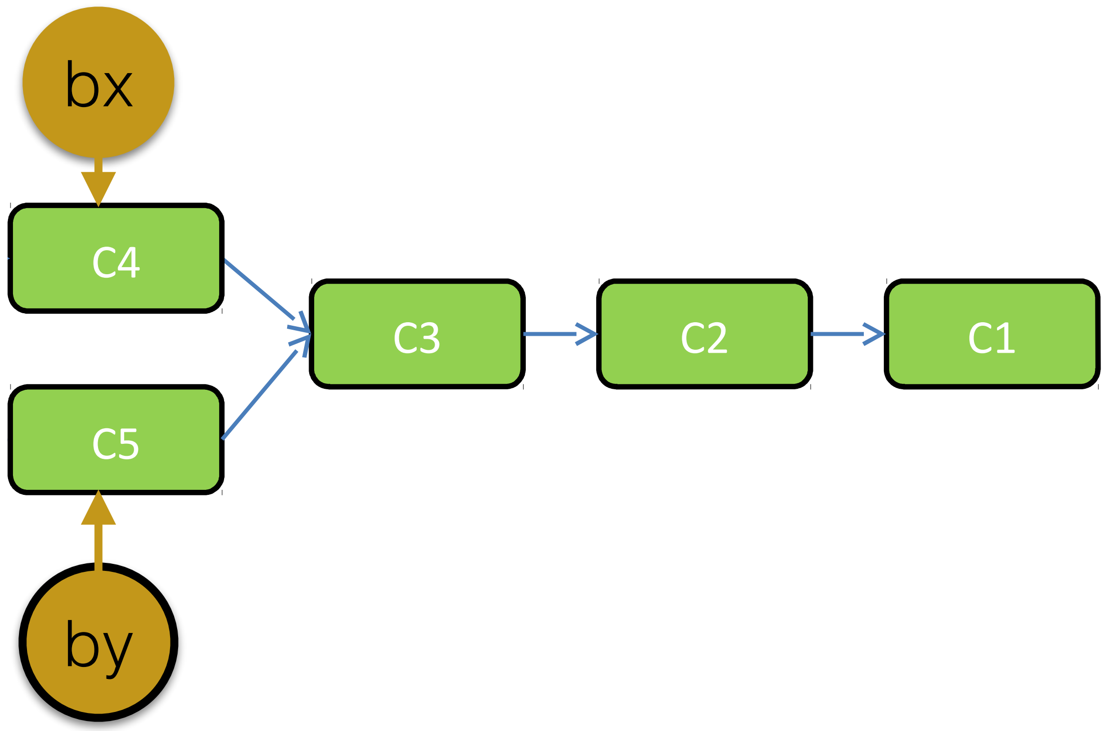
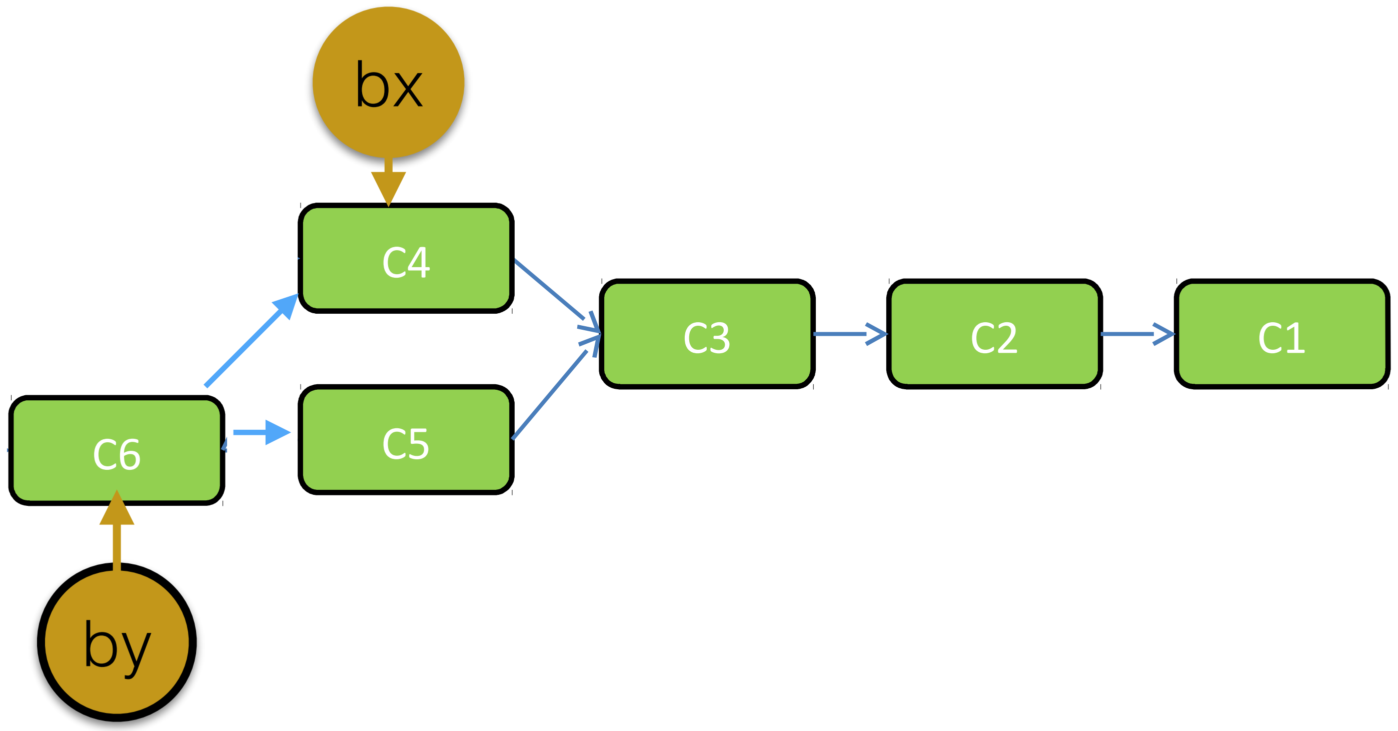


git merge bx

merging

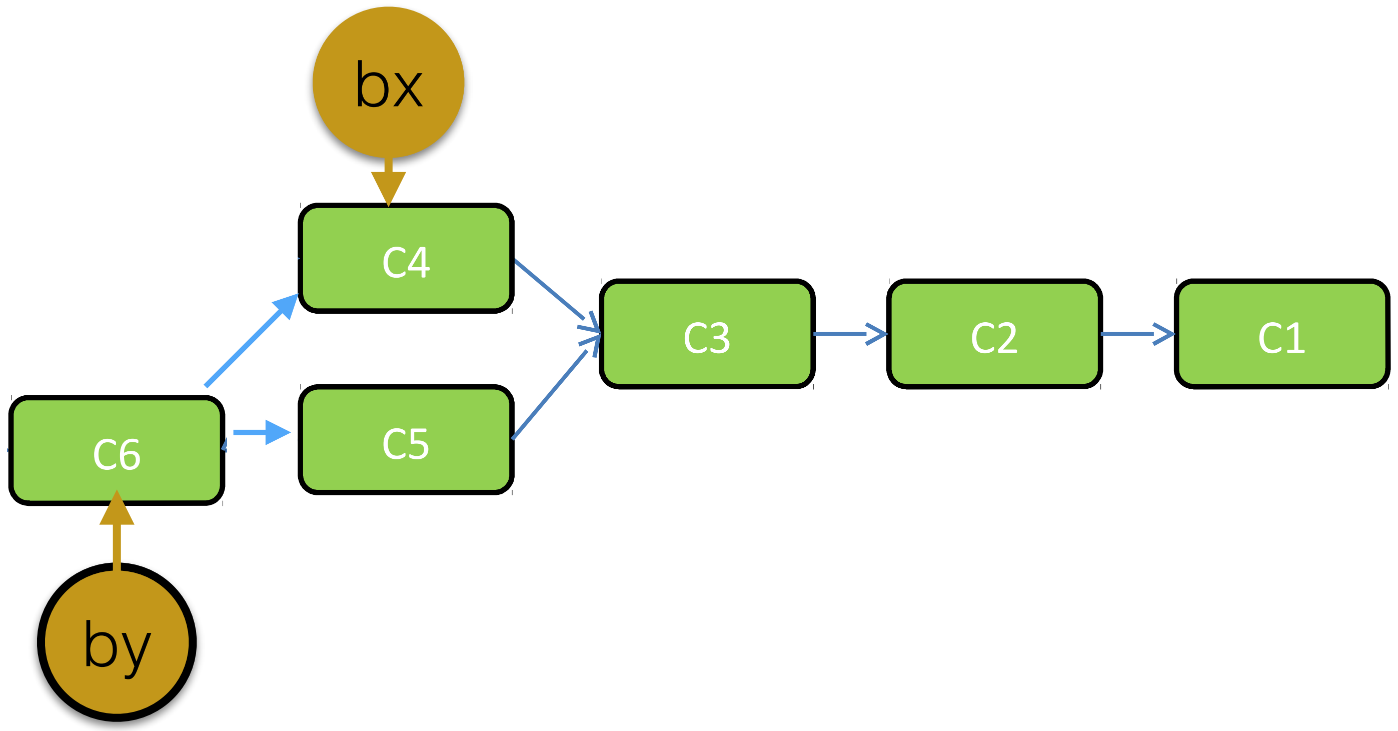
- merging two different modifications



git merge bx

merging

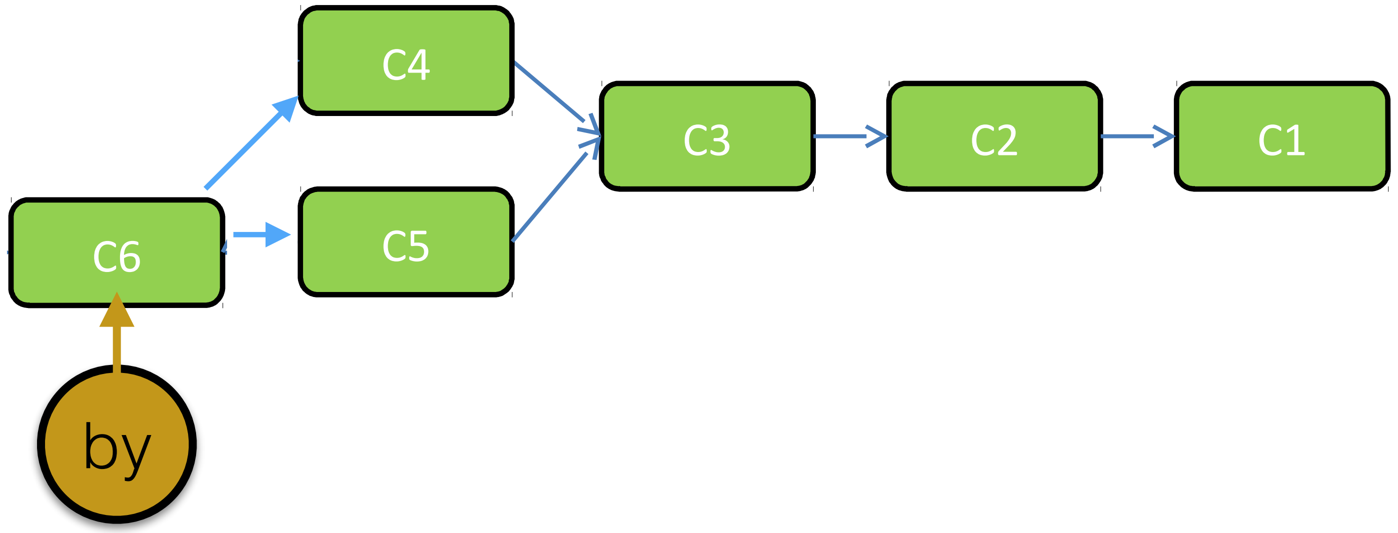
- merging two different modifications



```
git merge bx
git branch -d bx
```

merging

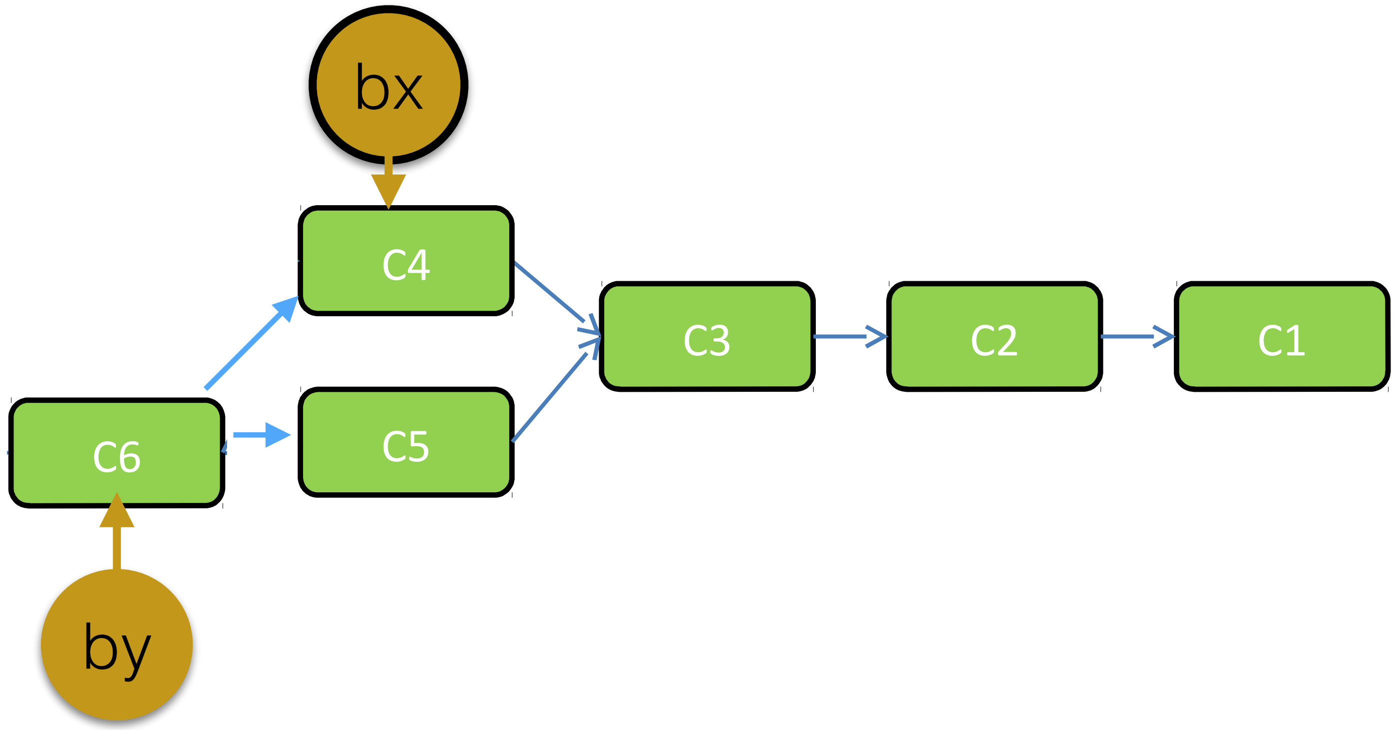
- merging two different modifications



```
git merge bx
git branch -d bx
```

merging

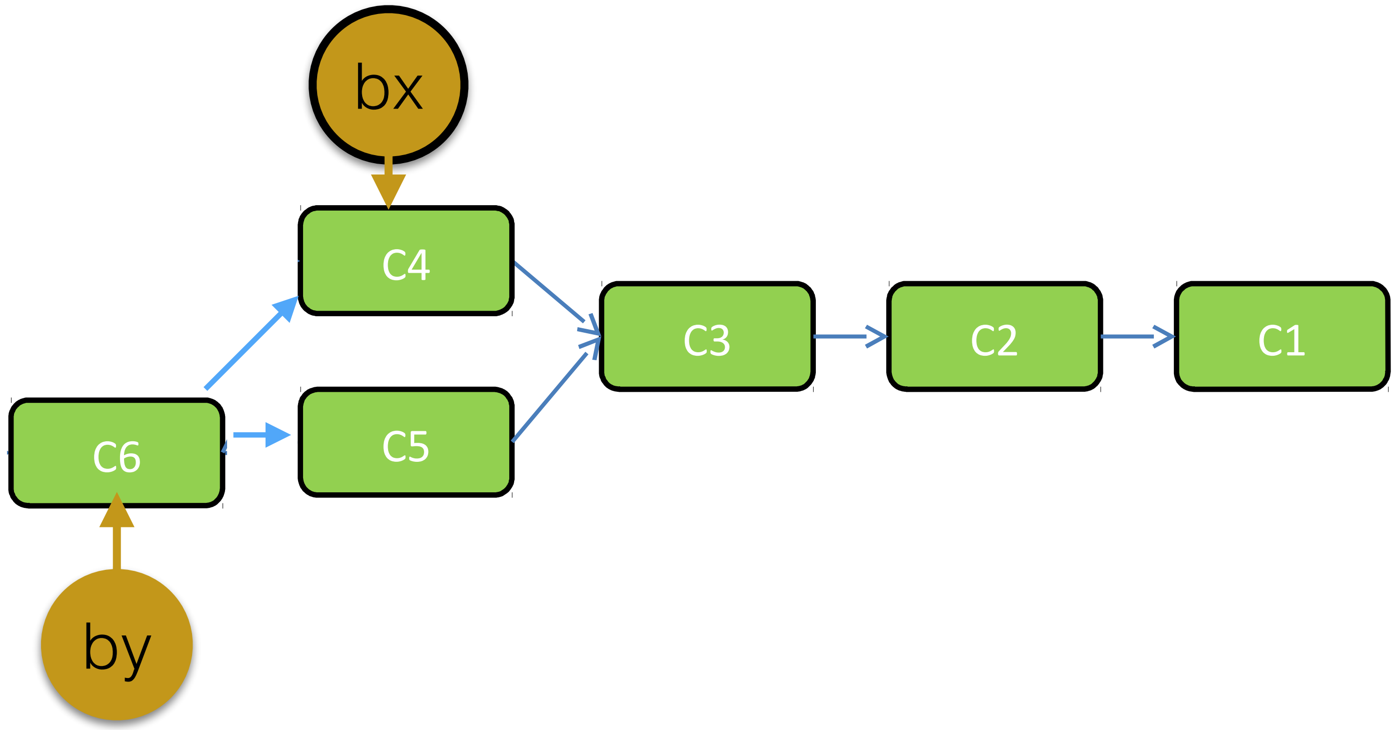
- merging two different modifications



```
git merge bx
  git switch bx
```

merging

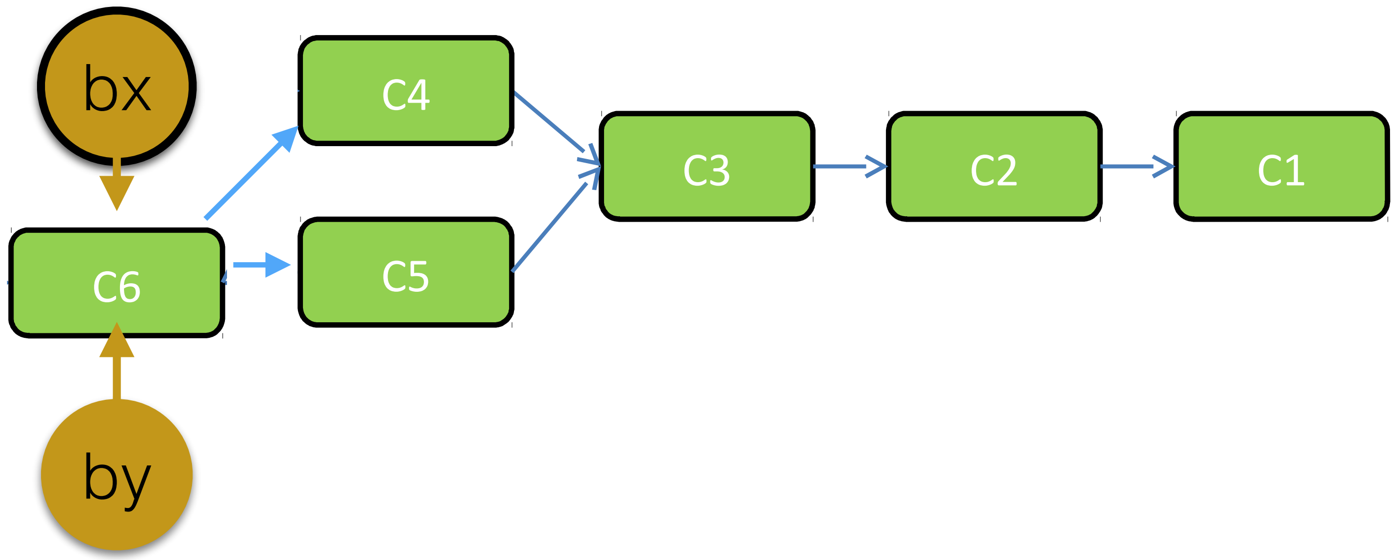
- merging two different modifications



git merge bx
  git switch bx
git merge by

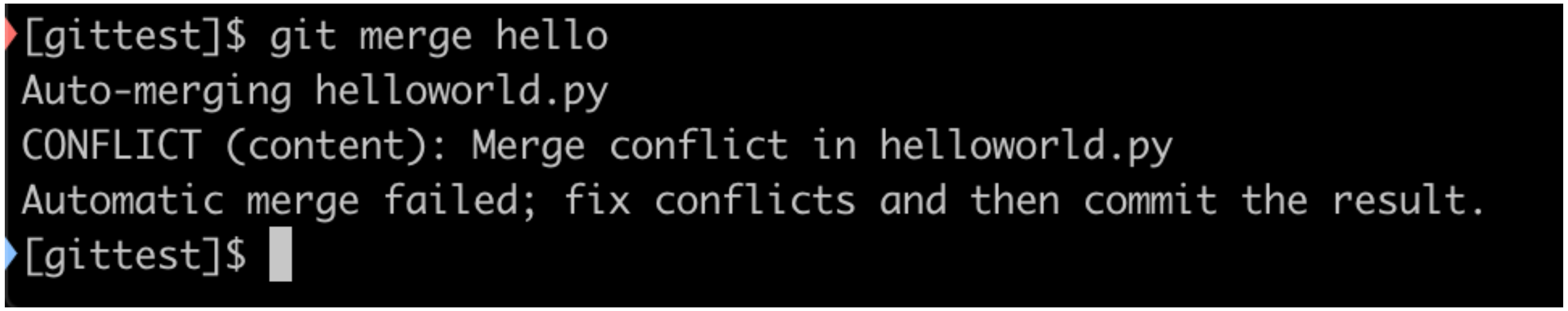
merging

- merging two different modifications



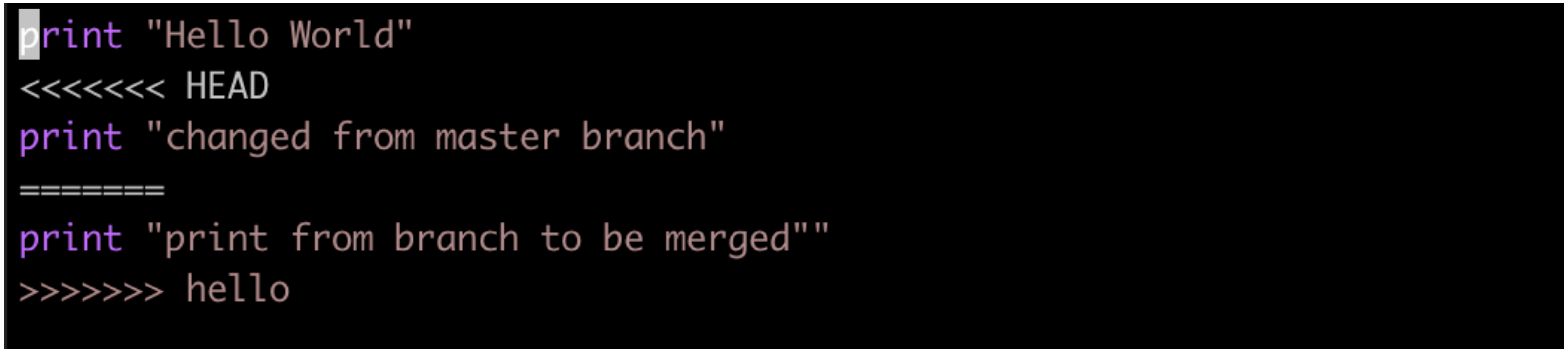
git merge bx
git checkout bx
git merge by

merging can lead to conflict



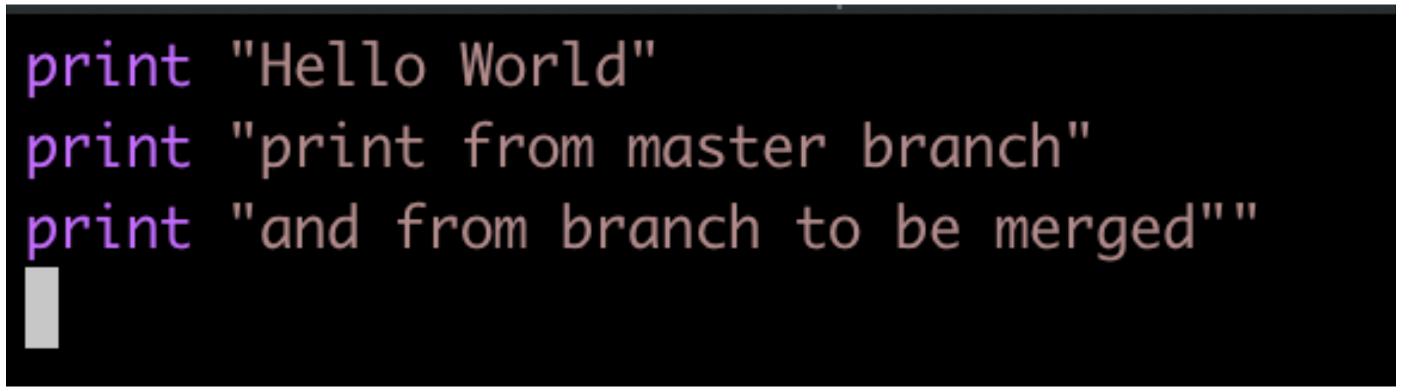
```
[gittest]$ git merge hello
Auto-merging helloworld.py
CONFLICT (content): Merge conflict in helloworld.py
Automatic merge failed; fix conflicts and then commit the result.
[gittest]$ 
```

Conflict



```
print "Hello World"
<<<<<<< HEAD
print "changed from master branch"
=======
print "print from branch to be merged""
>>>>>>> hello
```

Edit the file to the “correct” version



```
print "Hello World"
print "print from master branch"
print "and from branch to be merged""
```

