# Git Internals Continued

by Jonathan Miedel and Alvin Wang

## Last Time on 174

- Git Internals
- Content Addressable File System
- Hashing (specfically SHA-1)
- Git Objects
- Packfiles

# Quiz

1. What is the utility to learning git internals?
2. What does content-addressable filesystem mean?  How is it different from path based file-systems.
3. What are the 3 top-level pieces of information that compose a git object?
4. Give 4 types of git objects.
5. If I ran git hash-object -w on a file and it gave me back a hash that alternated “aabbaabb...” what is the path relative to the top level repository folder this hashed-object is located in?
6. What are loose objects?
7. What command in Git can be used to pack objects? And describe the packing process.
8. What is contained inside a tree object?
9. Name and describe one plumbing-command we learned last lecture.
10. What information can be found in the packfile index?

## The Refspec

- The refspec defines the mapping between local branch references and remote branch references when working with remotes
- You define a refspec for each remote not for each branch
- The refspec can be found in the .git/config file
- The format for the refspec is
- `<source>:<destination>`
    - source refers to the remote source and destination refers to the destination of the references locally
    - The + tells git to update the references even if they are not fast-forward updates, it is optional

```
[remote "origin"]
    url = git@github.com:Dogfalo/materialize.git
    fetch = +refs/heads/*:refs/remotes/origin/*
```

## Throwback to Exam Extra Credit

- EC5. Given there is a branch origin/toBeDeleted, write the command that would delete the toBeDeleted branch off of the remote.
- Think about this for a second
- Now that we know the refspec is formatted as `<source>:<destination>`, it makes much more sense that `git push origin :toBeDeleted` deletes a remote branch.
- What is this doing?
- Remember that Git likes to keep things around for a while before actually deleting them
- We are updating remote branch reference with nothing as the source so that the local branch reference

## Refspec Continued

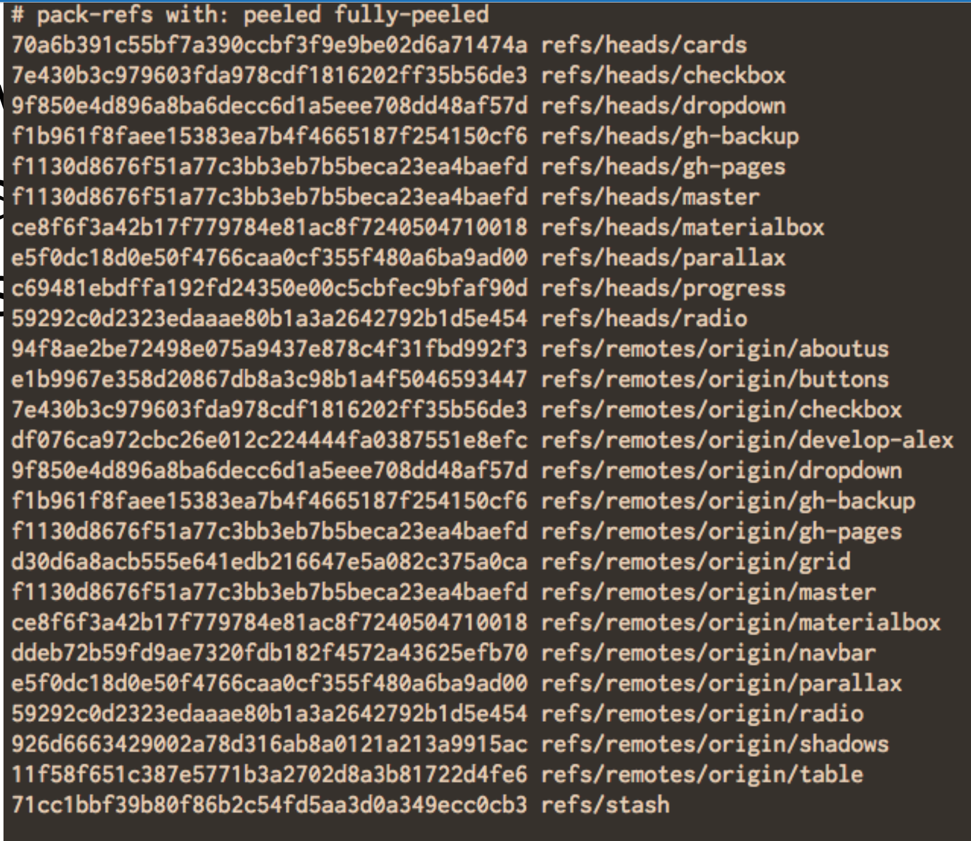
- Continuing on the example, when we run:
- `git remote add origin https://github.com/Dogfalo/materialize`
- Git goes to the server and and fetches down all references under refs/heads/ and places them in our local repository in refs/remotes/origin
- You now have all the references related to that remote!

