

Git Under the Hood*

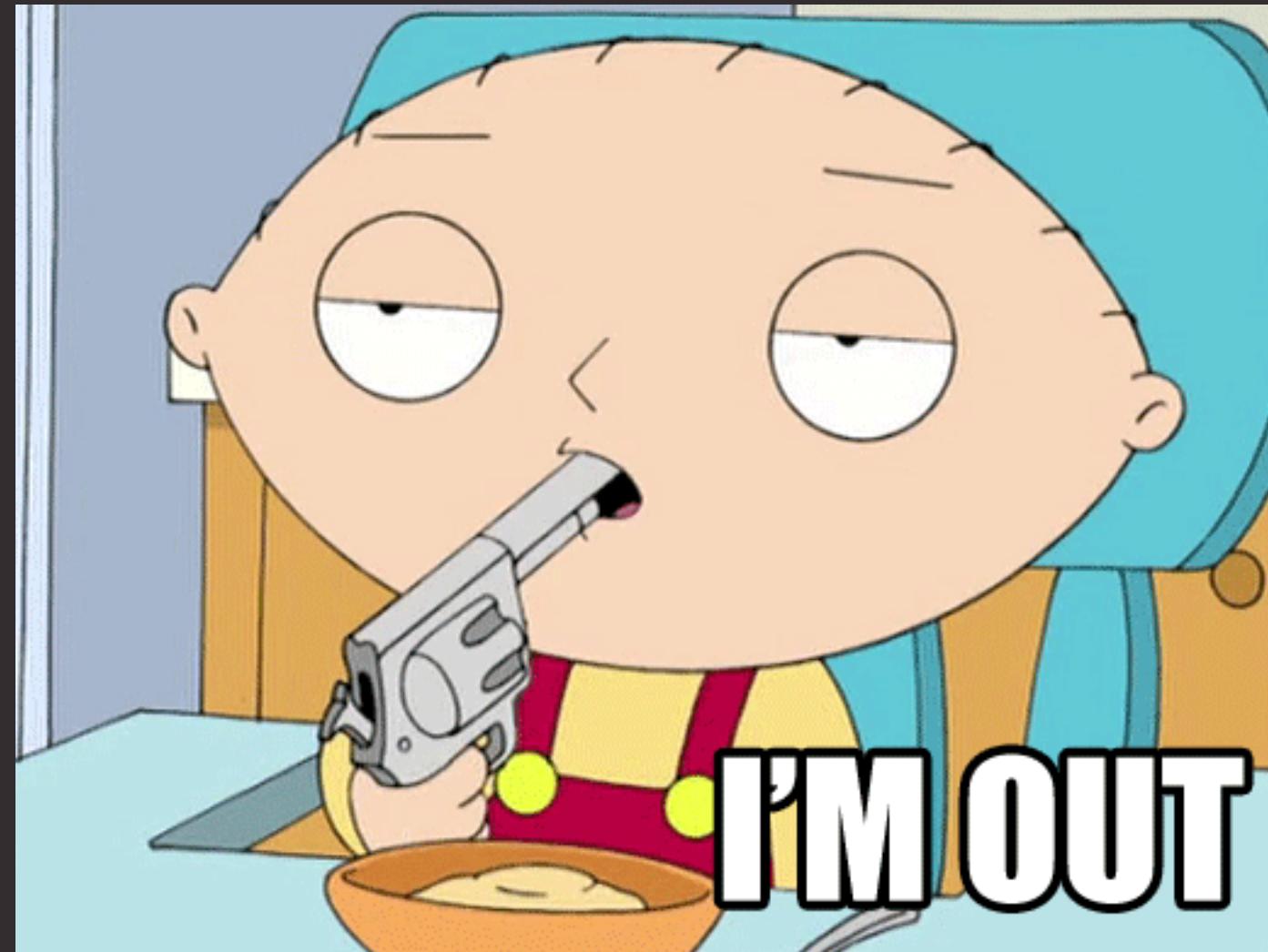
```
let author = "Konstantin Portnov"  
let github = "github.com/x0000ff"
```



* <https://octodex.github.com/bear-cavalry>



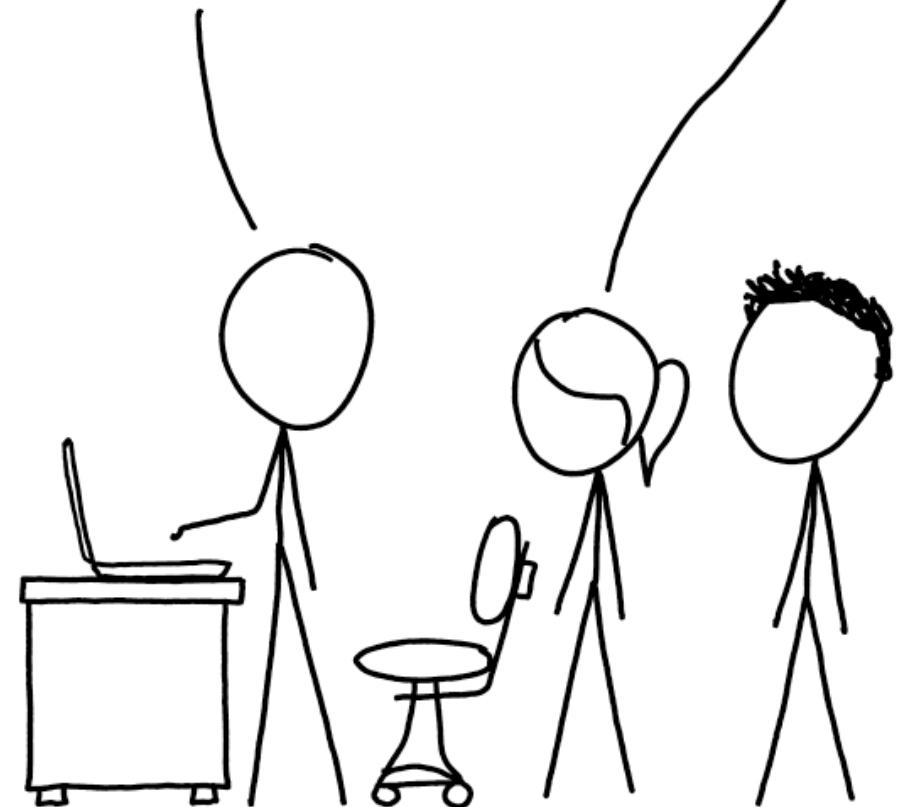
¿Git?



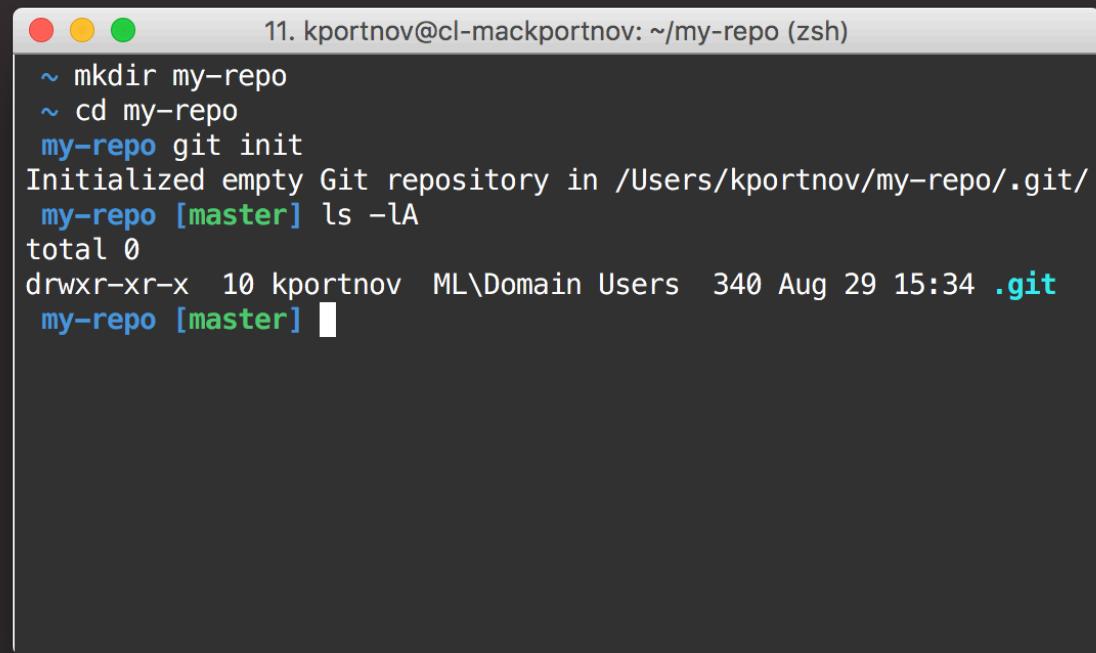
THIS IS GIT. IT TRACKS COLLABORATIVE WORK
ON PROJECTS THROUGH A BEAUTIFUL
DISTRIBUTED GRAPH THEORY TREE MODEL.

| COOL. HOW DO WE USE IT?

NO IDEA. JUST MEMORIZE THESE SHELL
COMMANDS AND TYPE THEM TO SYNC UP.
IF YOU GET ERRORS, SAVE YOUR WORK
ELSEWHERE, DELETE THE PROJECT,
AND DOWNLOAD A FRESH COPY.



Hello, Empty World



A screenshot of a macOS terminal window titled "11. kportnov@cl-mackportnov: ~/my-repo (zsh)". The window shows the following command sequence and output:

```
~ mkdir my-repo
~ cd my-repo
my-repo git init
Initialized empty Git repository in /Users/kportnov/my-repo/.git/
my-repo [master] ls -lA
total 0
drwxr-xr-x 10 kportnov ML\Domain Users 340 Aug 29 15:34 .git
my-repo [master] █
```