Run
-> git commit

Conflict

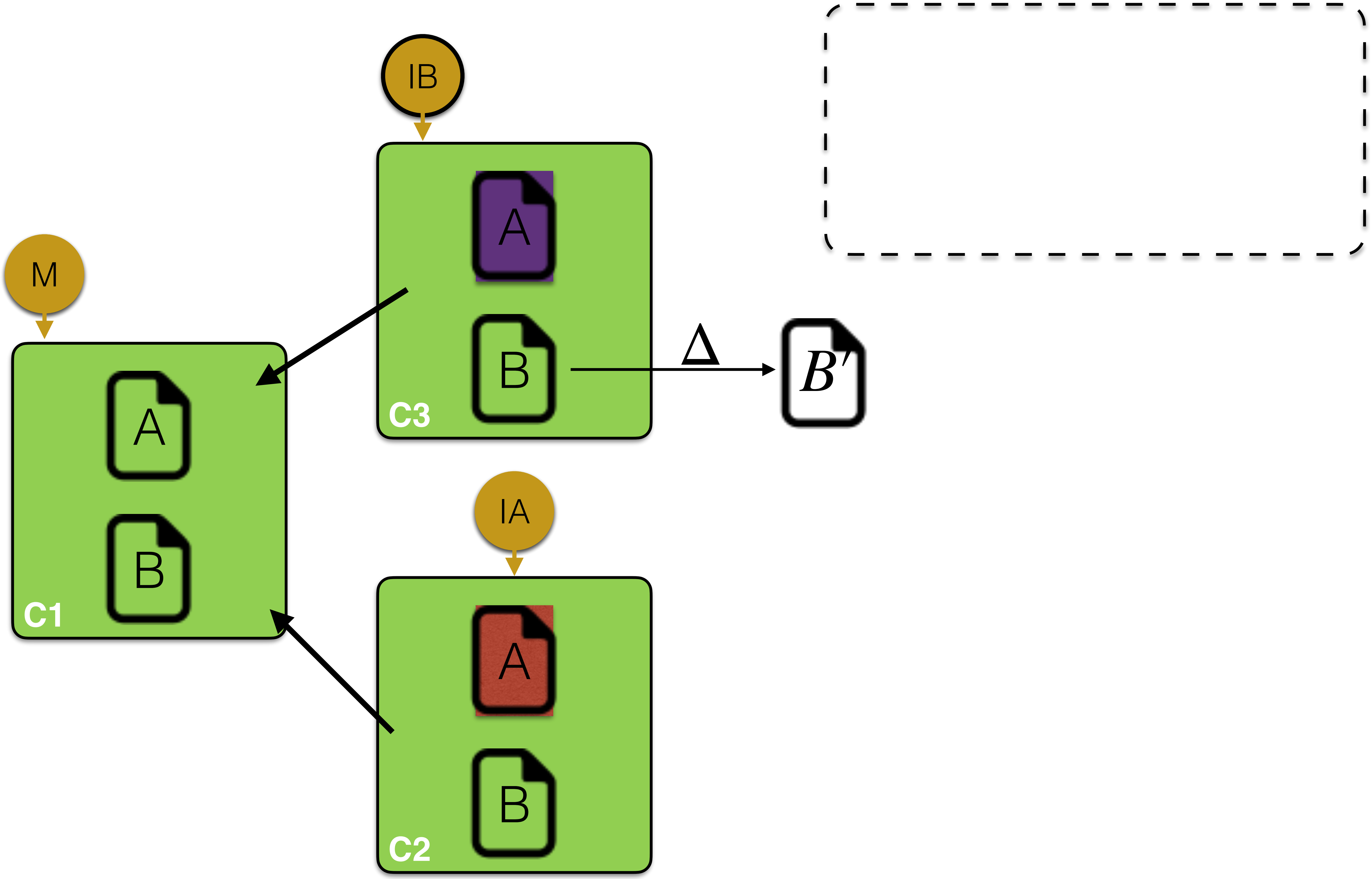
- **Multiple version of files** are great
  - Not always easy to know how to merge them
  - Conflict will happen (same line modify by both user)

- Conflict need to be resolved manually!
  - Boring task
  - need to understand why a conflict is present!
- **Do not be afraid of conflict!** Do not try to avoid them at all cost!
- stay in sync as most as possible and keep line short

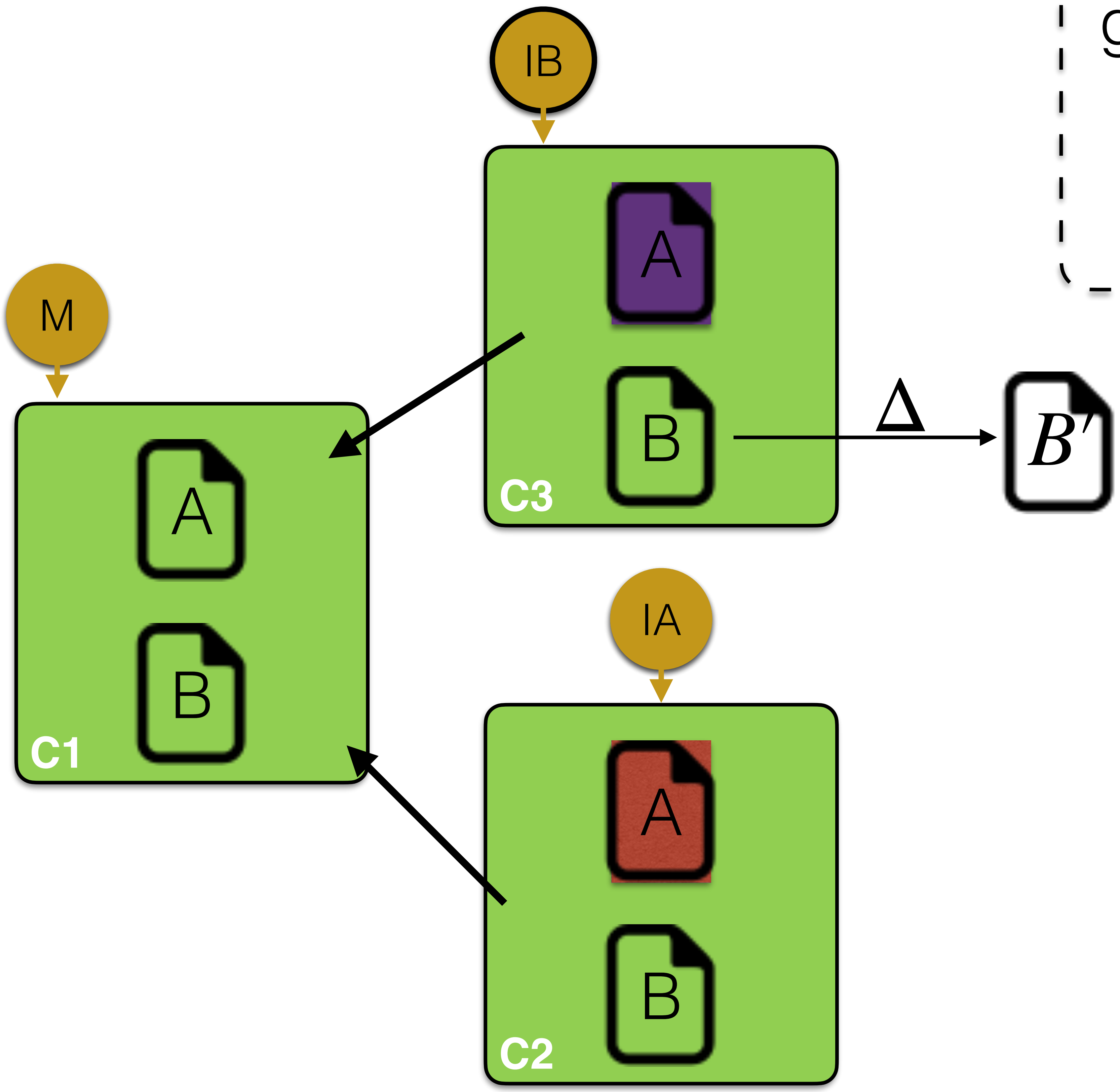
Do it yourself

- create two branch on your repository
- make new commit on each branch
- merge (test case with and without conflict)

Working on the wrong branch

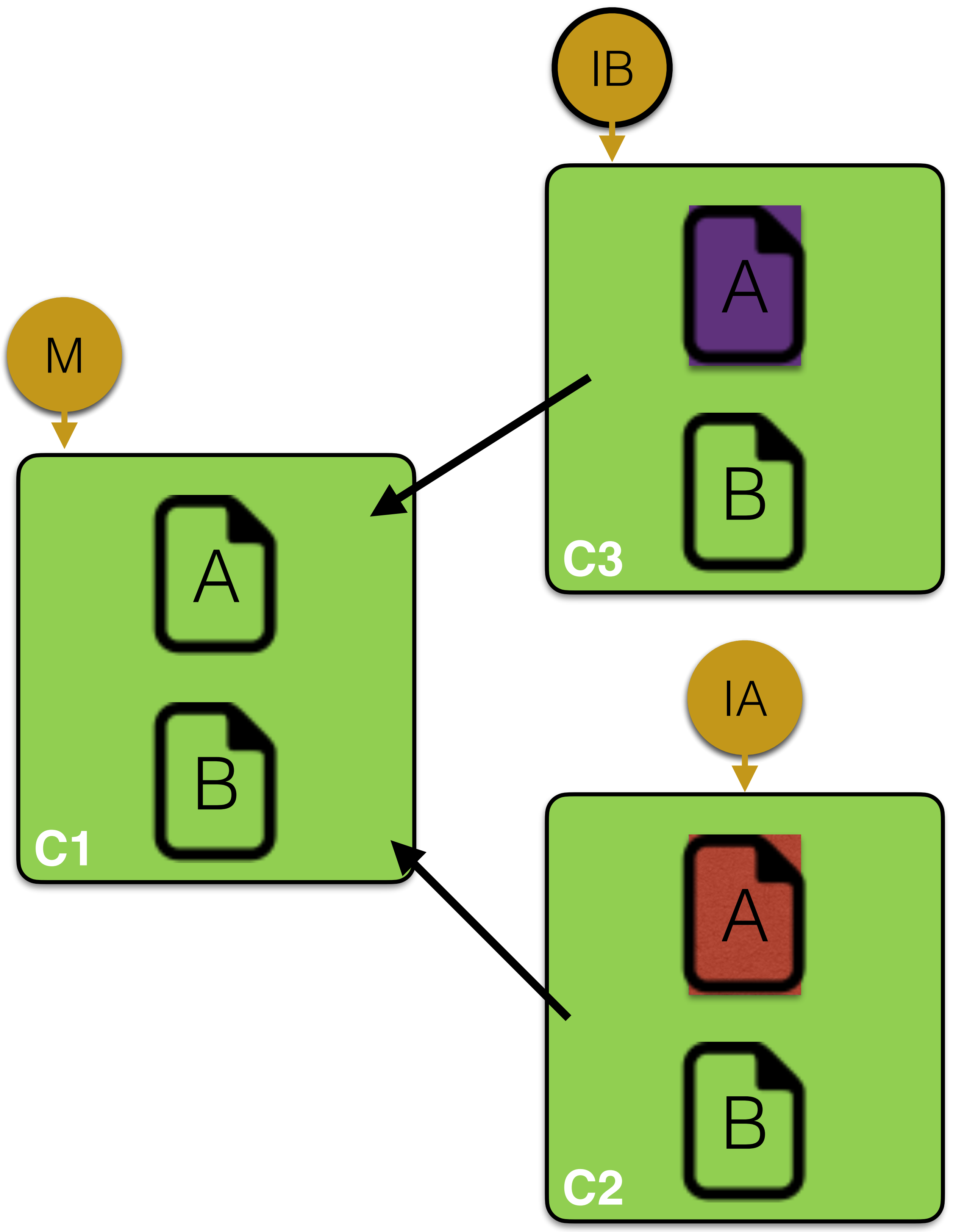


Working on the wrong branch



git stash save “INFO”

Working on the wrong branch



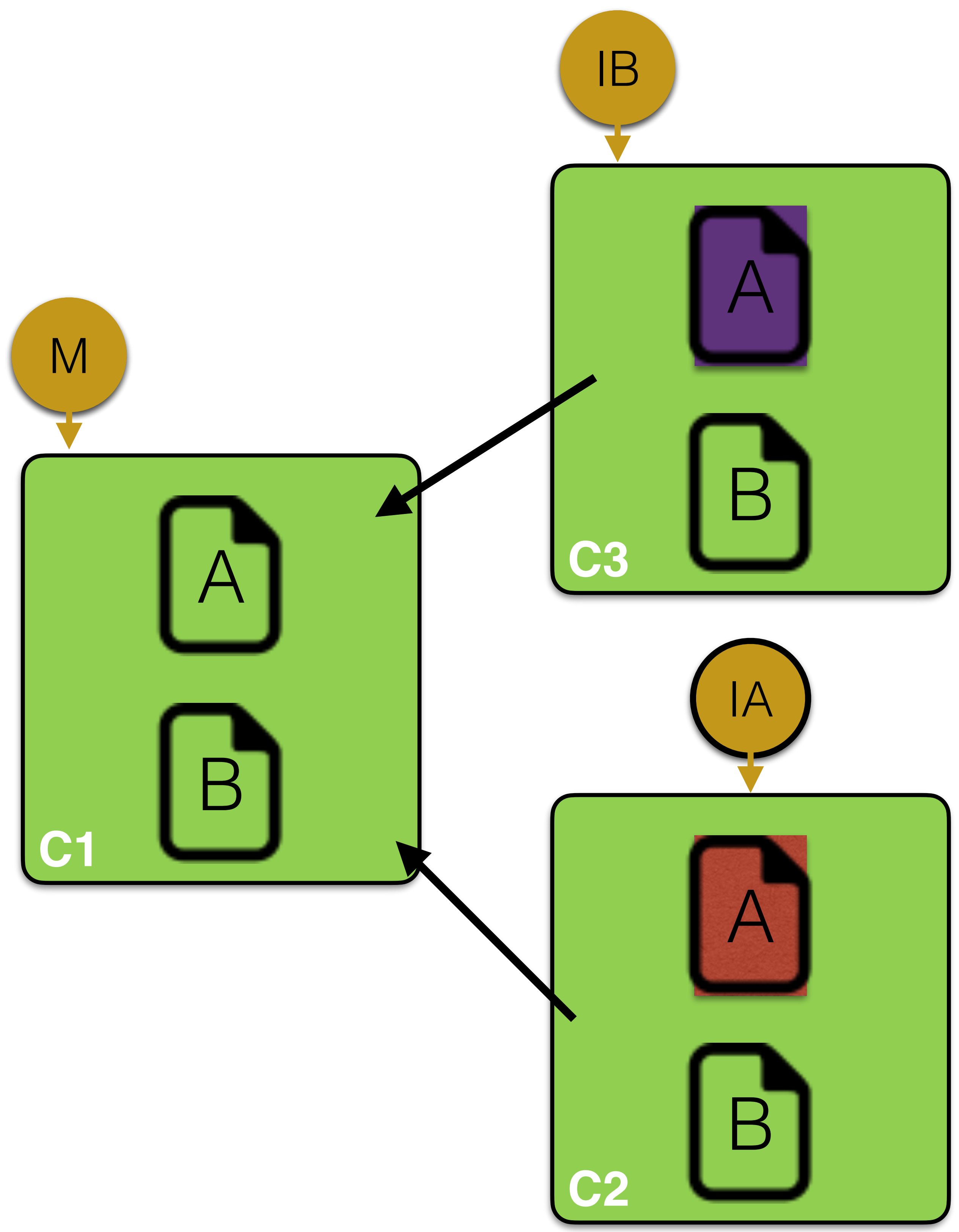
```
git stash save "INFO"
```

Stash storage

```
git stash list

stash@{0}  Δ
```

Working on the wrong branch

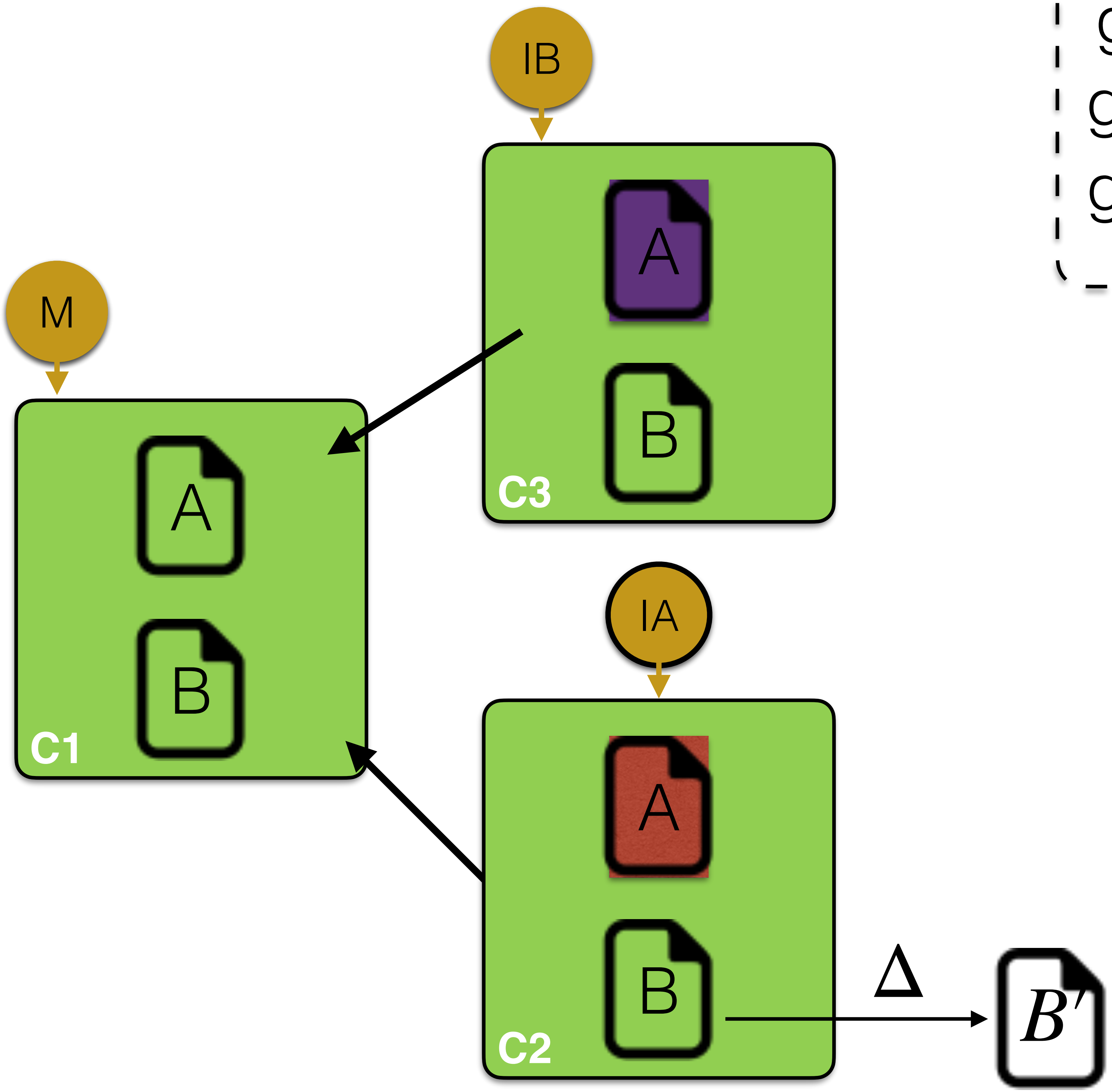


```
git stash save “INFO”
git checkout IA
```

Git stash list

stash@{0} Δ

Working on the wrong branch



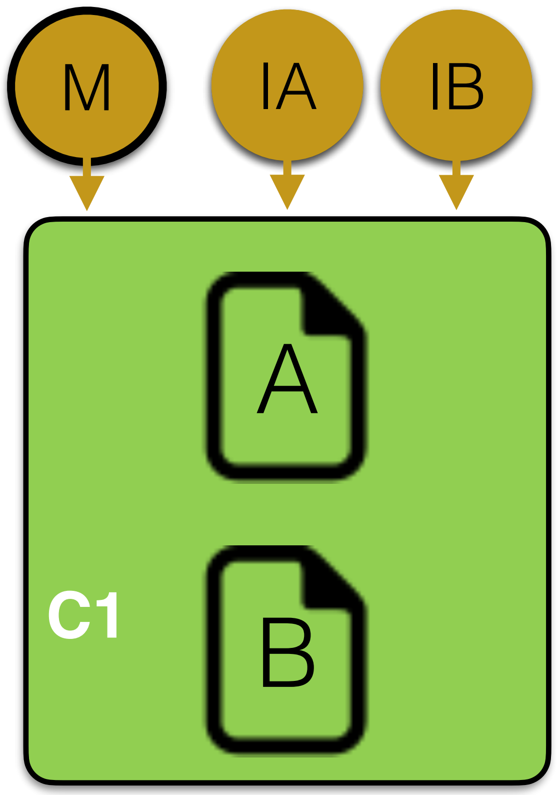
```
git stash save "INFO"
git checkout IA
git stash pop
```

Git stash list

Keep history clean: Rebase

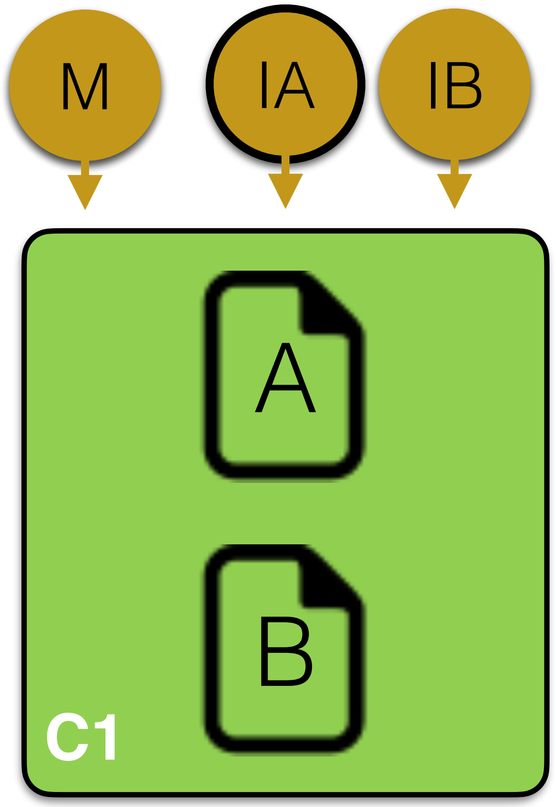
- Instead of merging, replays set of changes on top of another branch
- Affects the “rebased” branch only
- Changes the history of commits
- Can be dangerous
- Very useful to remove history clutter
- Simple rule, use locally only

Keep history clean: Rebase



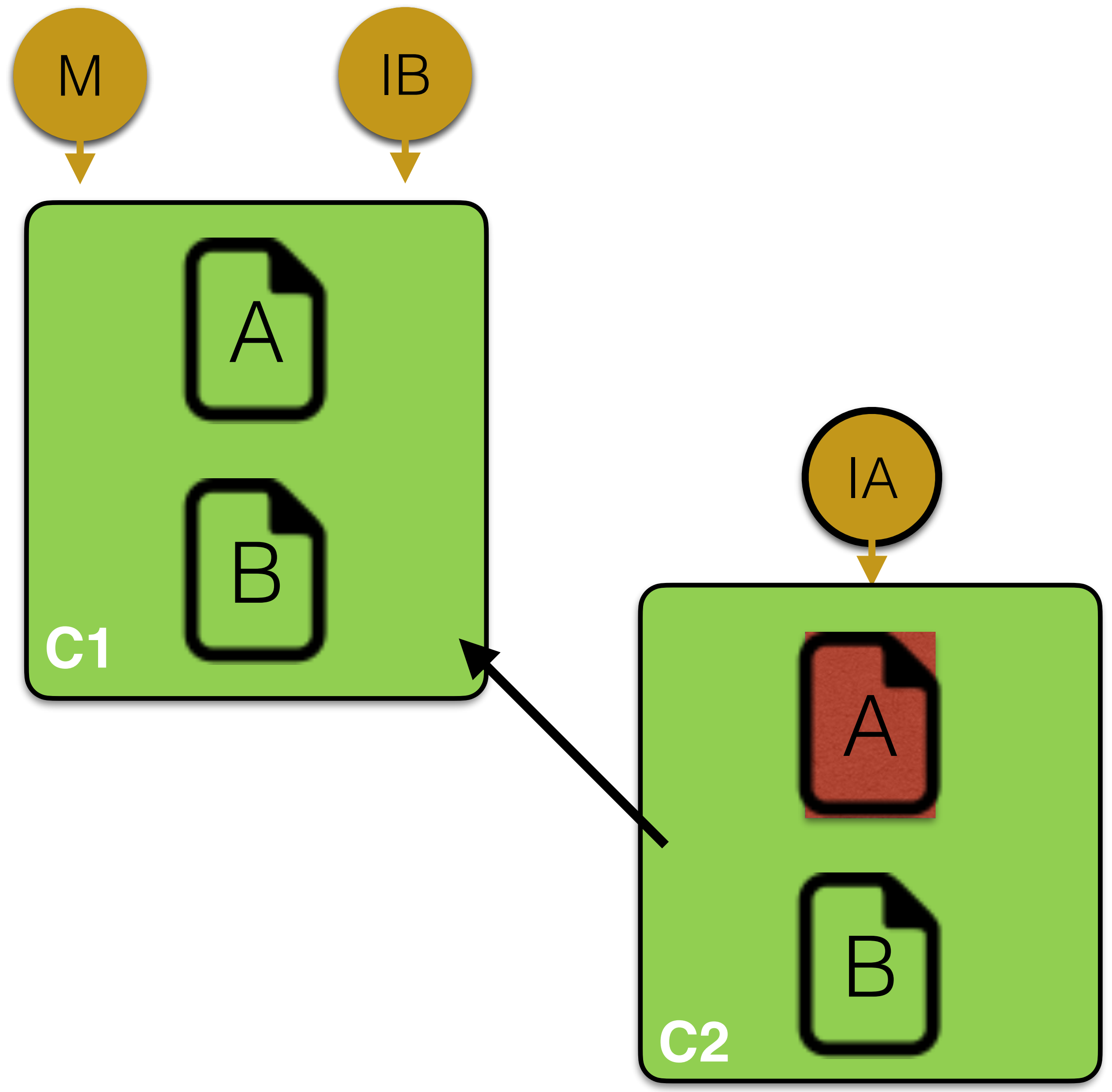
Keep history clean: Rebase

```
Git checkout IA
```



