

# Create new Git repository

`git init`

# Git object types

**Blob**

**Tree**

**Commit**

**Annotated  
Tag**

# Git low-level commands

`git hash-object`

`git cat-file`

`git mktree`

## JSON (JavaScript Object Notation)

```
{  
  "id": "1234567",  
  "name": "Mike",  
  "age": 25,  
  "city": "New York",  
  "hobbies": ["Skateboarding", "Running"]  
}
```

Variable length input

Any variable length input

Hash Function

C210FD2A1A62F9719955823CB31B7A7DA2E8D715

Fixed length hash

**MD5**  
128 bit

**SHA384**  
384 bit

**SHA1**  
160 bit

**SHA256**  
256 bit

**SHA512**  
512 bit

# SHA1

160 bits

40 hexadecimal  
characters

C210FD2A1A62F9719955823CB31B7A7DA2E8D715

## Hexadecimal

0 1 2 3 4 5 6 7 8 9 A B C D E F

Hex

C210FD2A1A62F9719955823CB31B7A7DA2E8D715

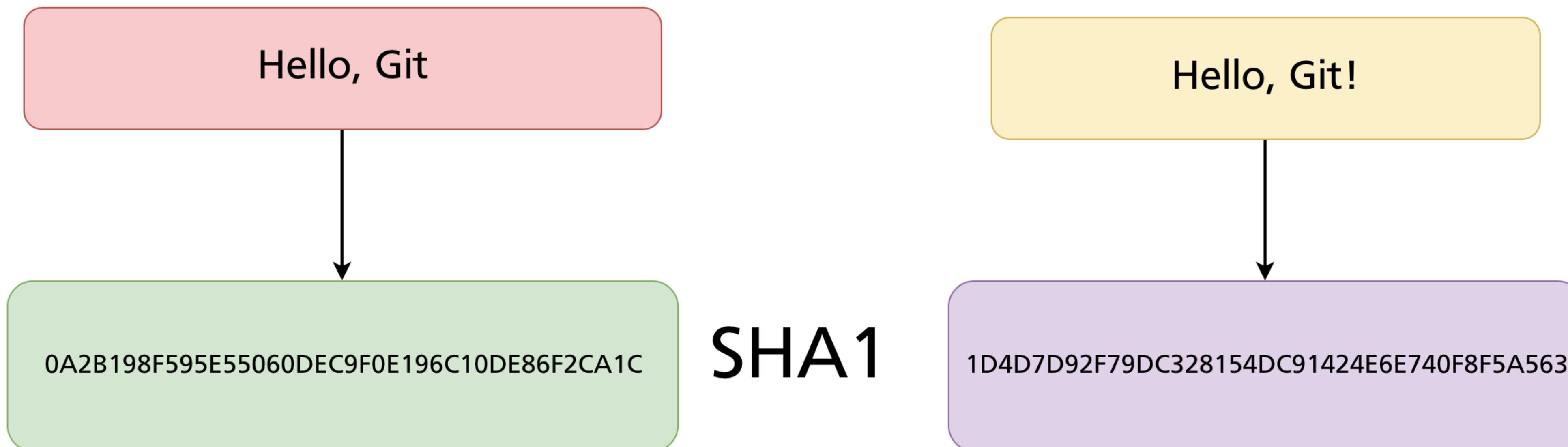
Base 16

Binary

110000100010001111101001010100011010011  
000101111001011100011001100101010101100000  
10001111001011001100011011011110100111110110  
100010111010001101011100010101

Base 2

## Different hashes



How many files Git can store  
in the same repository?

What is the chance of producing  
same **exact** hash for different files?

What is the chance of producing  
same **any** hash for different files  
(hash collision)?

# Combinations

$$2^2 = 4$$

00  
01  
10  
11

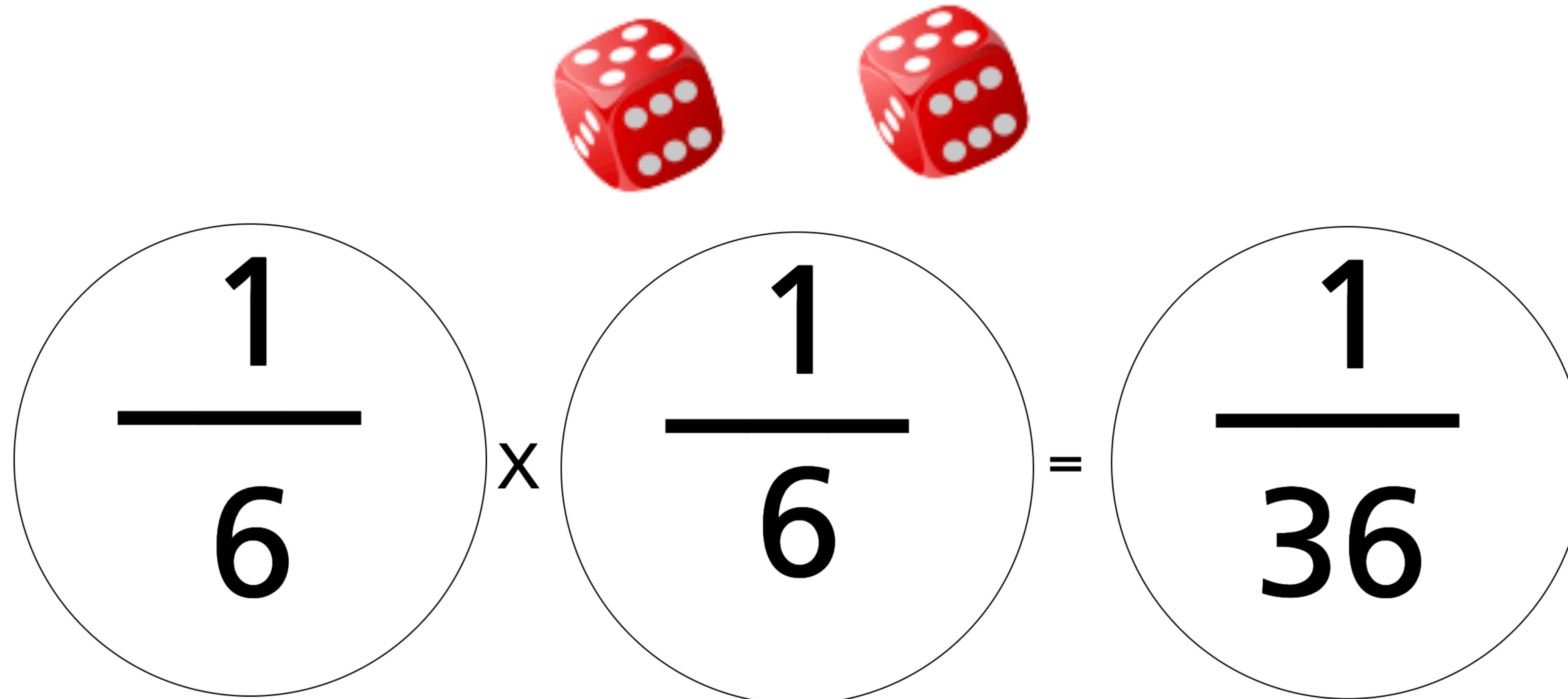
$$2^3 = 8$$

000	100
001	101
010	110
011	111

## SHA1 combinations

$2^{160}$

1461501637330902918203684832716283019655932542976



Exact combination  
probability when **order**  
**does matter**

0.028

$$\frac{1}{2^{160}}$$

Probability of  
each SHA1 hash

6.84e-49

Probability of  
the **same specific** SHA1 hash

$$\frac{1}{2^{160}} \times \frac{1}{2^{160}} = \frac{1}{2^{320}}$$

$$2^{320} = 2.13e+96$$

$$\frac{1}{2^{320}} = 4.68e-97 = 0.000...004$$

96 zeros

## Probability of any same number on two dices



$$\frac{1}{6} \times \frac{1}{6} \times 6 = \frac{1}{36} \times 6 = \frac{6}{36} = \frac{1}{6}$$