Install tree command⁰

⁰ On Mac ⚡: <http://bit.ly/2xKh0PX>

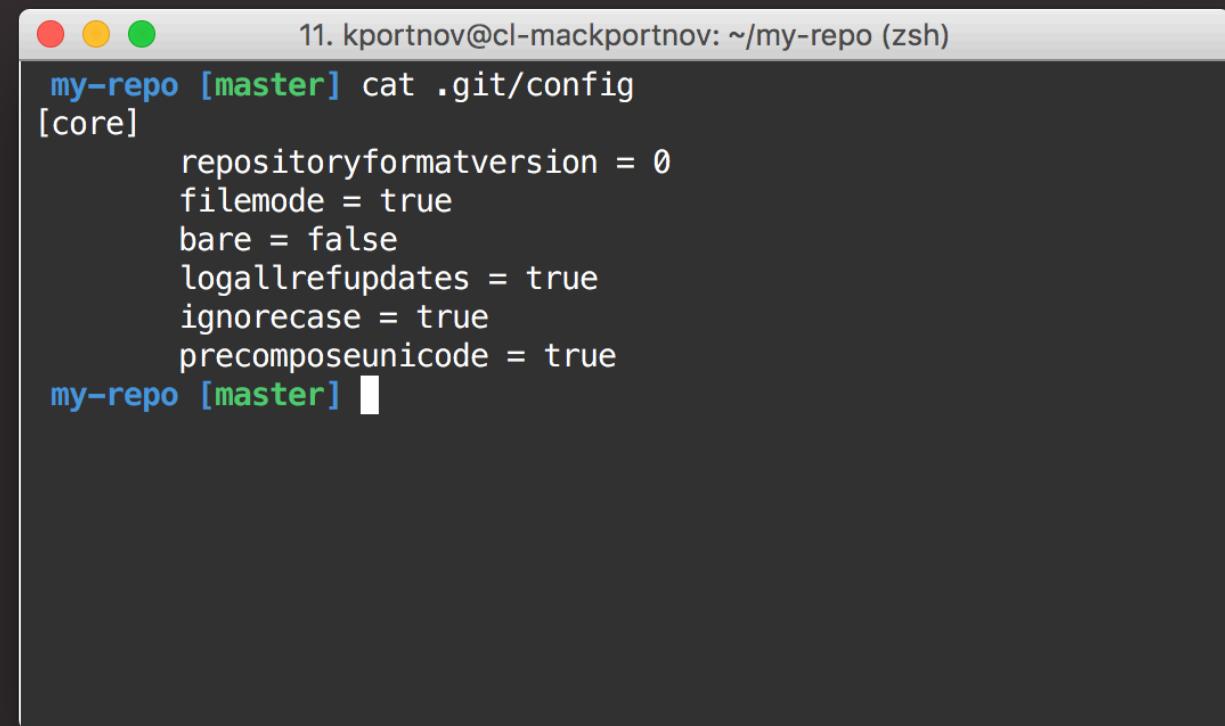
q
u
e
s
t
i
o
n
s
?

```
my-repo [master] tree .git
.git
├── HEAD
├── branches
├── config
├── description
└── hooks
    ├── applypatch-msg.sample
    ├── commit-msg.sample
    ├── post-update.sample
    ├── pre-applypatch.sample
    ├── pre-commit.sample
    ├── pre-push.sample
    ├── pre-rebase.sample
    ├── prepare-commit-msg.sample
    └── update.sample
```

```
my-repo [master] tree .git
.git
├── pre-commit.sample
├── pre-push.sample
├── pre-rebase.sample
├── prepare-commit-msg.sample
└── update.sample
├── info
│   └── exclude
└── objects
    ├── info
    └── pack
└── refs
    ├── heads
    └── tags
9 directories, 13 files
my-repo [master]
```

"config" it is a...

config 😱

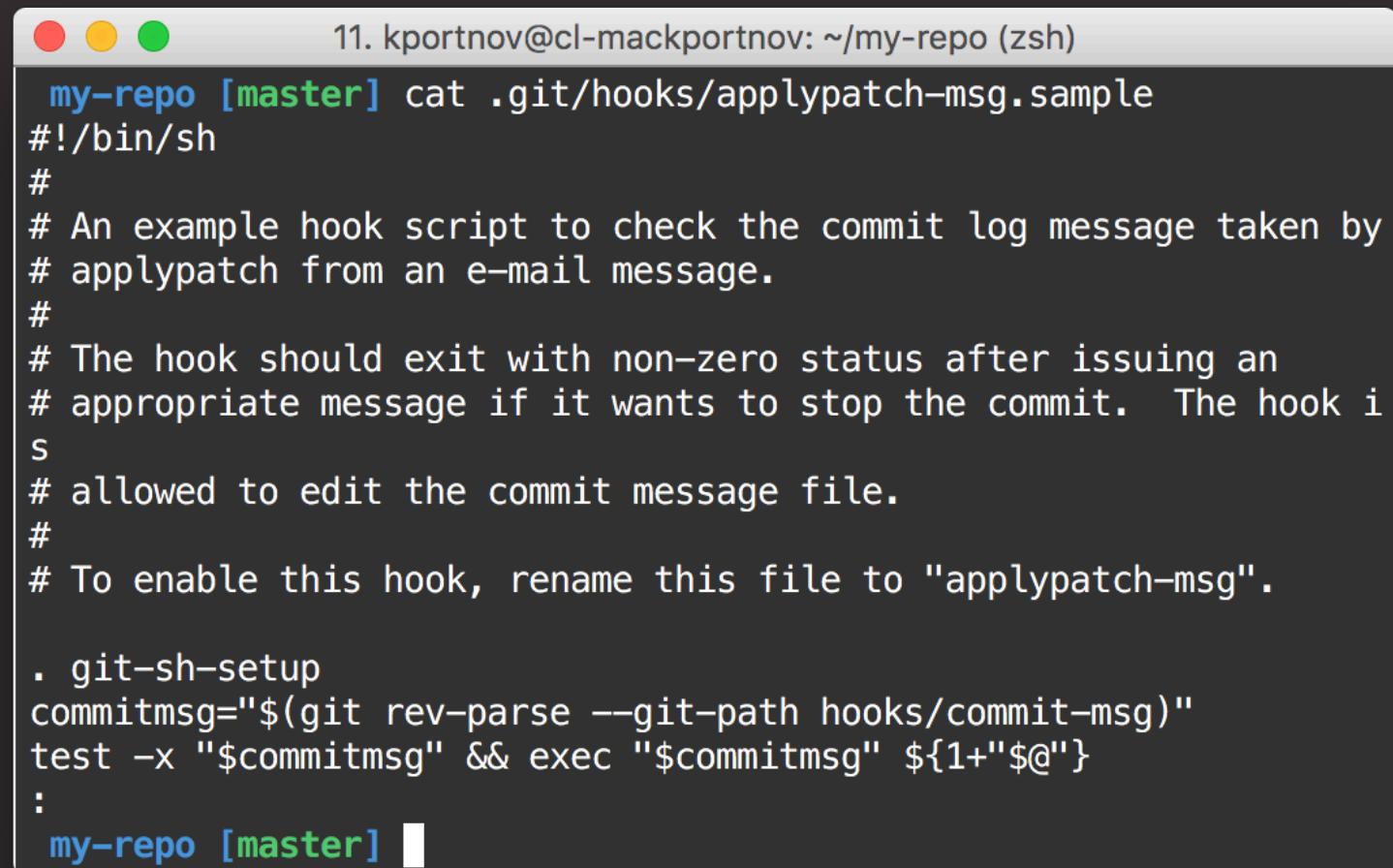


A screenshot of a terminal window with a dark background and light-colored text. The window title bar shows "11. kportnov@cl-mackportnov: ~/my-repo (zsh)". The command "cat .git/config" is run, displaying the contents of the .git/config file. The file contains a [core] section with the following settings:

```
repositoryformatversion = 0
filemode = true
bare = false
logallrefupdates = true
ignorecase = true
precomposeunicode = true
```

The command "cat .git/config" is followed by a new line, indicated by a small white square icon.

Captain Hook!



A screenshot of a terminal window titled "11. kportnov@cl-mackportnov: ~/my-repo (zsh)". The window displays a shell script named ".git/hooks/applypatch-msg.sample". The script is a template for a Git hook that checks commit log messages. It includes comments explaining its purpose, how to enable it, and how to use it. The script ends with a final colon ":" and the prompt "my-repo [master]".

```
my-repo [master] cat .git/hooks/applypatch-msg.sample
#!/bin/sh
#
# An example hook script to check the commit log message taken by
# applypatch from an e-mail message.
#
# The hook should exit with non-zero status after issuing an
# appropriate message if it wants to stop the commit. The hook is
# allowed to edit the commit message file.
#
# To enable this hook, rename this file to "applypatch-msg".
.
. git-sh-setup
commitmsg="$(git rev-parse --git-path hooks/commit-msg)"
test -x "$commitmsg" && exec "$commitmsg" ${1+"$@"}
:
```



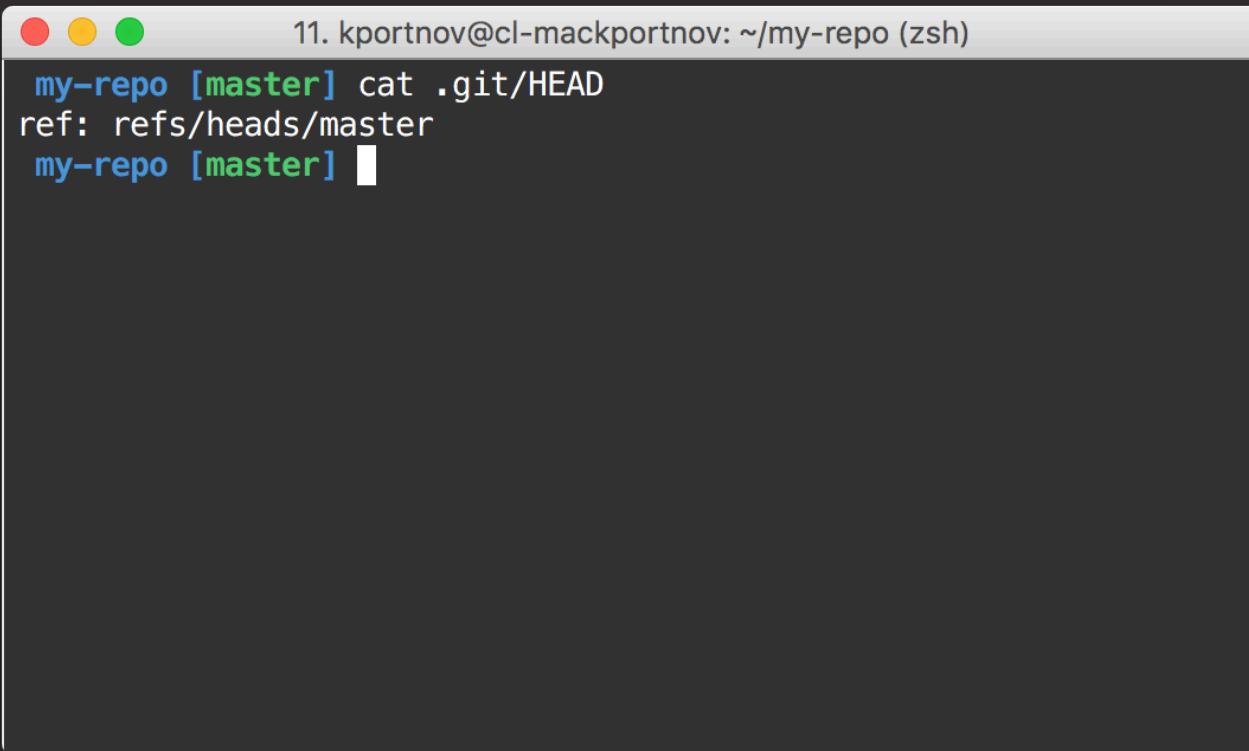
```
11. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] cat .git/info/exclude
# git ls-files --others --exclude-from=.git/info/exclude
# Lines that start with '#' are comments.
# For a project mostly in C, the following would be a good set of
# exclude patterns (uncomment them if you want to use them):
# *.oa
# *~
.DS_Store
my-repo [master] □
```