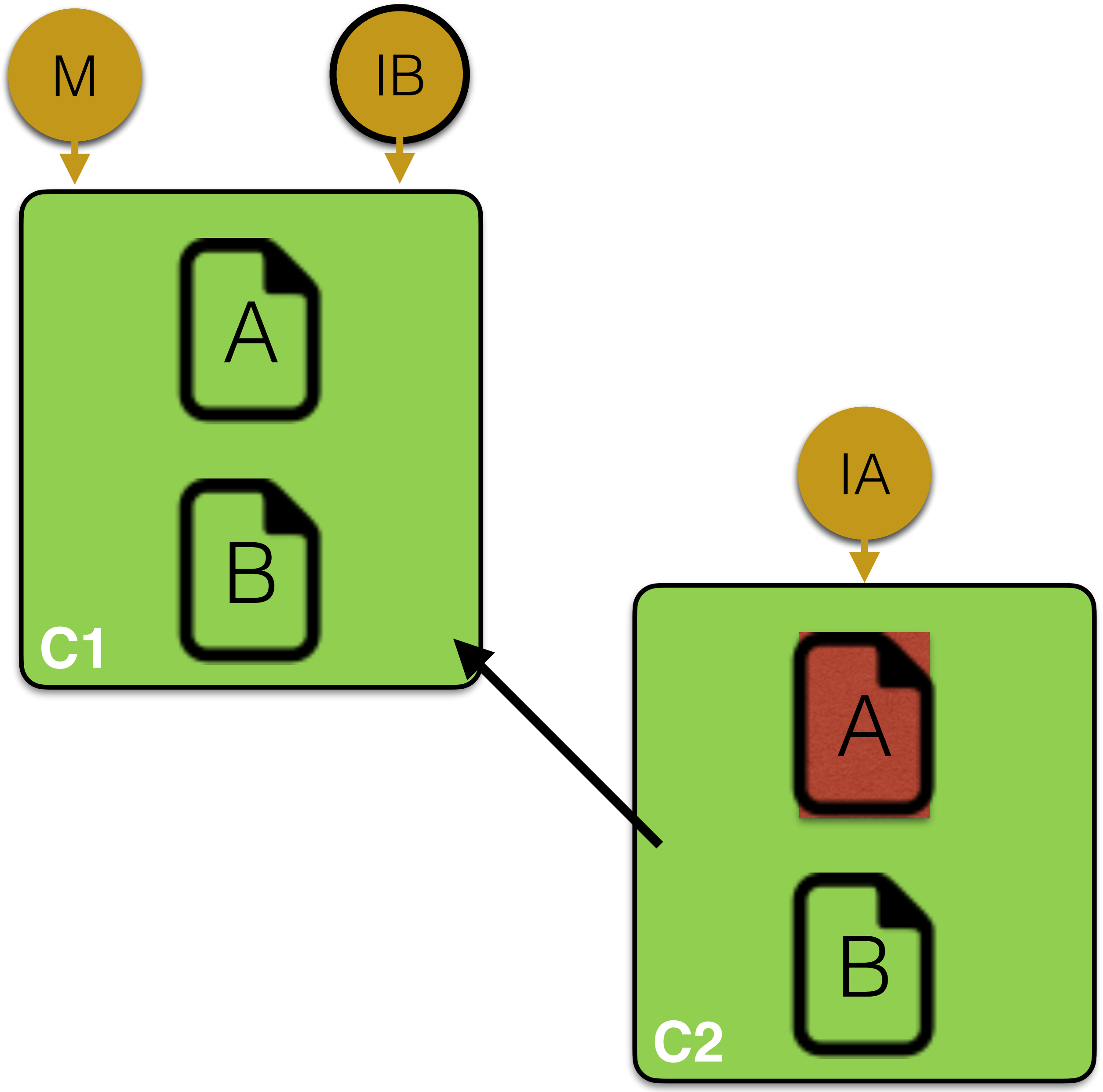
Keep history clean: Rebase

```
Git checkout IA
Git commit
```

