CSE306
SOFTWARE QUALITY IN PRACTICE

Dr. Carl Alphonce
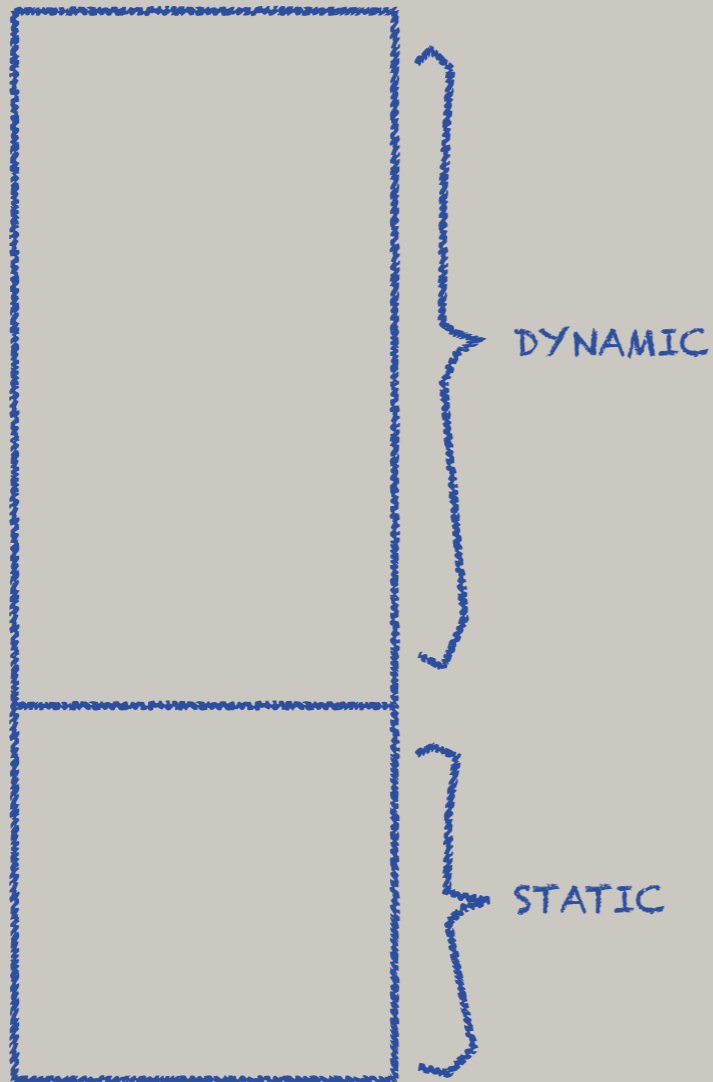alphonce@buffalo.edu
343 Davis Hall

www.cse.buffalo.edu/faculty/alphonce/FA24/CSE306

MEMORY ORGANIZATION

MEMORY ORGANIZATION

DYNAMIC

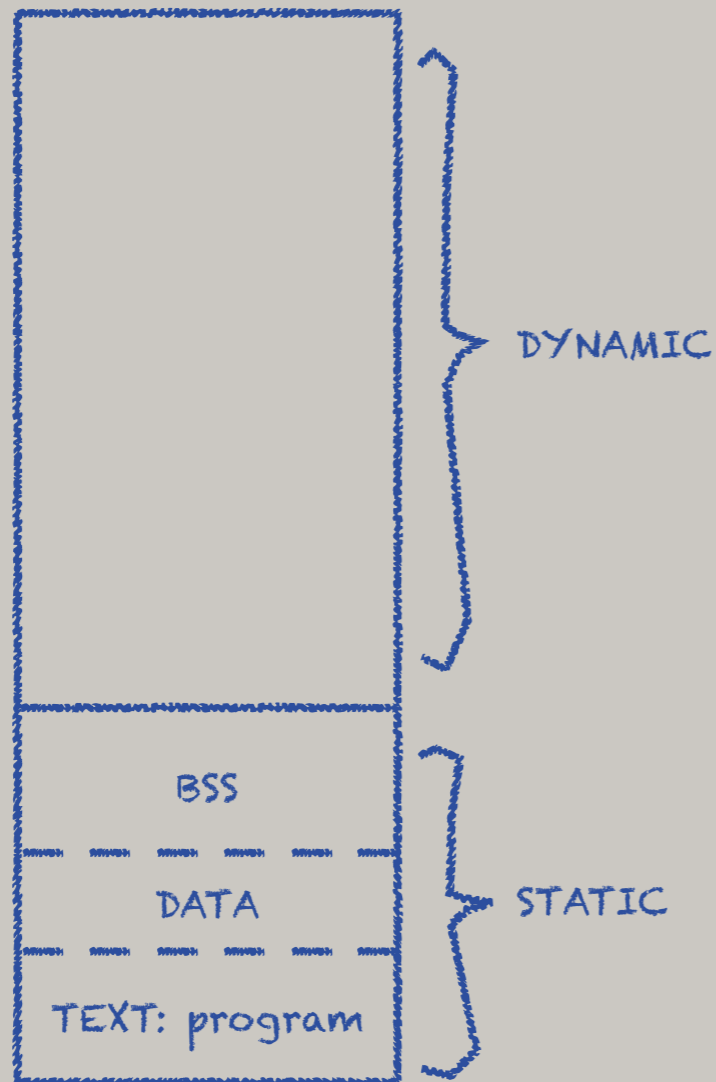STATIC

Each process (a running program) has a chunk of memory at its disposal.

This memory is divided into "static" memory (allocated/structured before execution begins) and "dynamic" memory (allocated while the program executes.

MEMORY ORGANIZATION

DYNAMIC

BSS

DATA

STATIC

TEXT: program

The static segment is divided into a TEXT segment (holding the machine language instructions of the program), a DATA segment (for initialized variables), and a BSS segment (for uninitialized but implicitly zero-assigned values).

MEMORY ORGANIZATION

STACK

free memory

HEAP

DYNAMIC

BSS

DATA

STATIC

TEXT: program
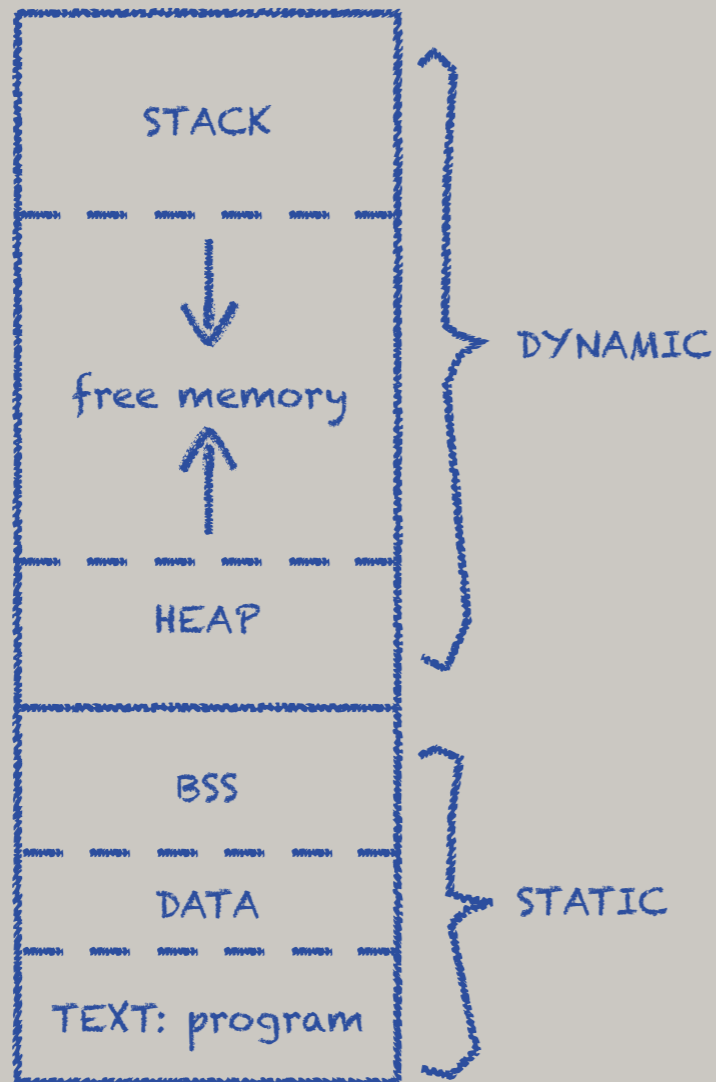
The STACK holds invocation records (also called stack frames).

An invocation record is created whenever a function is called. It has space for the function's parameters, local variables, any return value, as well as bookkeeping information related to the call itself (e.g. where to return to).

Discussion

- It prints "x has value y" for 9 times where the value y are numbers 0-9 in order.

- It loops 10 times and prints the value of x to the terminal

- will print 10 times with " x has value ___"

- It will print "x has value _" with values 0-9, each on a separate line, then it will exit.

When the program runs, it will print 10 lines.
x has value 0
x has value 1
x has value 2
x has value 3
x has value 4
x has value 5
x has value 6
x has value 7
x has value 8
x has value 9

WHERE IN MEMORY WILL SPACE FOR THE VARIABLE X BE ALLOCATED?

- it will be stored in the stack

- The variable x is stored on the heap.

- int x =0; is the space allocated

- 'x' is located on the stack, the main's invocation record due to it being a local variable in main.

TRANSFORM THIS PROGRAM SO THAT THE VALUE BEING PRINTED IS STORED ON THE HEAP RATHER THAN ON THE STACK.

```
#include <stdio.h>
#include <stdlib.h>

int main() {
    int *x = new int();
    x* = 0;
    while (x < 10) {
        printf("x has value %d\n",x);
        x = x + 1;
    }
    exit(EXIT_SUCCESS);
}
```

```
#include <stdio.h>
#include <stdlib.h>

int x = 0;

int main() {
    while (x < 10) {
        printf("x has value %d\n",x);
        x = x + 1;
    }
    exit(EXIT_SUCCESS);
}
```

```
#include <stdio.h>
#include <stdlib.h>

int main() {
    int *x = (int *)calloc(0);;

    while (x < 10) {
        printf(x has value %d\n",x);
        x = x + 1;
    }
    Free(x)
    exit(EXIT_SUCCESS);
}
```