Explicit repository excludes¹

¹ <http://bit.ly/1Poywz1>

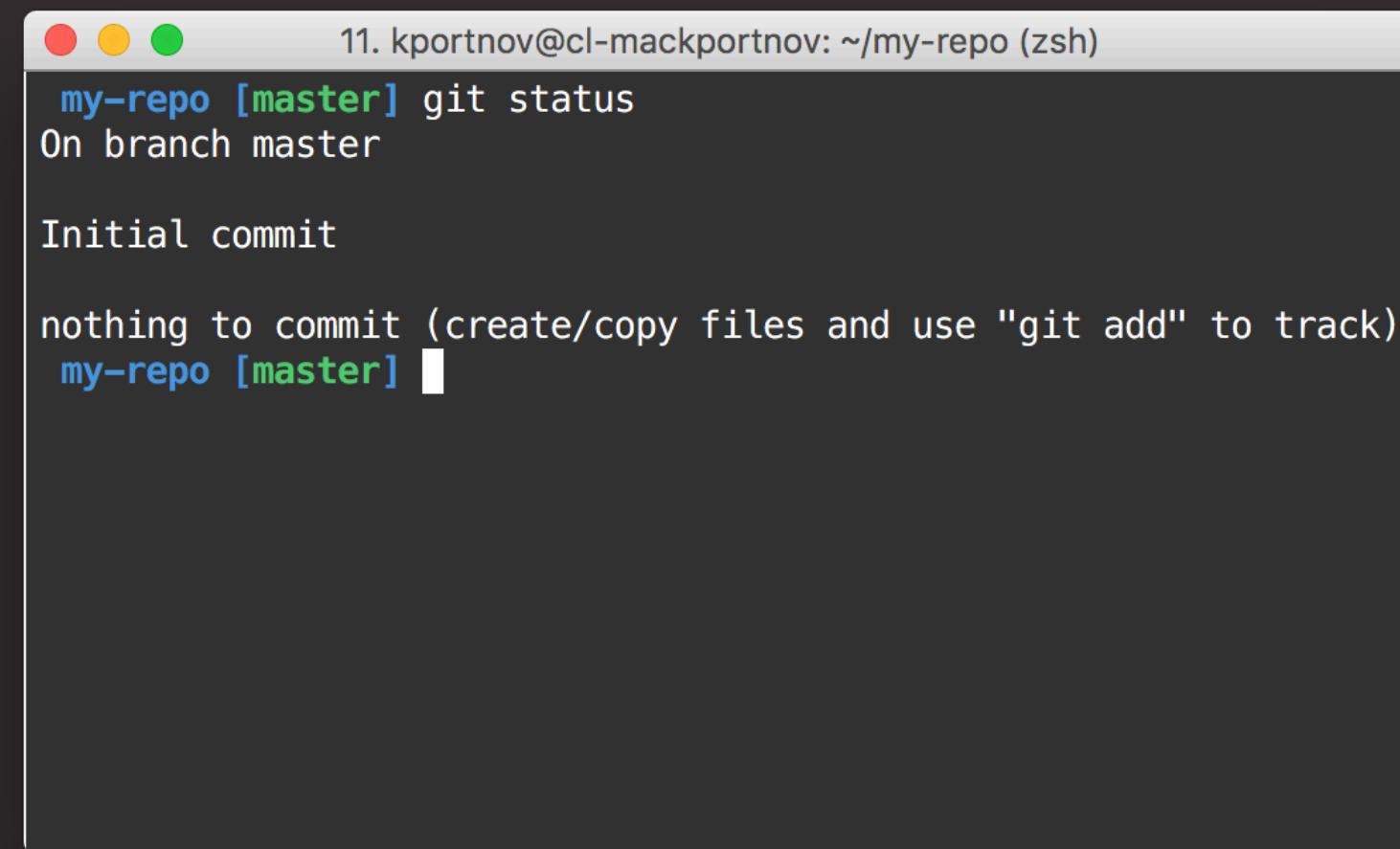
"HEAD"

It's simple text file!

A screenshot of a macOS terminal window. The title bar says "11. kportnov@cl-mackportnov: ~/my-repo (zsh)". The command "my-repo [master] cat .git/HEAD" is run, and the output shows "ref: refs/heads/master".

```
11. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] cat .git/HEAD
ref: refs/heads/master
my-repo [master]
```

On "master"?



A screenshot of a terminal window with a dark background and light-colored text. The window title bar shows "11. kportnov@cl-mackportnov: ~/my-repo (zsh)". The command "git status" is run, and the output is:

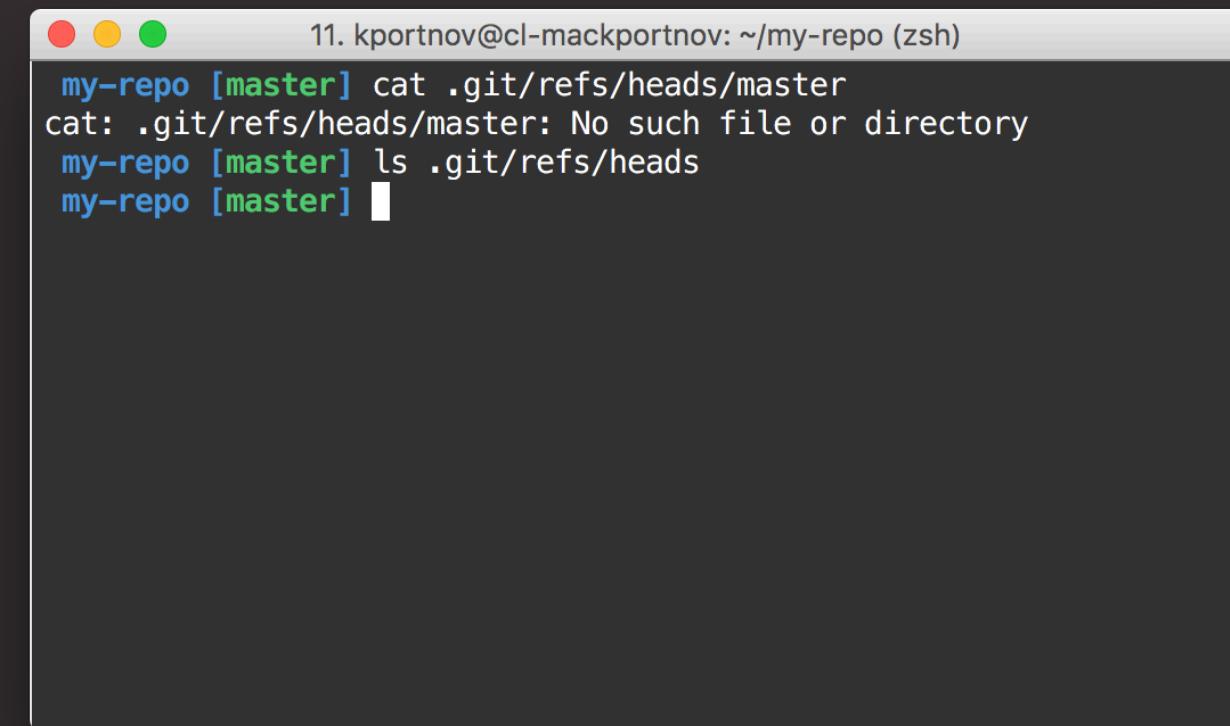
```
my-repo [master] git status
On branch master

Initial commit

nothing to commit (create/copy files and use "git add" to track)
my-repo [master] □
```

But "master" doesn't exist

Paradox!



```
11. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] cat .git/refs/heads/master
cat: .git/refs/heads/master: No such file or directory
my-repo [master] ls .git/refs/heads
my-repo [master] 
```

"In the beginning was the Word..."

```
11. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] echo "God" > 1.txt
my-repo [master] x git status
On branch master

Initial commit

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

    1.txt

nothing added to commit but untracked files present (use "git add"
" to track)
my-repo [master] x
```

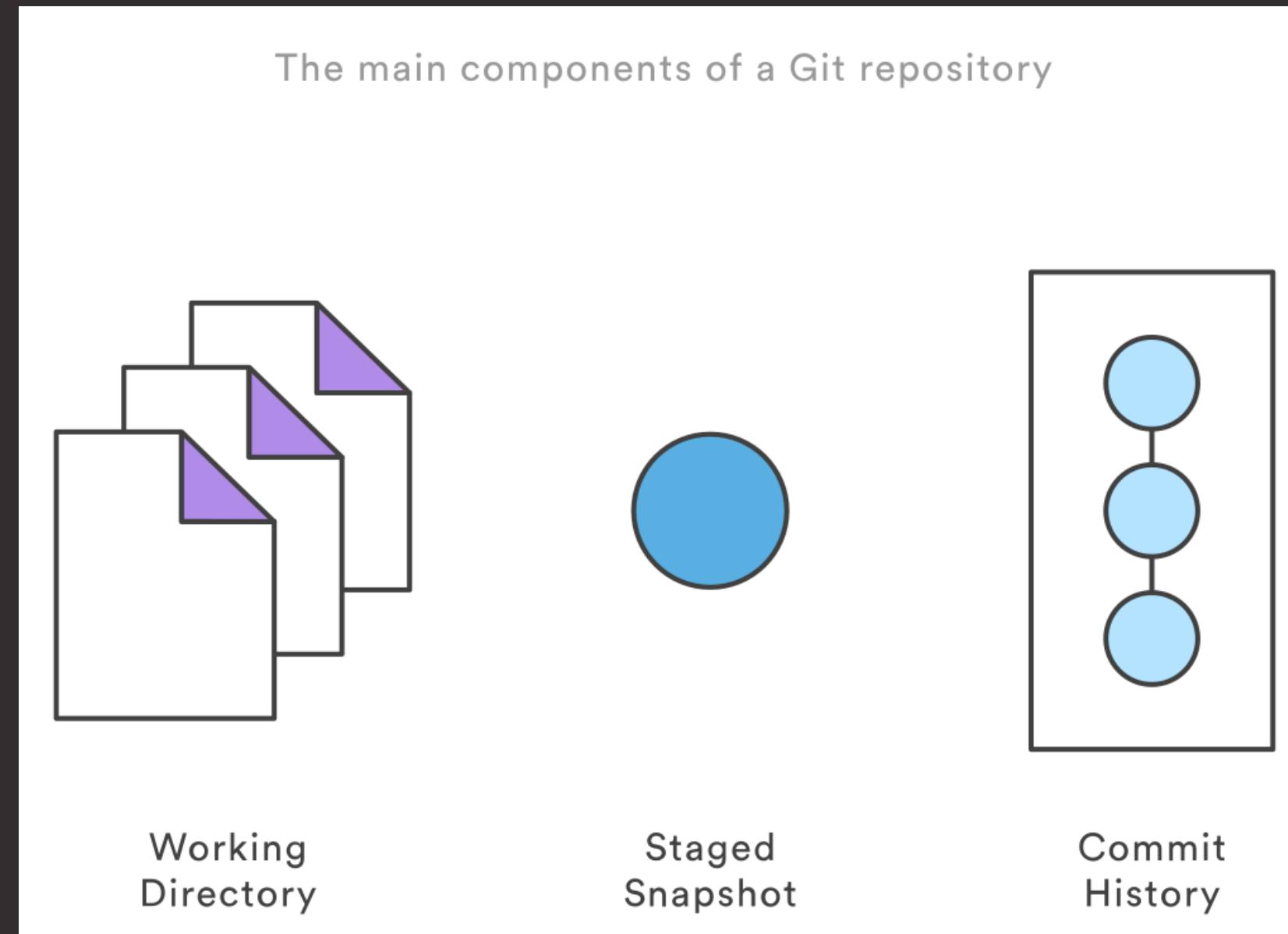
```
10. kportnov@cl-mackportnov: ~/my-repo...  
my-repo [master] tree .git  
.git  
├── HEAD  
├── branches  
├── config  
├── description  
├── hooks  
│   ├── applypatch-msg.sample  
│   ├── commit-msg.sample  
│   ├── post-update.sample  
│   ├── pre-applypatch.sample  
│   ├── pre-commit.sample  
│   ├── pre-push.sample  
│   ├── pre-rebase.sample  
│   └── prepare-commit-msg.sample  
└── update.sample
```

```
10. kportnov@cl-mackportnov: ~/my-repo...  
|   ├── pre-commit.sample  
|   ├── pre-push.sample  
|   ├── pre-rebase.sample  
|   └── prepare-commit-msg.sample  
└── update.sample  
    └── info  
        └── exclude  
    └── objects  
        ├── info  
        └── pack  
    └── refs  
        ├── heads  
        └── tags  
  
9 directories, 13 files  
my-repo [master] x □
```