Probability **0.17**

Probability of **any** number on the **single** dice

Possible pairs

1	1
2	2
3	3
4	4
5	5
6	6

## Probability of any **same** number on three dices



$$\frac{1}{6} \times \frac{1}{6} \times \frac{1}{6} \times 6 = \frac{1}{216} \times 6 = \frac{6}{216} = \frac{1}{36}$$

Probability

0.03

Possible combinations

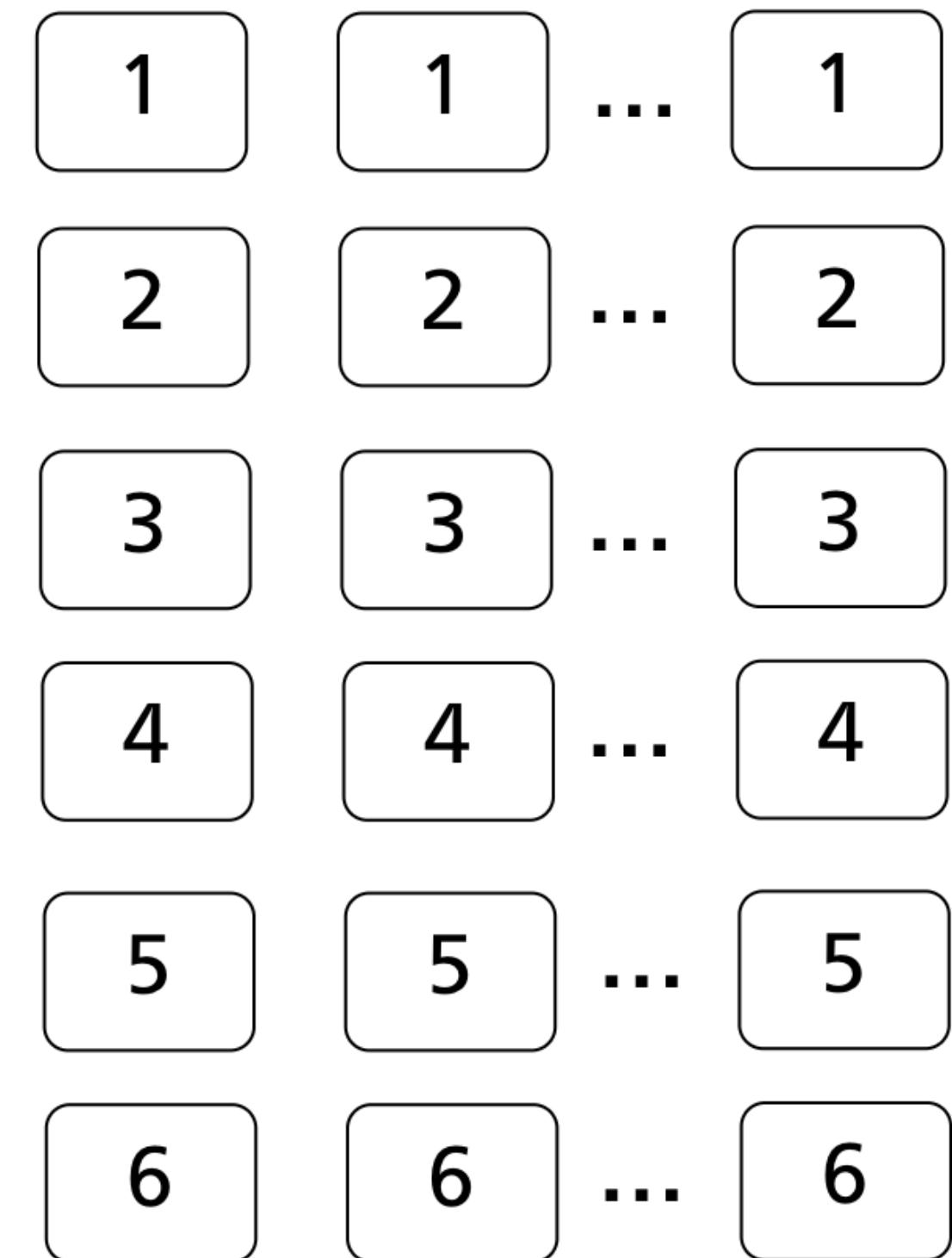
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6

## Probability of **any same** number on **N** dices



$$\frac{1}{6} \times \frac{1}{6} \times \dots \times \frac{1}{6} \times 6 = \frac{1}{6^N} \times 6 = \frac{1}{6^{N-1}}$$