TRANSFORM THIS PROGRAM SO THAT THE VALUE BEING PRINTED IS STORED ON THE HEAP RATHER THAN ON THE STACK.

```c
#include <stdio.h>
#include <stdlib.h>

int main() {
    int *x = malloc(sizeof(8));
    x[0] = 0;
    while (x[0] < 10) {
        printf("x has value %d\n",
x[0]);
        x[0] = x[0] + 1;
    }
    exit(EXIT_SUCCESS);

    free(x);
}
```

```c
#include <stdio.h>
#include <stdlib.h>

int main() {
    int *x;
    x = (int*)malloc(sizeof(int));
    while (*x < 10) {
        printf("x has value %d\n",*x);
        *x = *x + 1;
    }
    exit(EXIT_SUCCESS);
}
```

```c
#include <stdio.h>
#include <stdlib.h>

int main() {
    int *x = malloc(sizeof(int),0);
    while (x < 10) {
        printf("x has value %d\n",x);
        x = x + 1;
    }
    free(*x);
    exit(EXIT_SUCCESS);
}
```

```c
#include <stdio.h>
#include <stdlib.h>

int main(void) {

 int* ptr = (int*) malloc(sizeof(int));
 *ptr = 0;
 while (*ptr < 10) {
   printf("dereferenced x pointer has value %d\n", *ptr);
   *ptr = *ptr + 1;
 }
 free(ptr);
 exit(EXIT_SUCCESS);
}
```
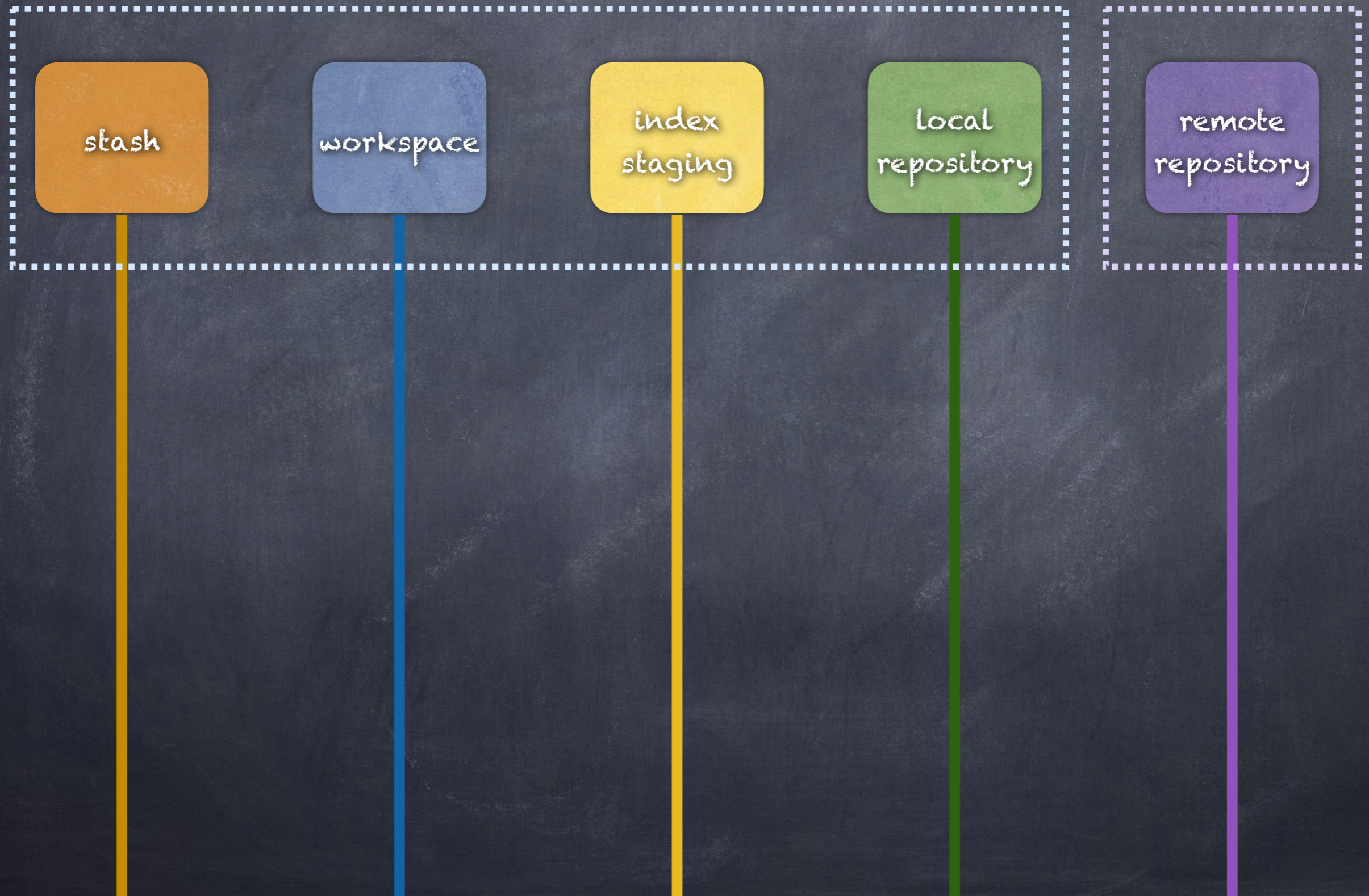
TOPHAT QUESTION

git

- distributed version control system

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

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

stash

workspace

index
staging

local
repository

remote
repository

What you see
when working

stash

workspace

index
staging

local
repository
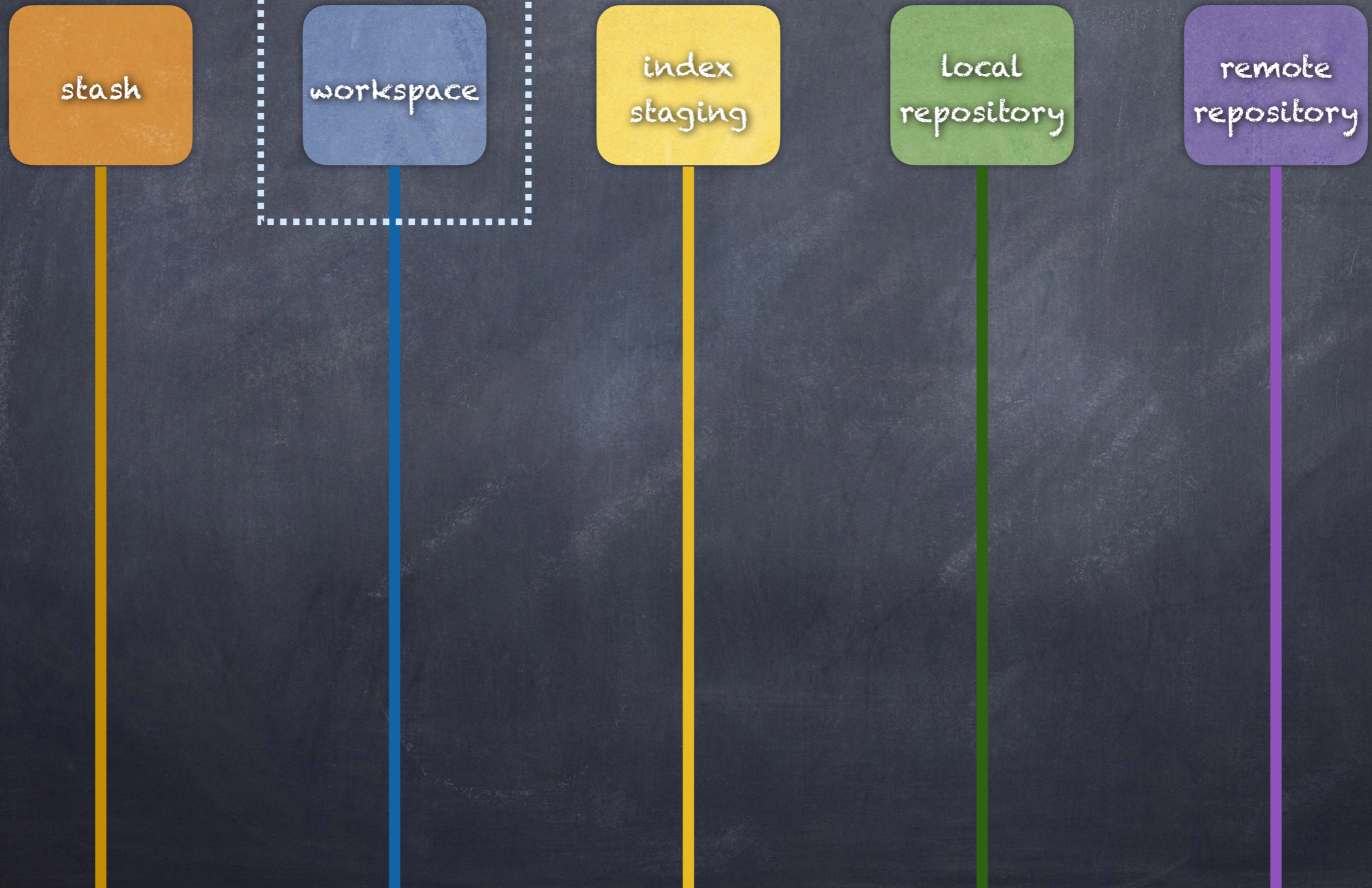
remote
repository

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

stash	workspace	index staging	local repository	remote repository

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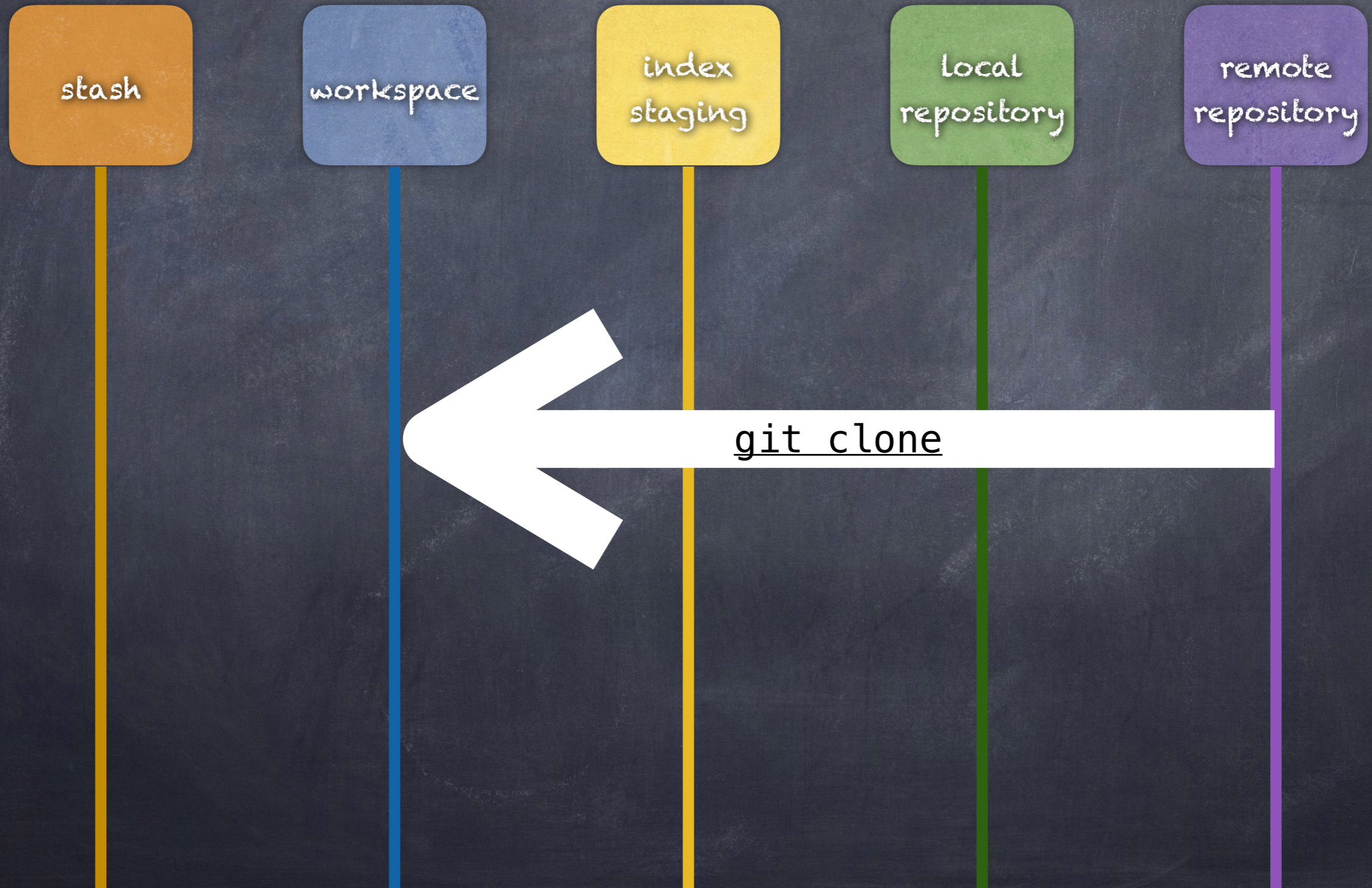
Add a file to the staging area
(add it to the index)