No one change! 😭

Because Git doesn't know about our file

"add"

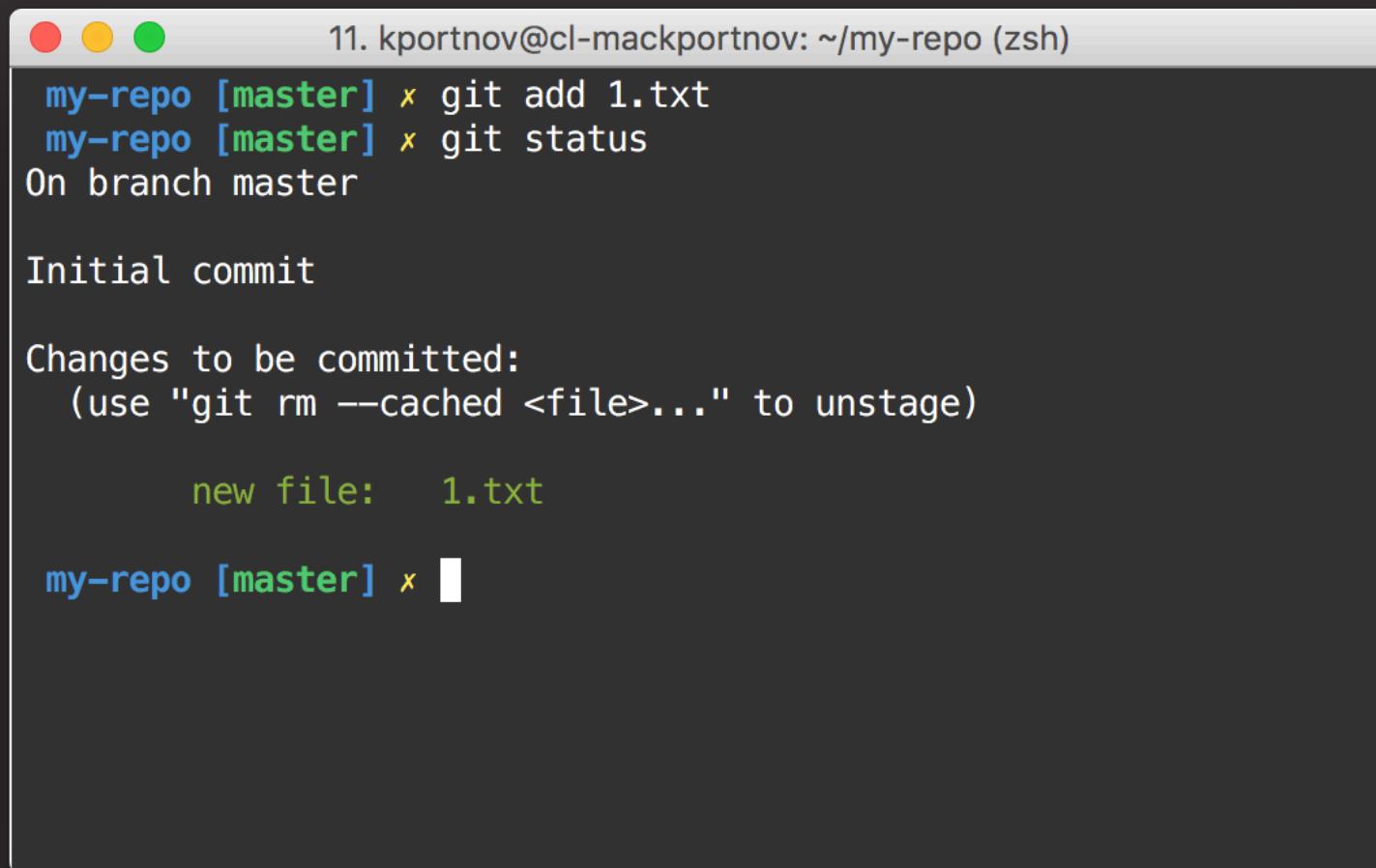


Working
Directory

Staged
Snapshot

Commit
History

"add"



```
11. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] ✘ git add 1.txt
my-repo [master] ✘ git status
On branch master

Initial commit

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

    new file:   1.txt

my-repo [master] ✘
```

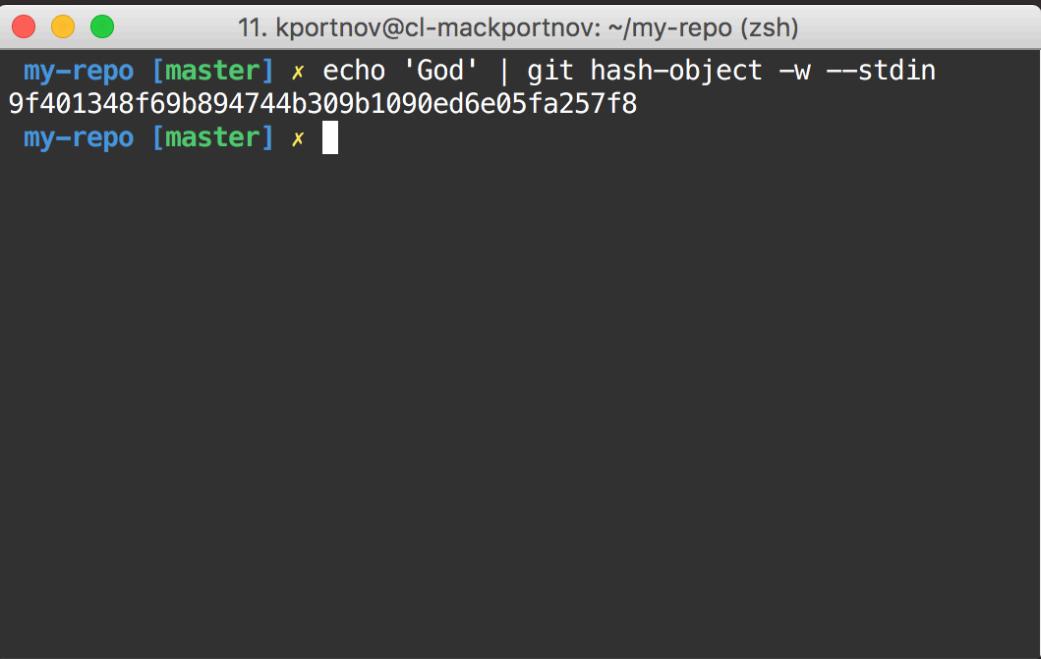
10. kportnov@cl-mackportnov: ~/my-repo (zs...)

```
my-repo [master] ✘ tree .git
.git
└── HEAD
└── branches
└── config
└── description
└── hooks
    ├── applypatch-msg.sample
    ├── commit-msg.sample
    ├── post-update.sample
    ├── pre-applypatch.sample
    ├── pre-commit.sample
    ├── pre-push.sample
    ├── pre-rebase.sample
    ├── prepare-commit-msg.sample
    └── update.sample
└── index
└── info
    └── exclude
└── objects
    ├── 9f
    └── 401348f69b894744b309b1090ed6e05fa257f8
```

10. kportnov@cl-mackportnov: ~/my-repo (zs...)

```
└── commit-msg.sample
└── post-update.sample
└── pre-applypatch.sample
└── pre-commit.sample
└── pre-push.sample
└── pre-rebase.sample
└── prepare-commit-msg.sample
    └── update.sample
└── index
└── info
    └── exclude
└── objects
    ├── 9f
    └── 401348f69b894744b309b1090ed6e05fa257f8
    └── info
    └── pack
└── refs
    ├── heads
    └── tags
10 directories, 15 files
my-repo [master] ✘
```

Who are you "9f" and "401348"?



A screenshot of a macOS terminal window titled "11. kportnov@cl-mackportnov: ~/my-repo (zsh)". The window contains the following text:

```
my-repo [master] x echo 'God' | git hash-object -w --stdin  
9f401348f69b894744b309b1090ed6e05fa257f8  
my-repo [master] x
```