## Refspec Cont2.

- We’ve been using shorted refs all along
- branch "test" is short for "refs/heads/test"
- tag v1.5 is short for “refs/tags/v1.5”
- origin/master is short for “refs/remotes/origin/master”
- The HEAD file in refs/remotes/origin/ does not indicate the location of your current HEAD, but rather it defines the default branch of the

## Packed Refs

- `git gc`, which we saw
  loose objects, also pa
- The packed refs are s
  as a file



```
# pack-refs with: peeled fully-peeled
70a6b391c55bf7a390ccbf3f9e9be02d6a71474a refs/heads/cards
7e430b3c979603fda978cdf1816202ff35b56de3 refs/heads/checkbox
9f850e4d896a8ba6decc6d1a5eee708dd48af57d refs/heads/dropdown
f1b961f8faee15383ea7b4f4665187f254150cf6 refs/heads/gh-backup
f1130d8676f51a77c3bb3eb7b5beca23ea4baefd refs/heads/gh-pages
f1130d8676f51a77c3bb3eb7b5beca23ea4baefd refs/heads/master
ce8f6f3a42b17f779784e81ac8f7240504710018 refs/heads/materialbox
e5f0dc18d0e50f4766caa0cf355f480a6ba9ad00 refs/heads/parallax
c69481ebdffa192fd24350e00c5cbfec9bfaf90d refs/heads/progress
59292c0d2323edaaae80b1a3a2642792b1d5e454 refs/heads/radio
94f8ae2be72498e075a9437e878c4f31fbd992f3 refs/remotes/origin/aboutus
e1b9967e358d20867db8a3c98b1a4f5046593447 refs/remotes/origin/buttons
7e430b3c979603fda978cdf1816202ff35b56de3 refs/remotes/origin/checkbox
df076ca972cbc26e012c224444fa0387551e8efc refs/remotes/origin/develop-alex
9f850e4d896a8ba6decc6d1a5eee708dd48af57d refs/remotes/origin/dropdown
f1b961f8faee15383ea7b4f4665187f254150cf6 refs/remotes/origin/gh-backup
f1130d8676f51a77c3bb3eb7b5beca23ea4baefd refs/remotes/origin/gh-pages
d30d6a8acb555e641edb216647e5a082c375a0ca refs/remotes/origin/grid
f1130d8676f51a77c3bb3eb7b5beca23ea4baefd refs/remotes/origin/master
ce8f6f3a42b17f779784e81ac8f7240504710018 refs/remotes/origin/materialbox
ddeb72b59fd9ae7320fdb182f4572a43625efb70 refs/remotes/origin/navbar
e5f0dc18d0e50f4766caa0cf355f480a6ba9ad00 refs/remotes/origin/parallax
59292c0d2323edaaae80b1a3a2642792b1d5e454 refs/remotes/origin/radio
926d6663429002a78d316ab8a0121a213a9915ac refs/remotes/origin/shadows
11f58f651c387e5771b3a2702d8a3b81722d4fe6 refs/remotes/origin/table
71cc1bbf39b80f86b2c54fd5aa3d0a349ecc0cb3 refs/stash
```