| stash | workspace | index staging | local repository | remote repository |

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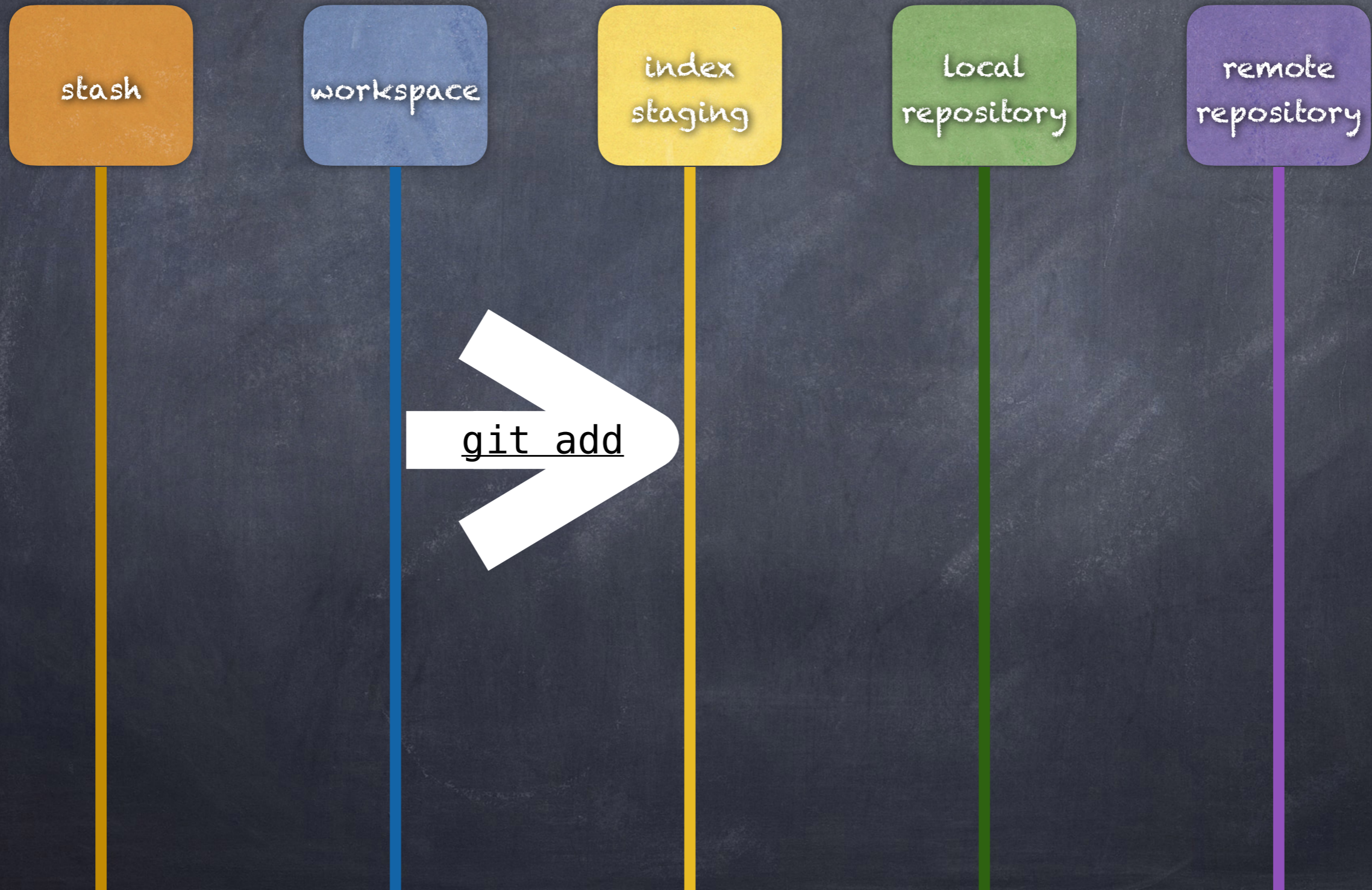
Create a new commit object with the staged items from the index