Folder "9f" and file "401348f69b894744b309b1090ed6e05fa257f8"²

² 10.2 Git Internals - Git Objects: <http://bit.ly/2xK9Hb1>

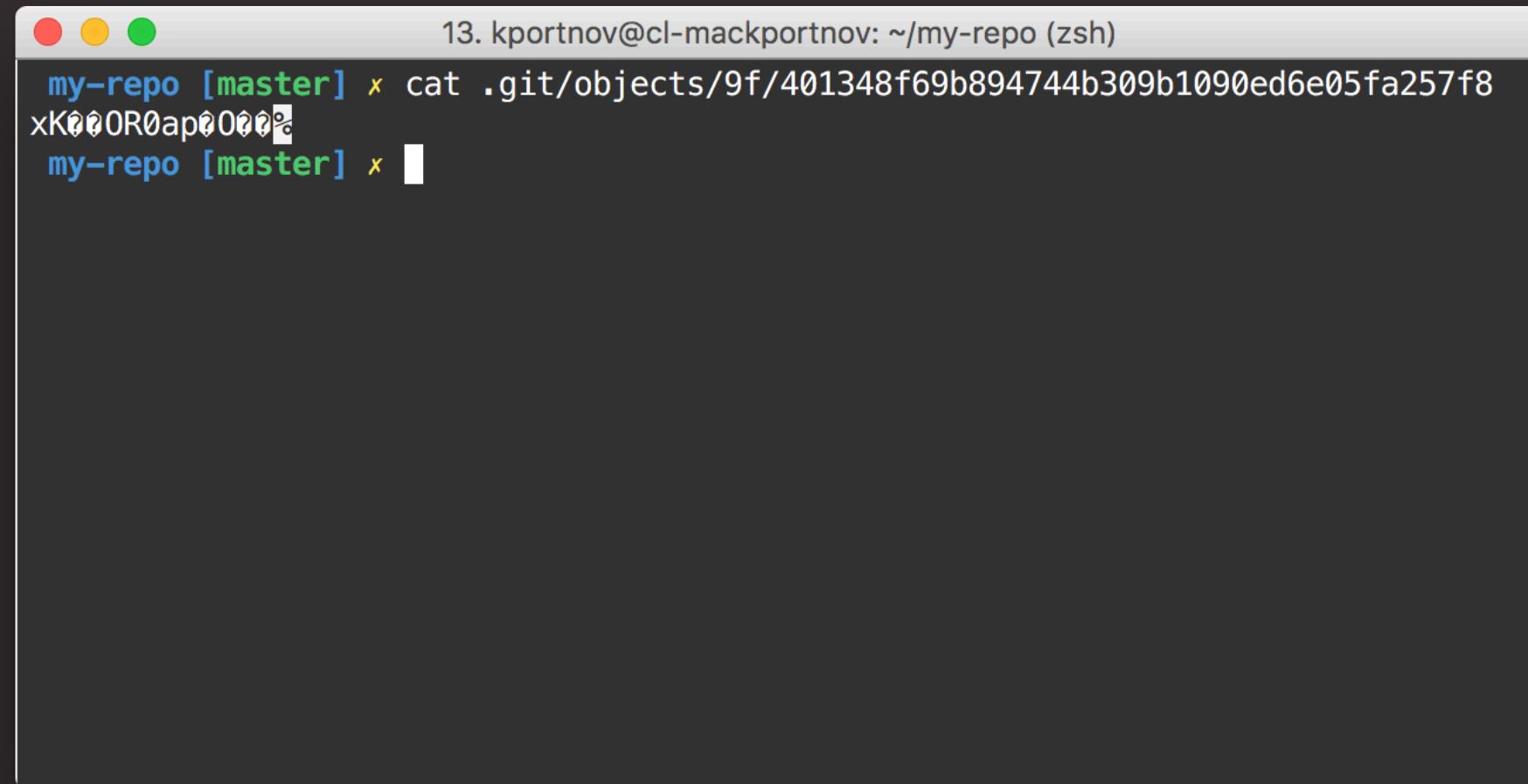
**But if we add another
file with the same
content?**



**Hash doesn't depend of time, OS,
localization and so on.**

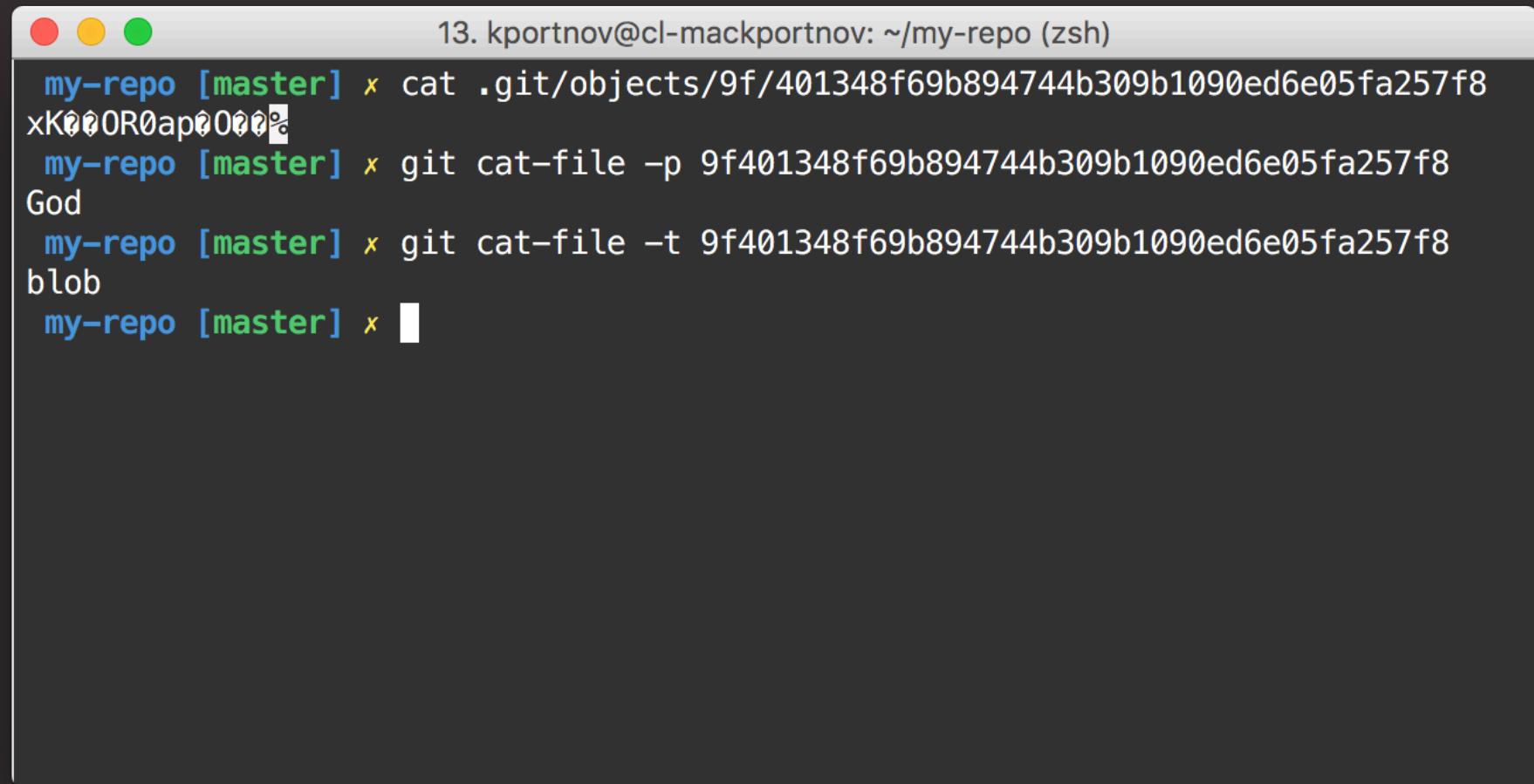


And inside we have...



13. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] ✘ cat .git/objects/9f/401348f69b894744b309b1090ed6e05fa257f8
xK00R0ap000%
my-repo [master] ✘

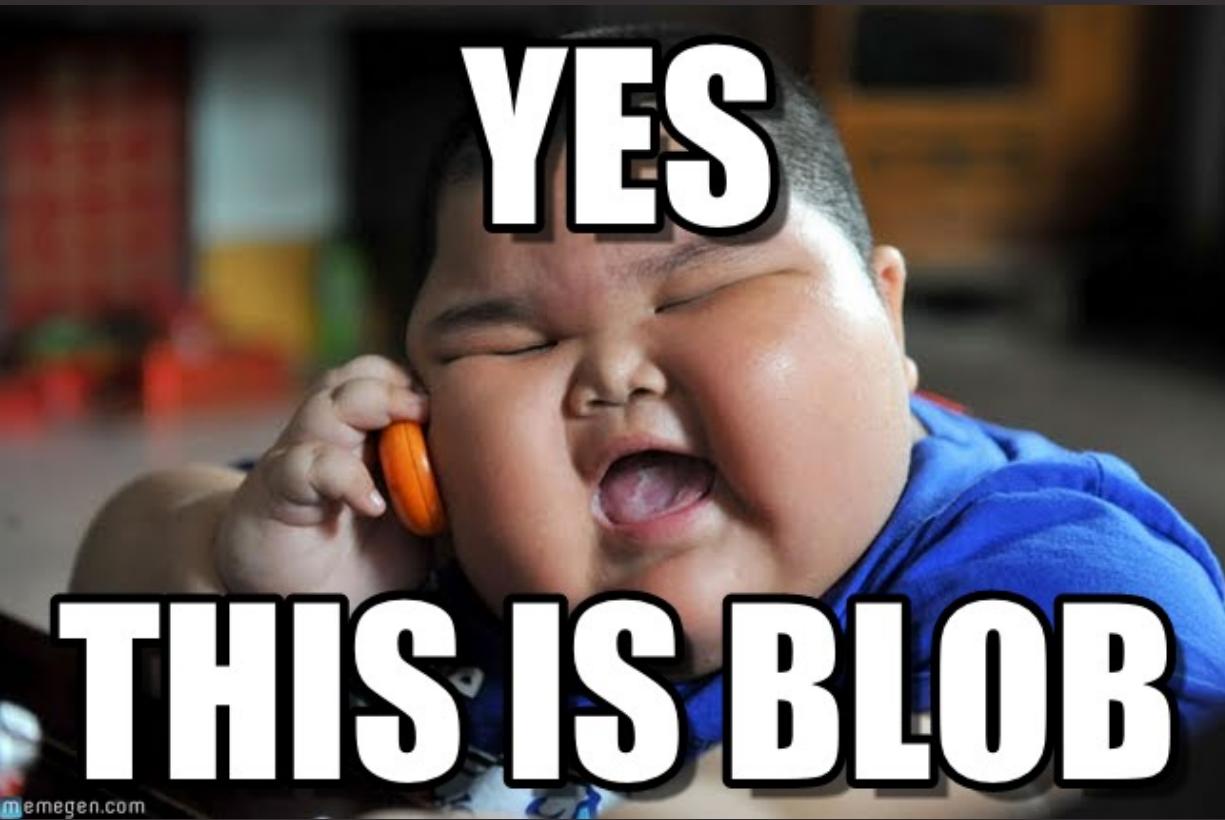
Swiss knife "cat-file"



13. kportnov@cl-mackportnov: ~/my-repo (zsh)

```
my-repo [master] ✘ cat .git/objects/9f/401348f69b894744b309b1090ed6e05fa257f8
xK00R0ap0000%
my-repo [master] ✘ git cat-file -p 9f401348f69b894744b309b1090ed6e05fa257f8
God
my-repo [master] ✘ git cat-file -t 9f401348f69b894744b309b1090ed6e05fa257f8
blob
my-repo [master] ✘
```

¿Blob?