## Basic Data recovery

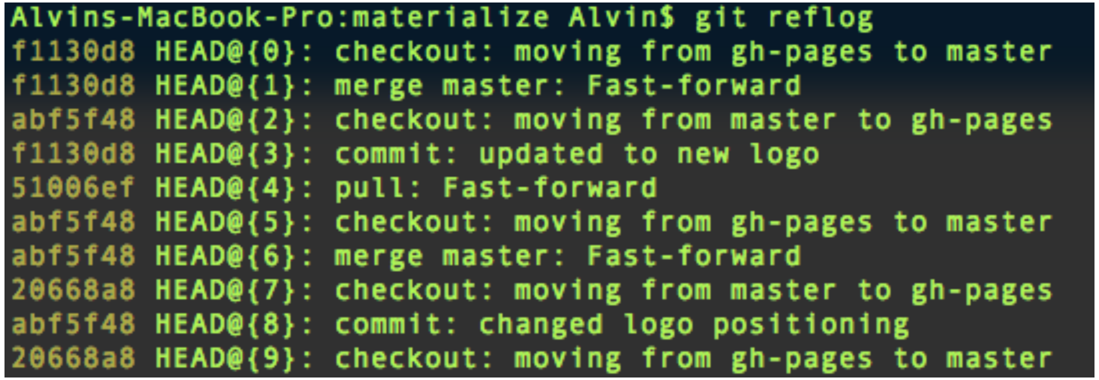
What are some ways we can “lose” our commits in git?

- git reset --hard HEAD~3
- git branch -D topicBranch

## Process of undoing git reset --hard

- Current structure is A<--B<--C<--D
- git reset --hard HEAD~2 puts us at A<--B
- To restore back to A<--B<--C<--D, we just need the references to the commits
- They are no longer in the log, but now are in reflog (located in .git/logs/refs)
- The reflog stores changes to the HEAD as a queue
  - hashB HEAD@{0}: reset  moving to B
  - hashD HEAD@{1}: commit added D
  - hashC HEAD@{2}: commit added C

## Reflog example output



```
Alvins-MacBook-Pro:materialize Alvin$ git reflog
f1130d8 HEAD@{0}: checkout: moving from gh-pages to master
f1130d8 HEAD@{1}: merge master: Fast-forward
abf5f48 HEAD@{2}: checkout: moving from master to gh-pages
f1130d8 HEAD@{3}: commit: updated to new logo
51006ef HEAD@{4}: pull: Fast-forward
abf5f48 HEAD@{5}: checkout: moving from gh-pages to master
abf5f48 HEAD@{6}: merge master: Fast-forward
20668a8 HEAD@{7}: checkout: moving from master to gh-pages
abf5f48 HEAD@{8}: commit: changed logo positioning
20668a8 HEAD@{9}: checkout: moving from gh-pages to master
```

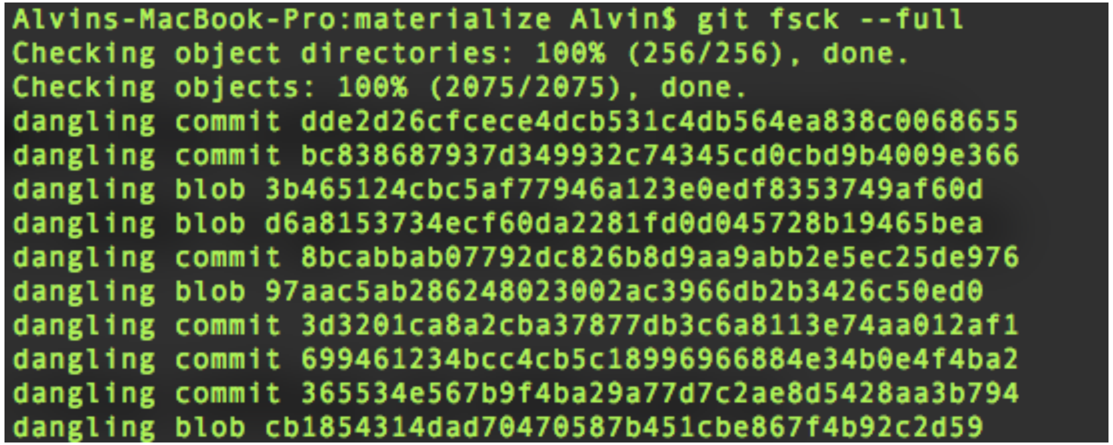
## Recovering continued

- You want to grab the latest commit of what you want to recover, in this case hashD
- right now these are dangling commits because they do not reside in a branch and will eventually be deleted
- to save them:
- git branch recover-branch hashD
- This creates a new branch called recover-branch which contains the commits of hashD and everything before
- Now we can just merge with master

## Recovery scenario 2

- That was fairly easy, but what if we don’t have the commit in the reflog?
- This may happen because the reflog is not copied to anything during git push; after a git clone, you have no reflog
- However remember that the reflog, is still just a reference in the end, this means our data may still be there floating around.
- Now we have to run git fsck --full, to show objects that aren’t being pointed to by anything else.