stash

workspace

index
staging

local
repository

remote
repository
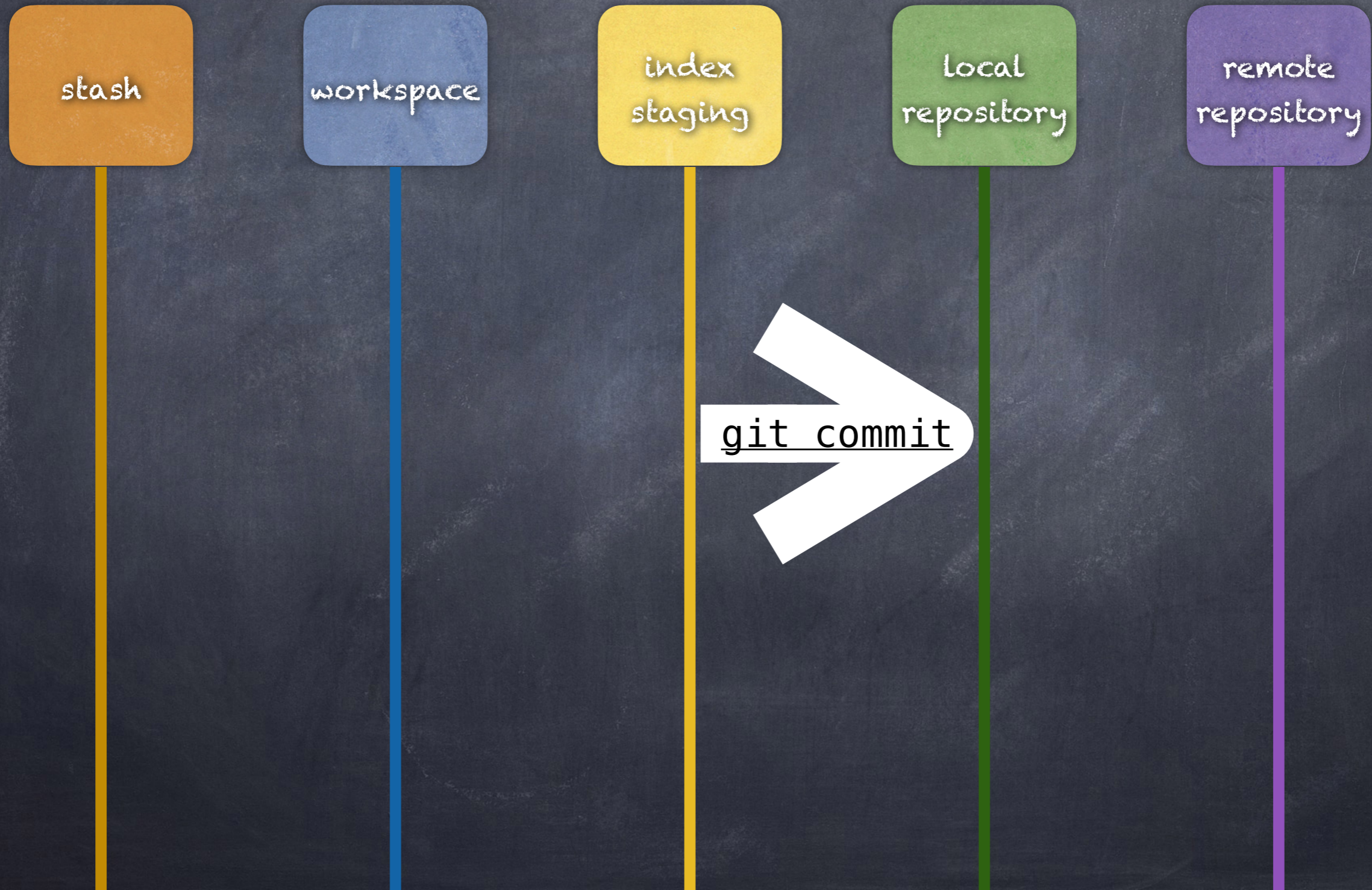
> git commit

Push files
from local repo
to remote repo

stash

workspace

index staging

local repository

remote repository

git push
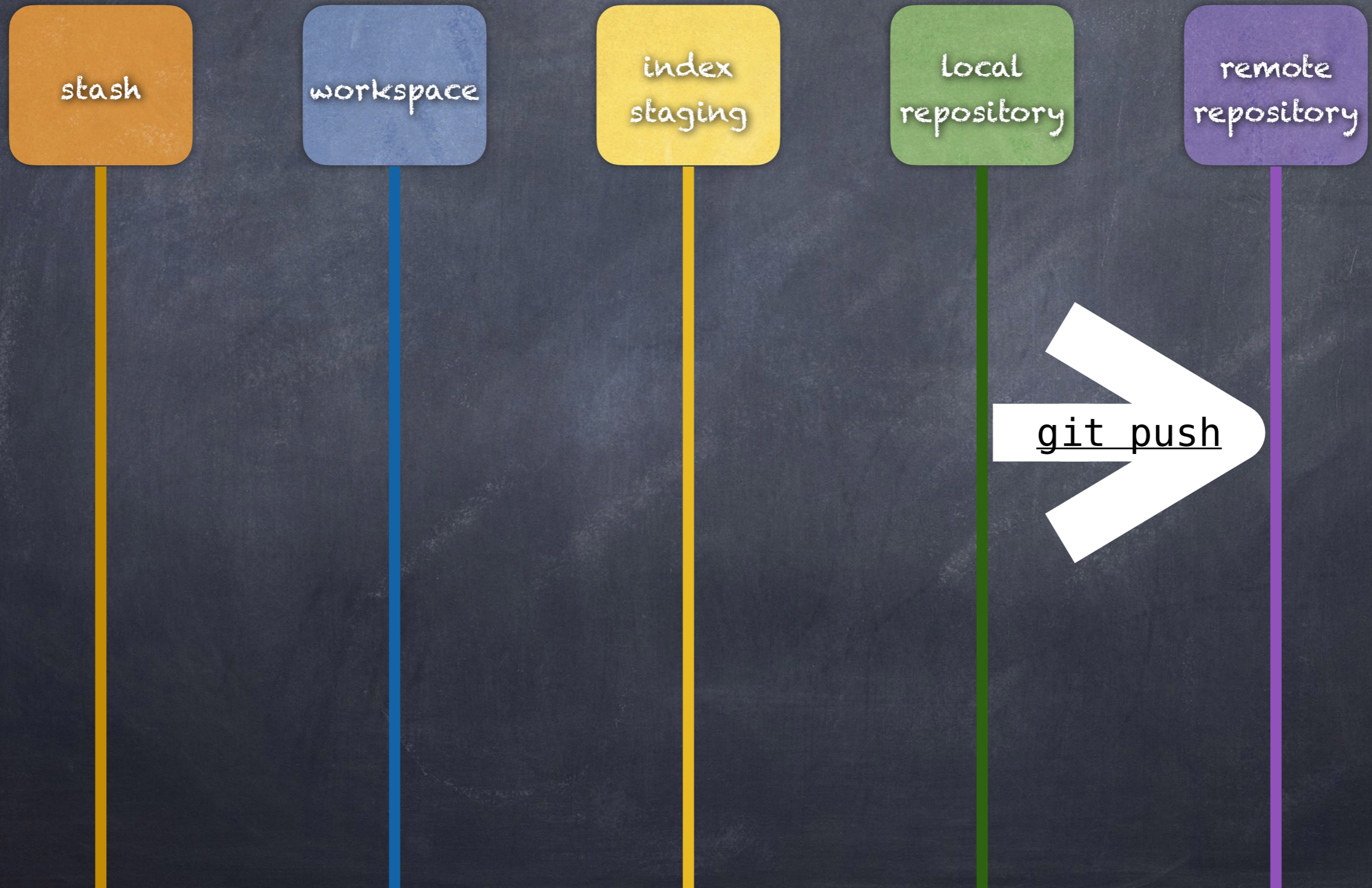
Pulling files

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

| stash | workspace | index staging | local repository | remote repository |

git pull

Grab files from remote

stash

workspace

index staging

local repository

remote repository

git fetch
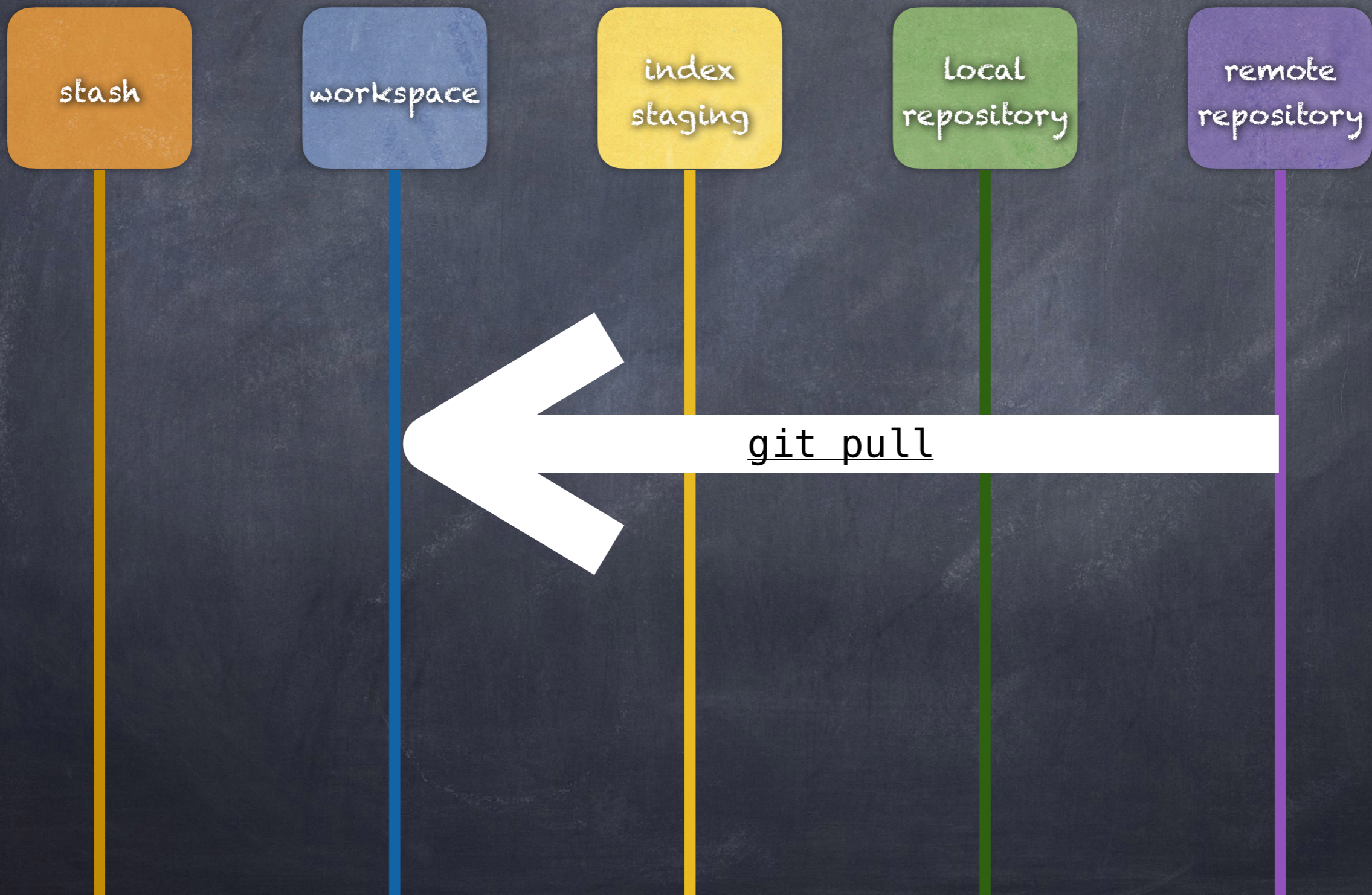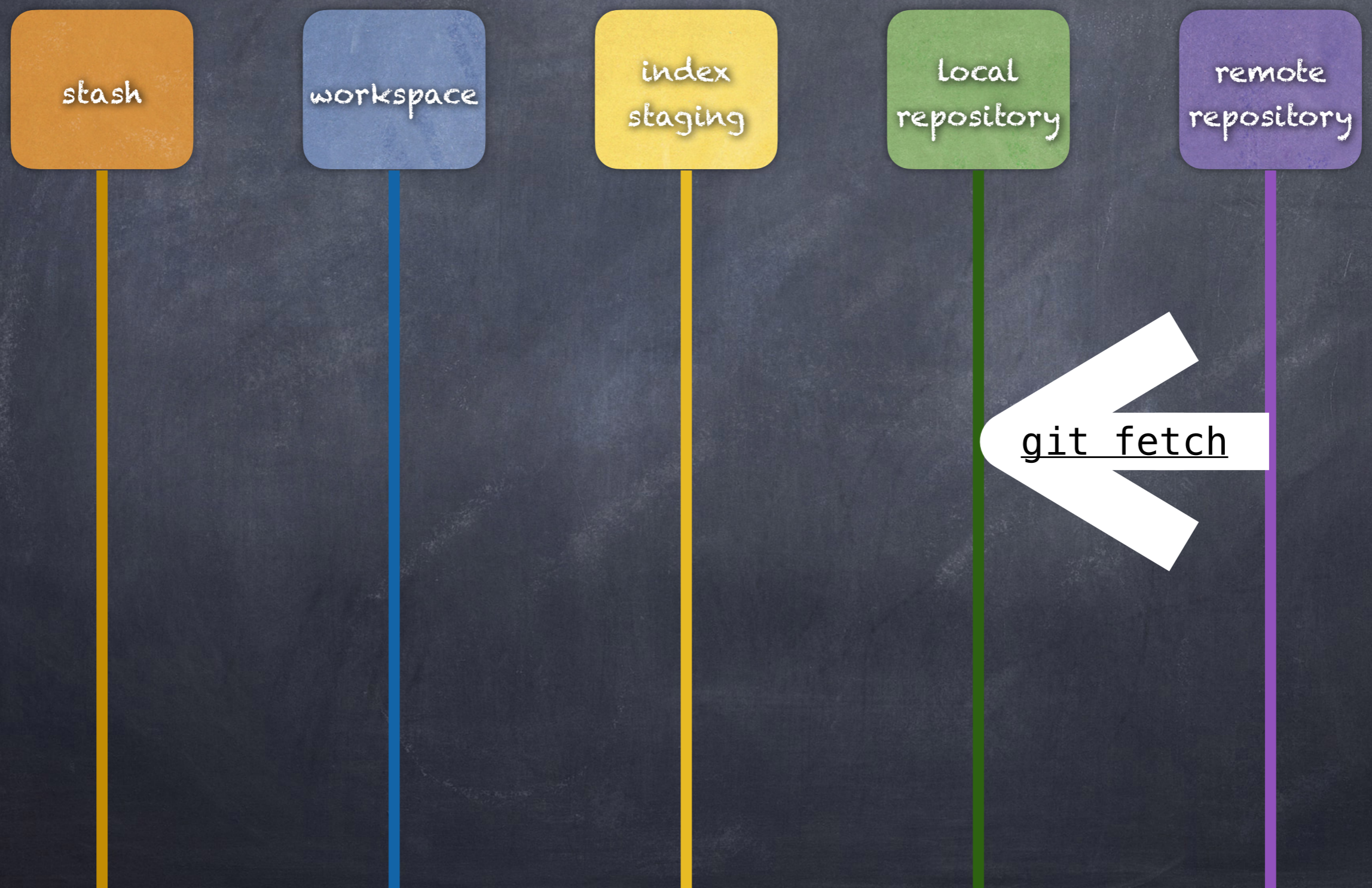
Create a commit combining
the contents of two branches

| stash | workspace | index staging | local repository | remote repository |

git merge
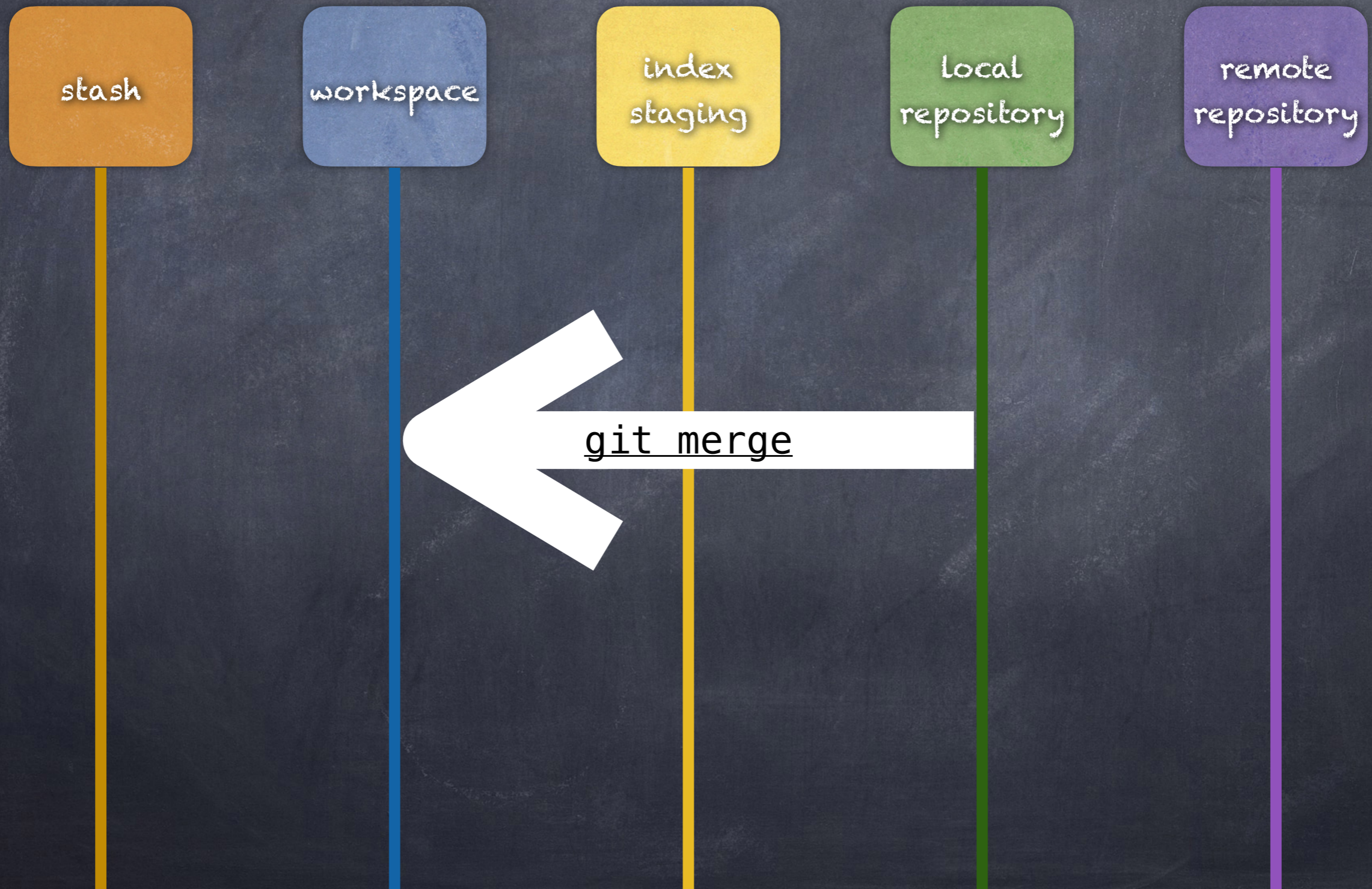
Let's start by cloning an existing repository

stash	workspace	index staging	local repository	remote repository

git clone

https://classroom.github.com/a/aLLMcziw

UB-CSE306 / **git-intro-carl-alphonce-1** 🔒

Type `/` to search

<> Code   ⊙ Issues   ⋔ Pull requests   ▶ Actions   ⊞ Projects   📖 Wiki   ⊘ Security   ⌁ Insights   ⚙ Settings

🖥 **git-intro-carl-alphonce-1** [Private]