Blob: "an object, especially a large one, having no distinct shape or definition:"[^3]

[^3] Blob: <http://bit.ly/2xKtirG>

Pfff... First commit...

```
11. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] ✘ git status
On branch master

Initial commit

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

    new file:   1.txt

my-repo [master] ✘ git commit -m "1st commit"
[master (root-commit) 081c175] 1st commit
 1 file changed, 1 insertion(+)
 create mode 100644 1.txt
my-repo [master] ┌
```

10. kportnov@cl-mackportnov: ~/my-repo (zsh)

```
my-repo [master] ✘ tree .git
.git
└── COMMIT_EDITMSG
└── HEAD
└── branches
└── config
└── description
└── hooks
    ├── applypatch-msg.sample
    ├── commit-msg.sample
    ├── post-update.sample
    ├── pre-applypatch.sample
    ├── pre-commit.sample
    ├── pre-push.sample
    ├── pre-rebase.sample
    └── prepare-commit-msg.sample
        └── update.sample
└── index
└── info
    └── exclude
└── logs
    └── HEAD
```

10. kportnov@cl-mackportnov: ~/my-repo (zsh)

```
└── logs
    └── HEAD
└── refs
    └── heads
        └── master
└── objects
    ├── 08
    │   └── 1c1751b6a2cc4be5666ce29ed78a35e7559ade
    ├── 3e
    │   └── 8164099bff60e25050fbe516386a9ac2d52c47
    ├── 9f
    │   └── 401348f69b894744b309b1090ed6e05fa257f8
    └── info
        └── pack
└── refs
    └── heads
        └── master
    └── tags
└── sourcetreeconfig
15 directories, 22 files
my-repo [master]
```

2 new Object? Why? 😱

```
13. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] git cat-file -t 081c1751b6a2cc4be5666ce29ed78a35e7559ade
commit
my-repo [master] git cat-file -t 3e8164099bff60e25050fbe516386a9ac2d52c47
tree
my-repo [master] □
```



13. kportnov@cl-mackportnov: ~/my-repo (zsh)

```
my-repo [master] git cat-file -p 081c1751b6a2cc4be5666ce29ed78a35e7559ade
tree 3e8164099bff60e25050fbe516386a9ac2d52c47
author Konstantin Portnov <konstantin.portnov@mercadolibre.cl> 1504036092 -0300
committer Konstantin Portnov <konstantin.portnov@mercadolibre.cl> 1504036092 -0300
```

1st commit

```
my-repo [master] □
```



13. kportnov@cl-mackportnov: ~/my-repo (zsh)

```
my-repo [master] git cat-file -p 081c1751b6a2cc4be5666ce29ed78a35e7559ade
tree 3e8164099bff60e25050fbe516386a9ac2d52c47
author Konstantin Portnov <konstantin.portnov@mercadolibre.cl> 1504036092 -0300
committer Konstantin Portnov <konstantin.portnov@mercadolibre.cl> 1504036092 -0300
```

1st commit

```
my-repo [master] git cat-file -p 3e8164099bff60e25050fbe516386a9ac2d52c47
100644 blob 9f401348f69b894744b309b1090ed6e05fa257f8    1.txt
```

```
my-repo [master] █
```



13. kportnov@cl-mackportnov: ~/my-repo (zsh)

```
my-repo [master] git cat-file -p 081c1751b6a2cc4be5666ce29ed78a35e7559ade
tree 3e8164099bff60e25050fbe516386a9ac2d52c47
author Konstantin Portnov <konstantin.portnov@mercadolibre.cl> 1504036092 -0300
committer Konstantin Portnov <konstantin.portnov@mercadolibre.cl> 1504036092 -0300
```

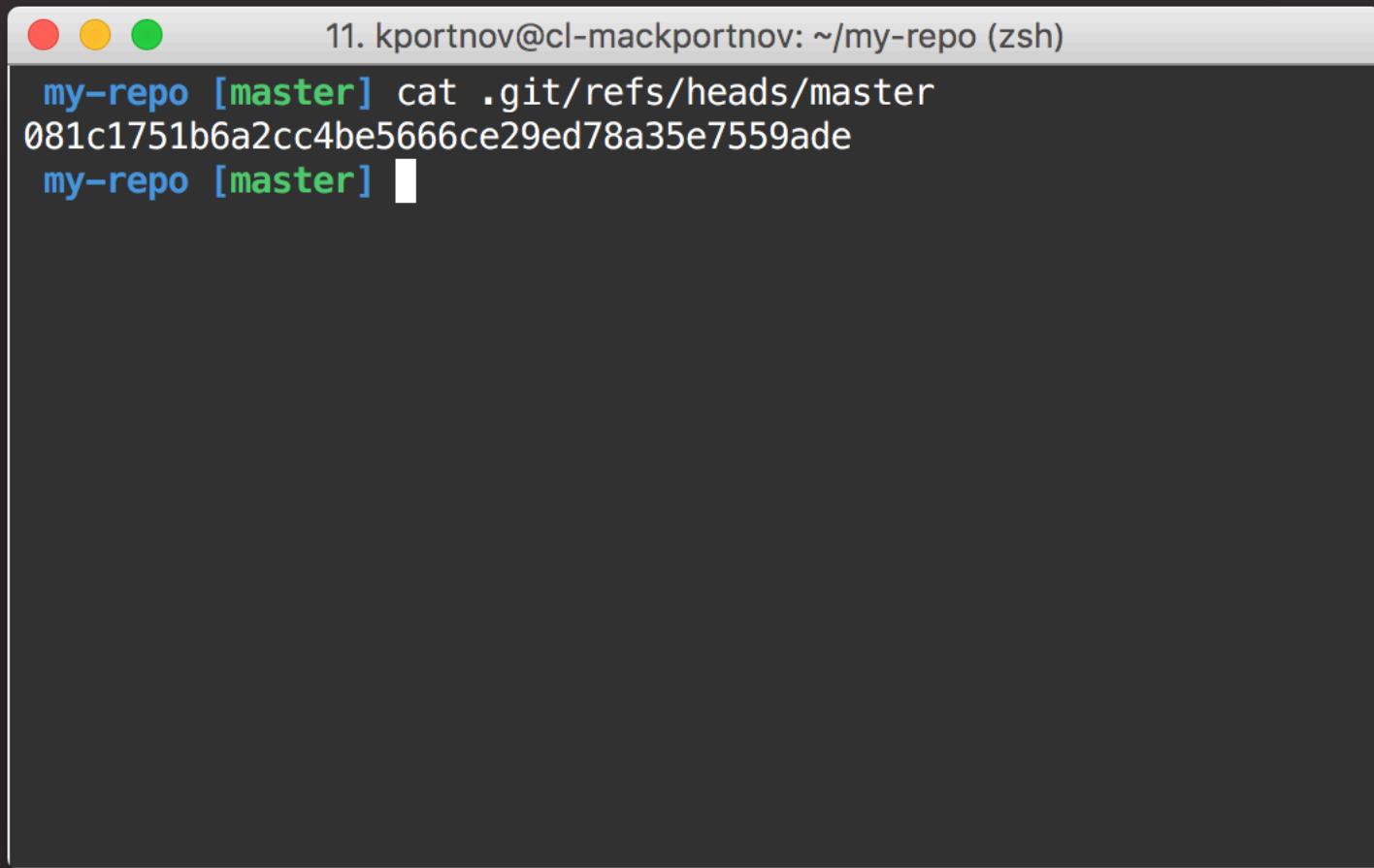
1st commit

```
my-repo [master] git cat-file -p 3e8164099bff60e25050fbe516386a9ac2d52c47
100644 blob 9f401348f69b894744b309b1090ed6e05fa257f8 1.txt
```

```
my-repo [master] git cat-file -p 9f401348f69b894744b309b1090ed6e05fa257f8
God
```

```
my-repo [master] █
```

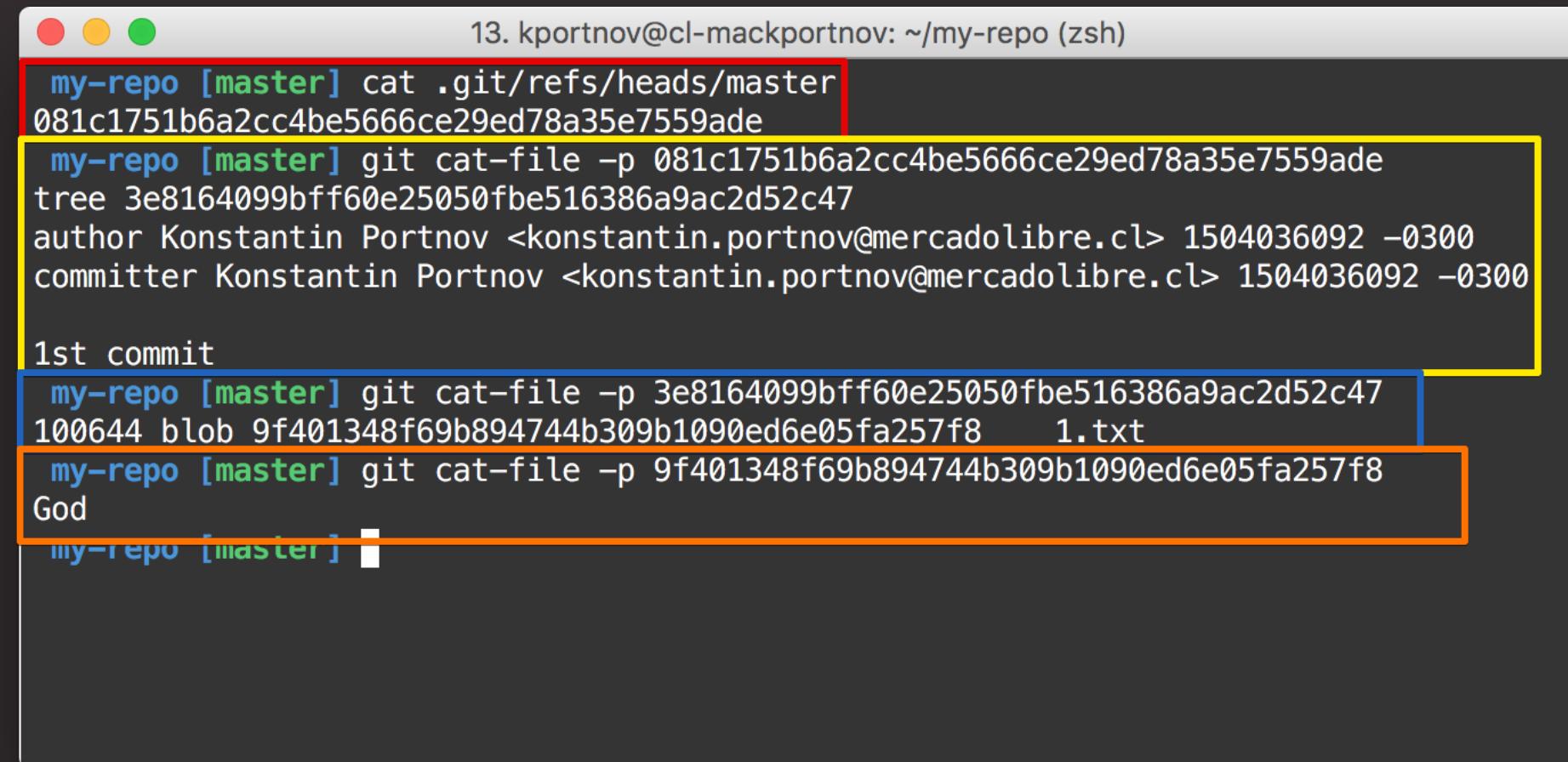
And what about "master"?