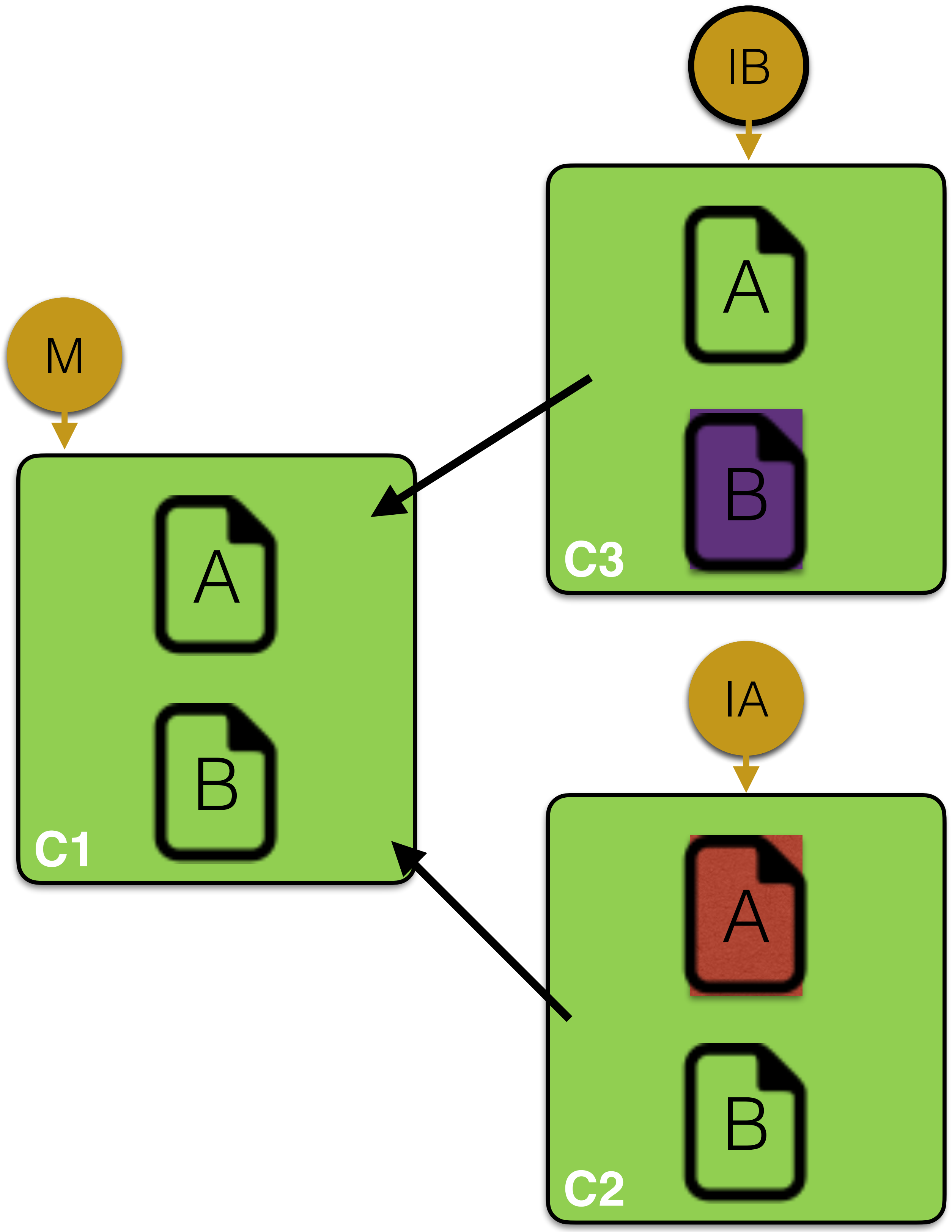


Keep history clean: Rebase

Git checkout IB



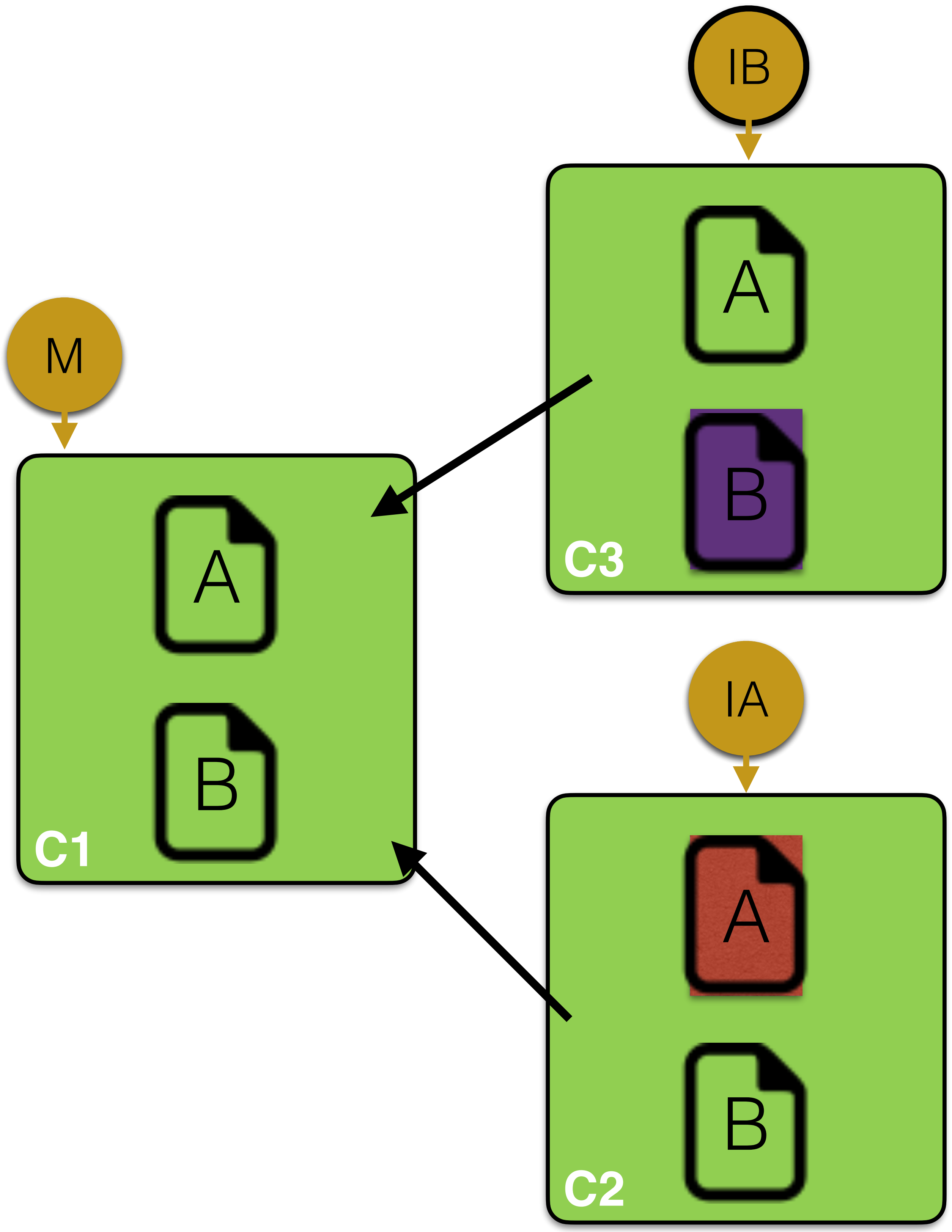
Keep history clean: Rebase



Git checkout IB

Git commit

Keep history clean: Rebase

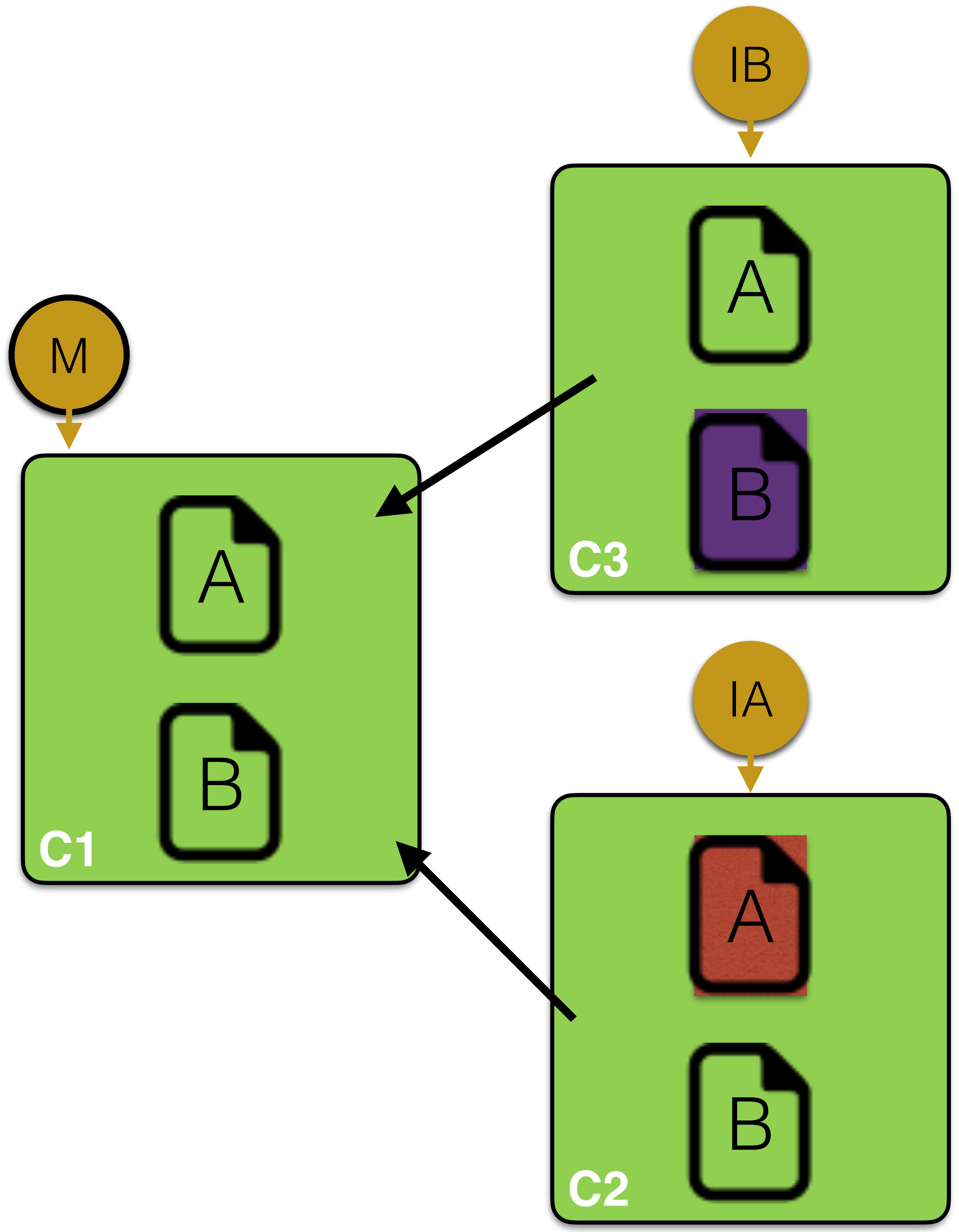


Git checkout IB

Git commit

I want to include **BOTH** changes in master branch

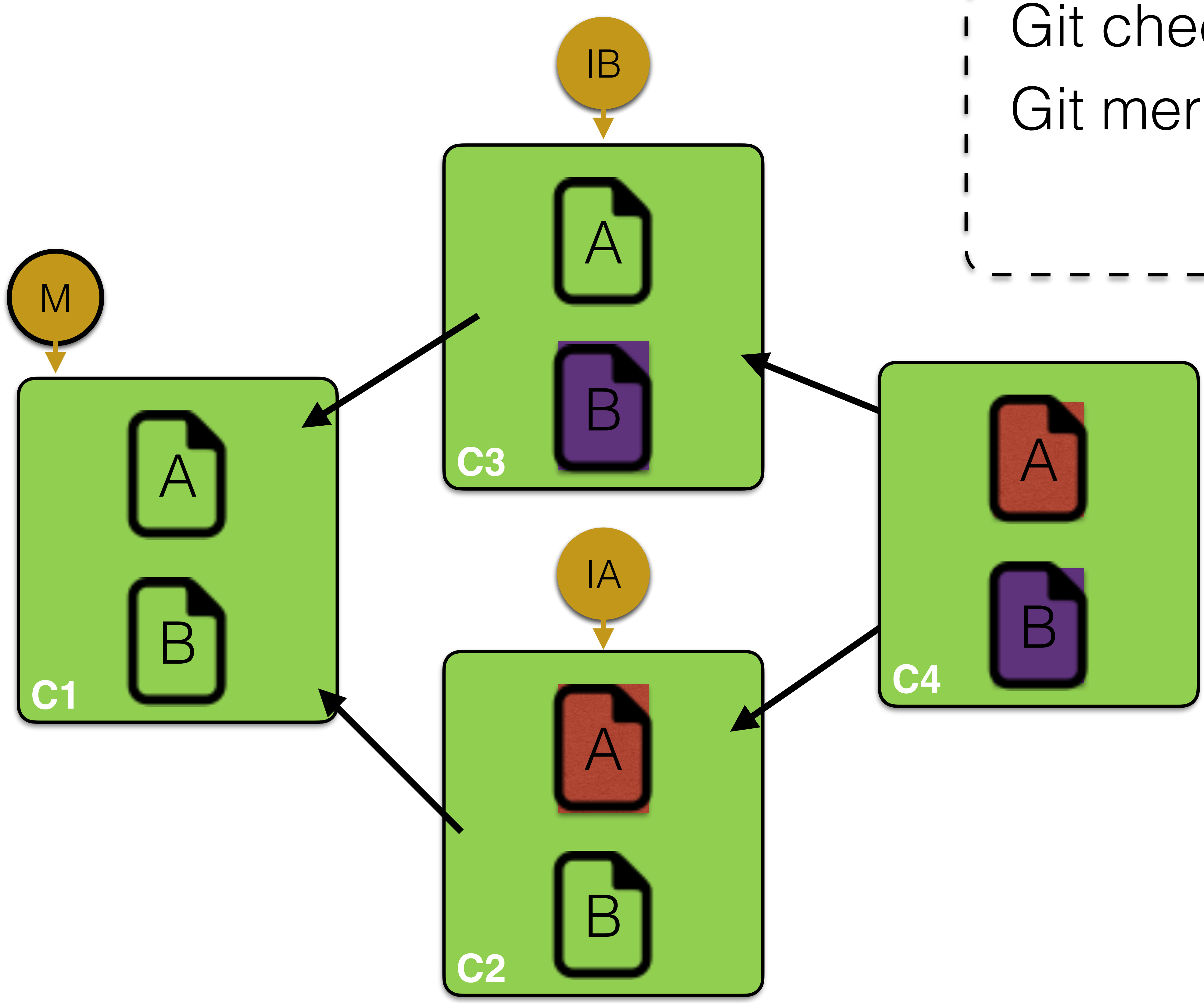
Keep history clean: Rebase



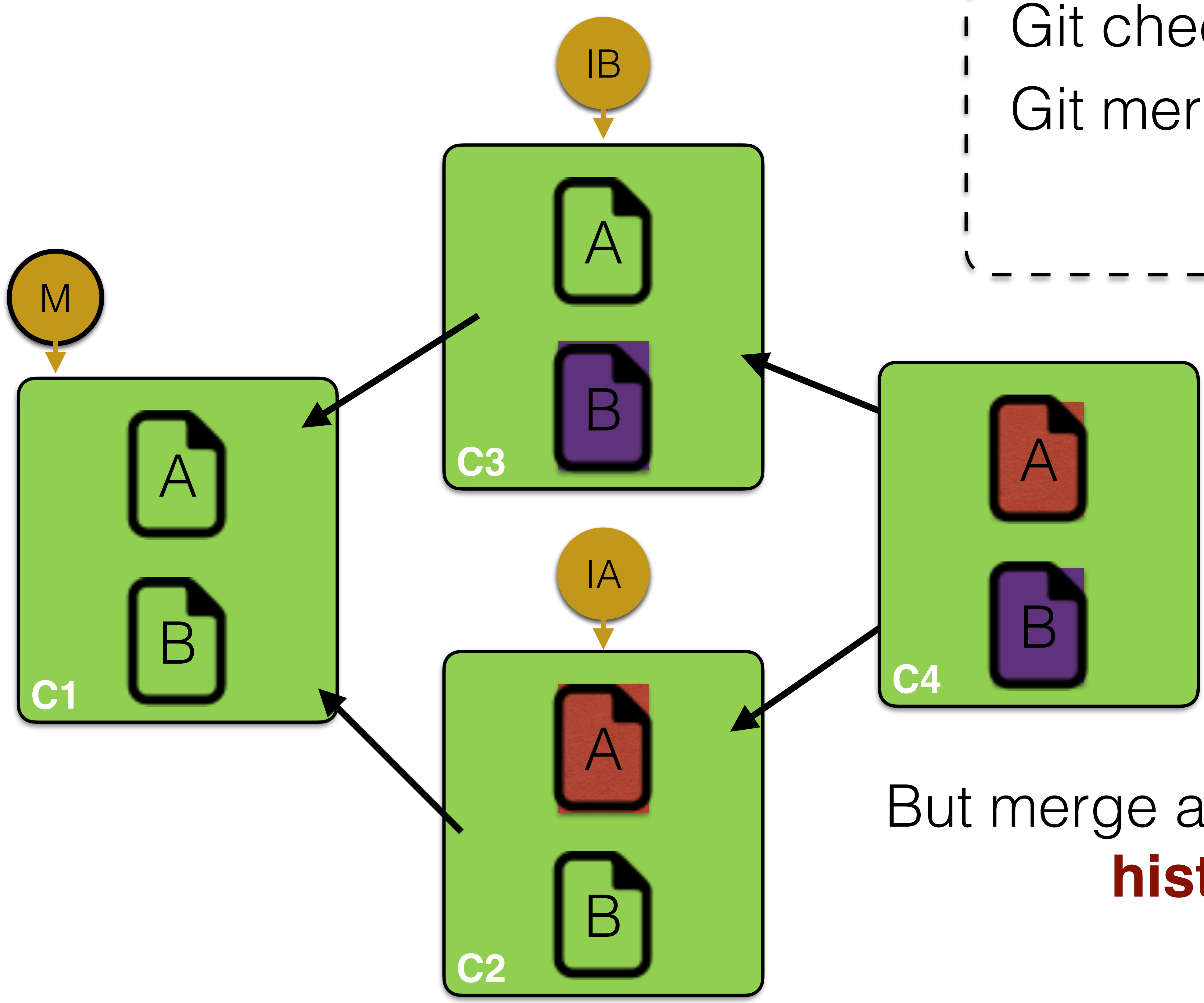
Git checkout M

Keep history clean: Rebase

```
Git checkout M
Git merge IA IB
```



Keep history clean: Rebase



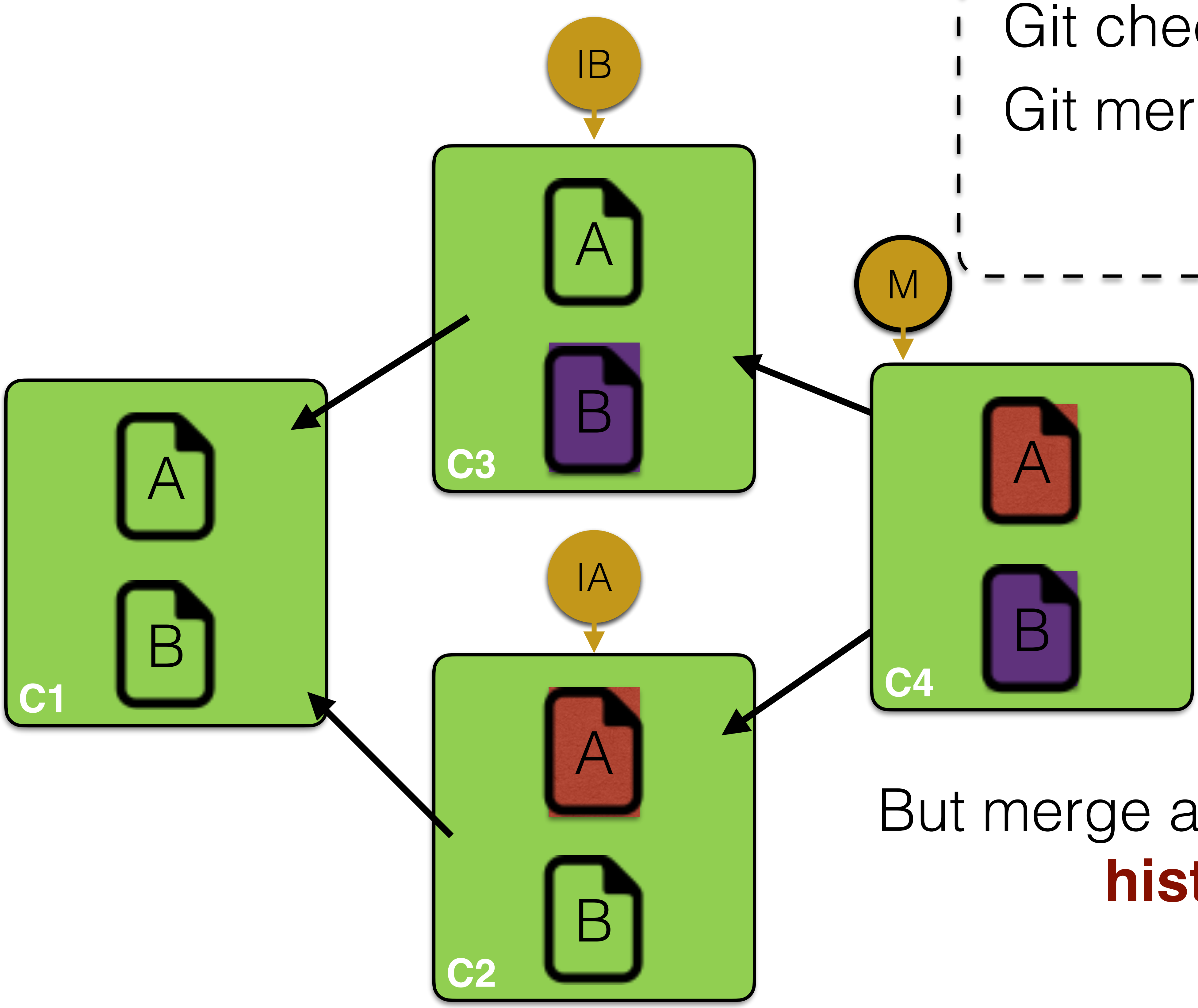
```
Git checkout M
Git merge IA IB
```

But merge are **not clean history**

Keep history clean: Rebase

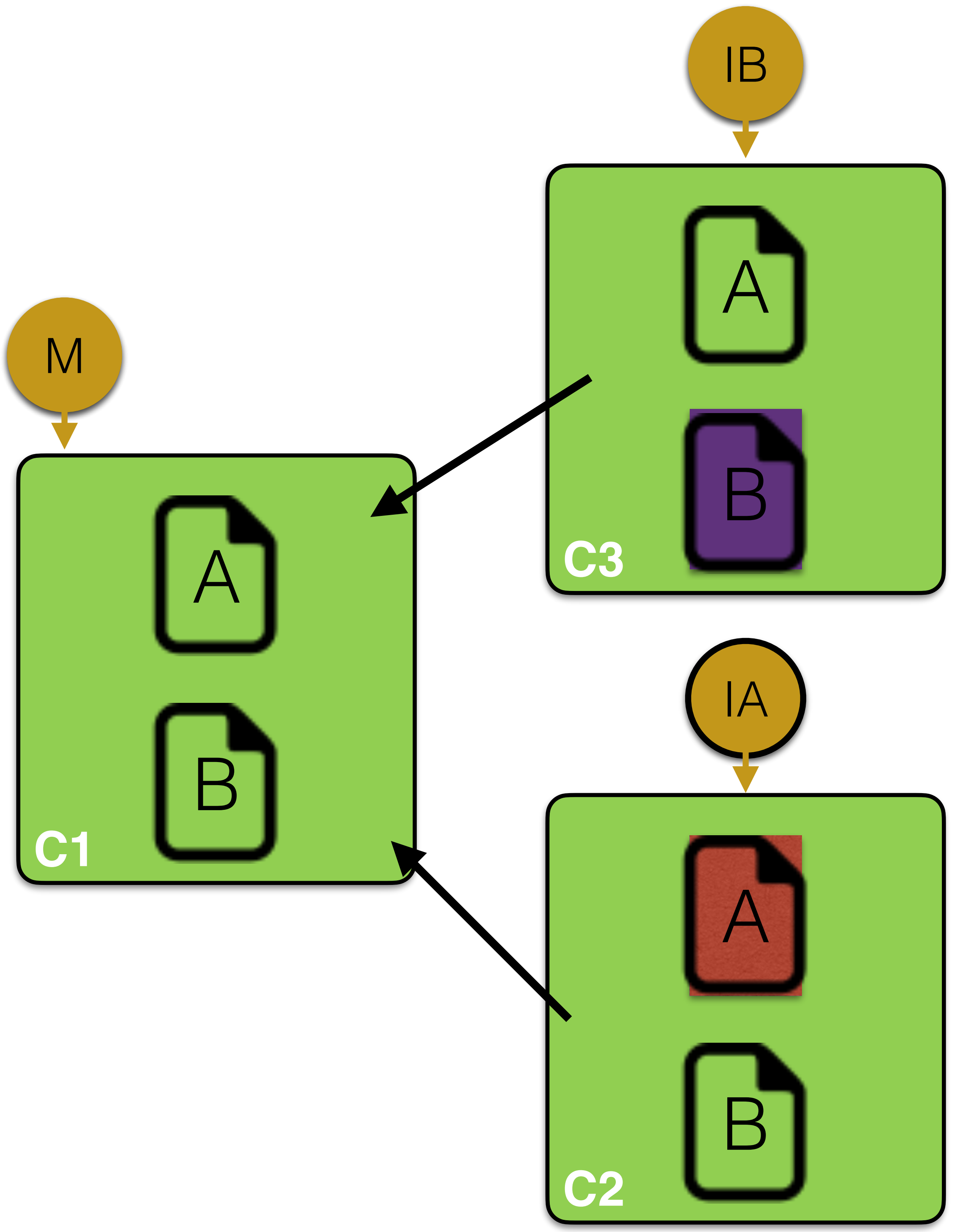
Git checkout M

Git merge IA IB



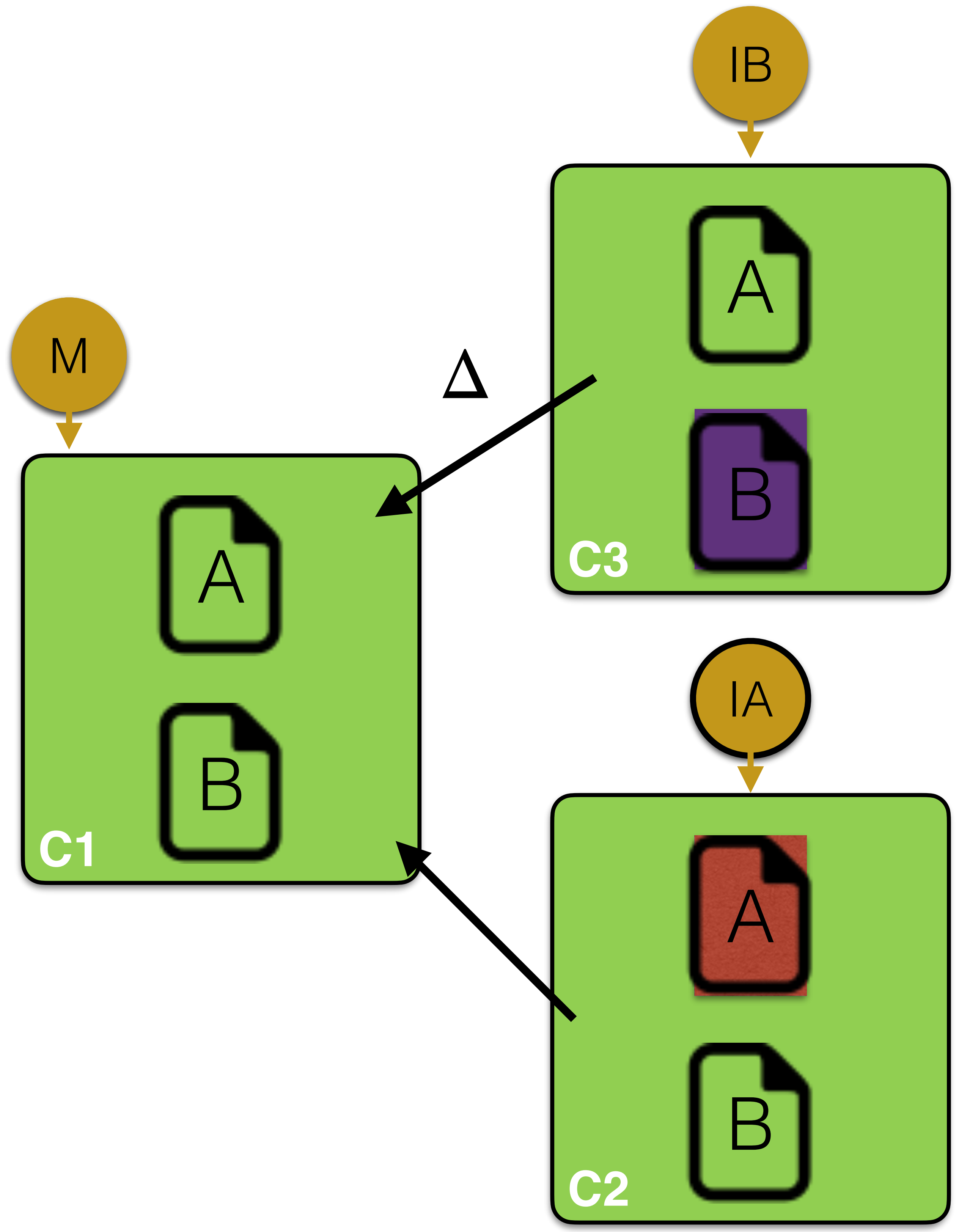
But merge are **not clean history**

Keep history clean: Rebase



Git checkout IA

Keep history clean: Rebase



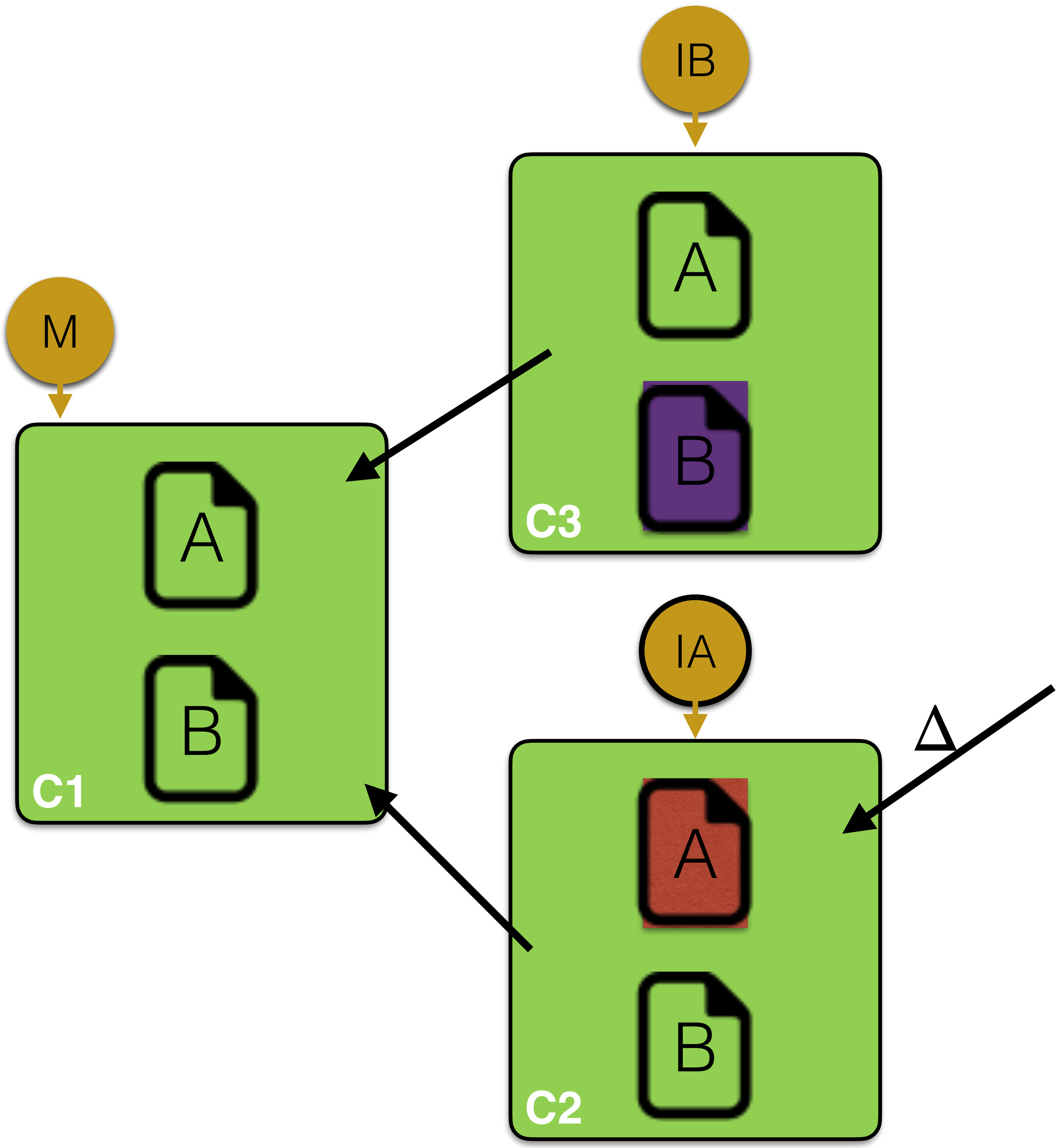
Git checkout IA

Manual change of B

Keep history clean: Rebase

Git checkout IA

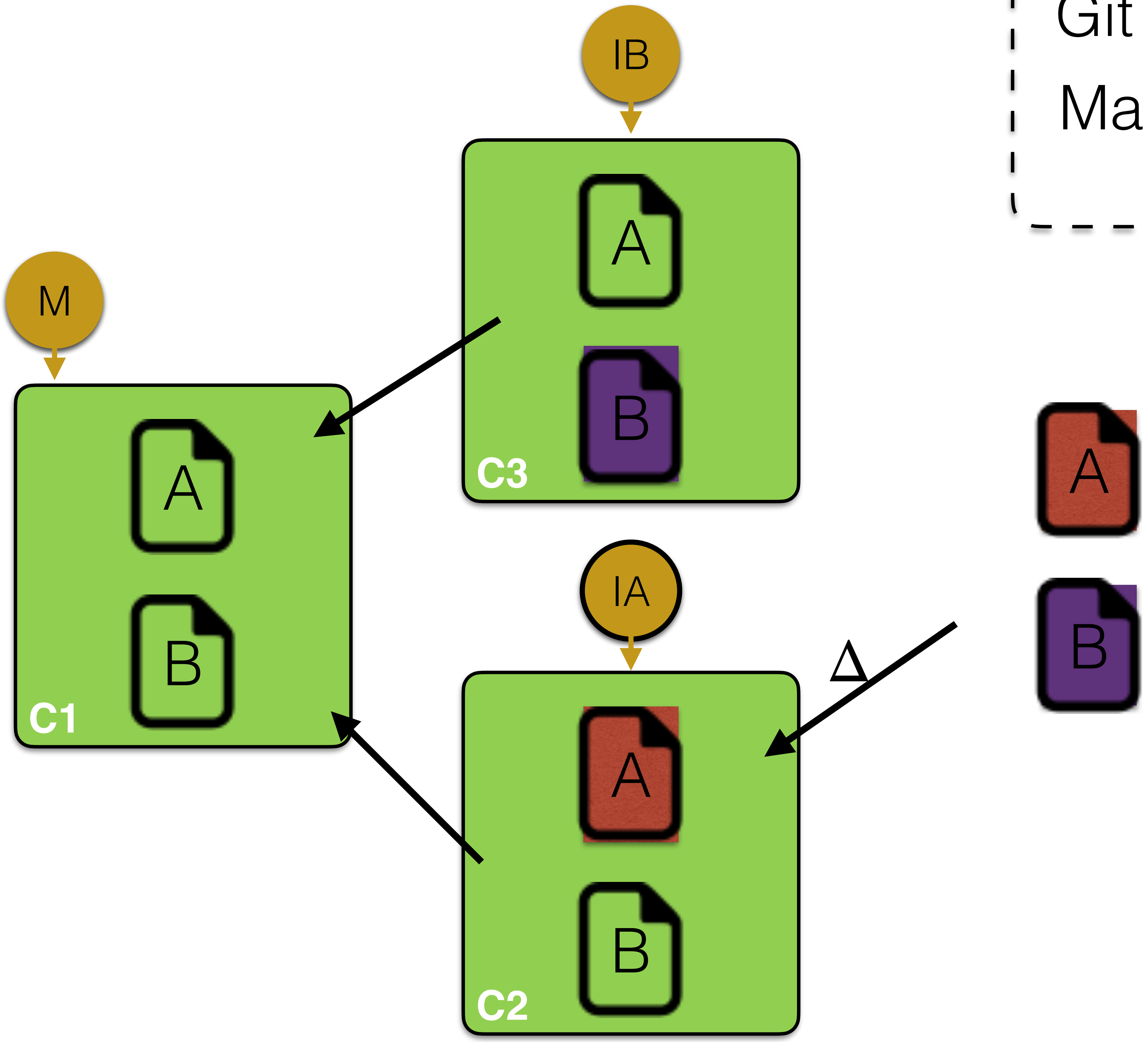
Manual change of B



Keep history clean: Rebase

Git checkout IA

Manual change of B

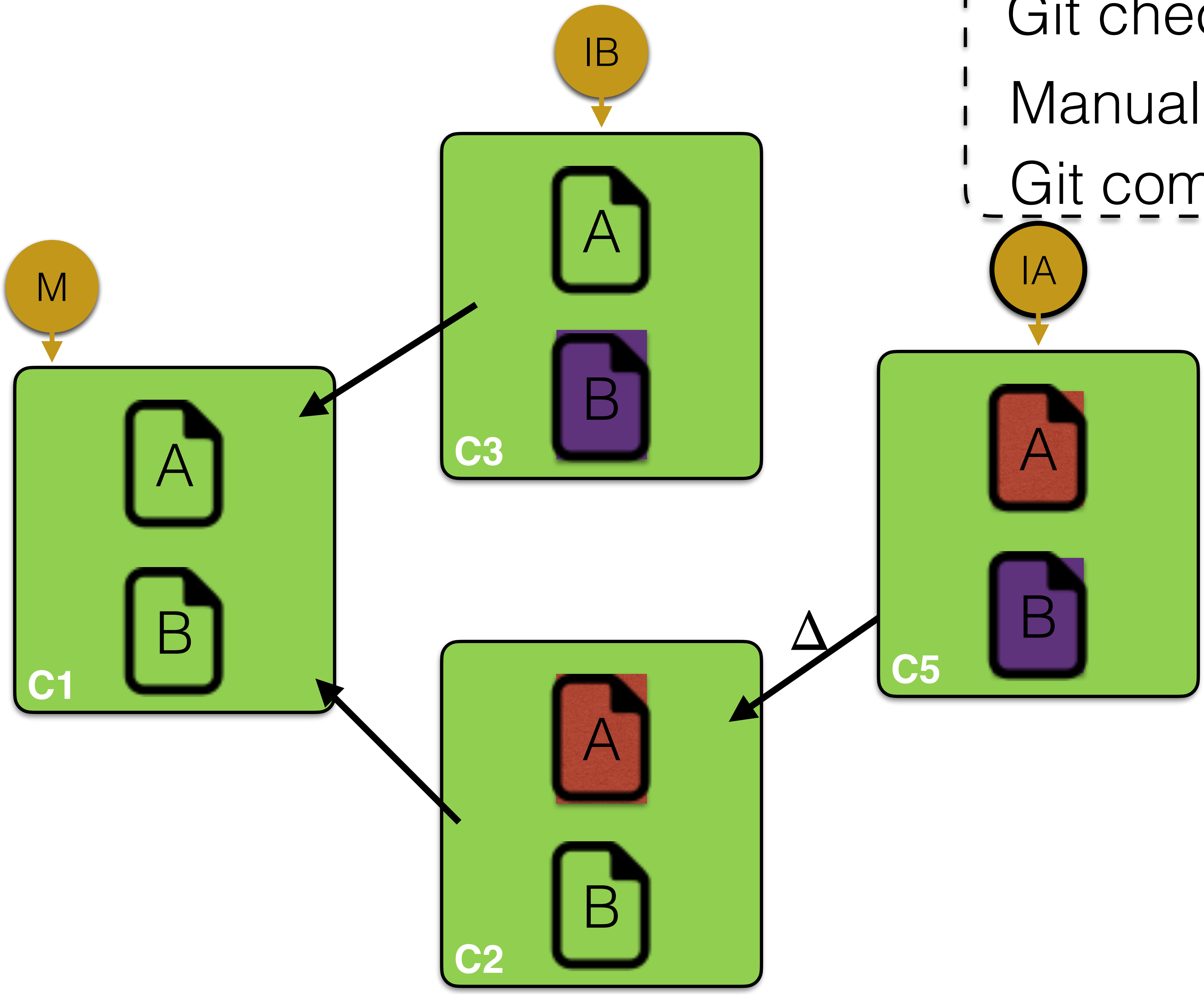


Keep history clean: Rebase

Git checkout IA

Manual change of B

Git commit

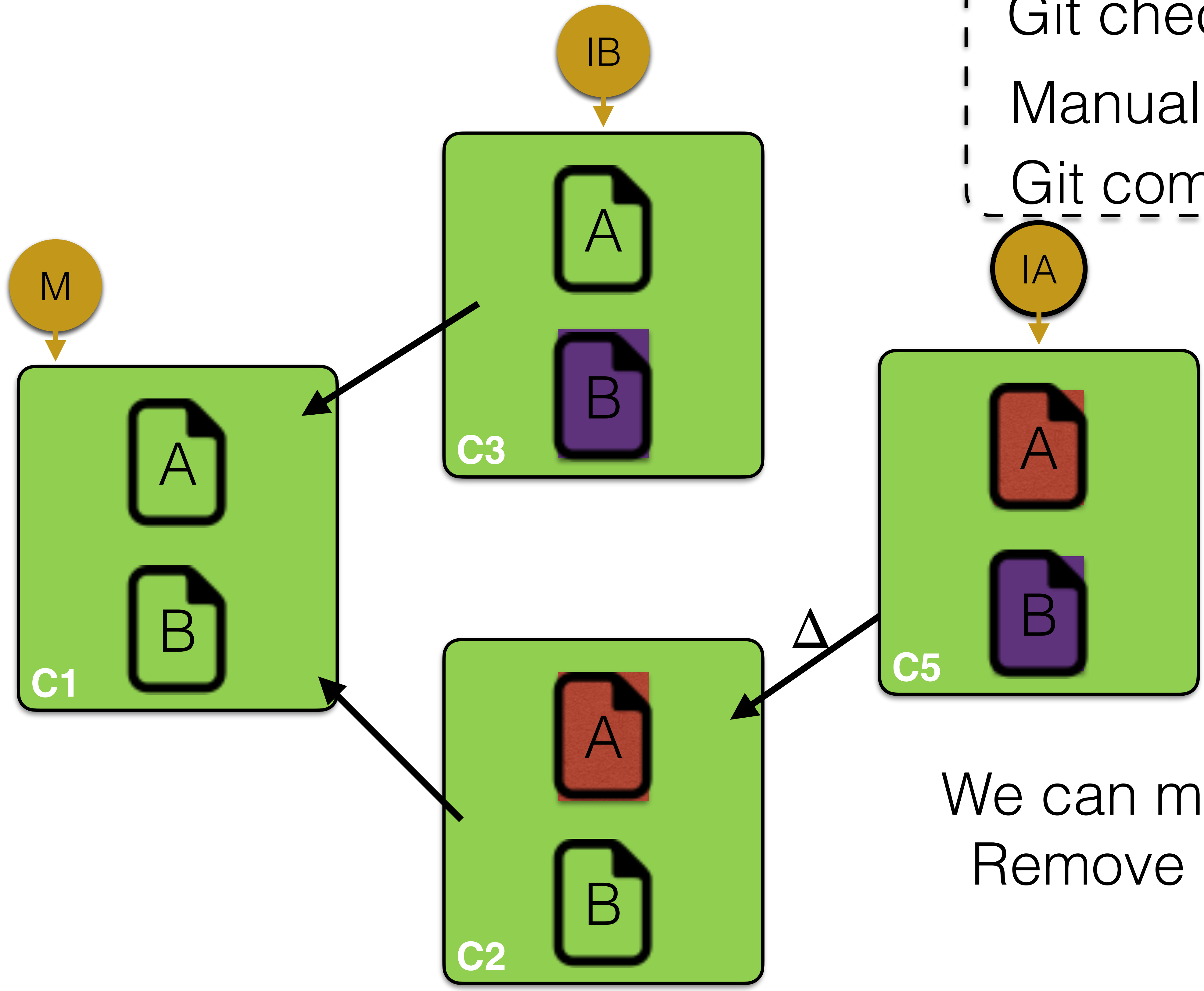


Keep history clean: Rebase

Git checkout IA

Manual change of B

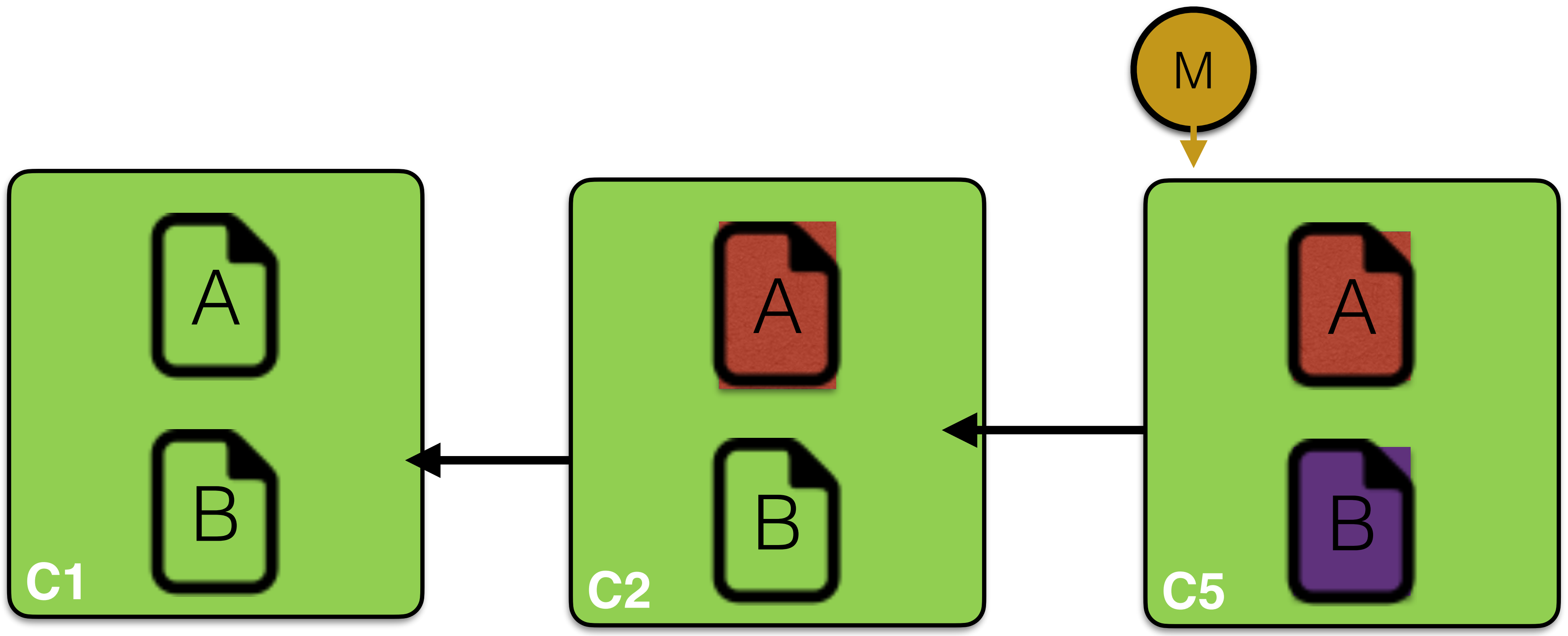
Git commit



We can merge M (ff)
Remove IB and IA

Keep history clean: Rebase

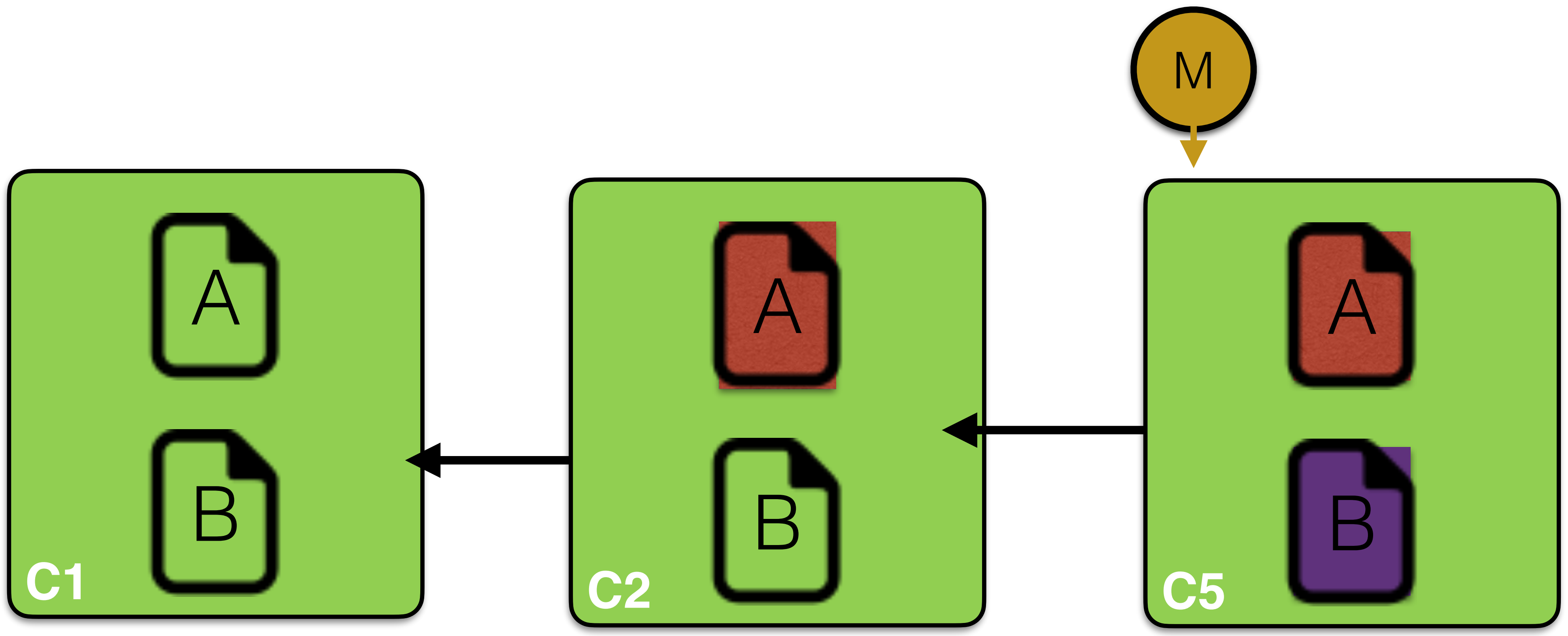
```
Git checkout IA
Manual change of B
Git commit
Git checkout M
Git merge IA
Git branch -D IA IB
```