generated from UB-CSE306/base-GitIntro
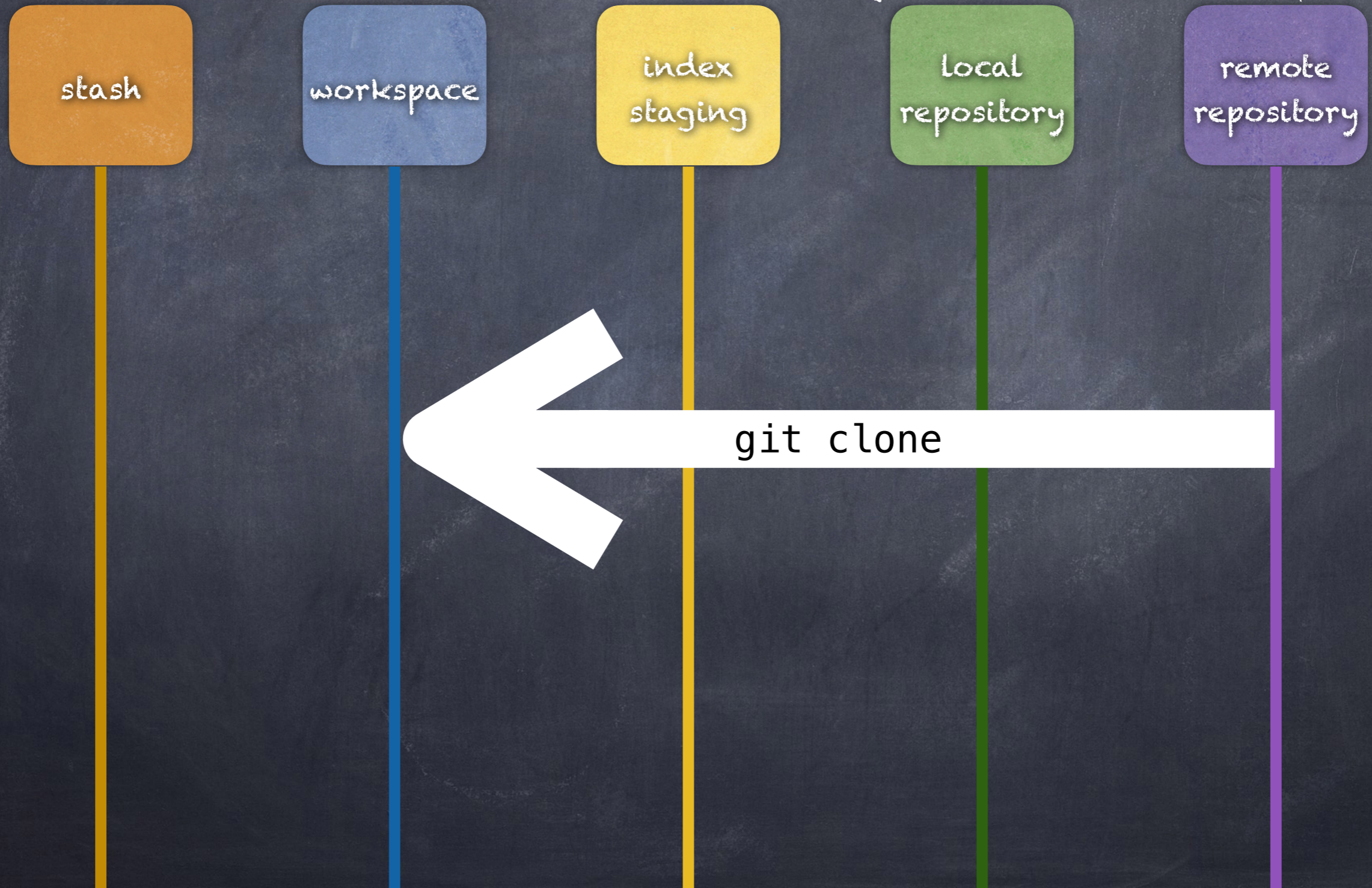
📌 Edit Pins ▾   👁 Watch 0 ▾   ⑂ Fork 0 ▾   ☆ Star 0 ▾

⑂ main ▾   ⑂ 1 Branch   ⬠ 0 Tags

Go to file   t   Add file ▾   <> Code ▾

| | Local | | Codespaces |

🖥 github-classroom[bot]   Initial commit

▣ Clone   ?

HTTPS   **SSH**   **GitHub CLI**

📄 README.md   Initial commit

git@github.com:UB-CSE306/git-intro-carl-a

Use a password-protected SSH key.

📖 **README**

⬇ Open with GitHub Desktop

GitIntro

📦 Download ZIP

A first repo to show students how to interact with repo on GitHub

About   ⚙

git-intro-carl-alphonce-1 created by GitHub Classroom

📖 Readme
⌁ Activity
▤ Custom properties
☆ 0 stars
👁 0 watching
⑂ 0 forks

Releases

No releases published
Create a new release

Packages

No packages published
Publish your first package

Clone the repo

```
% git clone git@github.com:UB-CSE306/git-intro-carl-alphonce-1.git
Cloning into 'git-intro-carl-alphonce-1'...
remote: Enumerating objects: 3, done.
remote: Counting objects: 100% (3/3), done.
remote: Compressing objects: 100% (2/2), done.
remote: Total 3 (delta 0), reused 2 (delta 0), pack-reused 0
Receiving objects: 100% (3/3), done.

% ls -la
total 0
drwxr-xr-x    3 alphonce  staff    96 Feb  4 18:10 .
drwxr-xr-x   19 alphonce  staff   608 Feb  4 18:09 ..
drwxr-xr-x    4 alphonce  staff   128 Feb  4 18:10 git-intro-carl-
alphonce-1
```

```
% cd git-intro-carl-alphonce-1
% ls -la
total 8
drwxr-xr-x    4 alphonce   staff   128 Feb  4 18:10 .
drwxr-xr-x    3 alphonce   staff    96 Feb  4 18:10 ..
drwxr-xr-x   12 alphonce   staff   384 Feb  4 18:10 .git
-rw-r--r--    1 alphonce   staff    77 Feb  4 18:10 README.md
```

```
% cd .git
% ls -la
total 40
drwxr-xr-x   12 alphonce   staff   384 Feb   4 18:10 .
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 ..
-rw-r--r--    1 alphonce   staff    21 Feb   4 18:10 HEAD
-rw-r--r--    1 alphonce   staff   320 Feb   4 18:10 config
-rw-r--r--    1 alphonce   staff    73 Feb   4 18:10 description
drwxr-xr-x   15 alphonce   staff   480 Feb   4 18:10 hooks
-rw-r--r--    1 alphonce   staff   137 Feb   4 18:10 index
drwxr-xr-x    3 alphonce   staff    96 Feb   4 18:10 info
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 logs
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 objects
-rw-r--r--    1 alphonce   staff   112 Feb   4 18:10 packed-refs
drwxr-xr-x    5 alphonce   staff   160 Feb   4 18:10 refs
```

```
-rw-r--r--    1 alphonce   staff    21 Feb   4 18:10 HEAD
-rw-r--r--    1 alphonce   staff   320 Feb   4 18:10 config
-rw-r--r--    1 alphonce   staff    73 Feb   4 18:10 description
drwxr-xr-x   15 alphonce   staff   480 Feb   4 18:10 hooks
-rw-r--r--    1 alphonce   staff   137 Feb   4 18:10 index
drwxr-xr-x    3 alphonce   staff    96 Feb   4 18:10 info
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 logs
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 objects
-rw-r--r--    1 alphonce   staff   112 Feb   4 18:10 packed-refs
drwxr-xr-x    5 alphonce   staff   160 Feb   4 18:10 refs
```

pointer to the current branch

```
-rw-r--r--    1 alphonce   staff    21 Feb   4 18:10 HEAD
-rw-r--r--    1 alphonce   staff   320 Feb   4 18:10 config
-rw-r--r--    1 alphonce   staff    73 Feb   4 18:10 description
drwxr-xr-x   15 alphonce   staff   480 Feb   4 18:10 hooks
-rw-r--r--    1 alphonce   staff   137 Feb   4 18:10 index
drwxr-xr-x    3 alphonce   staff    96 Feb   4 18:10 info
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 logs
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 objects
-rw-r--r--    1 alphonce   staff   112 Feb   4 18:10 packed-refs
drwxr-xr-x    5 alphonce   staff   160 Feb   4 18:10 refs
```

```
% more HEAD
ref: refs/heads/main
```

```
-rw-r--r--    1 alphonce   staff    21 Feb   4 18:10 HEAD
-rw-r--r--    1 alphonce   staff   320 Feb   4 18:10 config
-rw-r--r--    1 alphonce   staff    73 Feb   4 18:10 description
drwxr-xr-x   15 alphonce   staff   480 Feb   4 18:10 hooks
-rw-r--r--    1 alphonce   staff   137 Feb   4 18:10 index
drwxr-xr-x    3 alphonce   staff    96 Feb   4 18:10 info
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 logs
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 objects
-rw-r--r--    1 alphonce   staff   112 Feb   4 18:10 packed-refs
drwxr-xr-x    5 alphonce   staff   160 Feb   4 18:10 refs
```

workspace

index
staging

local repository

HEAD

main

content
(blobs, trees, commits)

```
-rw-r--r--    1 alphonce   staff    21 Feb   4 18:10 HEAD
-rw-r--r--    1 alphonce   staff   320 Feb   4 18:10 config
-rw-r--r--    1 alphonce   staff    73 Feb   4 18:10 description
drwxr-xr-x   15 alphonce   staff   480 Feb   4 18:10 hooks
-rw-r--r--    1 alphonce   staff   137 Feb   4 18:10 index
drwxr-xr-x    3 alphonce   staff    96 Feb   4 18:10 info
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 logs
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 objects
-rw-r--r--    1 alphonce   staff   112 Feb   4 18:10 packed-refs
drwxr-xr-x    5 alphonce   staff   160 Feb   4 18:10 refs
```

content
(blobs, trees, commits)

The `git man page` seems to be surprisingly bereft of an official definition, other than this (emphasis mine):

The **object database** contains objects of three main types: **blobs, which hold file data**; trees, which point to blobs and other trees to build up directory hierarchies; and commits, which each reference a single tree and some number of parent commits.

The repeated use of the term "object database" across git documentation suggests a borrowing of "blob" specifically from DBMSs.

In its article on Binary large objects Wikipedia defines the term as "a collection of binary data stored as a single entity in a database management system", further offering the following:

Blobs were originally just amorphous chunks of data invented by Jim Starkey at DEC, who describes them as "the thing that ate Cincinnati, Cleveland, or whatever" from "the 1958 Steve McQueen movie", referring to The Blob. Later, Terry McKiever, a marketing person for Apollo, felt that it needed to be an acronym and invented the backronym Basic Large Object. Then Informix invented an alternative backronym, Binary Large Object.

So, though it's not a definitive answer, the term "blob" has a conventional and well-defined usage across computer science as an opaque string of binary data, and git adheres to that definition without further specifying it.
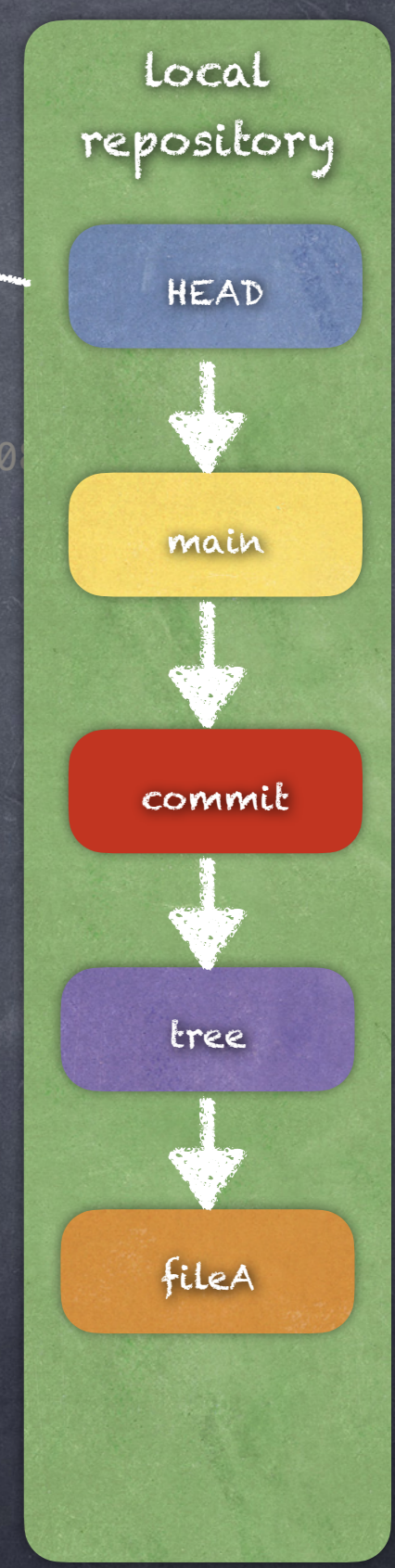
answered Jul 24 '15 at 17:12