A screenshot of a macOS terminal window. The title bar says "11. kportnov@cl-mackportnov: ~/my-repo (zsh)". The command entered is "my-repo [master] cat .git/refs/heads/master". The output shows the commit hash: "081c1751b6a2cc4be5666ce29ed78a35e7559ade". The prompt "my-repo [master]" is visible at the bottom.

```
my-repo [master] cat .git/refs/heads/master
081c1751b6a2cc4be5666ce29ed78a35e7559ade
my-repo [master]
```

And all together



13. kportnov@cl-mackportnov: ~/my-repo (zsh)

```
my-repo [master] cat .git/refs/heads/master
081c1751b6a2cc4be5666ce29ed78a35e7559ade
my-repo [master] git cat-file -p 081c1751b6a2cc4be5666ce29ed78a35e7559ade
tree 3e8164099bff60e25050fbe516386a9ac2d52c47
author Konstantin Portnov <konstantin.portnov@mercadolibre.cl> 1504036092 -0300
committer Konstantin Portnov <konstantin.portnov@mercadolibre.cl> 1504036092 -0300

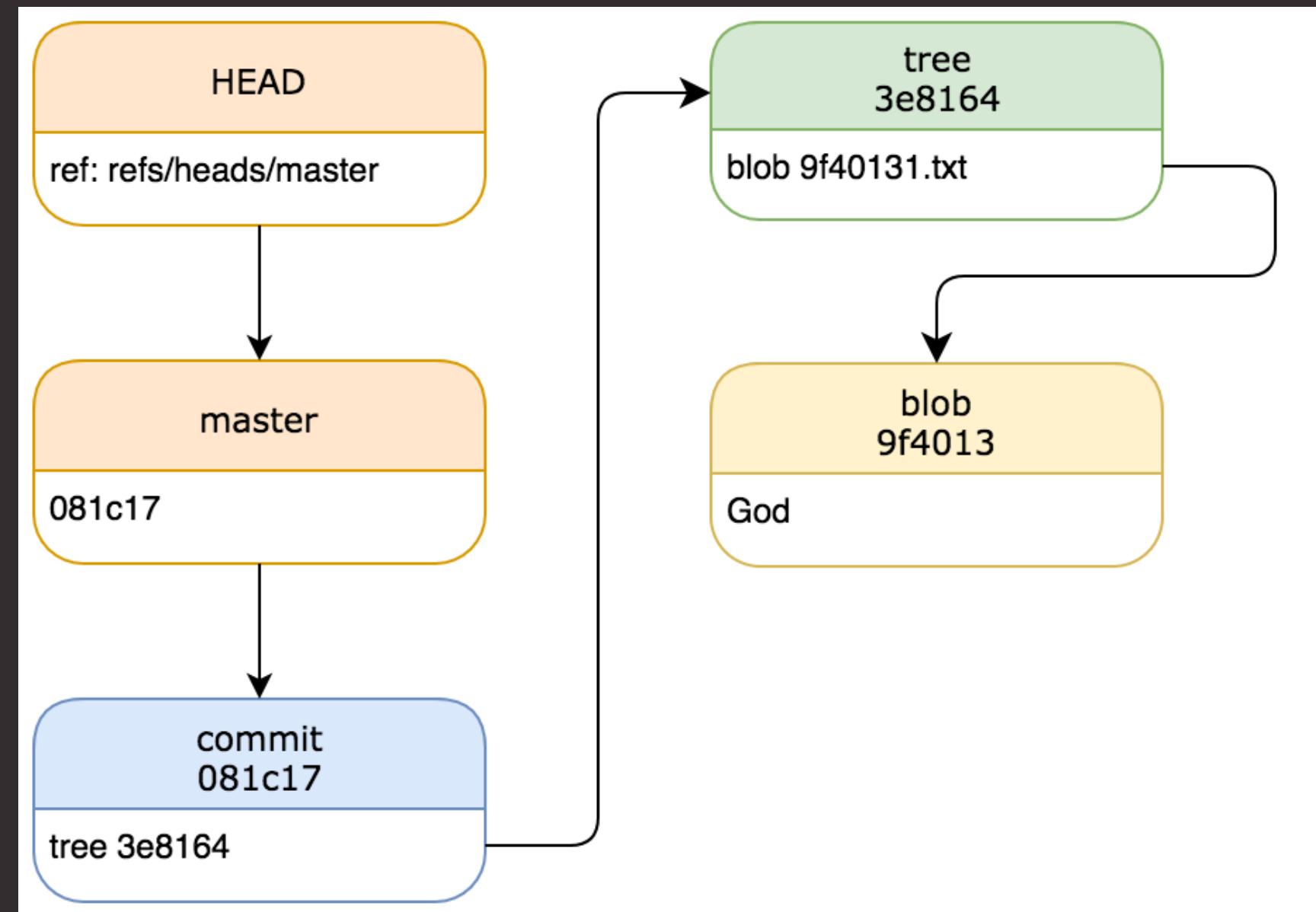
1st commit
my-repo [master] git cat-file -p 3e8164099bff60e25050fbe516386a9ac2d52c47
100644 blob 9f401348f69b894744b309b1090ed6e05fa257f8 1.txt
my-repo [master] git cat-file -p 9f401348f69b894744b309b1090ed6e05fa257f8
God
my-repo [master]
```

And all together

```
● ● ● 10. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] ✘ tree .git/objects
.git/objects
└── 08
    └── 1c1751b6a2cc4be5666ce29ed78a35e7559ade
└── 3e
    └── 8164099bff60e25050fbe516386a9ac2d52c47
└── 9f
    └── 401348f69b894744b309b1090ed6e05fa257f8
└── info
└── pack

5 directories, 3 files
my-repo [master] ✘ ┌
```

And all together



Add more files

```
11. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] ✘ mkdir files
my-repo [master] ✘ echo "a text" > README.md
my-repo [master] ✘ echo "a text" > files/README.md
my-repo [master] ✘ git add .
my-repo [master] ✘ tree .git/objects
.git/objects
├── 08
│   └── 1c1751b6a2cc4be5666ce29ed78a35e7559ade
├── 3e
│   └── 8164099bff60e25050fbe516386a9ac2d52c47
├── 80
│   └── b5f2984dcfa88f194c939b79ece64ebff90d36
└── 9f
    └── 401348f69b894744b309b1090ed6e05fa257f8
└── info
└── pack

6 directories, 4 files
my-repo [master] ✘
```

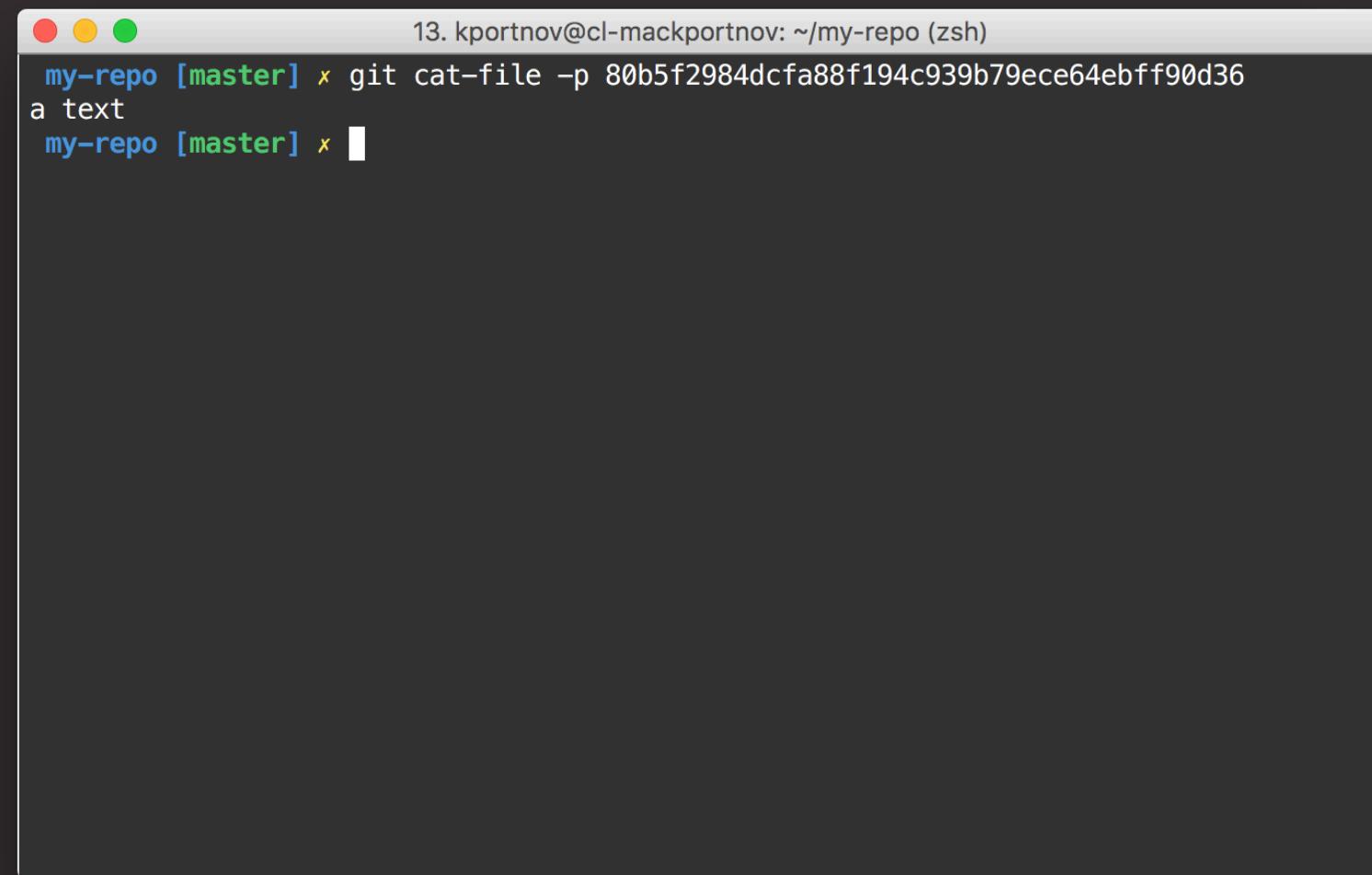
10. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] ✘ tree .git/objects
.git/objects
└── 08
 └── 1c1751b6a2cc4be5666ce29ed78a35e7559ade
── 3e
 └── 8164099bff60e25050fbe516386a9ac2d52c47
── 9f
 └── 401348f69b894744b309b1090ed6e05fa257f8
── info
└── pack

5 directories, 3 files
my-repo [master] ✘

10. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] ✘ tree .git/objects
.git/objects
└── 08
 └── 1c1751b6a2cc4be5666ce29ed78a35e7559ade
── 3e
 └── 8164099bff60e25050fbe516386a9ac2d52c47
── 80
 └── b5f2984dcfa88f194c939b79ece64ebff90d36
── 9f
 └── 401348f69b894744b309b1090ed6e05fa257f8
── info
└── pack