## Recovery 2 Continued



```
Alvins-MacBook-Pro:materialize Alvin$ git fsck --full
Checking object directories: 100% (256/256), done.
Checking objects: 100% (2075/2075), done.
dangling commit dde2d26cfcece4dcb531c4db564ea838c0068655
dangling commit bc838687937d349932c74345cd0cbd9b4009e366
dangling blob 3b465124cbc5af77946a123e0edf8353749af60d
dangling blob d6a8153734ecf60da2281fd0d045728b19465bea
dangling commit 8bcabbab07792dc826b8d9aa9abb2e5ec25de976
dangling blob 97aac5ab286248023002ac3966db2b3426c50ed0
dangling commit 3d3201ca8a2cba37877db3c6a8113e74aa012af1
dangling commit 699461234bcc4cb5c18996966884e34b0e4f4ba2
dangling commit 365534e567b9f4ba29a77d7c2ae8d5428aa3b794
dangling blob cb1854314dad70470587b451cbe867f4b92c2d59
```

- Here we use the skills/commands we learned last class. git cat-file -p <hash> will show us what is in these dangling commits.
- Then we just git branch recovery-branch <hash> just as before
- N.B. recovery-branch is just a name which can be changed to whatever you want

## Transfer Protocols

- Used for network actions
  - git pull, git clone, git push
- Dumb Protocol
  - Mostly outdated
  - used for reading only
- Smart Protocol
  - supported by most git hosting services

## The Dumb Protocol

- Uses simple HTTP
- Does not require any git specific code
- Series of GET requests to a known file structure to receive all necessary information
- Does not provide support from transferring from client to server
- Requires minor set up on server side

## Implementation

- GET info/refs
  - returns list of remote references
- GET HEAD
  - returns the head reference
- GET objects/...
  - start fetching objects
  - uncompressed and check to see what else is needed
  - if you 404 request the pack

## Smart Protocol

- More efficient
- Allows for reading and writing
- Uses HTTP/HTTPS or SSH
- More secure (if using HTTPS or SSH)

## Smart Protocol SSH Upload

- Runs git send-pack
  - Sets up ssh connection to server
  - runs git receive-pack on server
- The server then sends back a line for each reference
- Based on this the client determines what it has that the server does not

## Smart Protocol SSH Upload Continued

- Then the client sends a line back for each reference it was missing
- The server then returns if it was ok
- Next the client sends the packfile

## Smart Protocol SSH Download

- Runs git fetch-pack
  - Sets up ssh connection to server
  - runs git upload-pack on server
- Server responds with all of refs plus a HEAD
  - the head is used to tell the client what to check out if the command is a clone
- The client then sends back what it wants and has to the server

## Smart Protocol SSH Download Cont.

- The server replies with an appropriate pak file for the requested data

## Smart Protocol HTTP/HTTPS Upload

- GET $GIT_URL/info/refs?service=git-receive-pack
    - works the same way as before
- Initiates a new connection with data from git upload-pack
    - provides the pack and references unlike before

## Smart Protocol HTTP/HTTPS Download

- GET $GIT_URL/info/refs?service=git-upload-pack
    - works the same was as the other download
- POST $GIT_URL/git-upload-pack HTTP/1.0
    - initiates a new connection
    - response has success or failure along with packfile

## Example of server responding

```
005bca82a6dff817ec66f4437202690a93763949
    refs/heads/master report-status \
    delete-refs side-band-64k quiet ofs-delta \
    agent=git/2:2.1.1+github-607-gfba4028 delete-refs
003e085bb3bcb608e1e84b2432f8ecbe6306e7e7
refs/heads/topic
0000
```

## Advantages and Disadvantages of SSH

- Easy server side
- Secure
- No anonymous access
  - bad for open source
- Harder for users
  - Sometimes firewalled
  - Have to generate key

## Next Week in Git Stuco

- git filter-branch
- git bisect
- Hooks

## Homework

Due next Saturday 11:59PM

Will be released on Saturday

Will be give a .zip file, ref log will be deleted