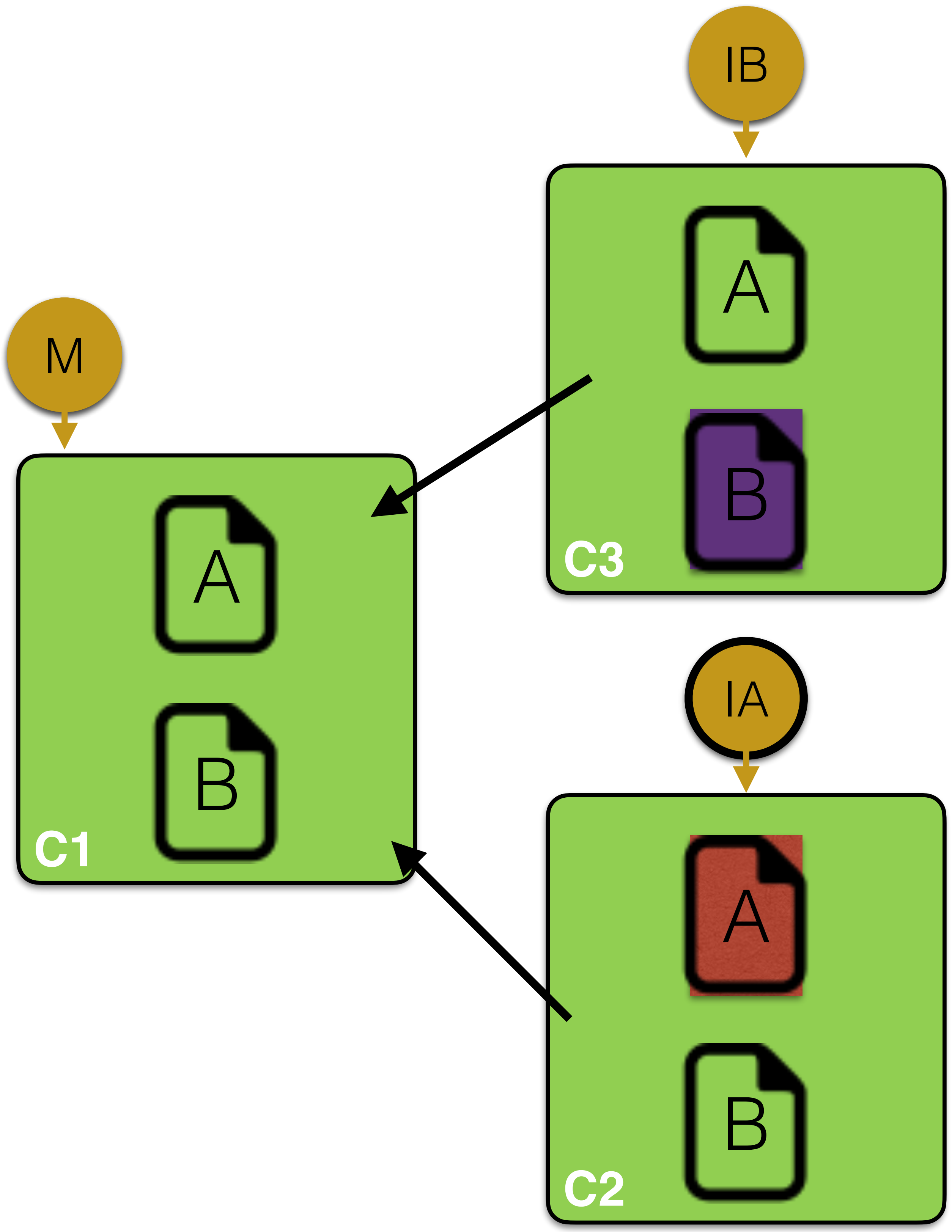
Keep history clean: Rebase

This is **not easy** to do
-> let automate that
-> "rebase"

```
Git checkout IA
Manual change of B
Git commit
Git checkout M
Git merge IA
Git branch -D IA IB
```

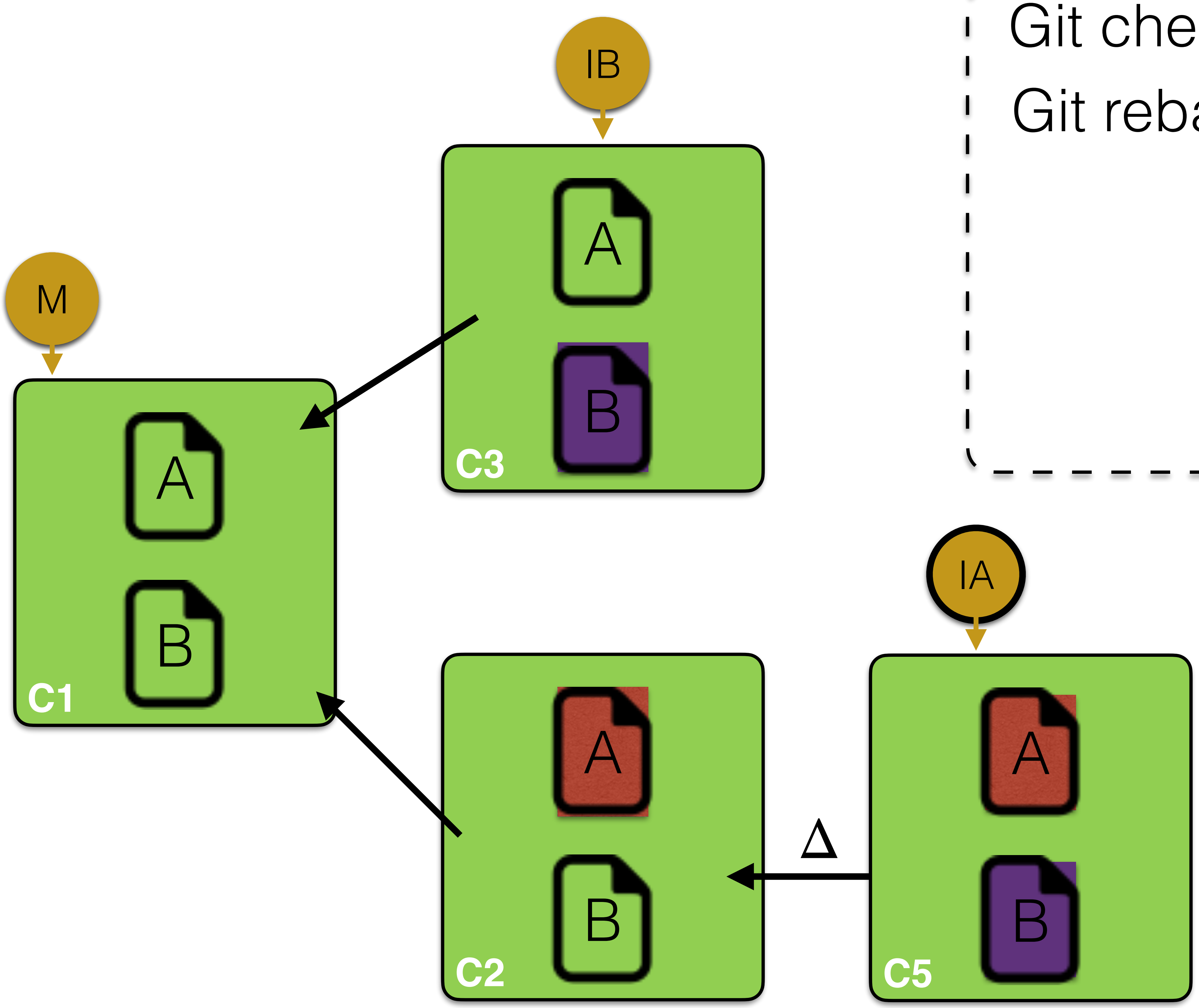


Keep history clean: Rebase



Git checkout IA

Keep history clean: Rebase



Git checkout IA

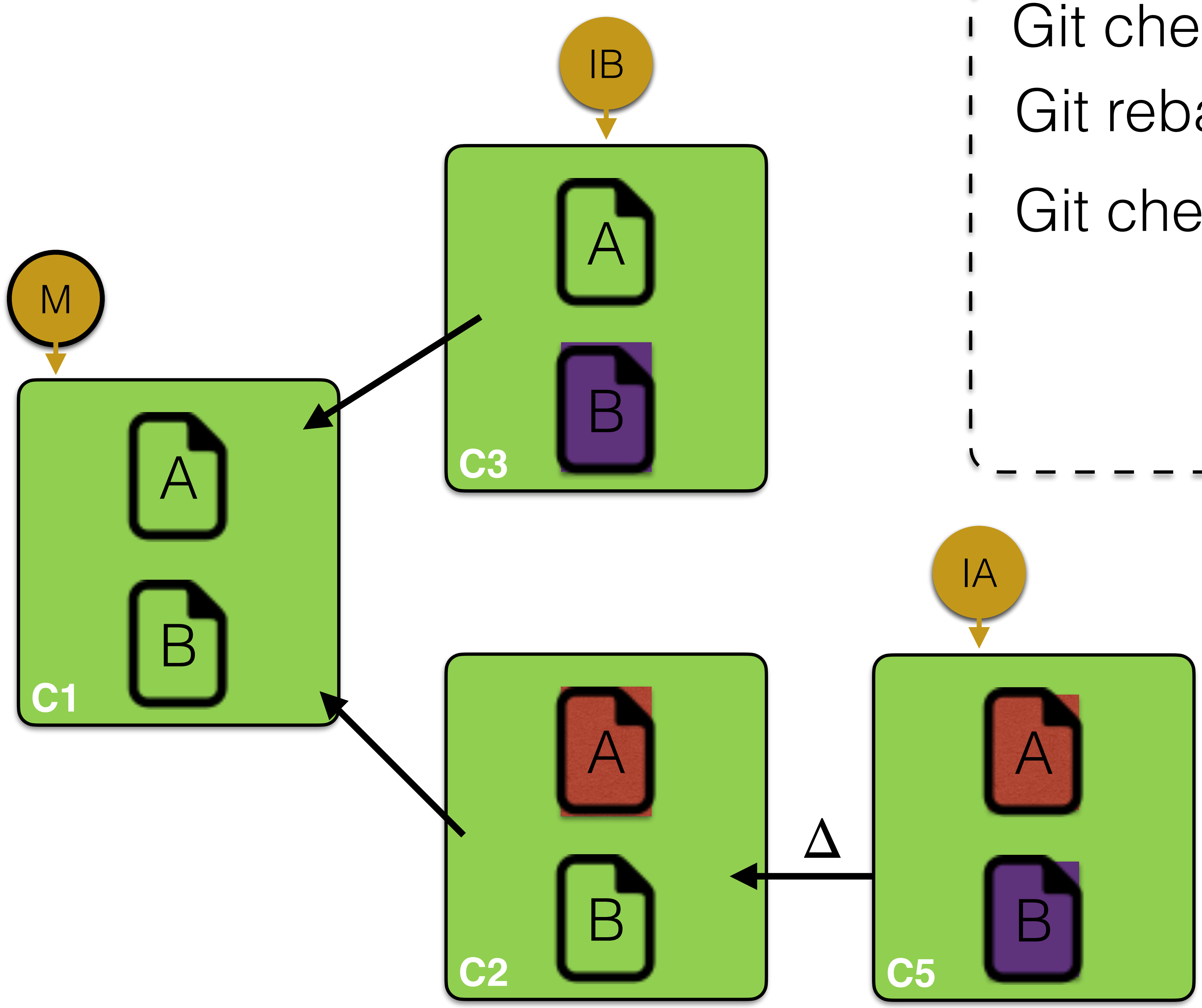
Git rebase IB

Keep history clean: Rebase

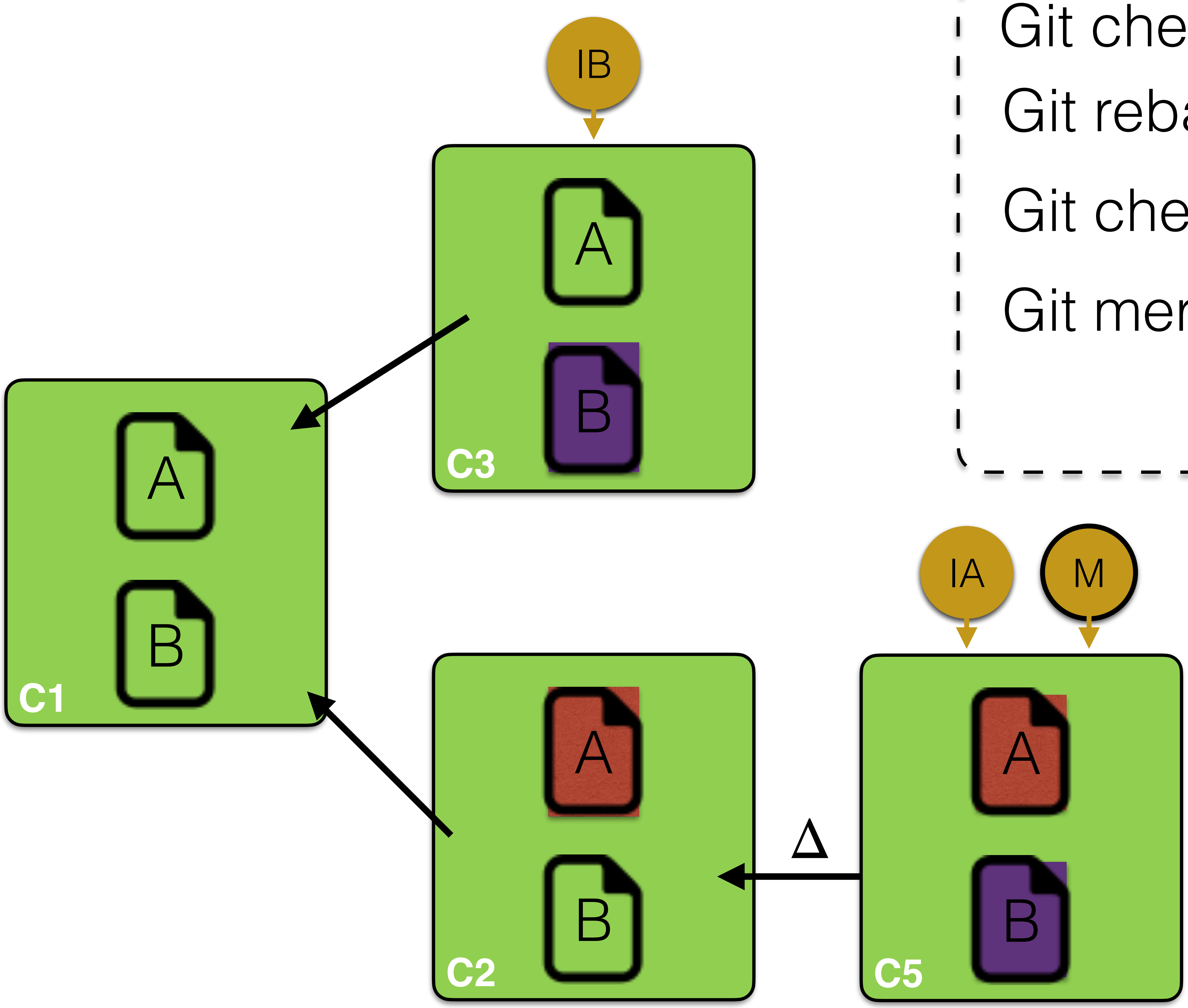
Git checkout IA

Git rebase IB

Git checkout M



Keep history clean: Rebase



Git checkout IA

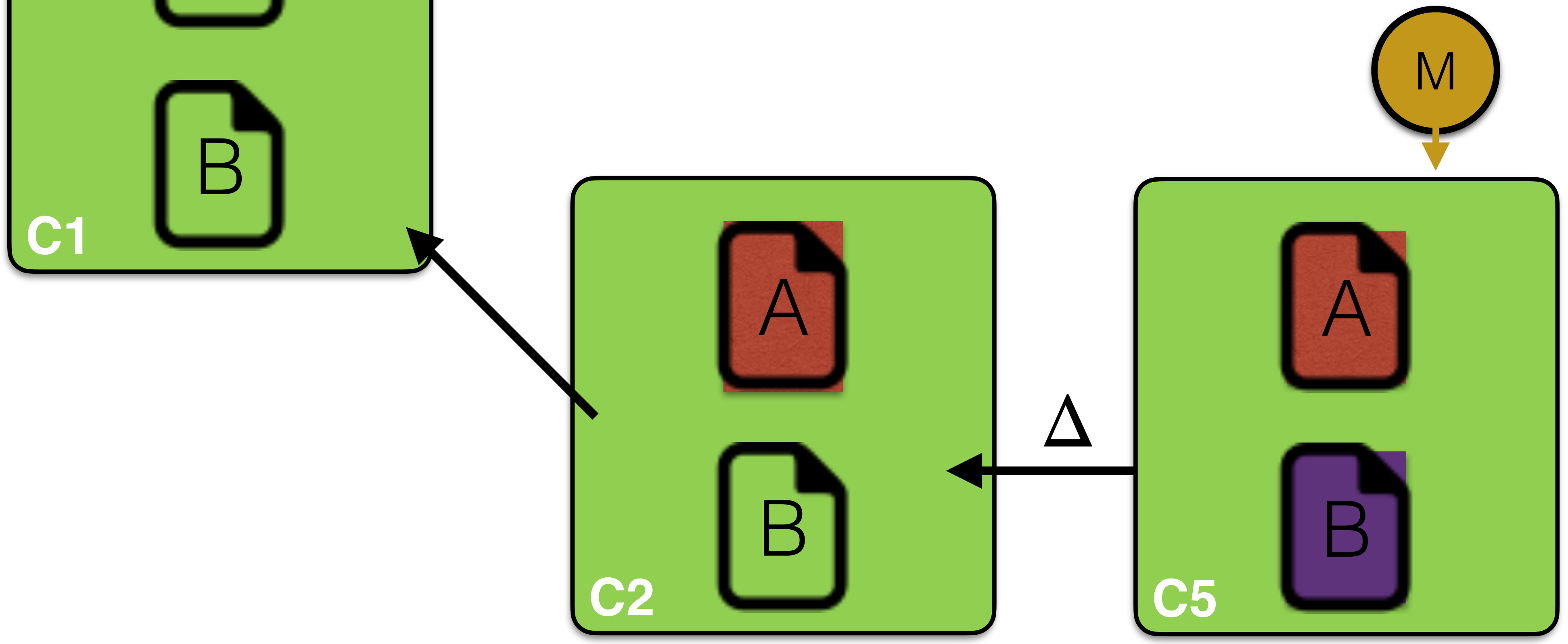
Git rebase IB

Git checkout M

Git merge IA

Keep history clean: Rebase

```
Git checkout IA
Git rebase  IB
Git checkout M
Git merge IA
Git branch -D IA IB
```



History

- Changing your history can create a lot of conflict with your collaborator!
- Keep it simple, secure and local
- Rebase has many additional features:
  - Split and or merge (squash) commit
  - Change commit message
  - Delete some commit / …
- Remember reflog in case of issue

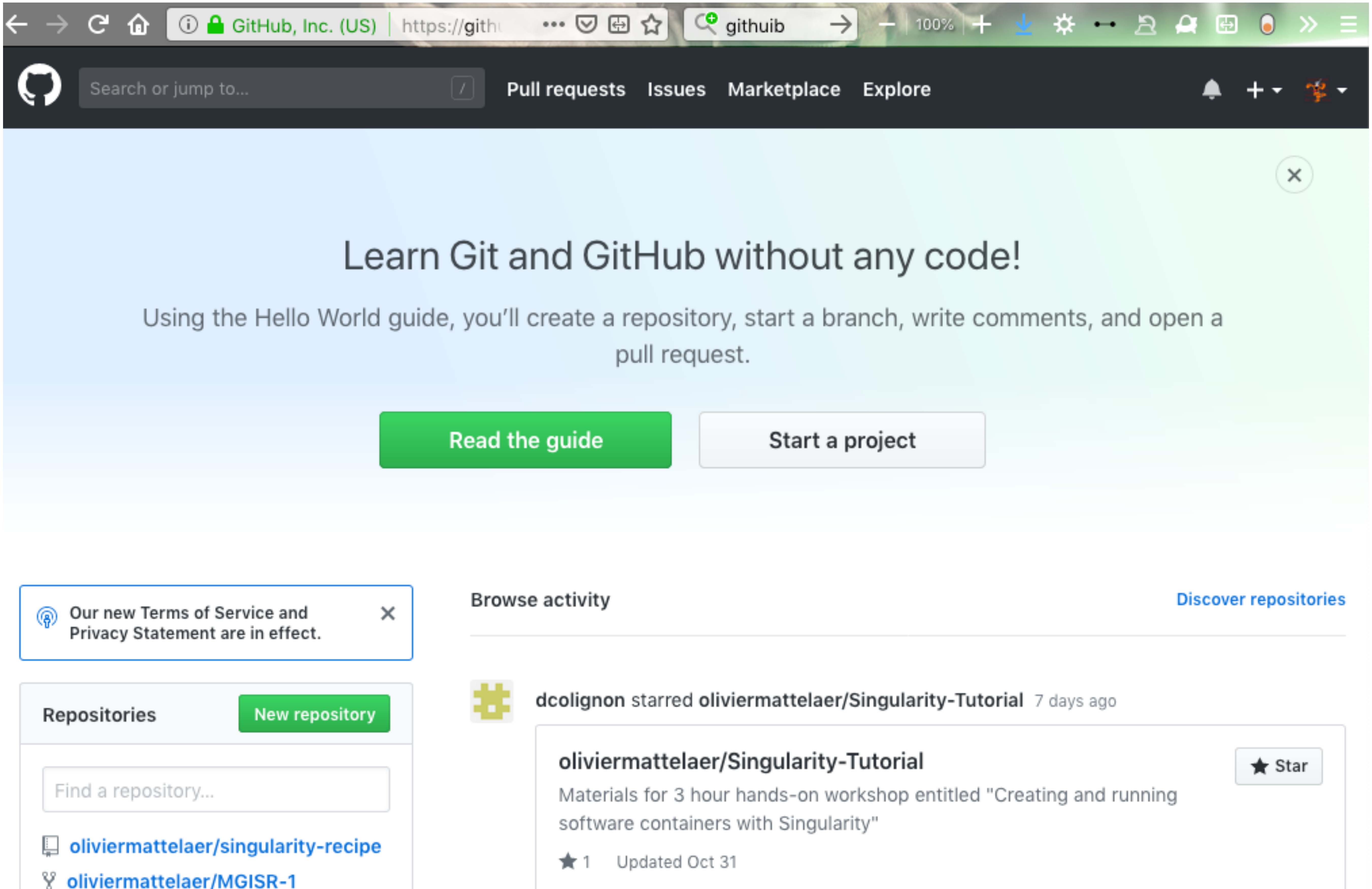
Nice video about history modification:
https://www.youtube.com/watch?v=EIRzTuYIn0M

Do it yourself

- Change a file in a wrong branch and use stash to change it from one branch to the next one

Team Work

GitHub/Gitlab



Learn Git and GitHub without any code!

Using the Hello World guide, you'll create a repository, start a branch, write comments, and open a pull request.