6 directories, 4 files
my-repo [master] ✘

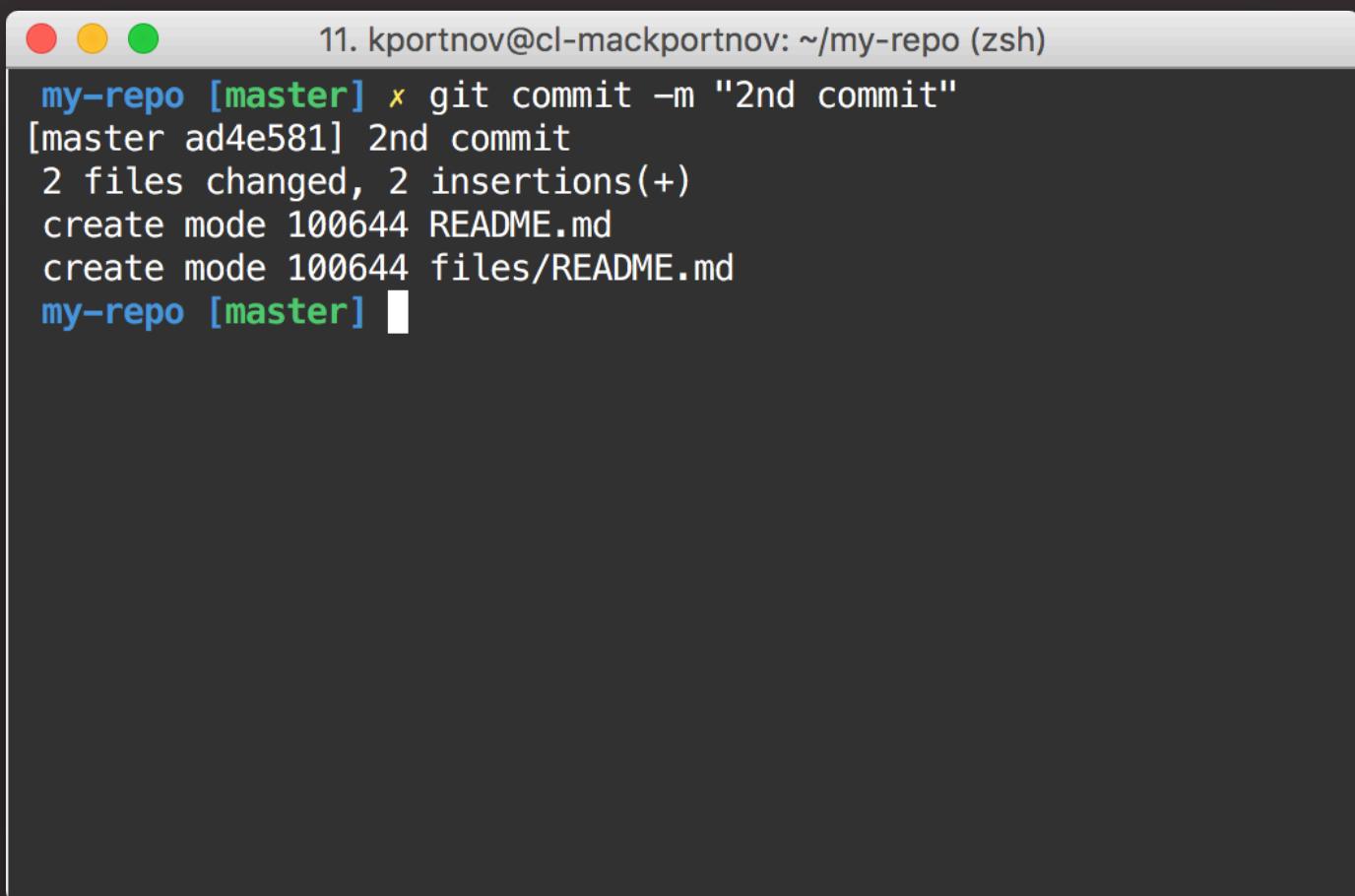
Who are you "80b5f2"?



A screenshot of a terminal window with a dark background and light-colored text. The window title bar shows the session details: "13. kportnov@cl-mackportnov: ~/my-repo (zsh)". The terminal prompt is "my-repo [master] >". The user has run the command "git cat-file -p 80b5f2984dcfa88f194c939b79ece64ebff90d36", which outputs the text "a text". The terminal ends with another prompt "my-repo [master] >".

```
13. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] > git cat-file -p 80b5f2984dcfa88f194c939b79ece64ebff90d36
a text
my-repo [master] >
```

2nd commit



A screenshot of a terminal window with a dark background and light-colored text. The window title bar says "11. kportnov@cl-mackportnov: ~/my-repo (zsh)". The terminal output shows a git commit command:

```
my-repo [master] ✘ git commit -m "2nd commit"
[master ad4e581] 2nd commit
 2 files changed, 2 insertions(+)
  create mode 100644 README.md
  create mode 100644 files/README.md
my-repo [master] □
```

10. kportnov@cl-mackportnov: ~/my-repo (zsh)

```
my-repo [master] ✘ tree .git/objects
.git/objects
|-- 08
|   |-- 1c1751b6a2cc4be5666ce29ed78a35e7559ade
|-- 3e
|   |-- 8164099bff60e25050fbe516386a9ac2d52c47
|-- 80
|   |-- b5f2984dcfa88f194c939b79ece64ebff90d36
|-- 9f
|   |-- 401348f69b894744b309b1090ed6e05fa257f8
|-- info
|-- pack
```

6 directories, 4 files

```
my-repo [master] ✘
```

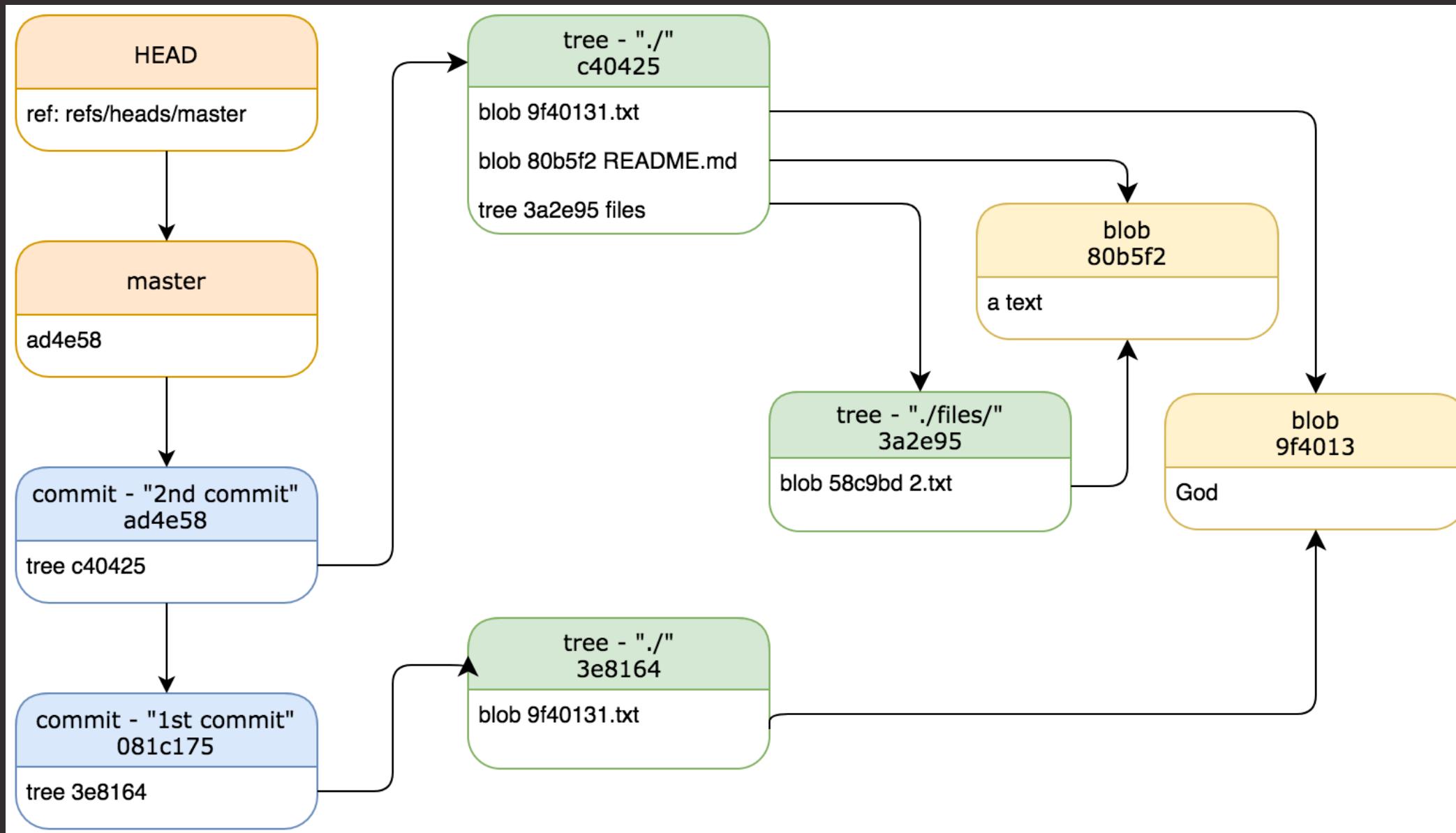
10. kportnov@cl-mackportnov: ~/my-repo (zsh)

```
my-repo [master] ✘ tree .git/objects
.git/objects
|-- 08
|   |-- 1c1751b6a2cc4be5666ce29ed78a35e7559ade
|-- 3a
|   |-- 2e95eee744279a6e633430a809faca0627f7c3
|-- 3e
|   |-- 8164099bff60e25050fbe516386a9ac2d52c47
|-- 80
|   |-- b5f2984dcfa88f194c939b79ece64ebff90d36
|-- 9f
|   |-- 401348f69b894744b309b1090ed6e05fa257f8
|-- ad
|   |-- 4e5811be01e6b999171083eacda8c504275a7c
|-- c4
|   |-- 0425b5335222fe00a344e6676653062e9455d9
|-- info
|-- pack
```

9 directories, 7 files

```
my-repo [master] ✘
```

And all together



Where am I ?

All Branches	Hide Remote Branches	Date Order	Jump to:	
Graph	Description	Commit	Author	Date
	master 2nd commit 1st commit	ad4e581 081c175	Konstantin Portn... Konstantin Portno...	Today, 6:37 PM Today, 4:48 PM


```
11. kportnov@cl-mackportnov: ~/my-repo (zsh)
my-repo [master] cat .git/HEAD
ref: refs/heads/master
my-repo [master] cat .git/refs/heads/master
ad4e5811be01e6b999171083eacda8c504275a7c
my-repo [master]
```

And how?

- 😱 Change HEAD of a branch?
- 🤔 Jump ("checkout") to another branch?
- 😊 Edit manually a commit message?
- 😯 Edit manually a commit content?
- ...

What next?

- Repeat all the steps
- git ...
 - amend
 - reset
 - rebase
- Pro Git: <http://bit.ly/1MRoX7u>
- This presentation: <https://github.com/x0000ff/git-under-the-hood>

Questions? 😊



Thanks a lot!

¡Muchas gracias!

¡Moltes gràcies!

Большое спасибо!



Me...

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This Presentation



<http://bit.ly/2vHPOJS>

EOF