Jeff Bowman
33.9k65685

```
alphonce@dhcp-10-83-16-71 .git % cat HEAD
ref: refs/heads/main
alphonce@dhcp-10-83-16-71 .git % cat refs/heads/main
2303f4622cbb330c9fb021cd216cd657e4942592
alphonce@dhcp-10-83-16-71 .git % git cat-file -t HEAD
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -t 2303f
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -p 2303f
tree e7c77e150f84d16ec763bd46dcffebfd8f2873f4
author github-classroom[bot] <66690702+github-classroom[bot]@users.noreply.github.com> 17070
committer GitHub <noreply@github.com> 1707088127 +0000
gpgsig -----BEGIN PGP SIGNATURE-----

 wsFcBAABCAAQBQJlwBj/CRC1aQ7uu5UhlAAAbt8QAJvL5XVgE7xXxNDM+ZqUWQgp
 nAdFnLO3nOfMqHskU9hG8FFnSw3DODZinpZ4se7cwqFdvDoH8ePcXDrZHKqmDq5c
 o6jwkejRAuFwwaYgqu5jn1YsdpNpPPFWjSmHZHQawF6TNIOD+V2n4YjhjJcmLdqp
 iJ4WmeB4oGqcEUVr0m11mgcZSeCusrQV4yKTvKtWzJoh6Z5U0nYlkOaNxdD6gZ/9
 lIUDr0/2NrpqUmoR2w1V9+0F334LLK5lONy2CDV3DIKvODDM8OTD6DhStZBBYIsm
 ji0wxHbbh4wH2o3QH/eqwV850GtAvaryKal9WfhtKkoBkEY7Tu9F63biuFbeXyjY
 URrT2AgfH0vIaOtwtrFxOKaD5FJyux6YXXX/gbPO/uu4DIxiLI4wQdCDAt9VGHkJ
 44CyucSgG0Zfai5xO8tC88V80mwXXVHok9+SWooD+pJ5El4qsBs9MYxenYH6cc45
 +Dh4gEq4bDj77TkTAlGaaXlHy2Sp+ROCnO/iiUol6g/7tmPyCMZ8YB6+FoOpCa7q
 NBGDnspHMOoKX7Ms1Gki03HeXws8NJUzbslnZg9oPP7pD9d83dQvKxfWa+LXl+L3
 wwh5jNYepteA/3BIpAcdgFsvkJpZ5qleZQe6AGTR5rUNZtm2xy7UEqLVAjucpREZ
 PHhEGRBDBD1EWHvQiArh
 =onC9
 -----END PGP SIGNATURE-----

Initial commit%
alphonce@dhcp-10-83-16-71 .git % git cat-file -t e7c77
tree
alphonce@dhcp-10-83-16-71 .git % git cat-file -p e7c77
100644 blob da80e272f601badf16da372517a26bba132b5bab  README.md
alphonce@dhcp-10-83-16-71 .git % git cat-file -t da80e
blob
alphonce@dhcp-10-83-16-71 .git % git cat-file -p da80e
# GitIntro
A first repo to show students how to interact with repo on GitHub
```

local
repository

HEAD

main

commit

tree

fileA

```
alphonce@dhcp-10-83-16-71 .git % cat HEAD
ref: refs/heads/main
alphonce@dhcp-10-83-16-71 .git % cat refs/heads/main
2303f4622cbb330c9fb021cd216cd657e4942592
alphonce@dhcp-10-83-16-71 .git % git cat-file -t HEAD
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -t 2303f
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -p 2303f
tree e7c77e150f84d16ec763bd46dcffebfd8f2873f4
author github-classroom[bot] <66690702+github-classroom[bot]@users.noreply.github.com> 17070
committer GitHub <noreply@github.com> 1707088127 +0000
gpgsig -----BEGIN PGP SIGNATURE-----

 wsFcBAABCAAQBQJlwBj/CRC1aQ7uu5UhlAAAbt8QAJvL5XVgE7xXxNDM+ZqUWQgp
 nAdFnLO3nOfMqHskU9hG8FFnSw3DODZinpZ4se7cwqFdvDoH8ePcXDrZHKqmDq5c
 o6jwkejRAuFwwaYgqu5jn1YsdpNpPPFWjSmHZHQawF6TNIOD+V2n4YjhjJcmLdqp
 iJ4WmeB4oGqcEUVr0m11mgcZSeCusrQV4yKTvKtWzJoh6Z5U0nYlkOaNxdD6gZ/9
 lIUDr0/2NrpqUmoR2w1V9+0F334LLK5lONy2CDV3DIKvODDM8OTD6DhStZBBYIsm
 ji0wxHbbh4wH2o3QH/eqwV850GtAvaryKal9WfhtKkoBkEY7Tu9F63biuFbeXyjY
 URrT2AgfH0vIaOtwtrFxOKaD5FJyux6YXXX/gbPO/uu4DIxiLI4wQdCDAt9VGHkJ
 44CyucSgG0Zfai5xO8tC88V80mwXXVHok9+SWooD+pJ5El4qsBs9MYxenYH6cc45
 +Dh4gEq4bDj77TkTAlGaaXlHy2Sp+ROCnO/iiUol6g/7tmPyCMZ8YB6+FoOpCa7q
 NBGDnspHMOoKX7Ms1Gki03HeXws8NJUzbslnZg9oPP7pD9d83dQvKxfWa+LXl+L3
 wwh5jNYepteA/3BIpAcdgFsvkJpZ5qleZQe6AGTR5rUNZtm2xy7UEqLVAjucpREZ
 PHhEGRBDBD1EWHvQiArh
 =onC9
 -----END PGP SIGNATURE-----

Initial commit%
alphonce@dhcp-10-83-16-71 .git % git cat-file -t e7c77
tree
alphonce@dhcp-10-83-16-71 .git % git cat-file -p e7c77
100644 blob da80e272f601badf16da372517a26bba132b5bab	README.md
alphonce@dhcp-10-83-16-71 .git % git cat-file -t da80e
blob
alphonce@dhcp-10-83-16-71 .git % git cat-file -p da80e
# GitIntro
A first repo to show students how to interact with repo on GitHub
```
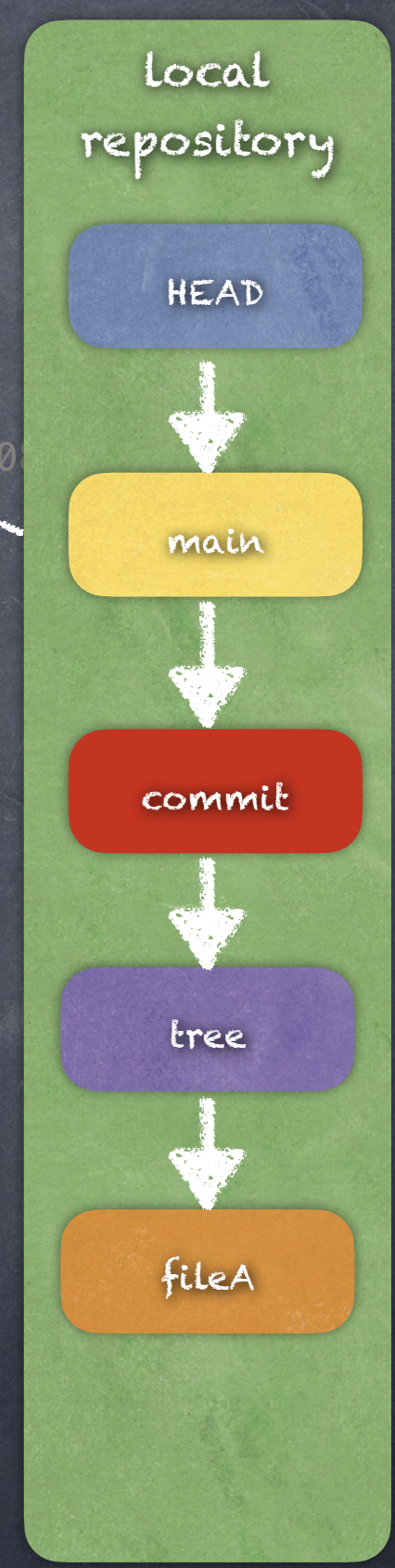

local repository

HEAD

main

commit

tree

fileA

NAME

git-cat-file - Provide contents or details of repository objects

SYNOPSIS

```
git cat-file <type> <object>
git cat-file (-e | -p) <object>
git cat-file (-t | -s) [--allow-unknown-type] <object>
git cat-file (--textconv | --filters)
            [<rev>:<path|tree-ish> | --path=<path|tree-ish> <rev>]
git cat-file (--batch | --batch-check | --batch-command) [--batch-all-
objects]
            [--buffer] [--follow-symlinks] [--unordered]
            [--textconv | --filters] [-Z]
```

DESCRIPTION

Output the contents or other properties such as size, type or delta information of one or more objects.

This command can operate in two modes, depending on whether an option from the `--batch` family is specified.

In non-batch mode, the command provides information on an object named on the command line.

In batch mode, arguments are read from standard input.

OPTIONS

`<object>`
   The name of the object to show. For a more complete list of ways to spell object names, see the "SPECIFYING REVISIONS" section in gitrevisions[7].

`-t`
   Instead of the content, show the object type identified by `<object>`.

`-s`
   Instead of the content, show the object size identified by `<object>`. If used with `--use-mailmap` option, will show the size of updated object after replacing idents using the mailmap mechanism.

`-e`
   Exit with zero status if `<object>` exists and is a valid object. If `<object>` is of an invalid format, exit with non-zero status and emit an error on stderr.

`-p`
   Pretty-print the contents of `<object>` based on its type.
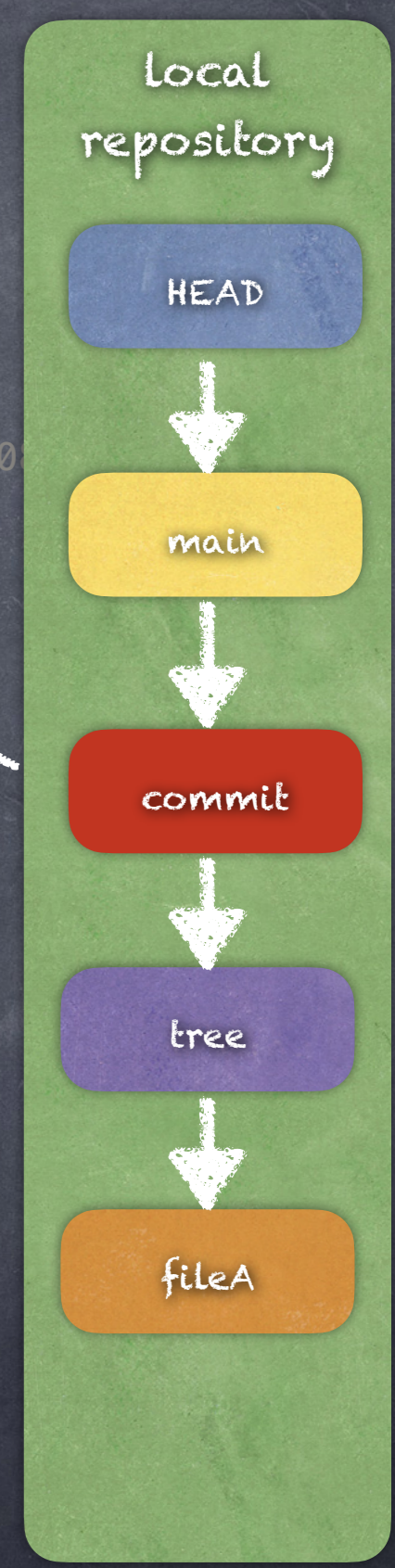
local
repository