Possible combinations



Probability of **any same number on any pair** of three dices

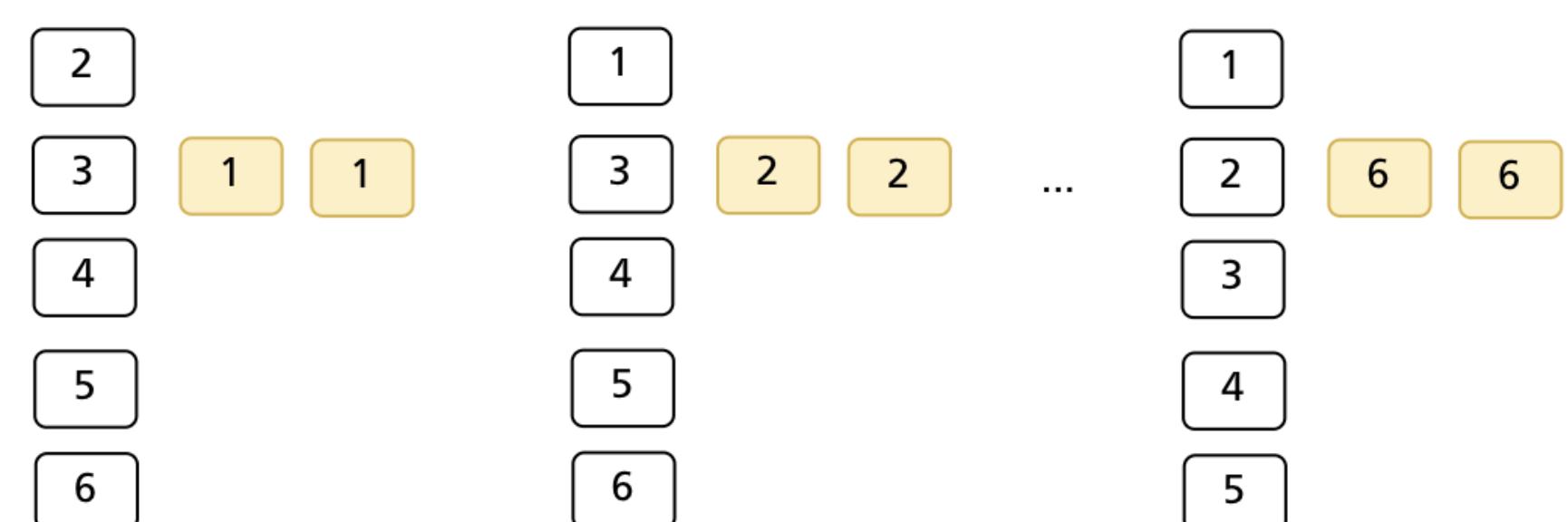
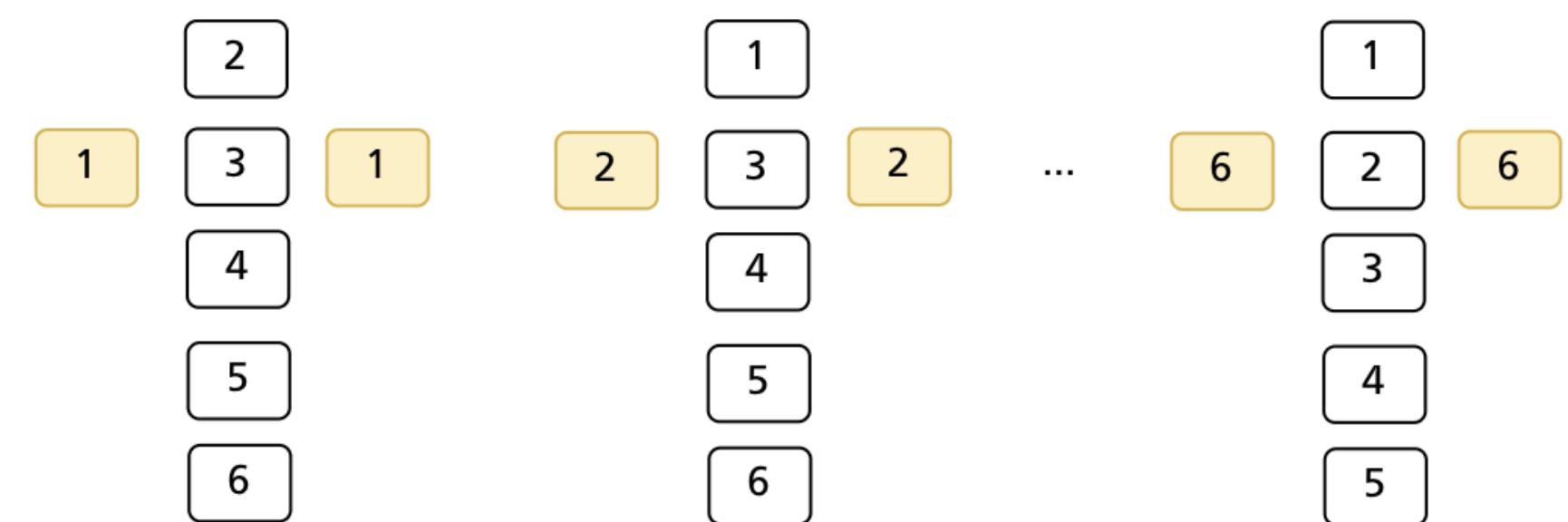
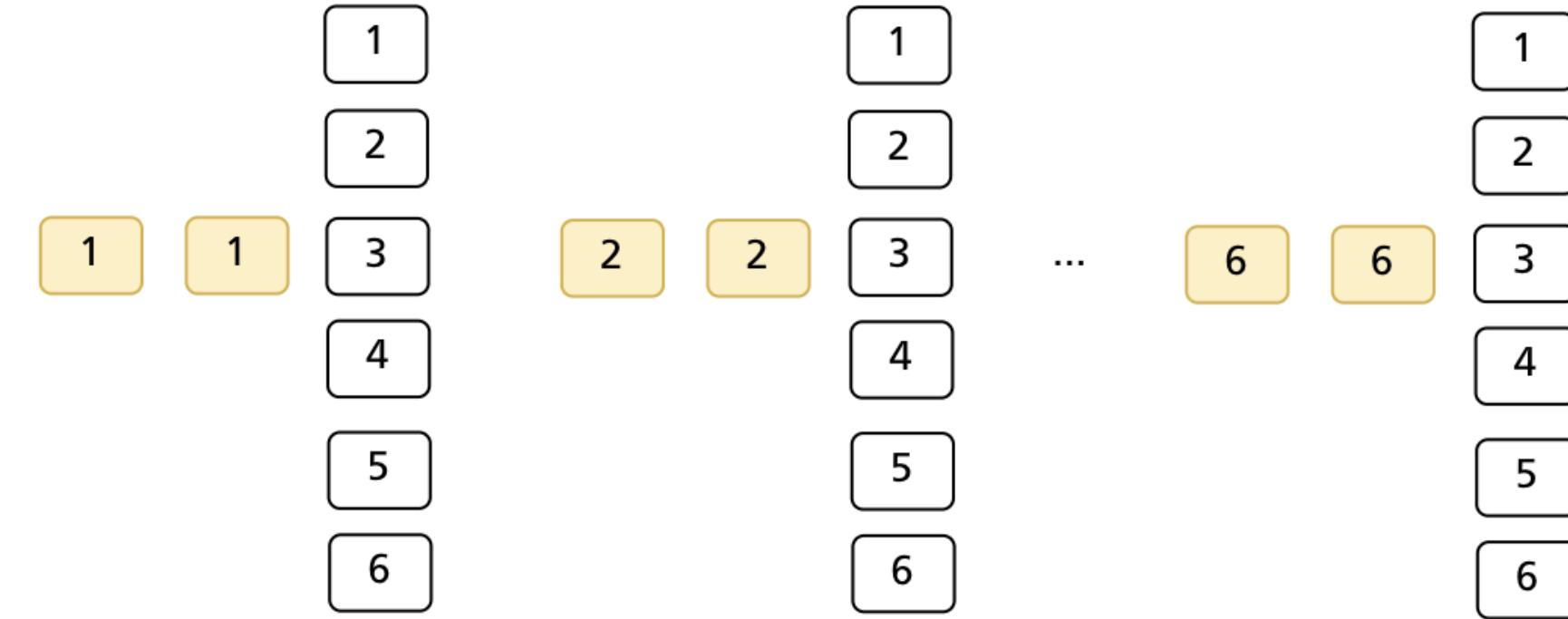


$$\frac{1}{6} \times \frac{1}{6} \times \frac{1}{6} \times 96 = \frac{16}{36}$$

Probability **0.44**

Matching results  $6 * 6 + 5 * 6 + 5 * 6 = 96$

## Possible pairs



Probability of **all different** numbers on **all** dices



$$\frac{6}{6} \times \frac{5}{6} \times \dots \times \frac{6+1-N}{6} = \frac{5!}{(6-N)! \times 6^{N-1}}$$

Example with 4 dices

1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6



$$\frac{6}{6} \times \frac{5}{6} \times \frac{4}{6} \times \frac{3}{6} = \frac{5}{18}$$