Our new Terms of Service and Privacy Statement are in effect.

oliviermattelaer/singularity-recipe

oliviermattelaer/MGISR-1

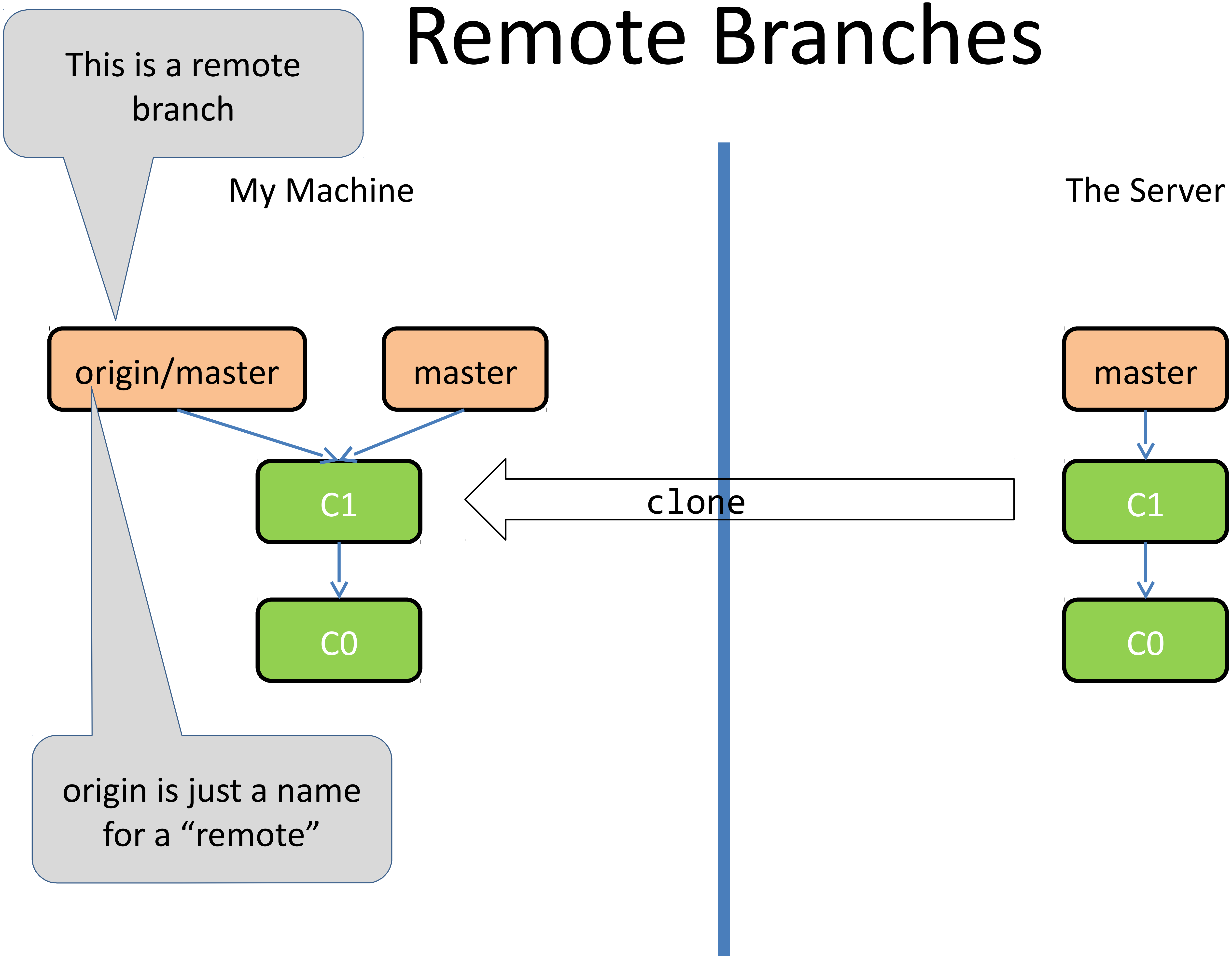
dcolignon starred oliviermattelaer/Singularity-Tutorial 7 days ago

oliviermattelaer/Singularity-Tutorial

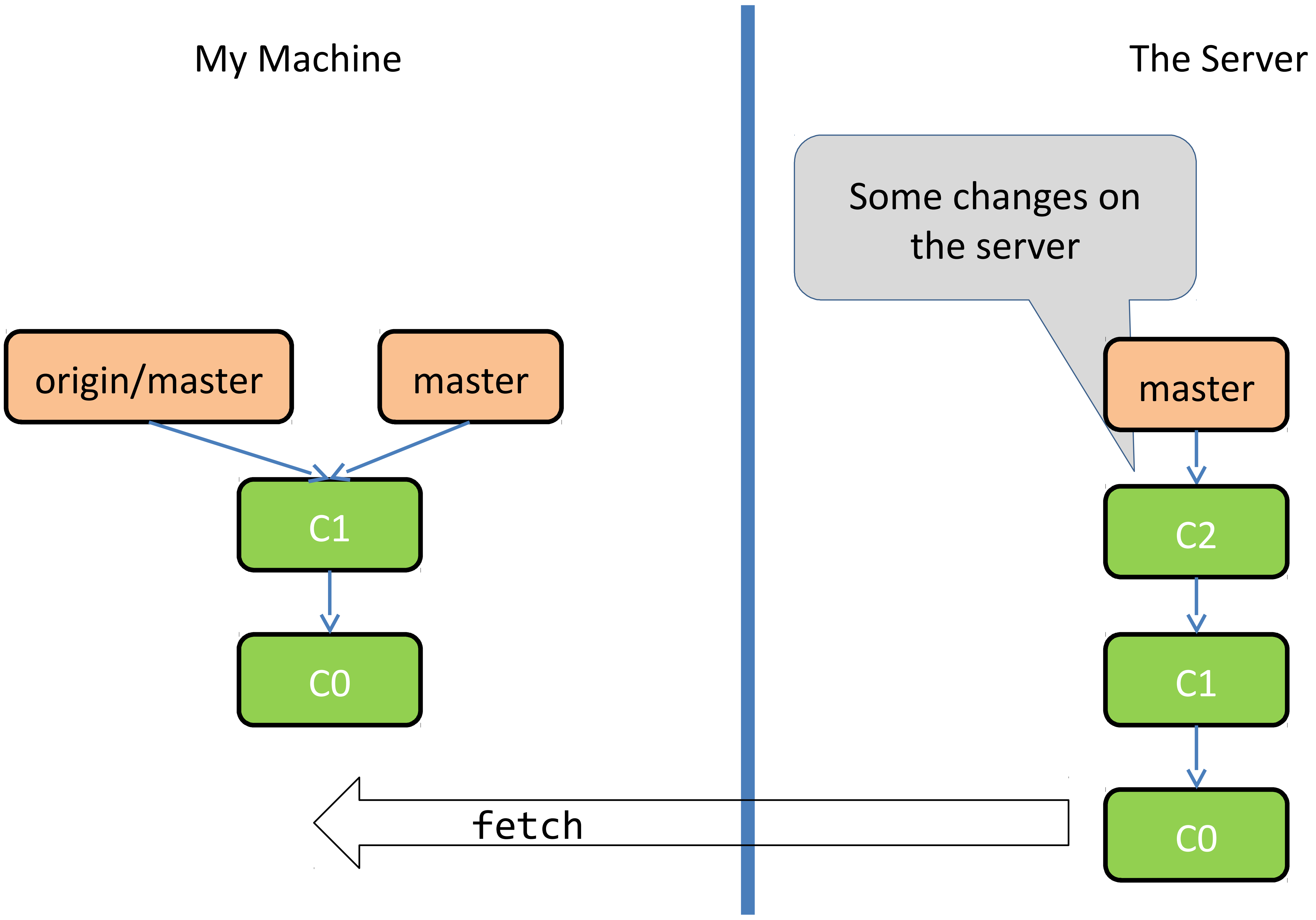
Materials for 3 hour hands-on workshop entitled "Creating and running software containers with Singularity"