HEAD

main

commit

tree

fileA

```
alphonce@dhcp-10-83-16-71 .git % cat HEAD
ref: refs/heads/main
alphonce@dhcp-10-83-16-71 .git % cat refs/heads/main
2303f4622cbb330c9fb021cd216cd657e4942592
alphonce@dhcp-10-83-16-71 .git % git cat-file -t HEAD
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -t 2303f
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -p 2303f
tree e7c77e150f84d16ec763bd46dcffebfd8f2873f4
author github-classroom[bot] <66690702+github-classroom[bot]@users.noreply.github.com> 17070
committer GitHub <noreply@github.com> 1707088127 +0000
gpgsig -----BEGIN PGP SIGNATURE-----

 wsFcBAABCAAQBQJlwBj/CRC1aQ7uu5UhlAAAbt8QAJvL5XVgE7xXxNDM+ZqUWQgp
 nAdFnLO3nOfMqHskU9hG8FFnSw3DODZinpZ4se7cwqFdvDoH8ePcXDrZHKqmDq5c
 o6jwkejRAuFwwaYgqu5jn1YsdpNpPPFWjSmHZHQawF6TNIOD+V2n4YjhjJcmLdqp
 iJ4WmeB4oGqcEUVr0m11mgcZSeCusrQV4yKTvKtWzJoh6Z5U0nYlkOaNxdD6gZ/9
 lIUDr0/2NrpqUmoR2w1V9+0F334LLK5lONy2CDV3DIKvODDM8OTD6DhStZBBYIsm
 ji0wxHbbh4wH2o3QH/eqwV850GtAvaryKal9WfhtKkoBkEY7Tu9F63biuFbeXyjY
 URrT2AgfH0vIaOtwtrFxOKaD5FJyux6YXXX/gbPO/uu4DIxiLI4wQdCDAt9VGHkJ
 44CyucSgG0Zfai5xO8tC88V80mwXXVHok9+SWooD+pJ5El4qsBs9MYxenYH6cc45
 +Dh4gEq4bDj77TkTAlGaaXlHy2Sp+ROCnO/iiUol6g/7tmPyCMZ8YB6+FoOpCa7q
 NBGDnspHMOoKX7Ms1Gki03HeXws8NJUzbslnZg9oPP7pD9d83dQvKxfWa+LXl+L3
 wwh5jNYepteA/3BIpAcdgFsvkJpZ5qleZQe6AGTR5rUNZtm2xy7UEqLVAjucpREZ
 PHhEGRBDBD1EWHvQiArh
 =onC9
 -----END PGP SIGNATURE-----

Initial commit%
alphonce@dhcp-10-83-16-71 .git % git cat-file -t e7c77
tree
alphonce@dhcp-10-83-16-71 .git % git cat-file -p e7c77
100644 blob da80e272f601badf16da372517a26bba132b5bab  README.md
alphonce@dhcp-10-83-16-71 .git % git cat-file -t da80e
blob
alphonce@dhcp-10-83-16-71 .git % git cat-file -p da80e
# GitIntro
A first repo to show students how to interact with repo on GitHub
```
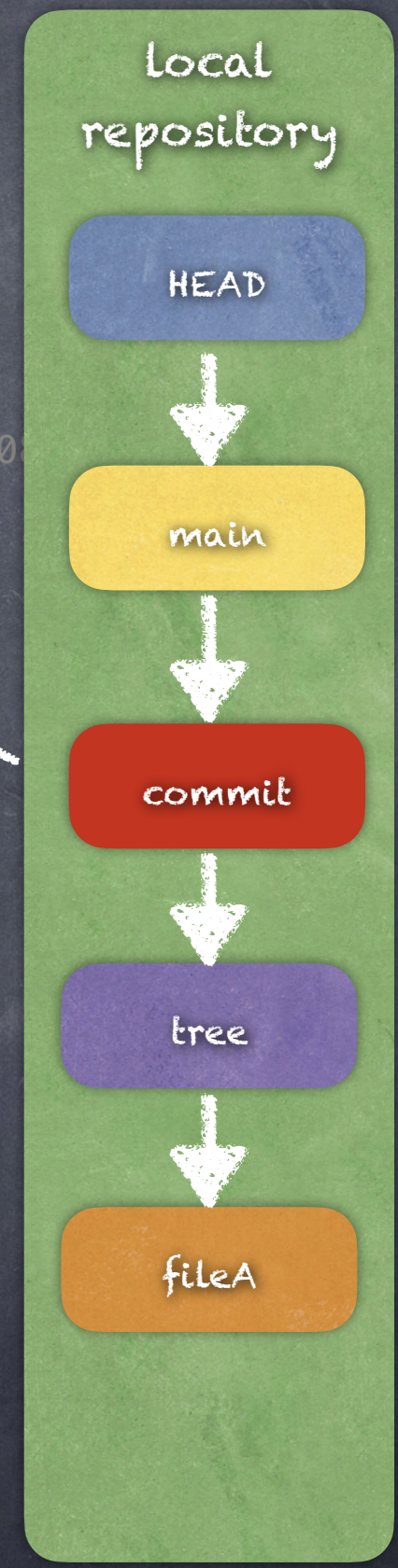

local
repository

HEAD

main

commit

tree

fileA

```
alphonce@dhcp-10-83-16-71 .git % cat HEAD
ref: refs/heads/main
alphonce@dhcp-10-83-16-71 .git % cat refs/heads/main
2303f4622cbb330c9fb021cd216cd657e4942592
alphonce@dhcp-10-83-16-71 .git % git cat-file -t HEAD
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -t 2303f
commit
```

Could even do:

```
alphonce@dhcp-10-83-16-71 .git % git cat-file -t refs/heads/main
commit
```

```
ti0bT6/2NfpqomuRZw1V9+0f3S4LERStoNy2cDVSD1RVoDDM8oTDoDHStzBBYTSm
ji0wxHbbh4wH2o3QH/eqwV850GtAvaryKal9WfhtKkoBkEY7Tu9F63biuFbeXyjY
URrT2AgfH0vIaOtwtrFx0KaD5FJyux6YXXX/gbPO/uu4DIxiLI4wQdCDAt9VGHkJ
44CyucSgG0Zfai5xO8tC88V80mwXXVHok9+SWooD+pJ5El4qsBs9MYxenYH6cc45
+Dh4gEq4bDj77TkTAlGaaXlHy2Sp+ROCnO/iiUol6g/7tmPyCMZ8YB6+FoOpCa7q
NBGDnspHMOoKX7Ms1GkiO3HeXws8NJJUzbslnZg9oPP7pD9d83dQvKxfWa+LXl+L3
wwh5jNYepteA/3BIpAcdgFsvkJpZ5qleZQe6AGTR5rUNZtm2xy7UEqLVAjucpREZ
PHhEGRBDBD1EWHvQiArh
=onC9
-----END PGP SIGNATURE-----

Initial commit%
alphonce@dhcp-10-83-16-71 .git % git cat-file -t e7c77
tree
alphonce@dhcp-10-83-16-71 .git % git cat-file -p e7c77
100644 blob da80e272f601badf16da372517a26bba132b5bab  README.md
alphonce@dhcp-10-83-16-71 .git % git cat-file -t da80e
blob
alphonce@dhcp-10-83-16-71 .git % git cat-file -p da80e
# GitIntro
A first repo to show students how to interact with repo on GitHub
```
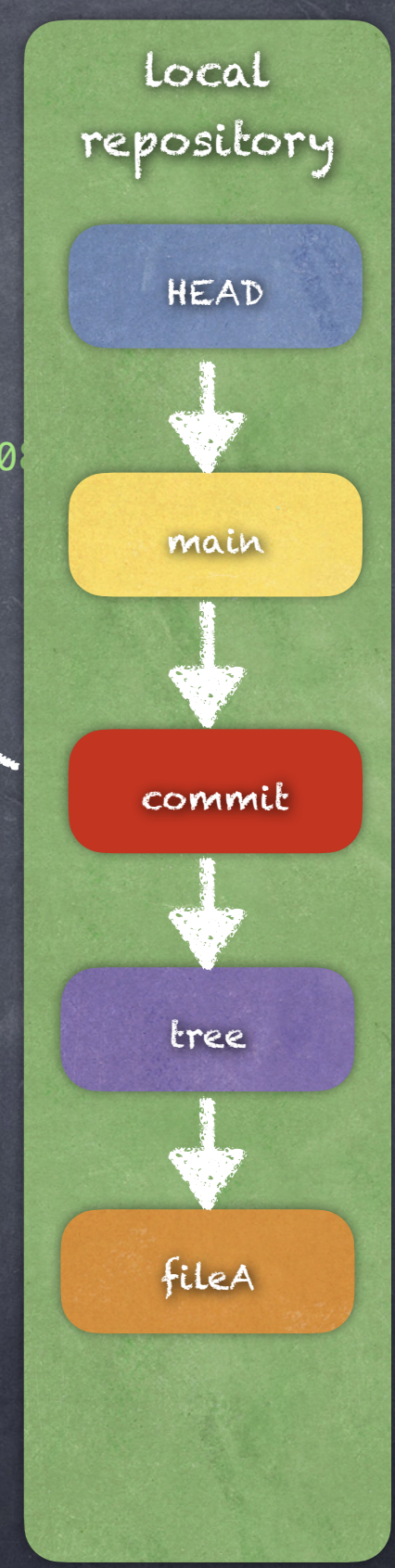
local repository

HEAD

main

commit

tree

fileA

```
alphonce@dhcp-10-83-16-71 .git % cat HEAD
ref: refs/heads/main
alphonce@dhcp-10-83-16-71 .git % cat refs/heads/main
2303f4622cbb330c9fb021cd216cd657e4942592
alphonce@dhcp-10-83-16-71 .git % git cat-file -t HEAD
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -t 2303f
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -p 2303f
tree e7c77e150f84d16ec763bd46dcffebfd8f2873f4
author github-classroom[bot] <66690702+github-classroom[bot]@users.noreply.github.com> 170708
committer GitHub <noreply@github.com> 1707088127 +0000
gpgsig -----BEGIN PGP SIGNATURE-----

 wsFcBAABCAAQBQJlwBj/CRC1aQ7uu5UhlAAAbt8QAJvL5XVgE7xXxNDM+ZqUWQgp
 nAdFnLO3nOfMqHskU9hG8FFnSw3DODZinpZ4se7cwqFdvDoH8ePcXDrZHKqmDq5c
 o6jwkejRAuFwwaYgqu5jn1YsdpNpPPFWjSmHZHQawF6TNIOD+V2n4YjhjJcmLdqp
 iJ4WmeB4oGqcEUVr0m11mgcZSeCusrQV4yKTvKtWzJoh6Z5U0nYlkOaNxdD6gZ/9
 lIUDr0/2NrpqUmoR2w1V9+0F334LLK5l0Ny2CDV3DIKvODDM8OTD6DhStZBBYIsm
 ji0wxHbbh4wH2o3QH/eqwV850GtAvaryKal9WfhtKkoBkEY7Tu9F63biuFbeXyjY
 URrT2AgfH0vIaOtwtrFxOKaD5FJyux6YXXX/gbPO/uu4DIxiLI4wQdCDAt9VGHkJ
 44CyucSgG0Zfai5xO8tC88V80mwXXVHok9+SWooD+pJ5El4qsBs9MYxenYH6cc45
 +Dh4gEq4bDj77TkTAlGaaXlHy2Sp+ROCnO/iiUol6g/7tmPyCMZ8YB6+FoOpCa7q
 NBGDnspHMOoKX7Ms1GkiO3HeXws8NJUzbslnZg9oPP7pD9d83dQvKxfWa+LXl+L3
 wwh5jNYepteA/3BIpAcdgFsvkJpZ5qleZQe6AGTR5rUNZtm2xy7UEqLVAjucpREZ
 PHhEGRBDBD1EWHvQiArh
 =onC9
 -----END PGP SIGNATURE-----

Initial commit%
alphonce@dhcp-10-83-16-71 .git % git cat-file -t e7c77
tree
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100644 blob da80e272f601badf16da372517a26bba132b5bab  README.md
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blob
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# GitIntro
A first repo to show students how to interact with repo on GitHub
```