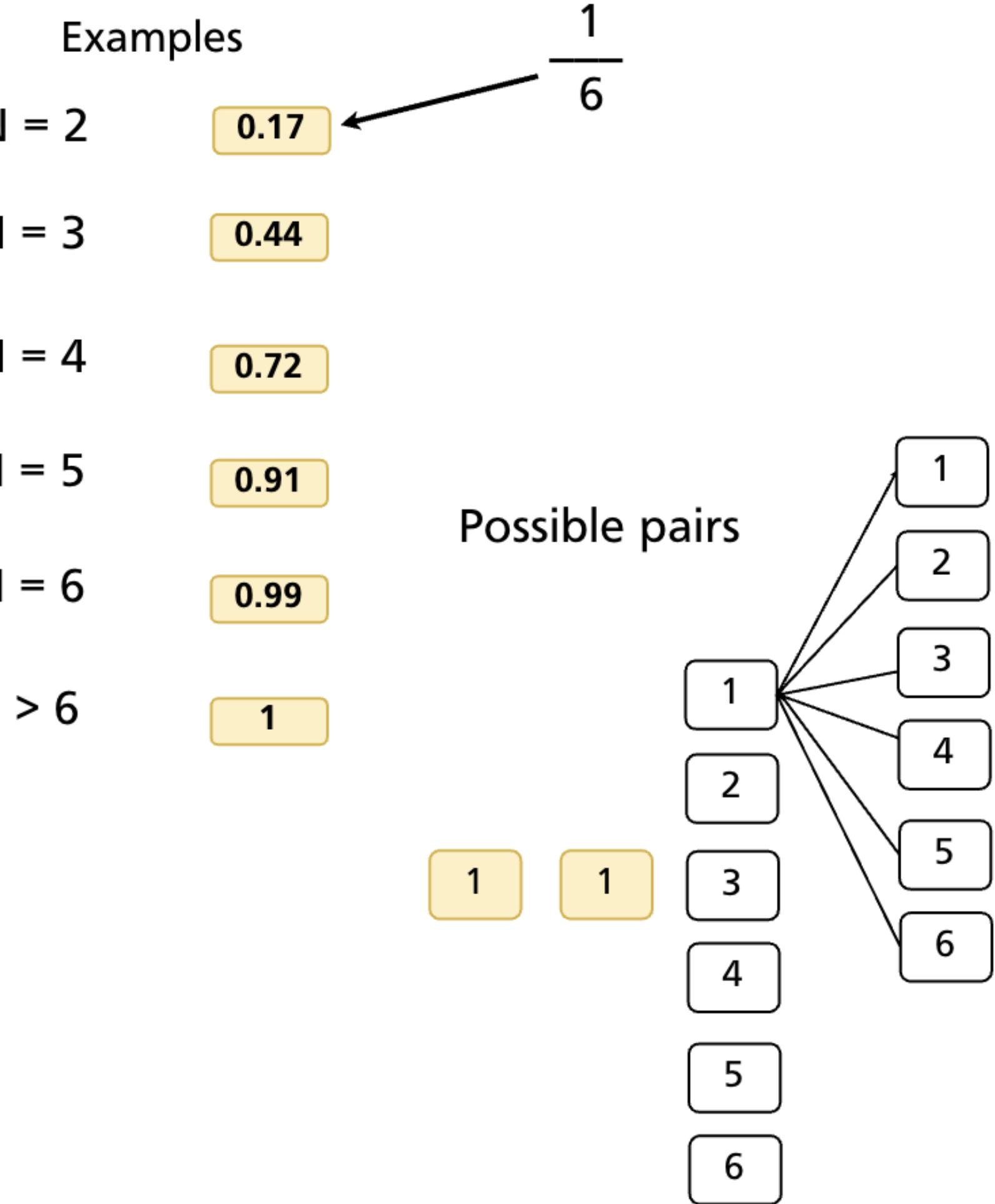
Probability **0.28**

**Probability of any same number on any pair of N dices**  
*(for  $N \leq 6$ )*

$$1 - \left( \frac{6}{6} \times \frac{5}{6} \times \dots \times \frac{6+1-N}{6} \right) = 1 - \frac{5!}{(6-N)! \times 6^{N-1}}$$

.....

↑  
Probability of getting all different numbers on all dices



# Probability of any same SHA1 hash on any pair of N files



# Hash Collision

$$1 - \frac{(2^{160} - 1)!}{(2^{160} - 2^N) \times 2^{160} * (N-1)!}$$

N = 2

6.84e-49

N = 3

2.05e-48

# git hash-object

```
echo "Hello, Git" | git hash-object --stdin -w
```

```
git hash-object <filename> -w
```

# git cat-file options

**git cat-file -p <hash>** Contents of the object

**git cat-file -s <hash>** Size of the object

**git cat-file -t <hash>** Type of the object

Where size and type  
of each object  
are stored in Git?

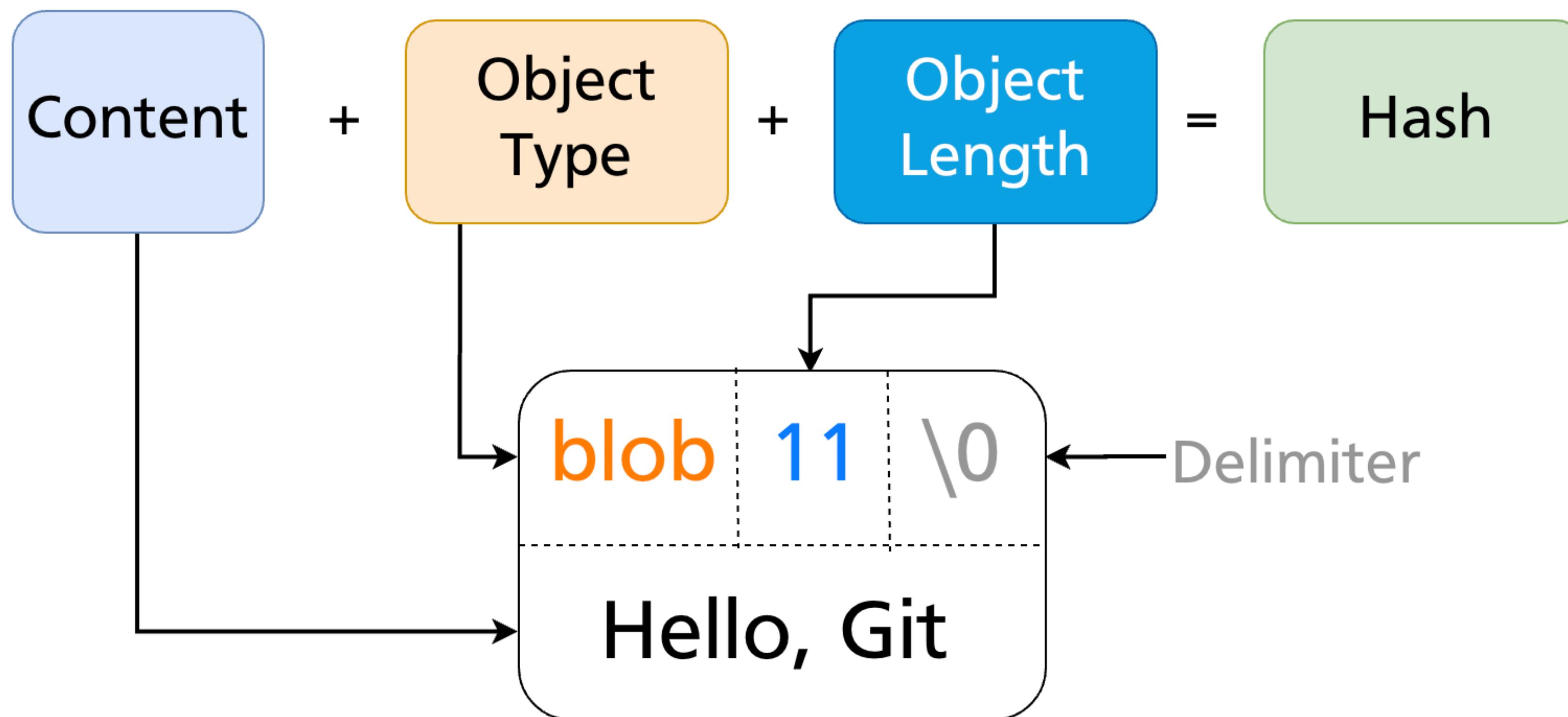
Inside of the Object!