★ 1 Updated Oct 31

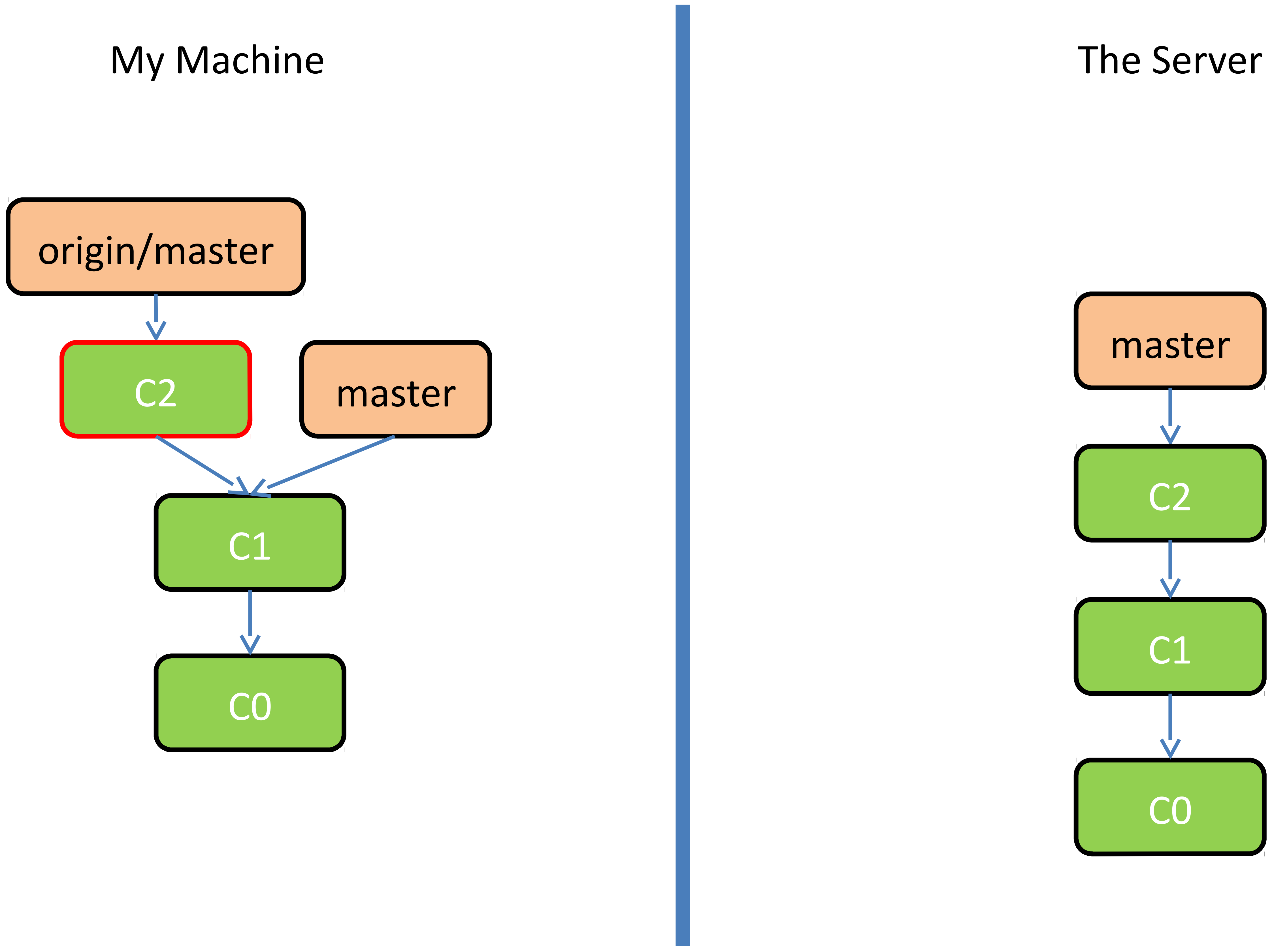
Remote Branches



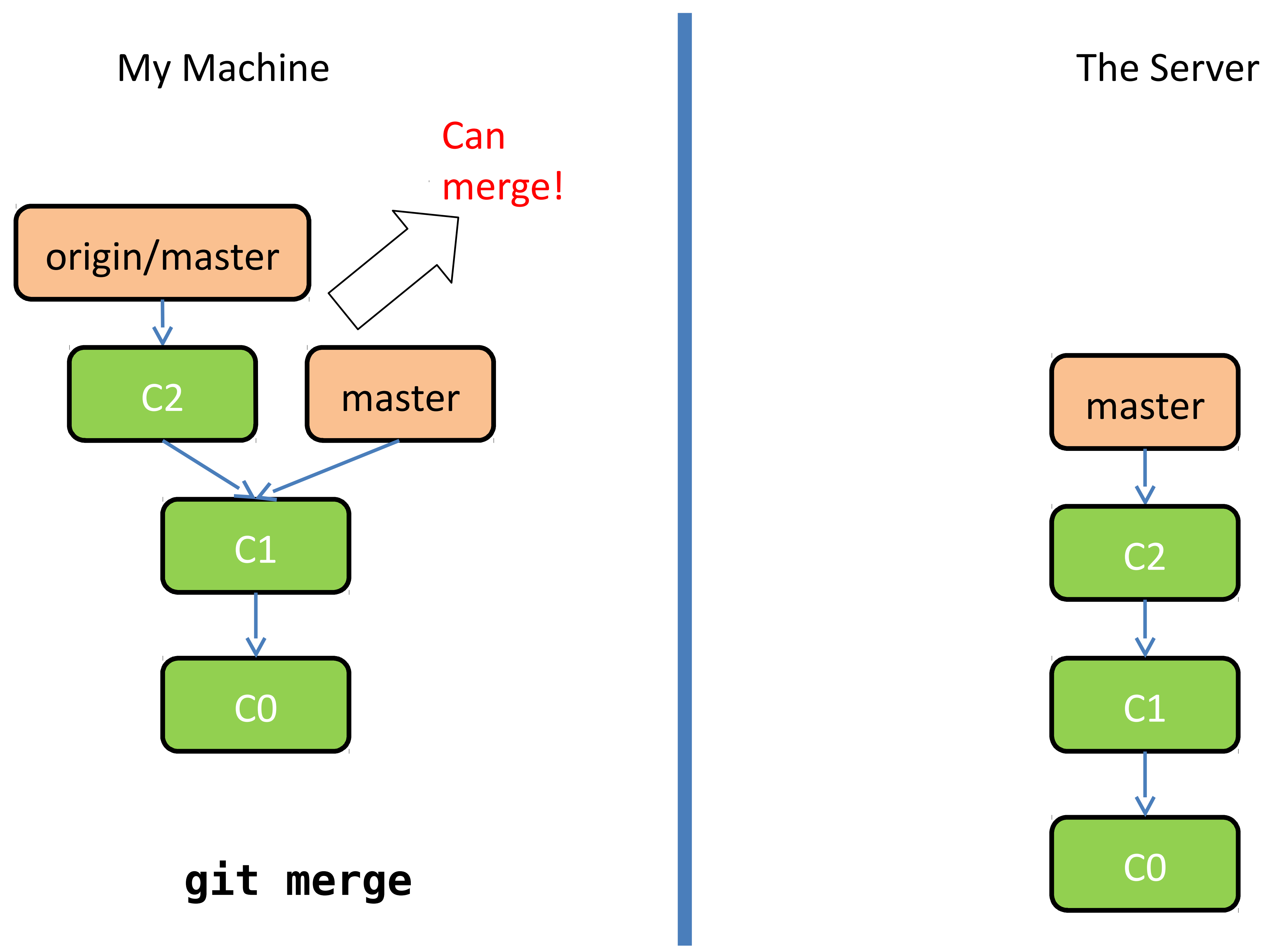
Remote Branches - fetch



Remote Branches - fetch

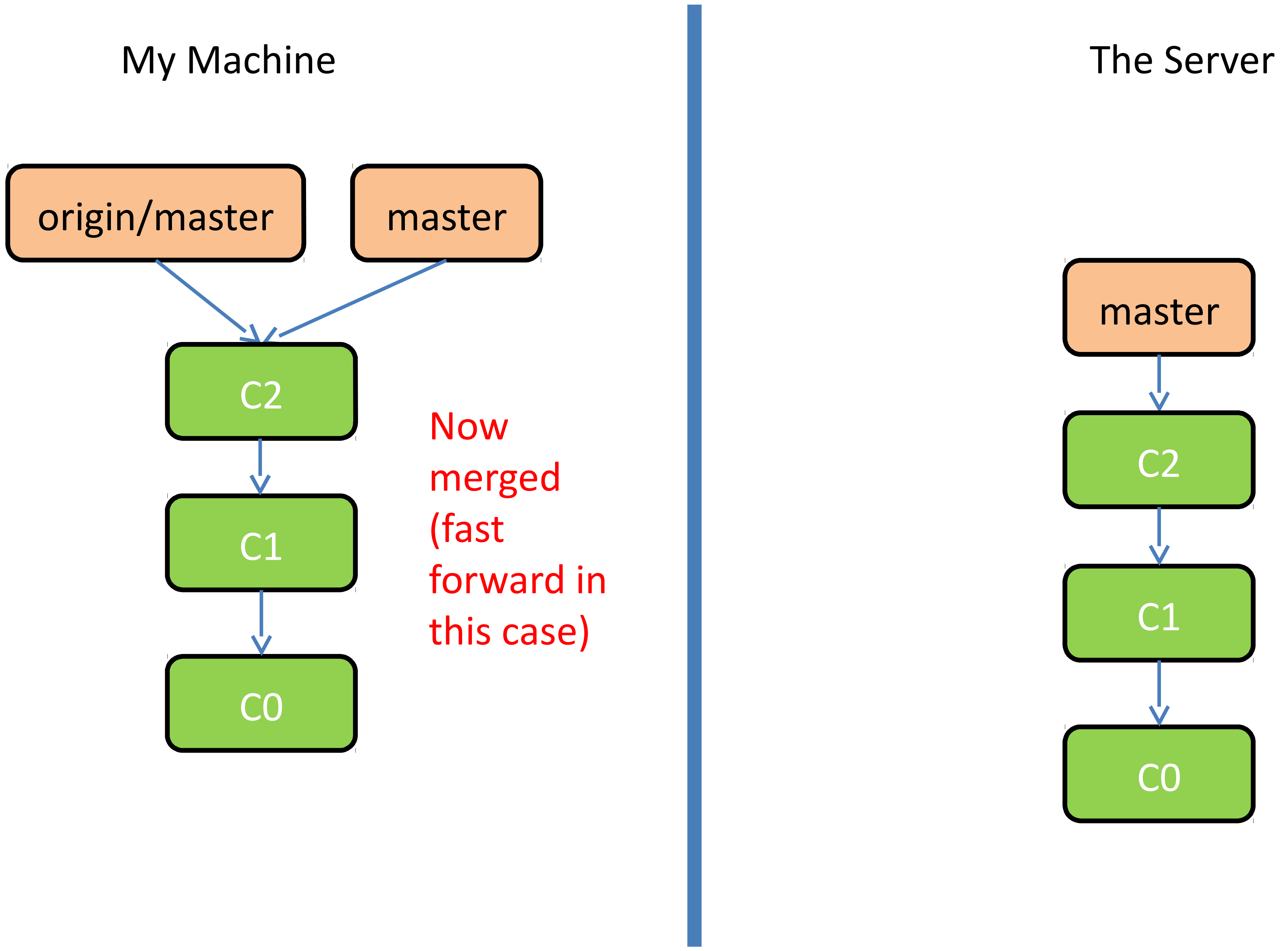


Remote Branches - fetch

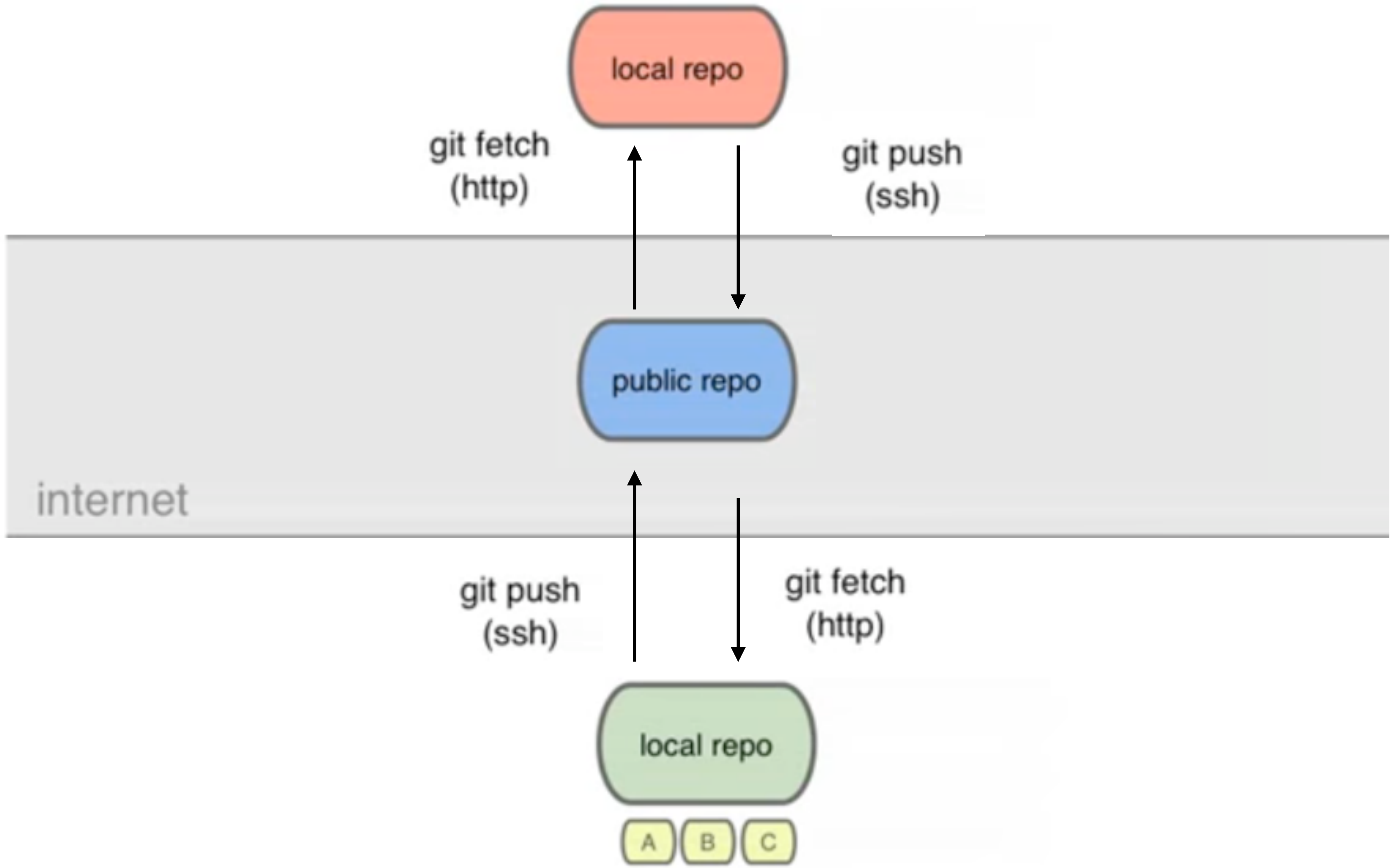


```
git merge
```

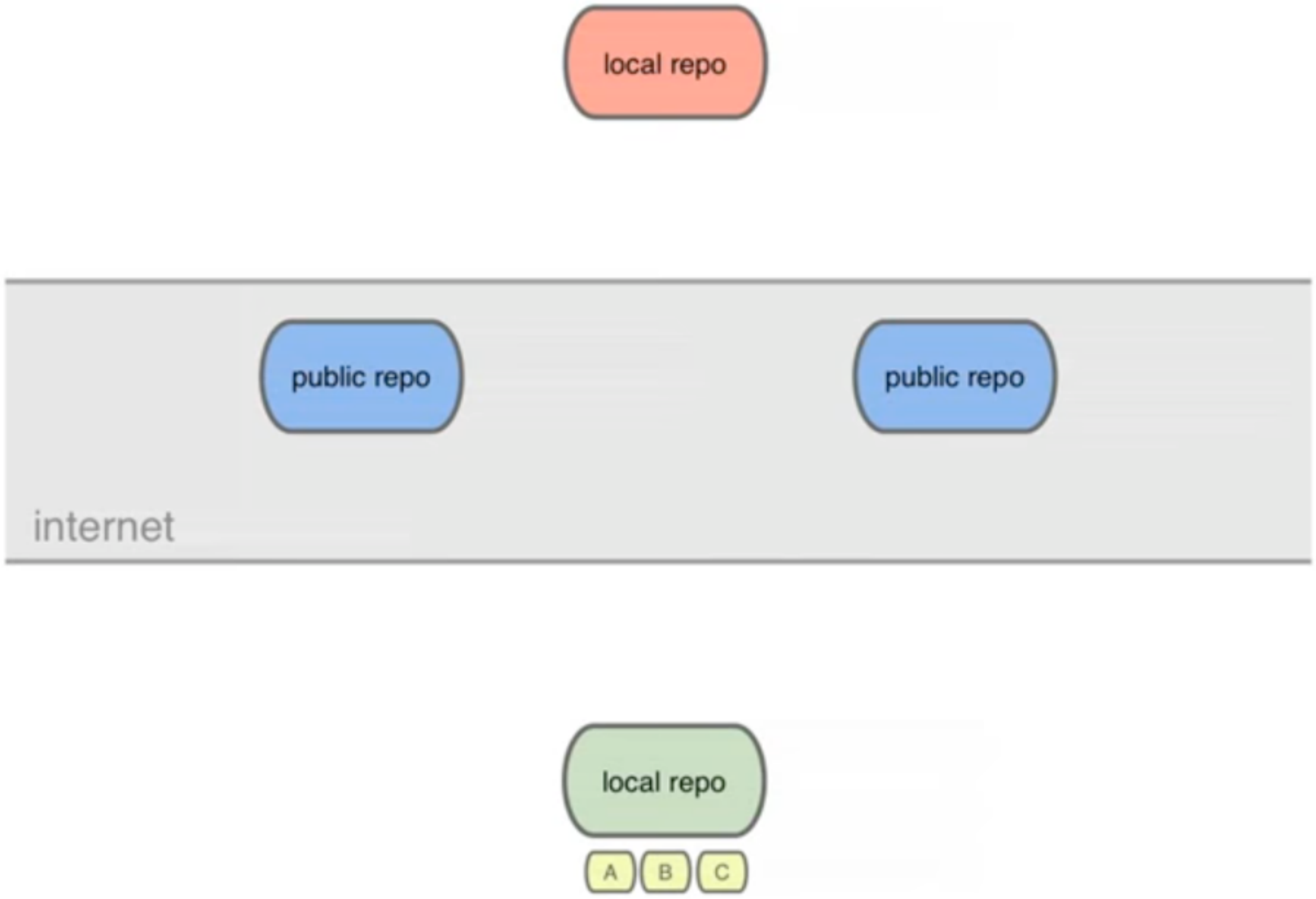
Remote Branches - fetch



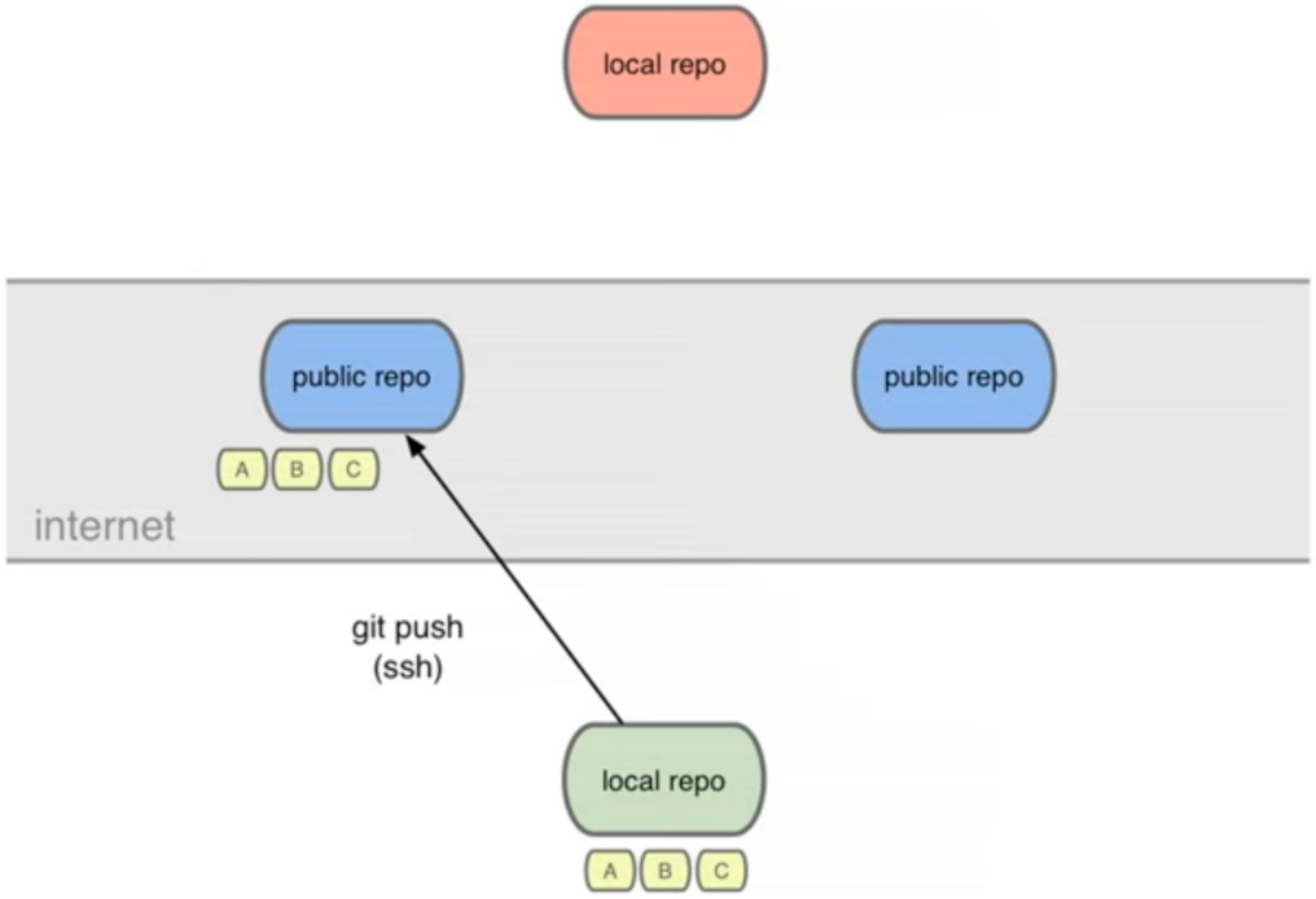
Collaboration



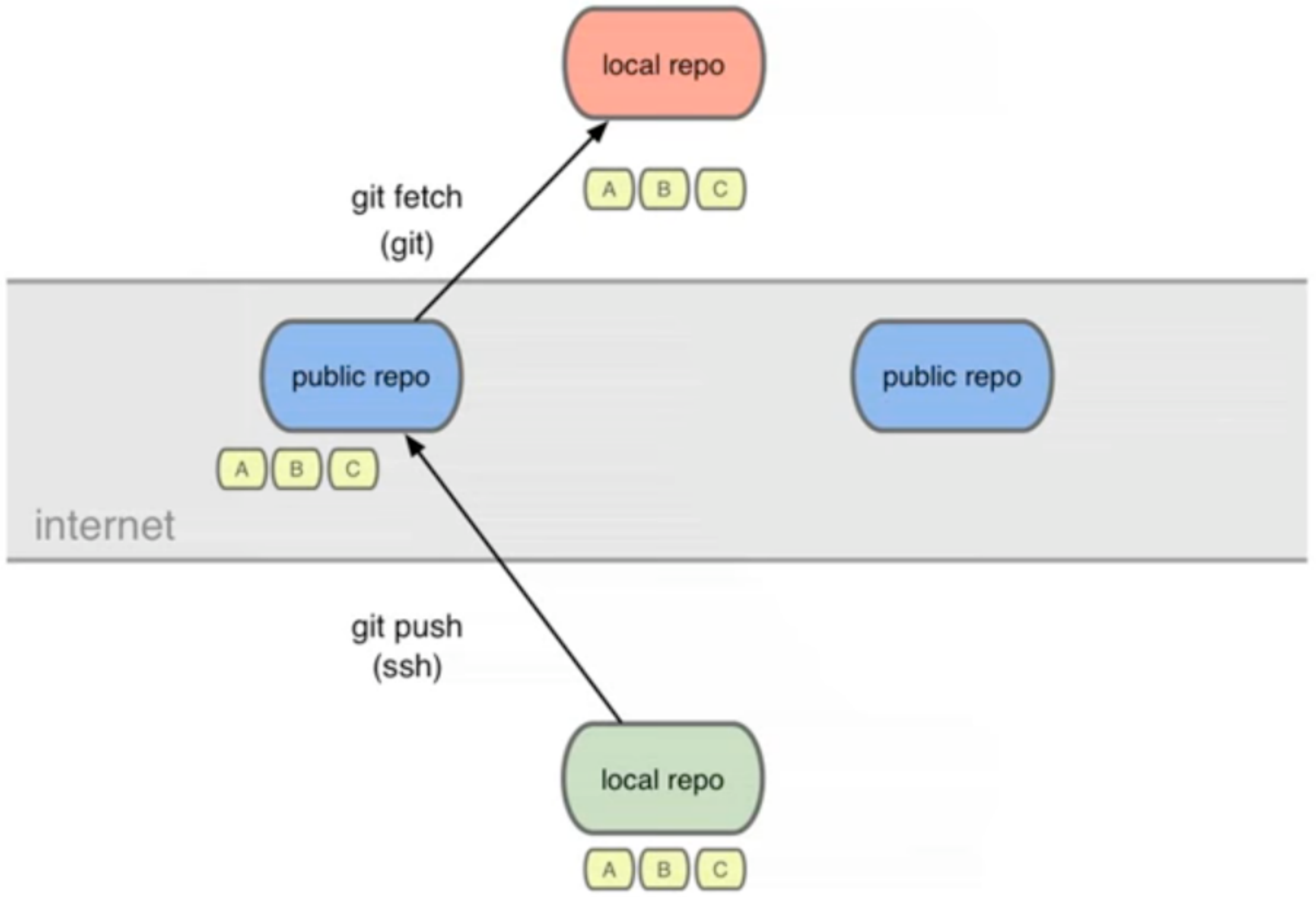
Collaboration



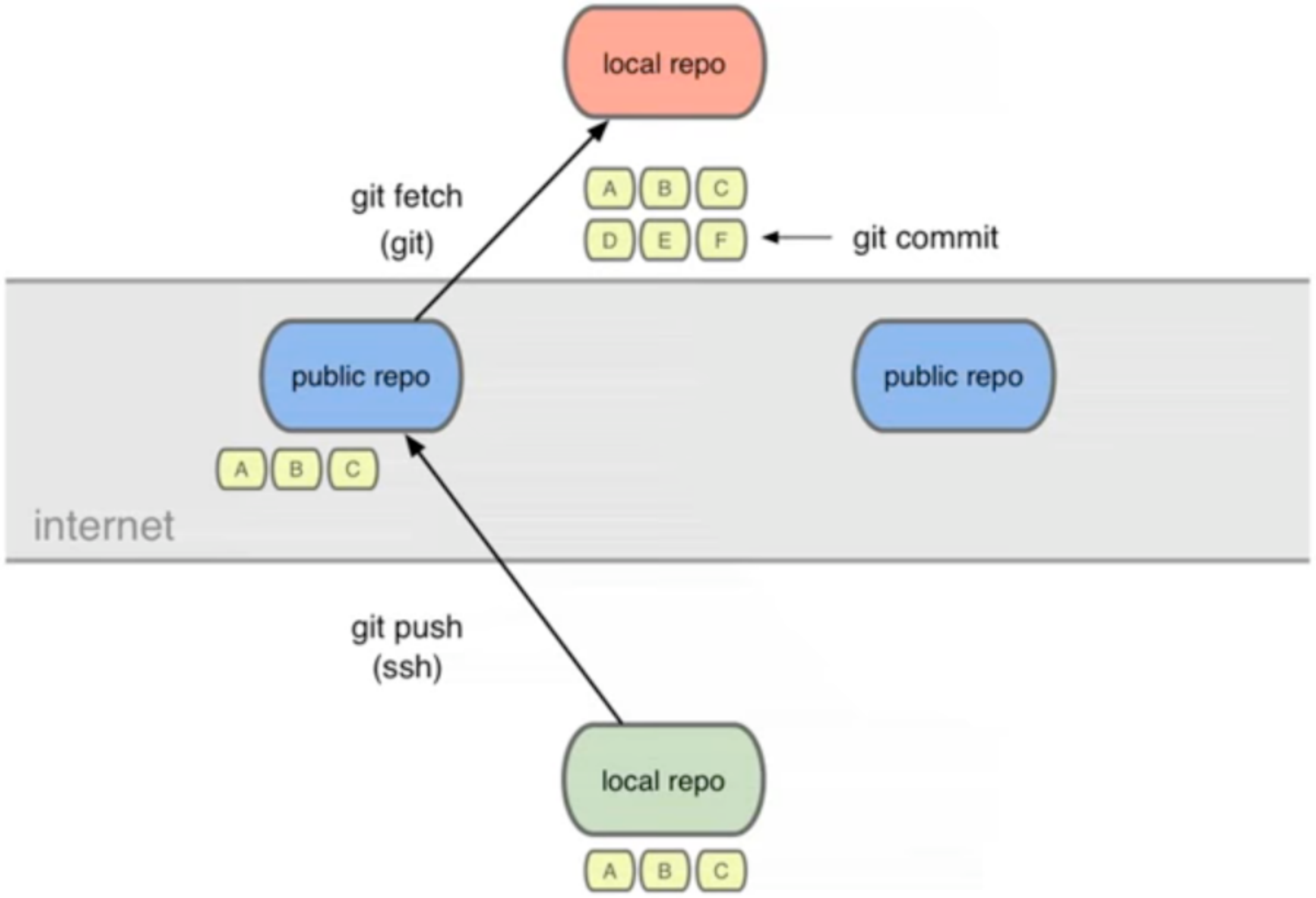
Collaboration



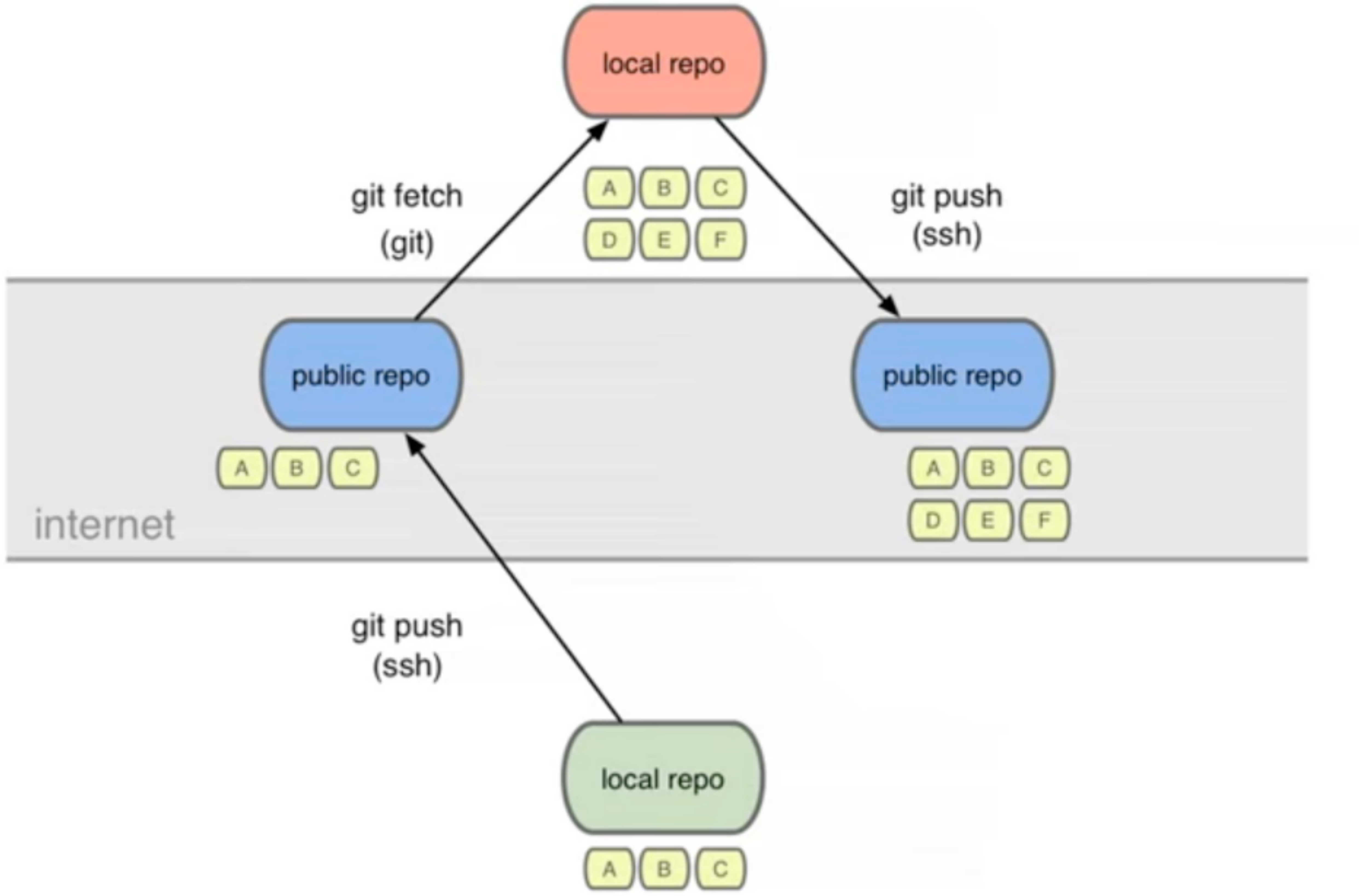
Collaboration



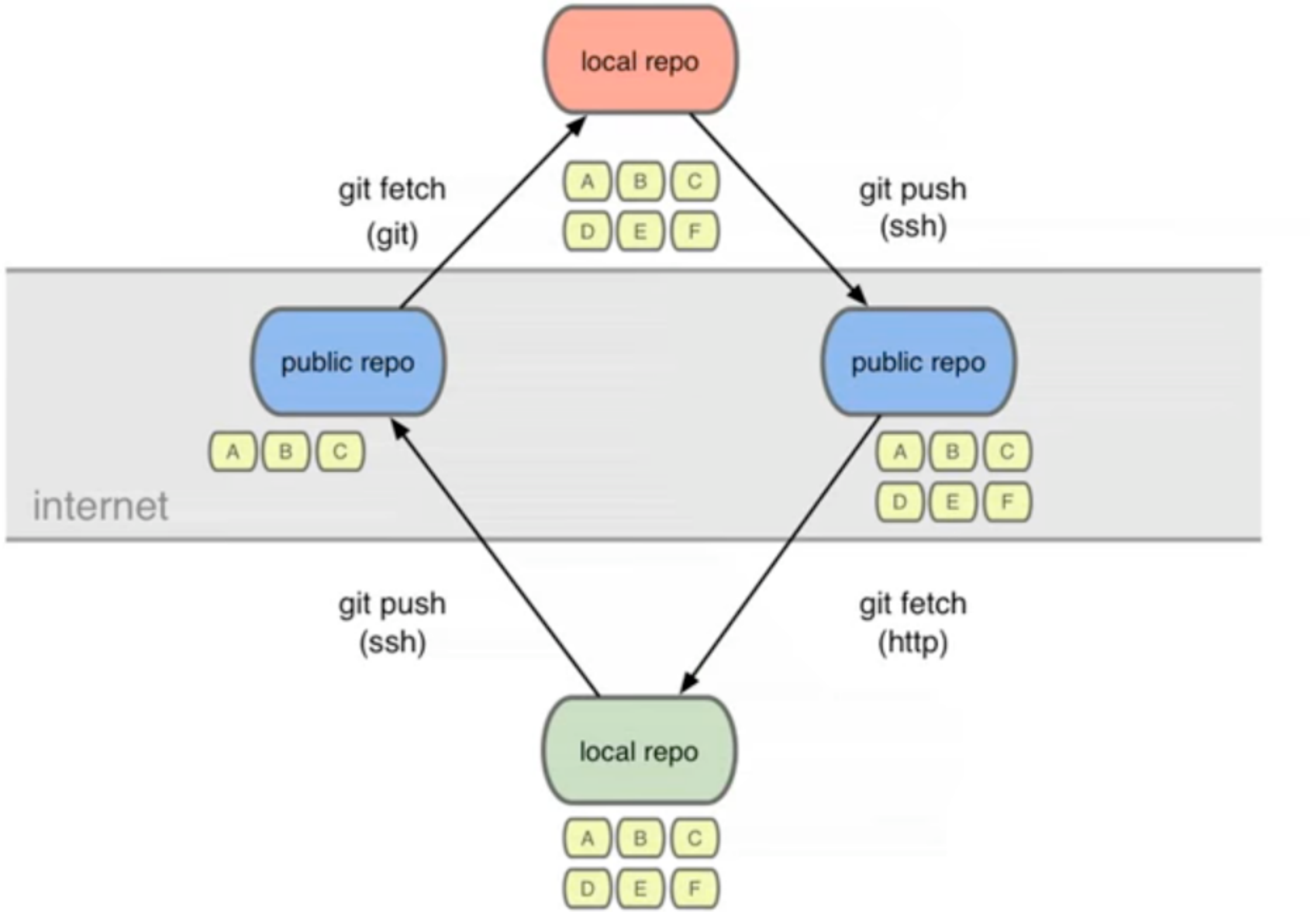
Collaboration



Collaboration



Collaboration



Remote Branches

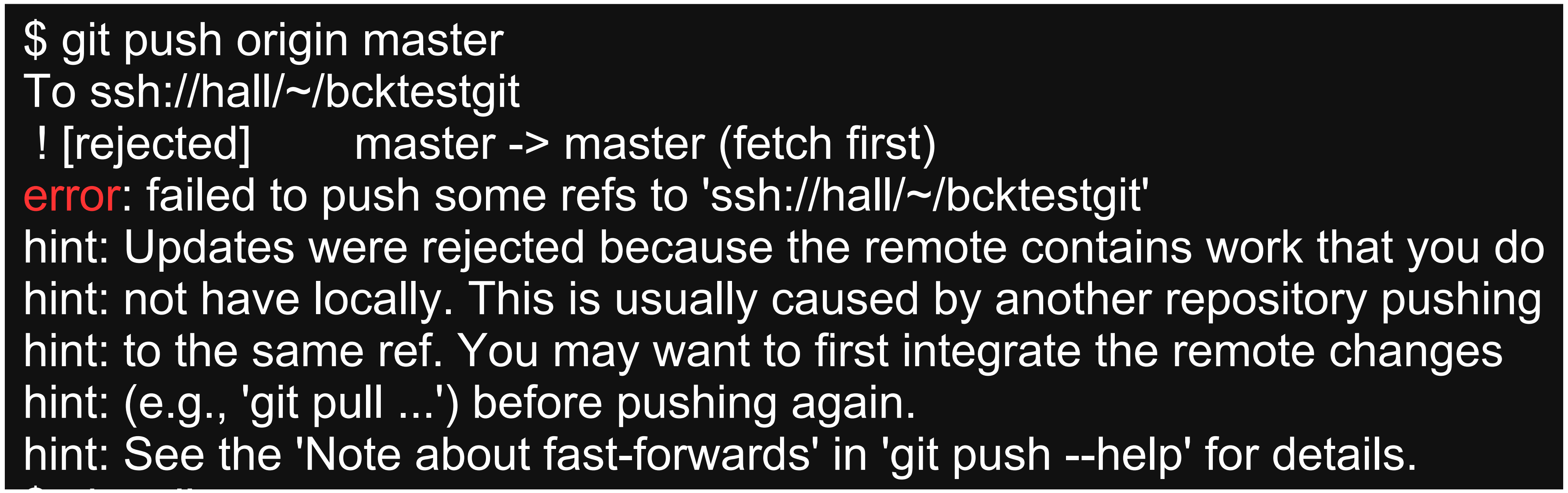
- Reminder - Remote branches represent a branch on a remote repository
- The branch origin/master for example is a local pointer to the “master” on “origin”
- It reflects what the **local** repository **currently knows** about the state of “master” on “origin”

Send information: push

- Will take local object which are required to make a remote branch complete and send them
- Will merge (fast-forward only) those local changes into the remote branch
- If fast-forward not possible:
  - the push will fail
  - need manual merge
    - git fetch; git merge origin/master; git add .; git commit

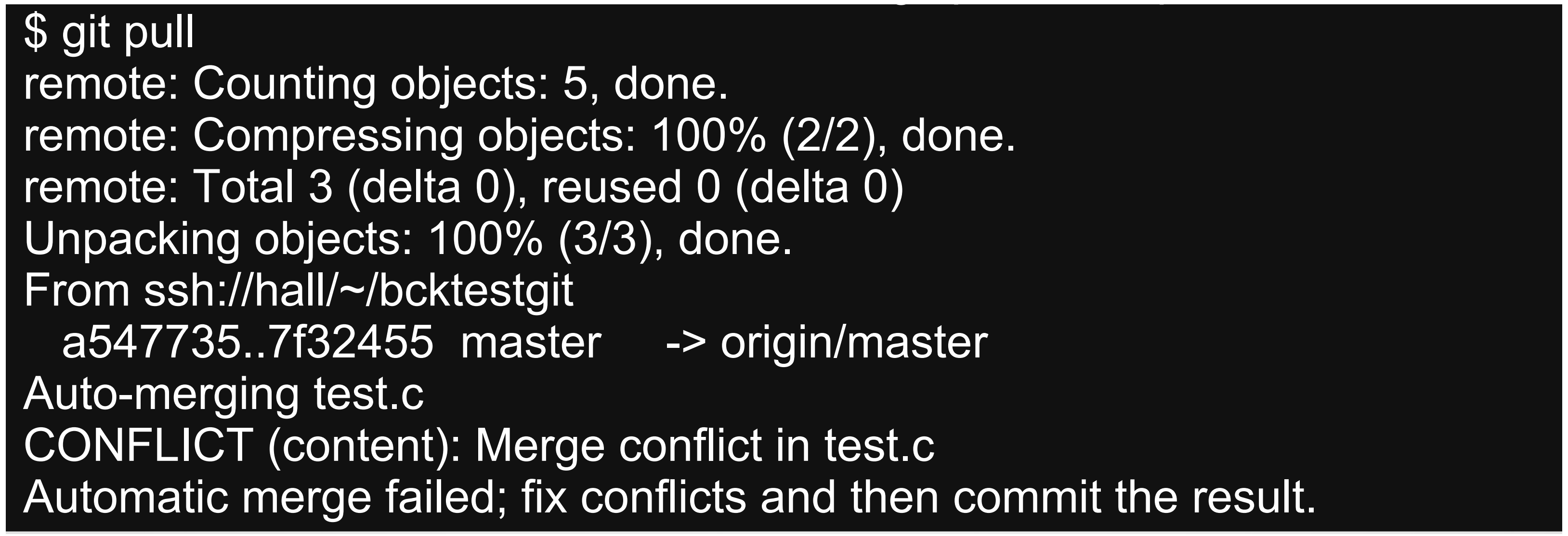
Conflict

Pushed on the server refused



```
$ git push origin master
To ssh://hall/~/bcktestgit
 ! [rejected]        master -> master (fetch first)
error: failed to push some refs to 'ssh://hall/~/bcktestgit'
hint: Updates were rejected because the remote contains work that you do
hint: not have locally. This is usually caused by another repository pushing
hint: to the same ref. You may want to first integrate the remote changes
hint: (e.g., 'git pull ...') before pushing again.
hint: See the 'Note about fast-forwards' in 'git push --help' for details.
```

1) import the change from the server



```
$ git pull
remote: Counting objects: 5, done.
remote: Compressing objects: 100% (2/2), done.
remote: Total 3 (delta 0), reused 0 (delta 0)
Unpacking objects: 100% (3/3), done.
From ssh://hall/~/bcktestgit
   a547735..7f32455  master     -> origin/master
Auto-merging test.c
CONFLICT (content): Merge conflict in test.c
Automatic merge failed; fix conflicts and then commit the result.
```

Some change create conflict ! Need manual resolution

Conflict

Open the file(s) with conflict and resolve them

```
$ cat test.c
<<<<<<< HEAD
line you wanted to push
=======
current version of the line on the server
>>>>>>> 7f32455dbe6bea745bc94efd6b3d5f473446d581
$ vim test.c
```

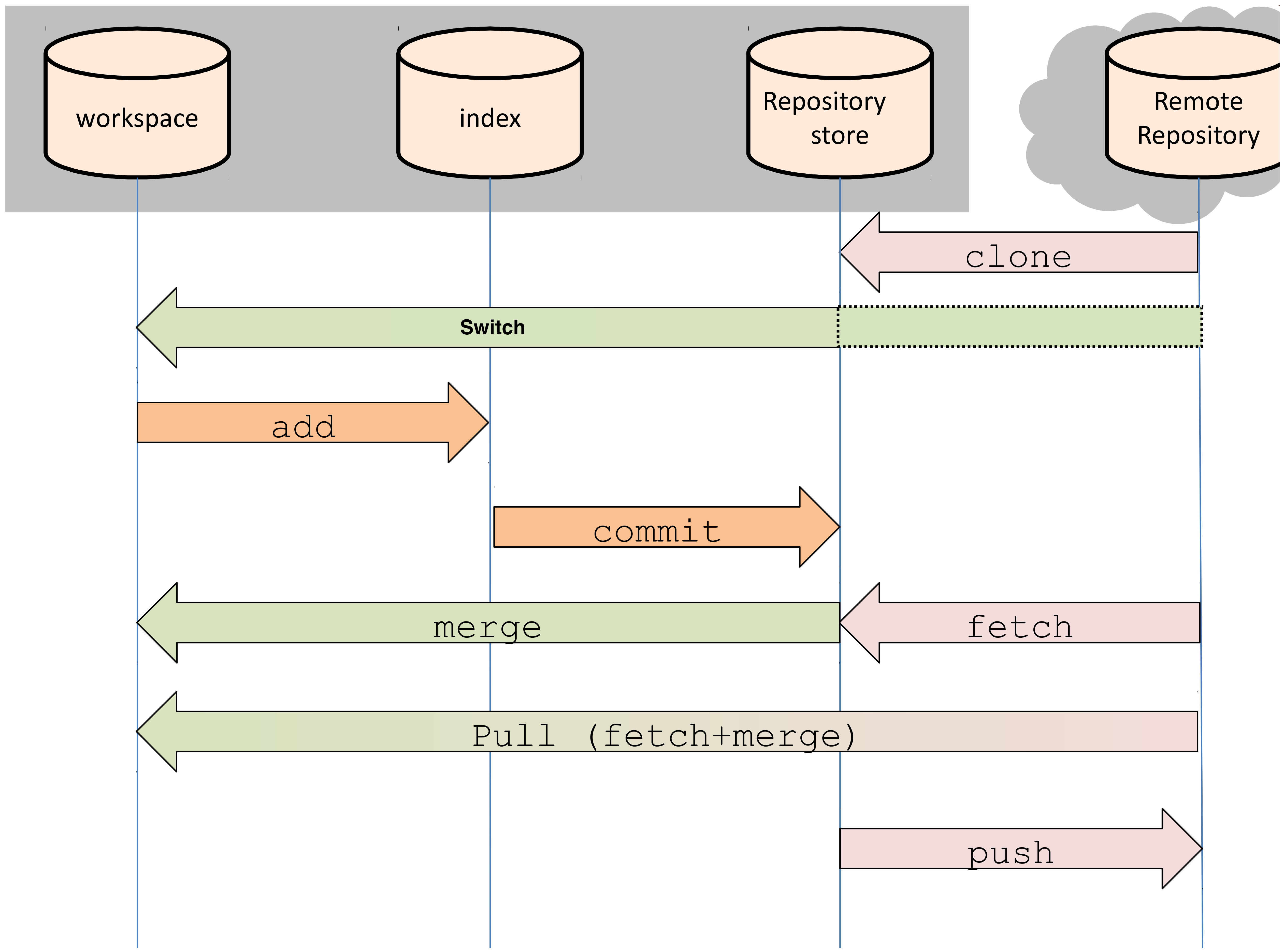
Commit your changes

```
$ git add .
$ git commit -m merge
[master 6b884f0] merge
```

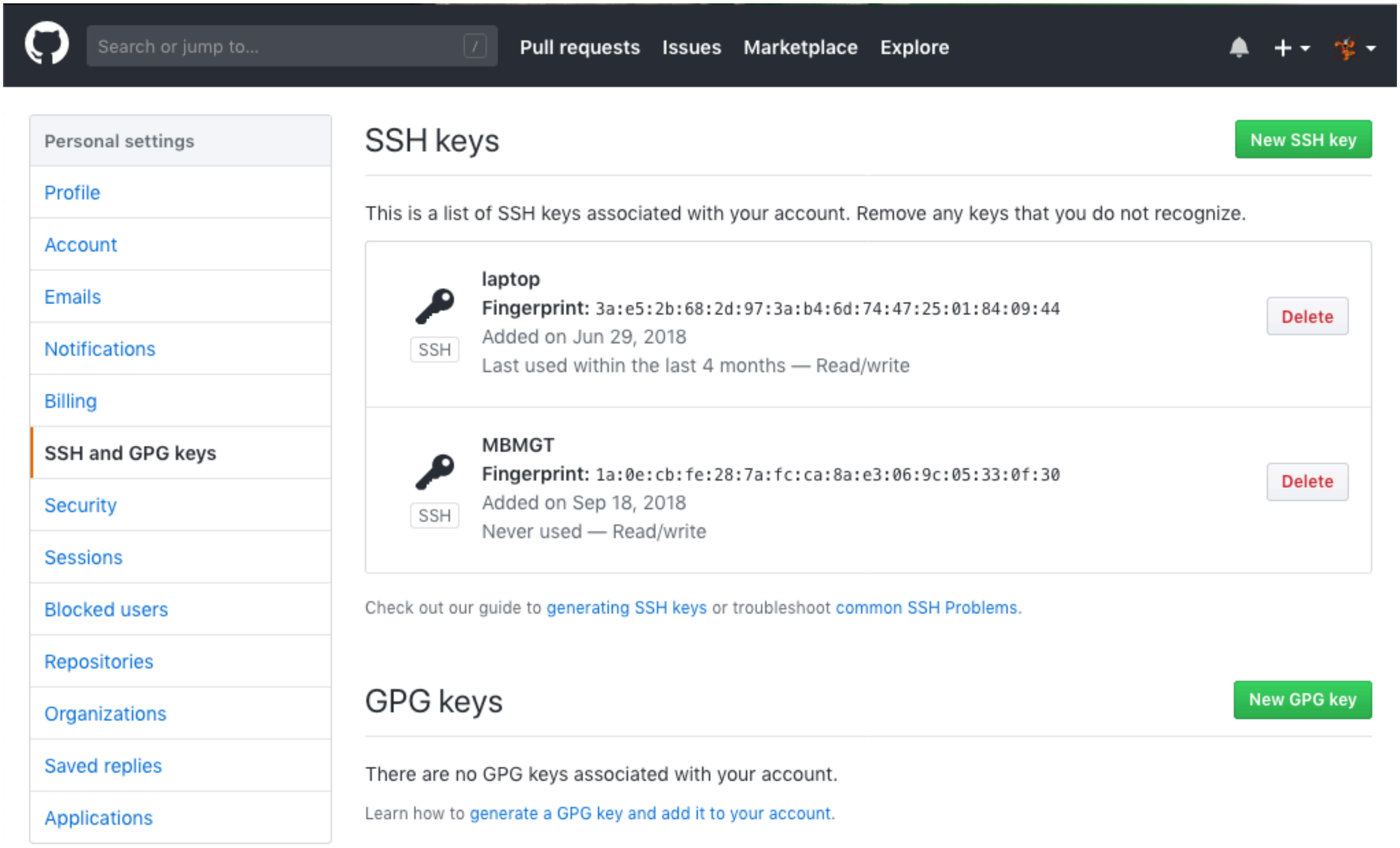
Push on the server

```
$ git push origin master
Counting objects: 6, done.
Delta compression using up to 8 threads.
Compressing objects: 100% (5/5), done.
Writing objects: 100% (6/6), 676 bytes | 0 bytes/s, done.
Total 6 (delta 0), reused 0 (delta 0)
To ssh://hall/~/bcktestgit
   7f32455..6b884f0  master -> master
```

Summary of operations



Add your ssh keys!