local
repository

HEAD

main

commit

tree

fileA

```
alphonce@dhcp-10-83-16-71 .git % cat HEAD
ref: refs/heads/main
alphonce@dhcp-10-83-16-71 .git % cat refs/heads/main
2303f4622cbb330c9fb021cd216cd657e4942592
alphonce@dhcp-10-83-16-71 .git % git cat-file -t HEAD
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -t 2303f
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -p 2303f
tree e7c77e150f84d16ec763bd46dcffebfd8f2873f4
author github-classroom[bot] <66690702+github-classroom[bot]@users.noreply.github.com> 17070
committer GitHub <noreply@github.com> 1707088127 +0000
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 nAdFnLO3nOfMqHskU9hG8FFnSw3DODZinpZ4se7cwqFdvDoH8ePcXDrZHKqmDq5c
 o6jwkejRAuFwwaYgqu5jn1YsdpNpPPFWjSmHZHQawF6TNIOD+V2n4YjhjJcmLdqp
 iJ4WmeB4oGqcEUVr0m11mgcZSeCusrQV4yKTvKtWzJoh6Z5U0nYlkOaNxdD6gZ/9
 lIUDr0/2NrpqUmoR2w1V9+0F334LLK5lONy2CDV3DIKvODDM8OTD6DhStZBBYIsm
 ji0wxHbbh4wH2o3QH/eqwV850GtAvaryKal9WfhtKkoBkEY7Tu9F63biuFbeXyjY
 URrT2AgfH0vIaOtwtrFxOKaD5FJyux6YXXX/gbPO/uu4DIxiLI4wQdCDAt9VGHkJ
 44CyucSgG0Zfai5xO8tC88V80mwXXVHok9+SWooD+pJ5El4qsBs9MYxenYH6cc45
 +Dh4gEq4bDj77TkTAlGaaXlHy2Sp+ROCnO/iiUol6g/7tmPyCMZ8YB6+FoOpCa7q
 NBGDnspHMOoKX7Ms1GkiO3HeXws8NJUzbslnZg9oPP7pD9d83dQvKxfWa+LXl+L3
 wwh5jNYepteA/3BIpAcdgFsvkJpZ5qleZQe6AGTR5rUNZtm2xy7UEqLVAjucpREZ
 PHhEGRBDBD1EWHvQiArh
 =onC9
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tree
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100644 blob da80e272f601badf16da372517a26bba132b5bab  README.md
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A first repo to show students how to interact with repo on GitHub
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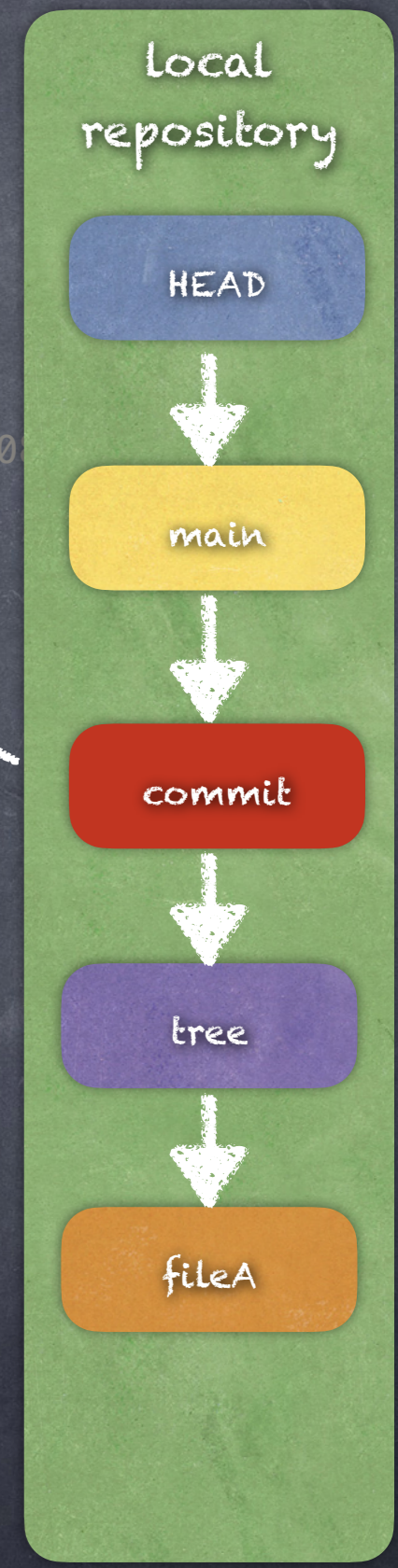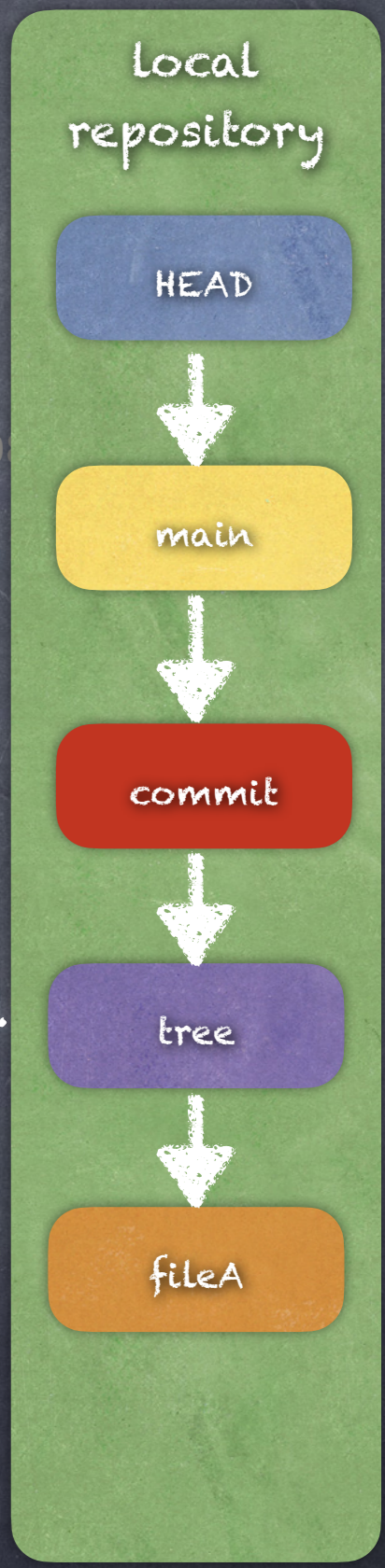
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commit
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author github-classroom[bot] <66690702+github-classroom[bot]@users.noreply.github.com> 17070
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 nAdFnLO3nOfMqHskU9hG8FFnSw3DODZinpZ4se7cwqFdvDoH8ePcXDrZHKqmDq5c
 o6jwkejRAuFwwaYgqu5jn1YsdpNpPPFWjSmHZHQawF6TNIOD+V2n4YjhjJcmLdqp
 iJ4WmeB4oGqcEUVr0m11mgcZSeCusrQV4yKTvKtWzJoh6Z5U0nYlkOaNxdD6gZ/9
 lIUDr0/2NrpqUmoR2w1V9+0F334LLK5lONy2CDV3DIKvODDM8OTD6DhStZBBYIsm
 ji0wxHbbh4wH2o3QH/eqwV850GtAvaryKal9WfhtKkoBkEY7Tu9F63biuFbeXyjY
 URrT2AgfH0vIaOtwtrFxOKaD5FJyux6YXXX/gbPO/uu4DIxiLI4wQdCDAt9VGHkJ
 44CyucSgG0Zfai5xO8tC88V80mwXXVHok9+SWooD+pJ5El4qsBs9MYxenYH6cc45
 +Dh4gEq4bDj77TkTAlGaaXlHy2Sp+ROCnO/iiUol6g/7tmPyCMZ8YB6+FoOpCa7q
 NBGDnspHMOoKX7Ms1GkiO3HeXws8NJUzbslnZg9oPP7pD9d83dQvKxfWa+LXl+L3
 wwh5jNYepteA/3BIpAcdgFsvkJpZ5qleZQe6AGTR5rUNZtm2xy7UEqLVAjucpREZ
 PHhEGRBDBD1EWHvQiArh
 =onC9
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Initial commit%
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tree
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100644 blob da80e272f601badf16da372517a26bba132b5bab  README.md
alphonce@dhcp-10-83-16-71 .git % git cat-file -t da80e
blob
alphonce@dhcp-10-83-16-71 .git % git cat-file -p da80e
# GitIntro
A first repo to show students how to interact with repo on GitHub
```
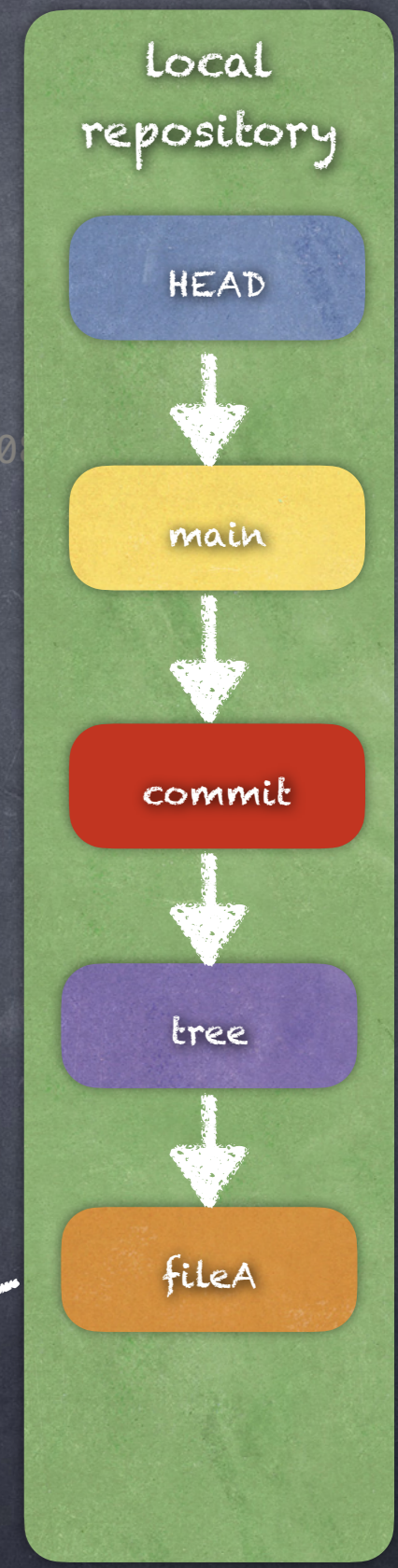
local
repository

HEAD

main

commit

tree

fileA

```
alphonce@dhcp-10-83-16-71 .git % cat HEAD
ref: refs/heads/main
alphonce@dhcp-10-83-16-71 .git % cat refs/heads/main
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alphonce@dhcp-10-83-16-71 .git % git cat-file -t HEAD
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -t 2303f
commit
alphonce@dhcp-10-83-16-71 .git % git cat-file -p 2303f
tree e7c77e150f84d16ec763bd46dcffebfd8f2873f4
author github-classroom[bot] <66690702+github-classroom[bot]@users.noreply.github.com> 17070
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 nAdFnLO3nOfMqHskU9hG8FFnSw3DODZinpZ4se7cwqFdvDoH8ePcXDrZHKqmDq5c
 o6jwkejRAuFwwaYgqu5jn1YsdpNpPPFWjSmHZHQawF6TNIOD+V2n4YjhjJcmLdqp
 iJ4WmeB4oGqcEUVr0m11mgcZSeCusrQV4yKTvKtWzJoh6Z5U0nYlkOaNxdD6gZ/9
 lIUDr0/2NrpqUmoR2w1V9+0F334LLK5lONy2CDV3DIKvODDM8OTD6DhStZBBYIsm
 ji0wxHbbh4wH2o3QH/eqwV850GtAvaryKal9WfhtKkoBkEY7Tu9F63biuFbeXyjY
 URrT2AgfH0vIaOtwtrFxOKaD5FJyux6YXXX/gbPO/uu4DIxiLI4wQdCDAt9VGHkJ
 44CyucSgG0Zfai5xO8tC88V80mwXXVHok9+SWooD+pJ5El4qsBs9MYxenYH6cc45
 +Dh4gEq4bDj77TkTAlGaaXlHy2Sp+ROCnO/iiUol6g/7tmPyCMZ8YB6+FoOpCa7q
 NBGDnspHMOoKX7Ms1GkiO3HeXws8NJUzbslnZg9oPP7pD9d83dQvKxfWa+LXl+L3
 wwh5jNYepteA/3BIpAcdgFsvkJpZ5qleZQe6AGTR5rUNZtm2xy7UEqLVAjucpREZ
 PHhEGRBDBD1EWHvQiArh
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Initial commit%
alphonce@dhcp-10-83-16-71 .git % git cat-file -t e7c77
tree
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100644 blob da80e272f601badf16da372517a26bba132b5bab  README.md
alphonce@dhcp-10-83-16-71 .git % git cat-file -t da80e
blob
alphonce@dhcp-10-83-16-71 .git % git cat-file -p da80e
# GitIntro
A first repo to show students how to interact with repo on GitHub
```

local
repository

HEAD

main

commit

tree

fileA

pointers to commits

```
-rw-r--r--    1 alphonce   staff    21 Feb   4 18:10 HEAD
-rw-r--r--    1 alphonce   staff   320 Feb   4 18:10 config
-rw-r--r--    1 alphonce   staff    73 Feb   4 18:10 description
drwxr-xr-x   15 alphonce   staff   480 Feb   4 18:10 hooks
-rw-r--r--    1 alphonce   staff   137 Feb   4 18:10 index
drwxr-xr-x    3 alphonce   staff    96 Feb   4 18:10 info
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 logs
drwxr-xr-x    4 alphonce   staff   128 Feb   4 18:10 objects
-rw-r--r--    1 alphonce   staff   112 Feb   4 18:10 packed-refs
drwxr-xr-x    5 alphonce   staff   160 Feb   4 18:10 refs
```

```
% ls -l refs
total 0
drwxr-xr-x   4 alphonce   staff   128 Feb   4 18:18 heads
drwxr-xr-x   3 alphonce   staff    96 Feb   4 18:10 remotes
drwxr-xr-x   2 alphonce   staff    64 Feb   4 18:10 tags
% ls refs/heads/
main
% ls refs/remotes/
origin
% ls refs/remotes/origin/
HEAD   main
```

-rw-r--r--   1 alphonce   staff   112 Feb   4 18:10 packed-refs
drwxr-xr-x   5 alphonce   staff   160 Feb   4 18:10 refs

TOPHAT QUESTION