# Git blobs don't have filenames!

# Git objects permissions

<b>040000</b>	Directory
<b>100644</b>	Regular non-executable file
<b>100664</b>	Regular non-executable group-writeable file
<b>100755</b>	Regular executable file
<b>120000</b>	Symbolic link
<b>160000</b>	Gitlink

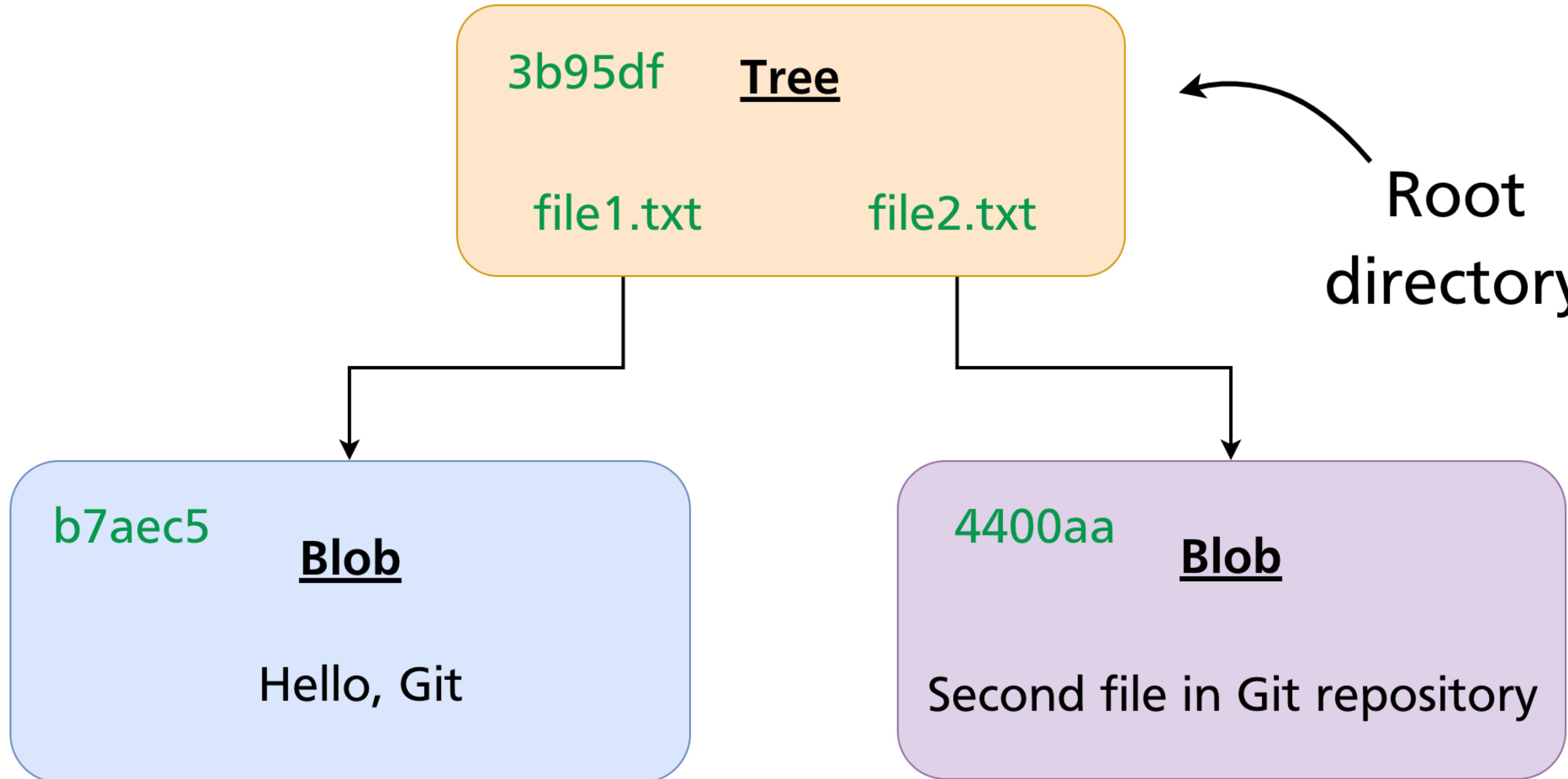
# Git Object



# Git Tree Objects

100644 blob 57537e1d8fba7d80c5bcc8b04e49666b1c1790f  
100644 blob 1fed445333e85fb9996542978fa56866de90a2fb  
040000 tree c167c406a72fd6f3ab232b905cc730588167340e  
100644 blob cb82ecb6e7b8f3d4be8f188fc495063aa5ae0c48  
040000 tree 5ddb0cfa6f45d4bce18247297b89353c9ae47af5  
100644 blob 8ce3a3772a346a19afc3bc9ee3a7fa999b36c5d0  
100644 blob 7fdb8f594ccda44eba69ea7ce95ea84c93bbfac0