Personal settings

- Profile
- Account
- Emails
- Notifications
- Billing
- SSH and GPG keys
- Security
- Sessions
- Blocked users
- Repositories
- Organizations
- Saved replies
- Applications

SSH keys

New SSH key

This is a list of SSH keys associated with your account. Remove any keys that you do not recognize.

laptop
Fingerprint: `3a:e5:2b:68:2d:97:3a:b4:6d:74:47:25:01:84:09:44`
SSH
Added on Jun 29, 2018
Last used within the last 4 months — Read/write
Delete

MBMGT
Fingerprint: `1a:0e:cb:fe:28:7a:fc:ca:8a:e3:06:9c:05:33:0f:30`
SSH
Added on Sep 18, 2018
Never used — Read/write
Delete

Check out our guide to generating SSH keys or troubleshoot common SSH Problems.

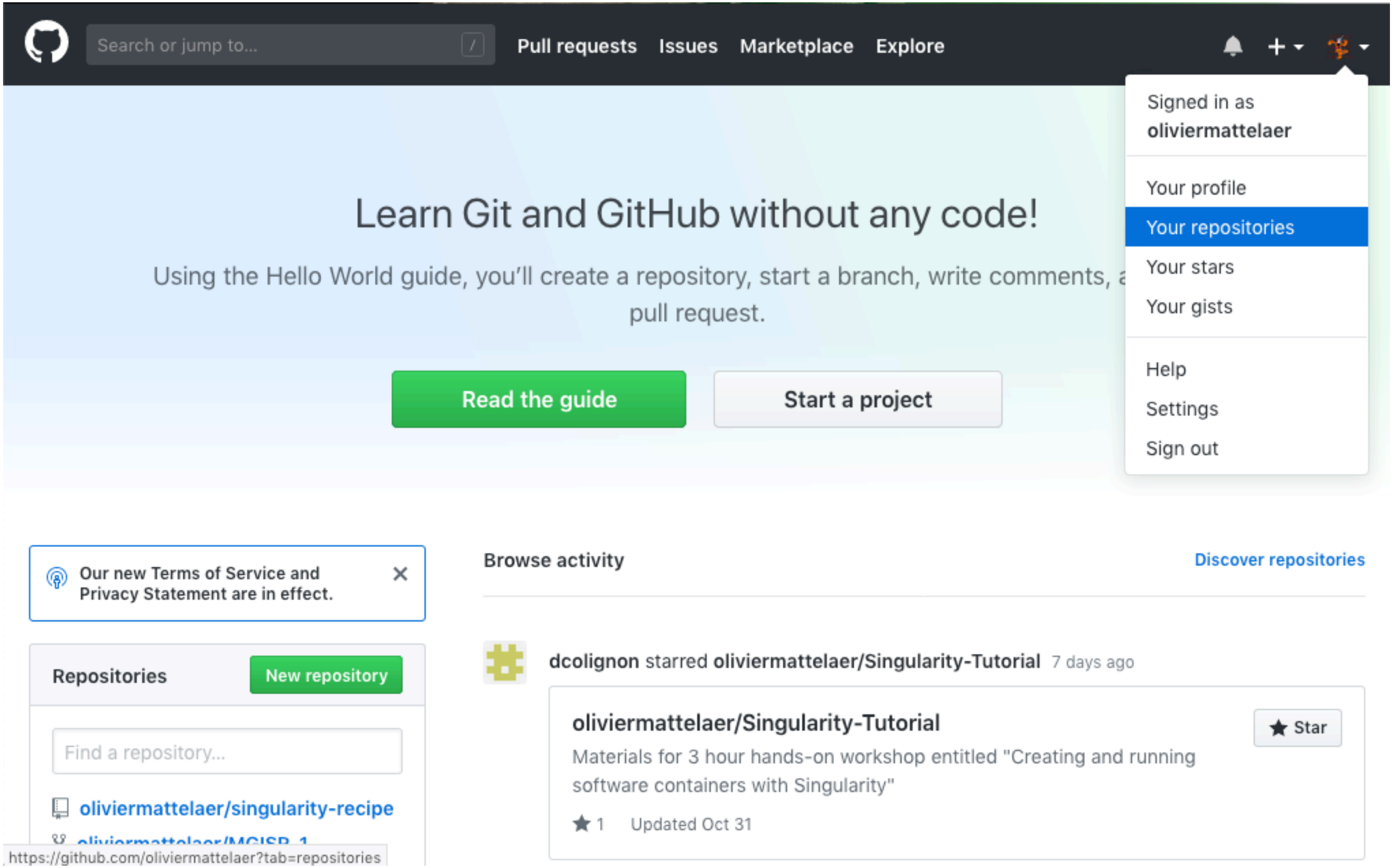
GPG keys

New GPG key

There are no GPG keys associated with your account.

Learn how to generate a GPG key and add it to your account.

Add your project in git



Search or jump to...

Pull requests Issues Marketplace Explore

Signed in as
oliviermattelaer

Your profile
Your repositories
Your stars
Your gists
Help
Settings
Sign out

Learn Git and GitHub without any code!

Using the Hello World guide, you'll create a repository, start a branch, write comments,
pull request.

Read the guide | Start a project

Our new Terms of Service and Privacy Statement are in effect.

Repositories | New repository

Find a repository...

oliviermattelaer/singularity-recipe

oliviermattelaer/MGISP_1

https://github.com/oliviermattelaer?tab=repositories

Browse activity | Discover repositories

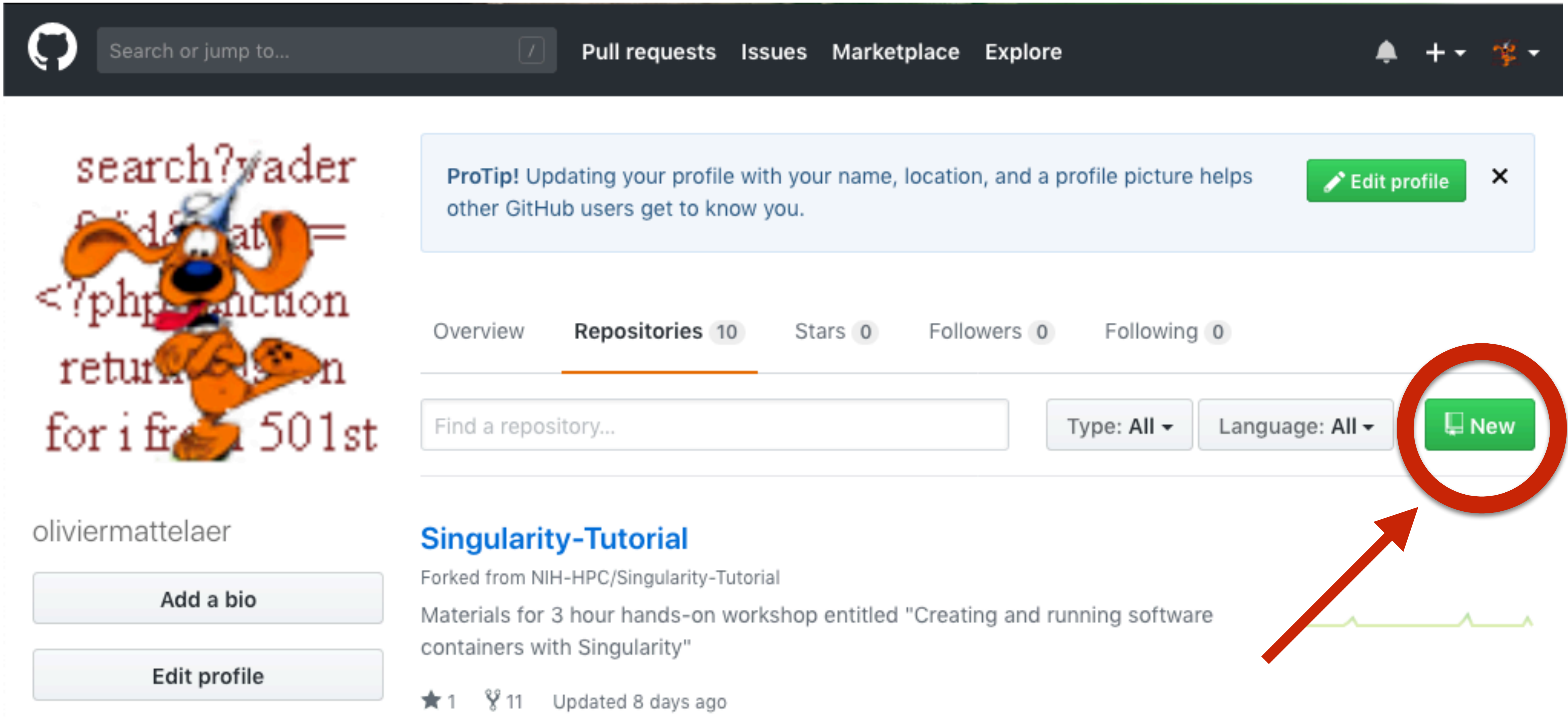
dcolignon starred oliviermattelaer/Singularity-Tutorial 7 days ago

oliviermattelaer/Singularity-Tutorial | Star

Materials for 3 hour hands-on workshop entitled "Creating and running software containers with Singularity"

★ 1 Updated Oct 31

Add it in a git repo



ProTip! Updating your profile with your name, location, and a profile picture helps other GitHub users get to know you.

oliviermattelaer

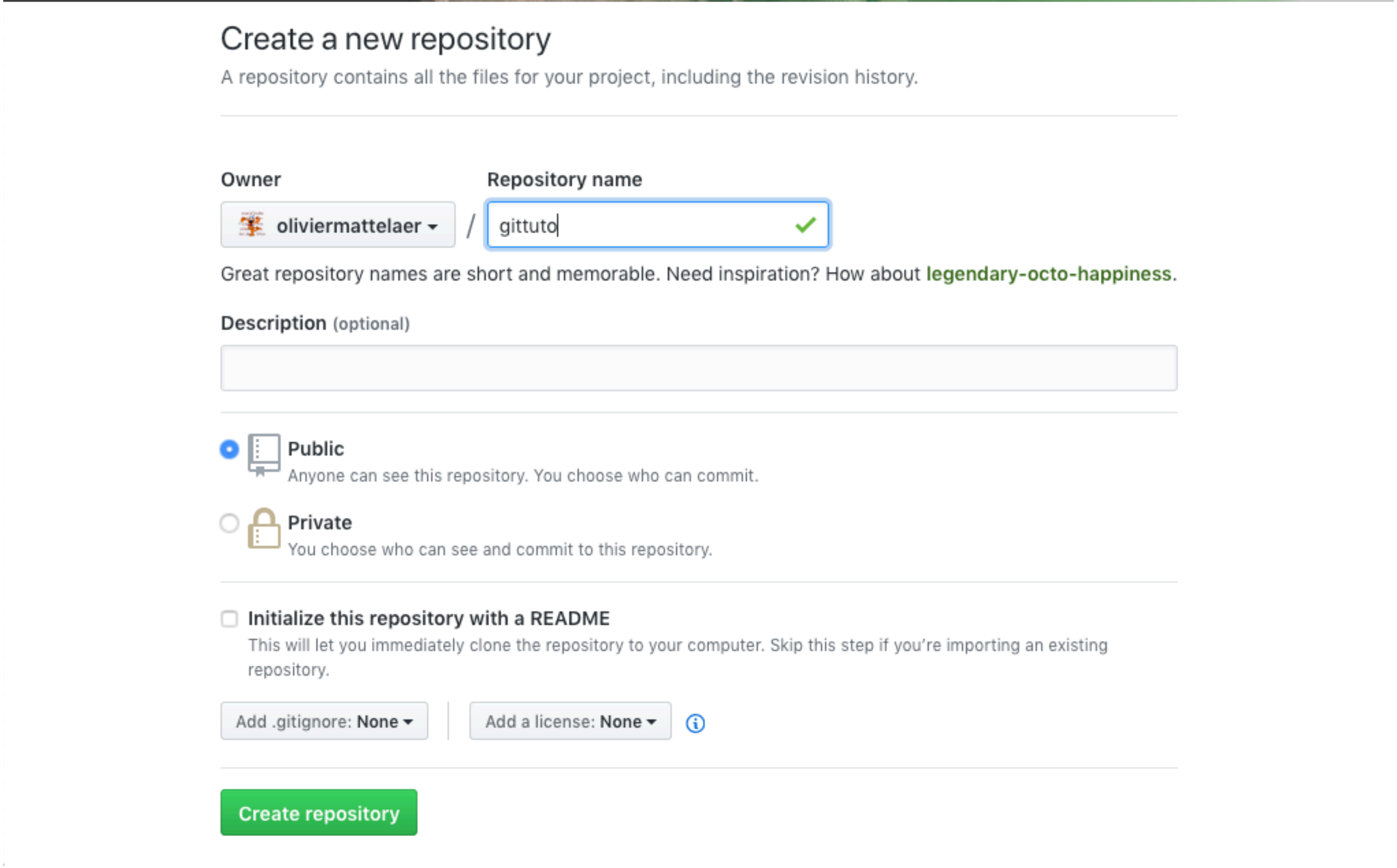
Singularity-Tutorial

Forked from NIH-HPC/Singularity-Tutorial

Materials for 3 hour hands-on workshop entitled "Creating and running software containers with Singularity"

★ 1 11 Updated 8 days ago

Add it in a git repo



Create a new repository

A repository contains all the files for your project, including the revision history.

Owner: oliviermattelaer / Repository name: gittuto

Great repository names are short and memorable. Need inspiration? How about legendary-octo-happiness.

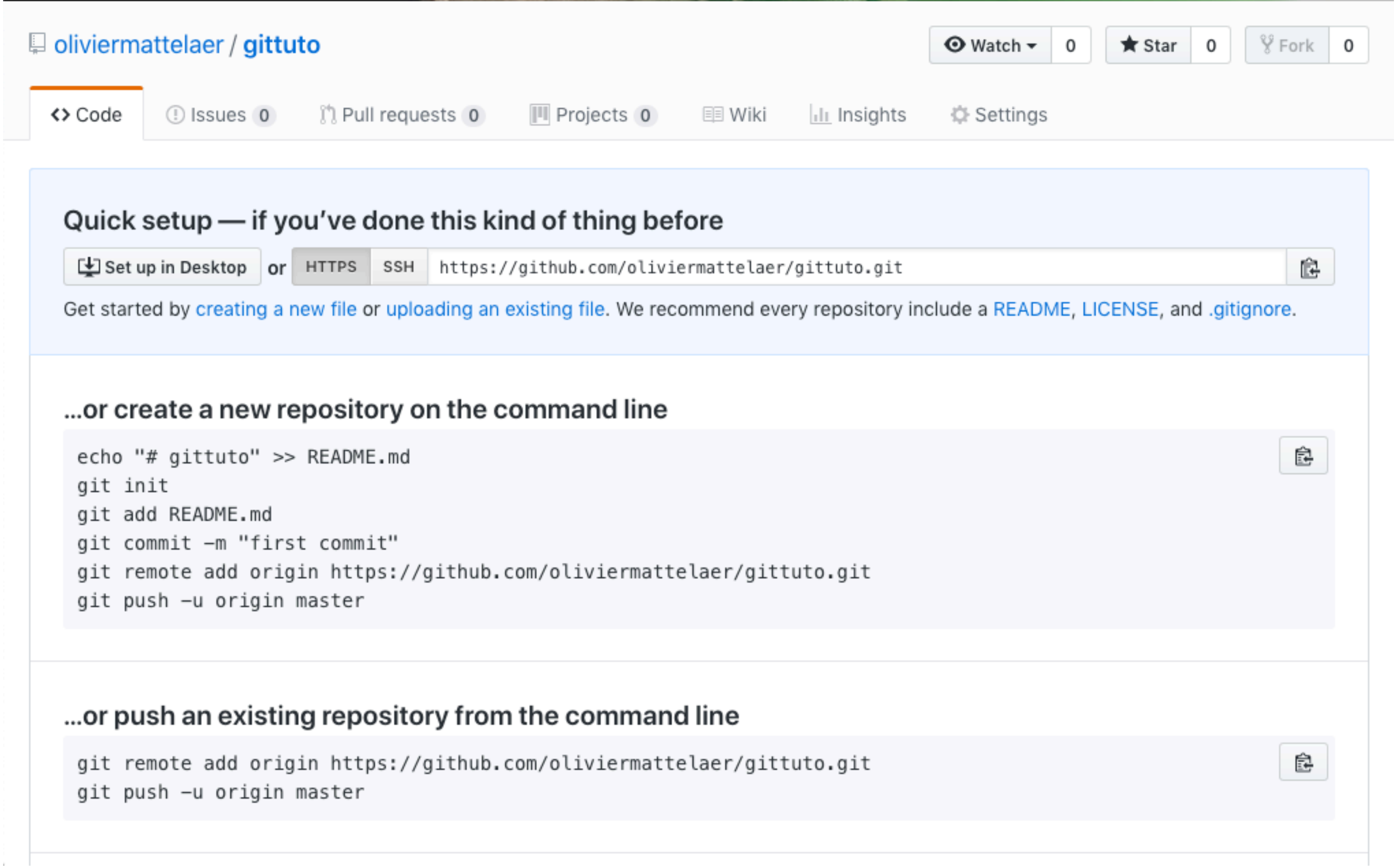
Description (optional)

[✓ Public] Anyone can see this repository. You choose who can commit.

Private You choose who can see and commit to this repository.

☐ Initialize this repository with a README
This will let you immediately clone the repository to your computer. Skip this step if you're importing an existing repository.

Add it in a git repo



oliviermattelaer / gittuto

Watch 0 Star 0 Fork 0

<> Code | Issues 0 | Pull requests 0 | Projects 0 | Wiki | Insights | Settings

Quick setup — if you've done this kind of thing before

Set up in Desktop or HTTPS SSH `https://github.com/oliviermattelaer/gittuto.git`

Get started by creating a new file or uploading an existing file. We recommend every repository include a README, LICENSE, and .gitignore.

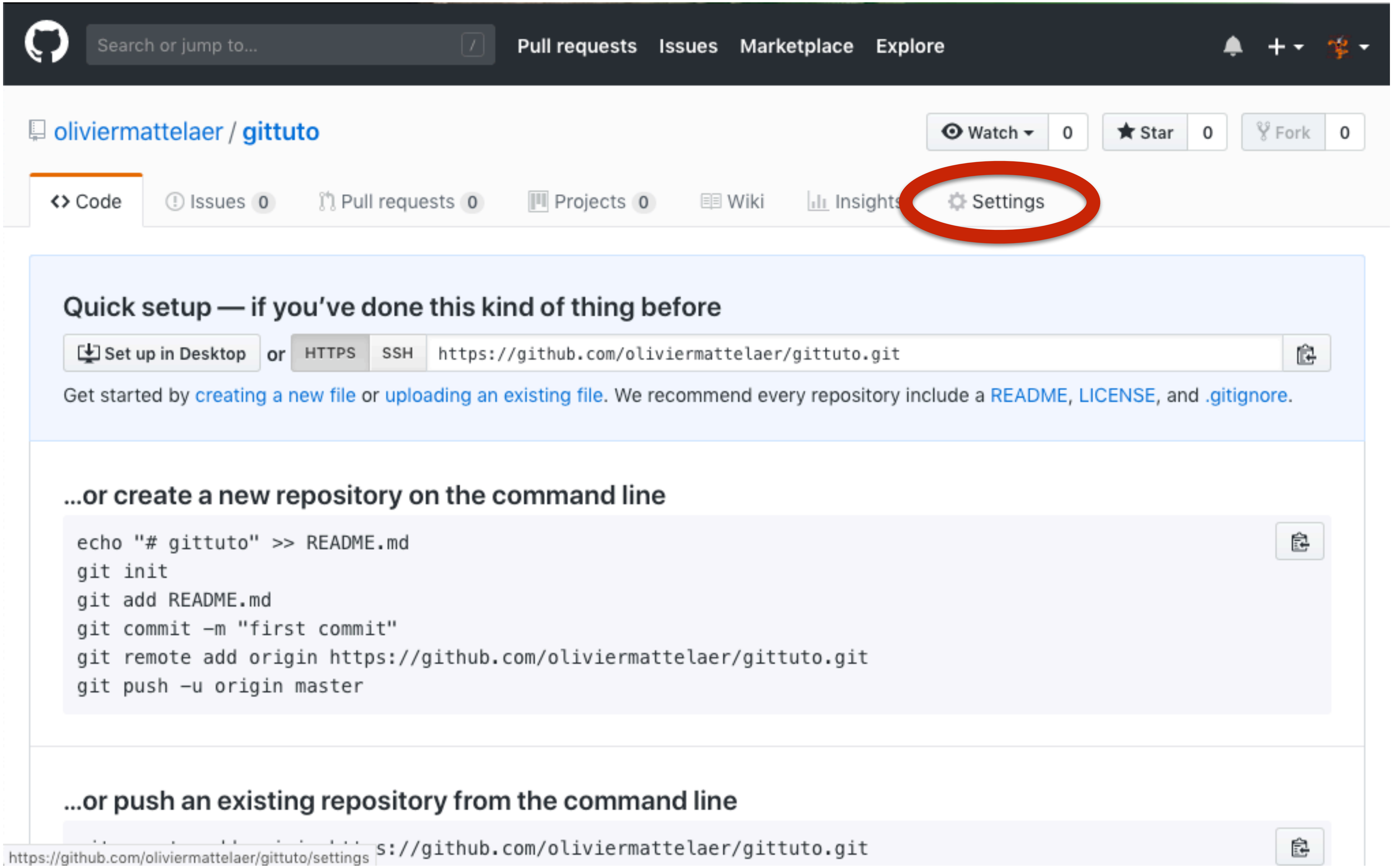
...or create a new repository on the command line

```
echo "# gittuto" >> README.md
git init
git add README.md
git commit -m "first commit"
git remote add origin https://github.com/oliviermattelaer/gittuto.git
git push -u origin master
```

...or push an existing repository from the command line

```
git remote add origin https://github.com/oliviermattelaer/gittuto.git
git push -u origin master
```

Adding Collaborator to GitHub



oliviermattelaer / gittuto

Quick setup — if you've done this kind of thing before

Set up in Desktop or HTTPS SSH `https://github.com/oliviermattelaer/gittuto.git`

Get started by creating a new file or uploading an existing file. We recommend every repository include a README, LICENSE, and .gitignore.

...or create a new repository on the command line

```
echo "# gittuto" >> README.md
git init
git add README.md
git commit -m "first commit"
git remote add origin https://github.com/oliviermattelaer/gittuto.git
git push -u origin master
```

...or push an existing repository from the command line

```
s://github.com/oliviermattelaer/gittuto.git
```

https://github.com/oliviermattelaer/gittuto/settings

Conclusion

- Versioning is crucial both for small/large project
  - Avoid dropbox for paper / project
- make meaningful commit
  - logical block
  - meaningful message
- git more complicated but the standard

More information

- Why an index: http://gitolite.com/uses-of-index.html
- technical tutorial on git (details on storage structure): https://www.youtube.com/watch?v=xbLVvrb2-fY
- https://git-scm.com/doc