.babelrc  
.flowconfig  
dist  
package.json  
src  
yarn-error.log  
yarn.lock



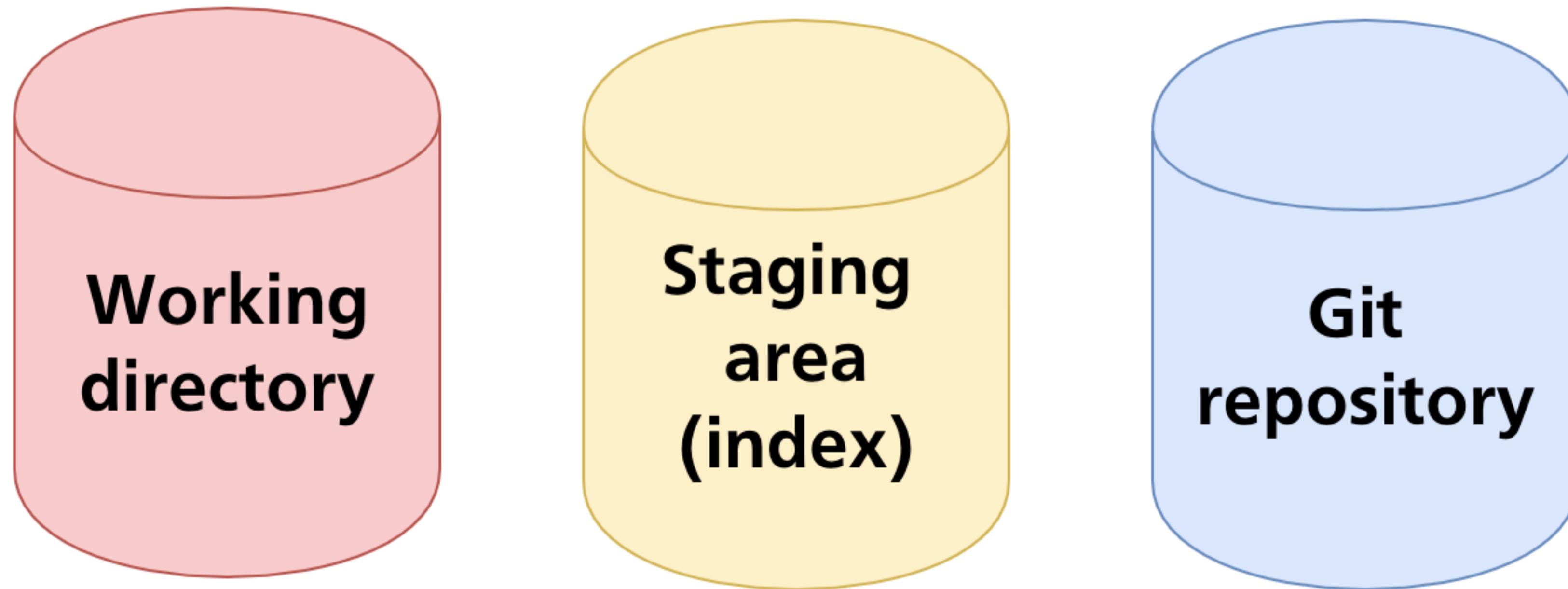
# Tree in our first-project

100644 blob b7aec520dec0a7516c18eb4c68b64ae1eb9b5a5e

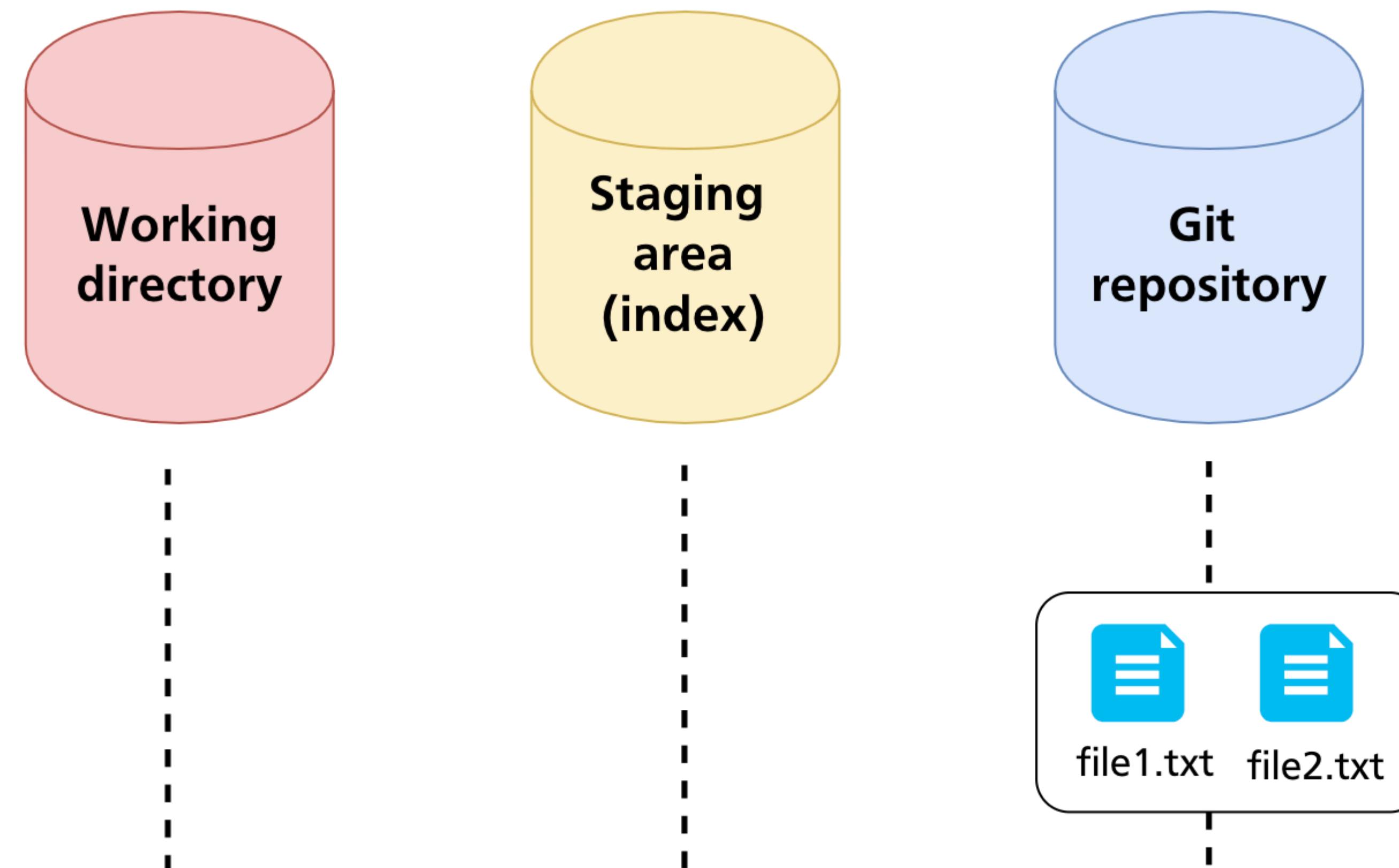
file1.txt

100644 blob 4400aae52a27341314f423095846b1f215a7cf08

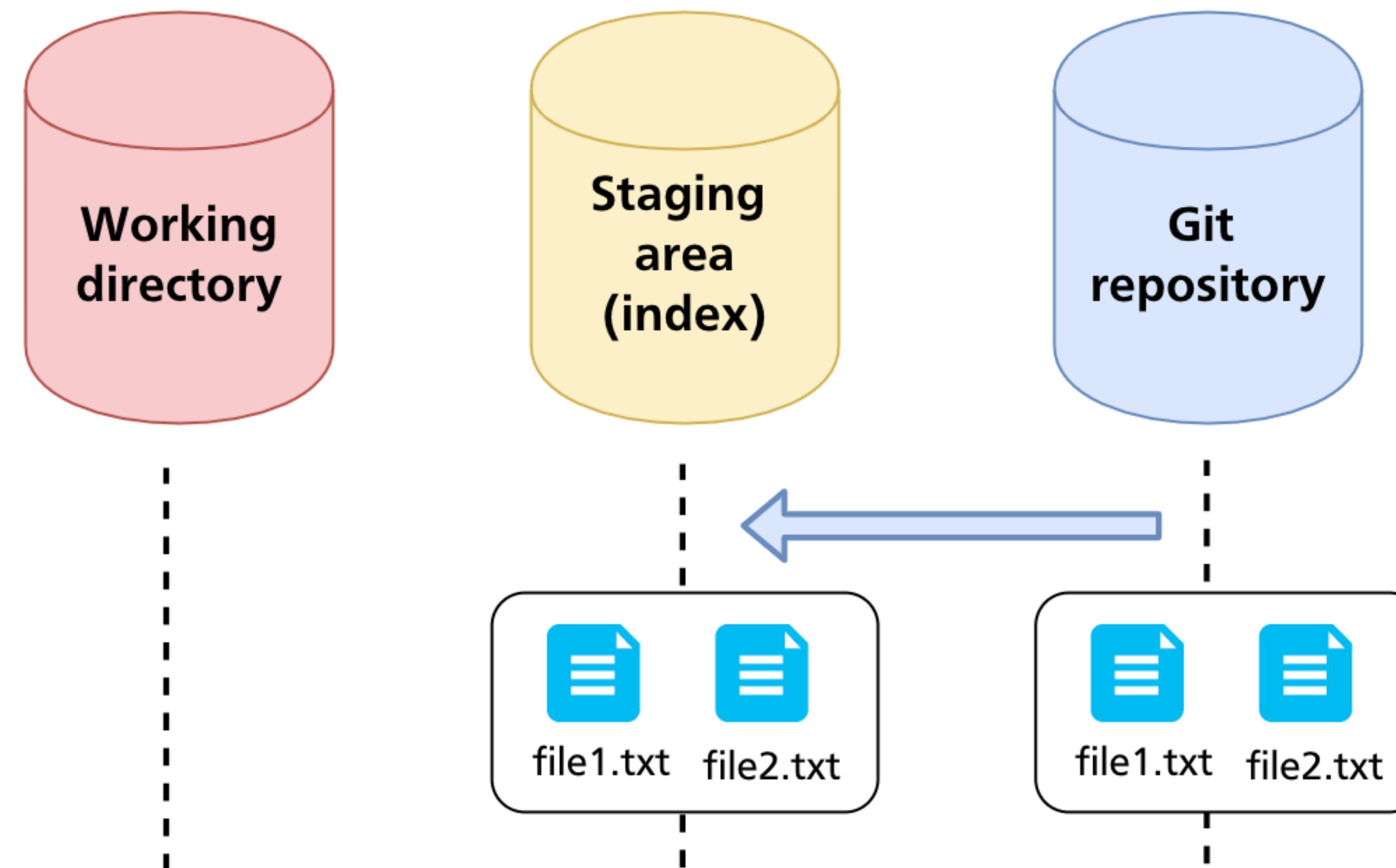
file2.txt



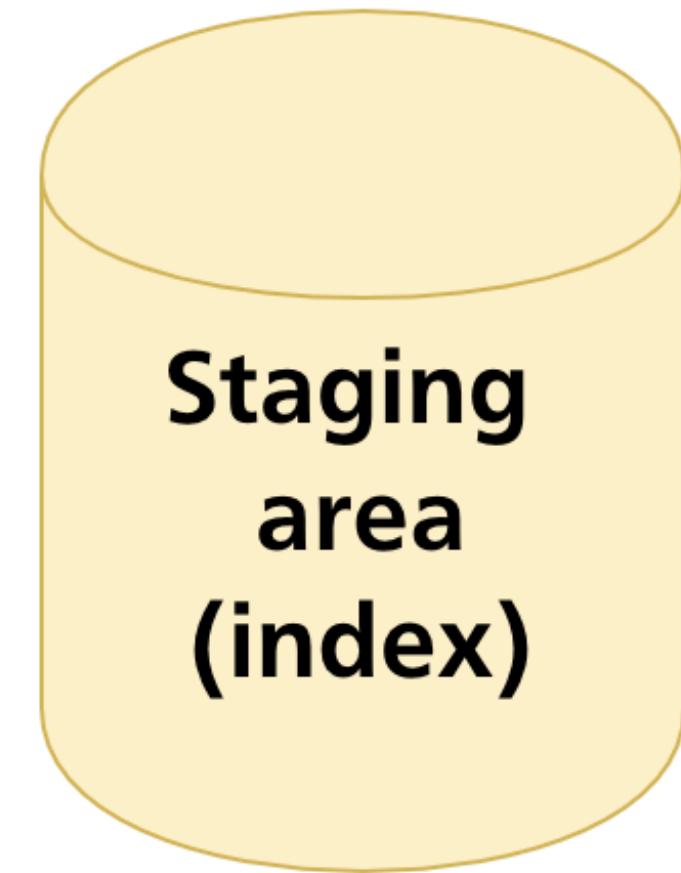
## Files in the "first-project"



## git read-tree <hash>

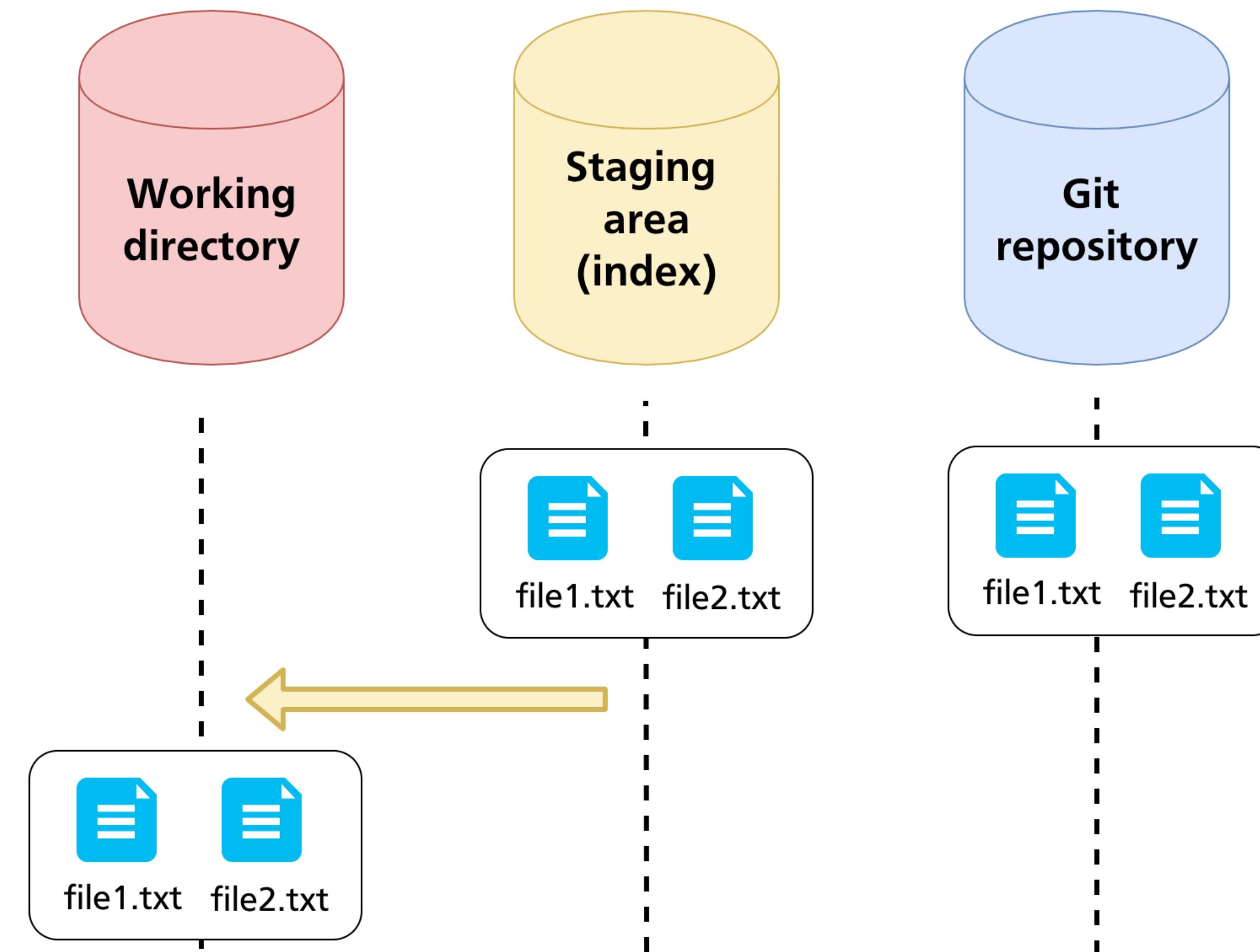


`git ls-files -s`

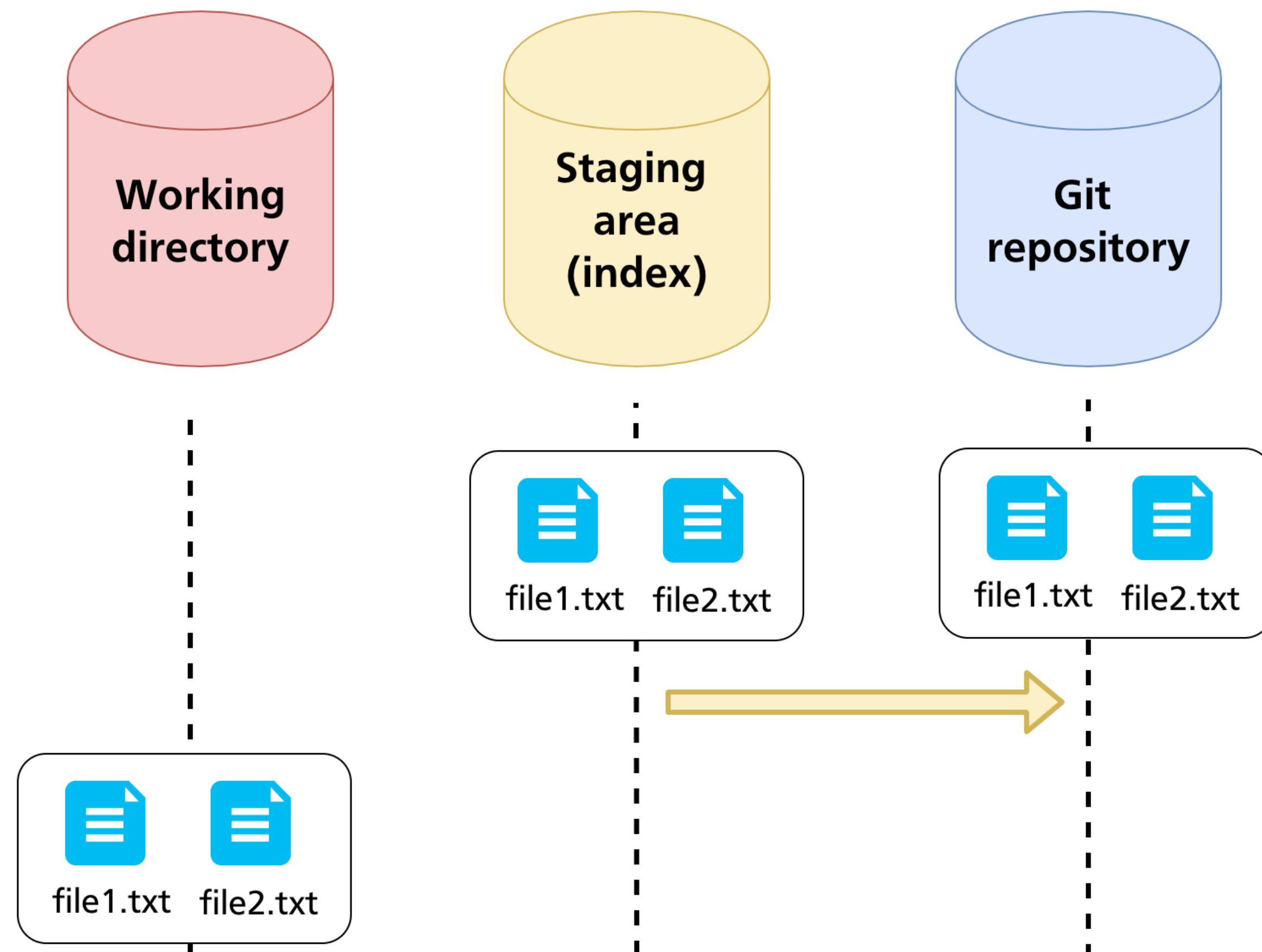


List files in the staging area

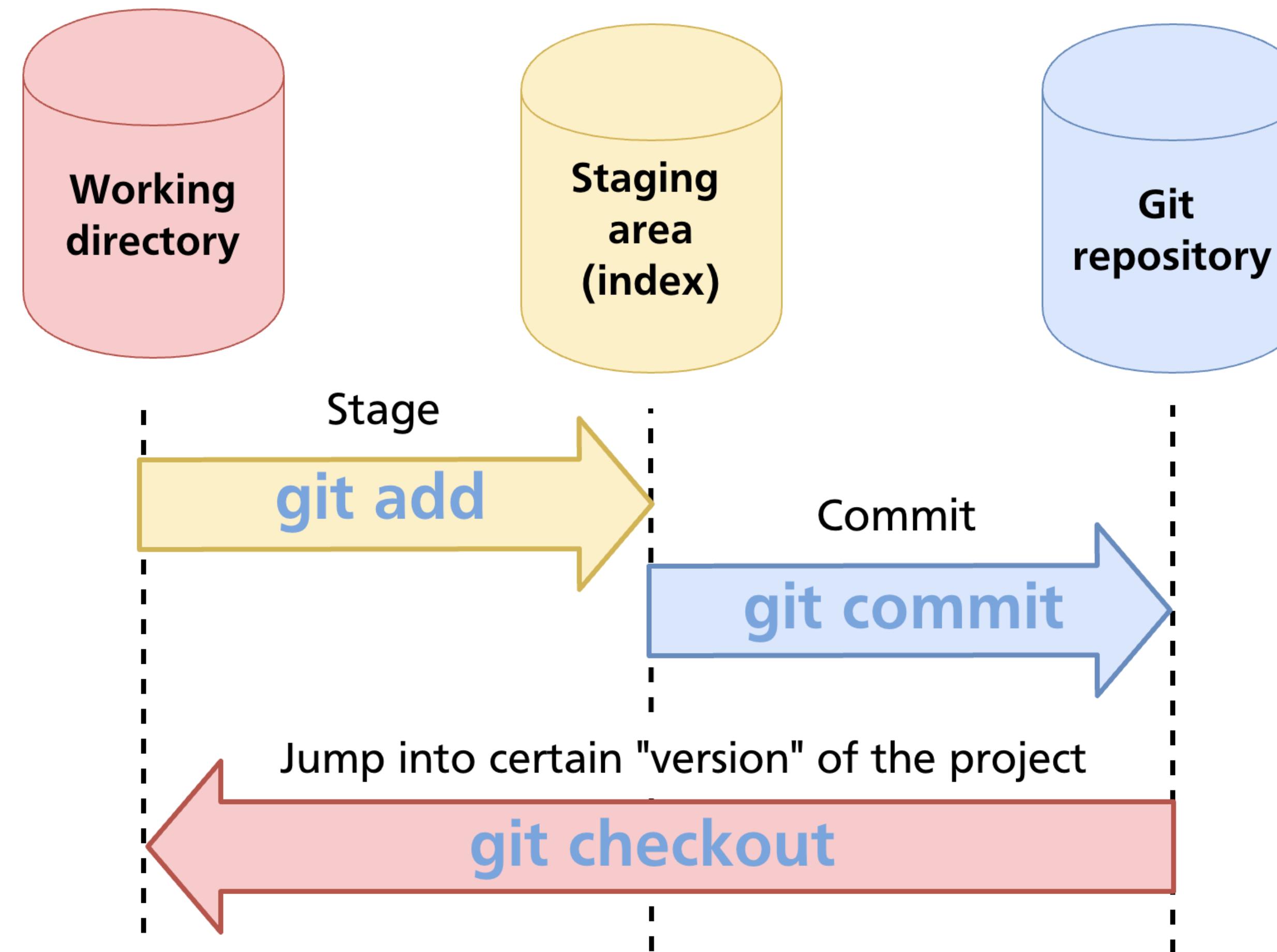
# git checkout-index -a



## git commit -m



# Most common operations



# File states in Git areas



**Working  
directory**



**Staging  
area  
(index)**



**Git  
repository**

**Untracked**

**Staged**

**Modified**

**Unmodified**

**Unmodified**

**Unmodified**

How many folders for  
objects Git create in  
"./git/objects"?

$$16 * 16 = 256$$