Advanced Git

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Xilopix, February 2015

About

This slides are using resources from the Pro Git book [isbn:1430218339] which is licensed under the Creative Commons v3.0 (by-nc-sa) license.

The sources of the book can be found at https://github.com/progit/progit2 .

The sources of this slides can be found at https://github.com/olbat/misc/tree/HEAD/slides/advanced-git .

Summary

1. Overview
2. Basic usage
3. Work with branches
4. Rewrite history
5. Code introspection
6. Useful commands
7. Internals

Overview

- Originally developed to work on the GNU/Linux kernel
- First release in 2005 (1 year after subversion 1.0)
- Free software (GPLv2)
- Main goals
  - Speed
  - Simple design
  - Data integrity
  - Support for distributed workflows
  - Support for non-linear development

Finding documentation

Read the manual

- Well written
- A lot of examples

Pro Git book

- Very complete
- Easy to read/understand
- Available in different formats

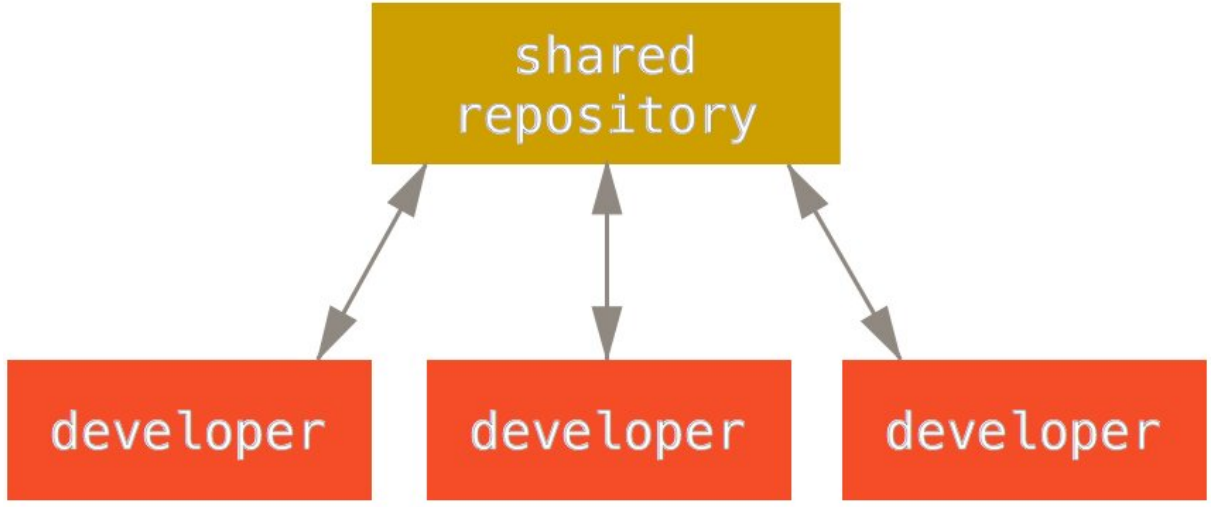
Other books

A distributed revision control system

[Pro Git, chapter 5]

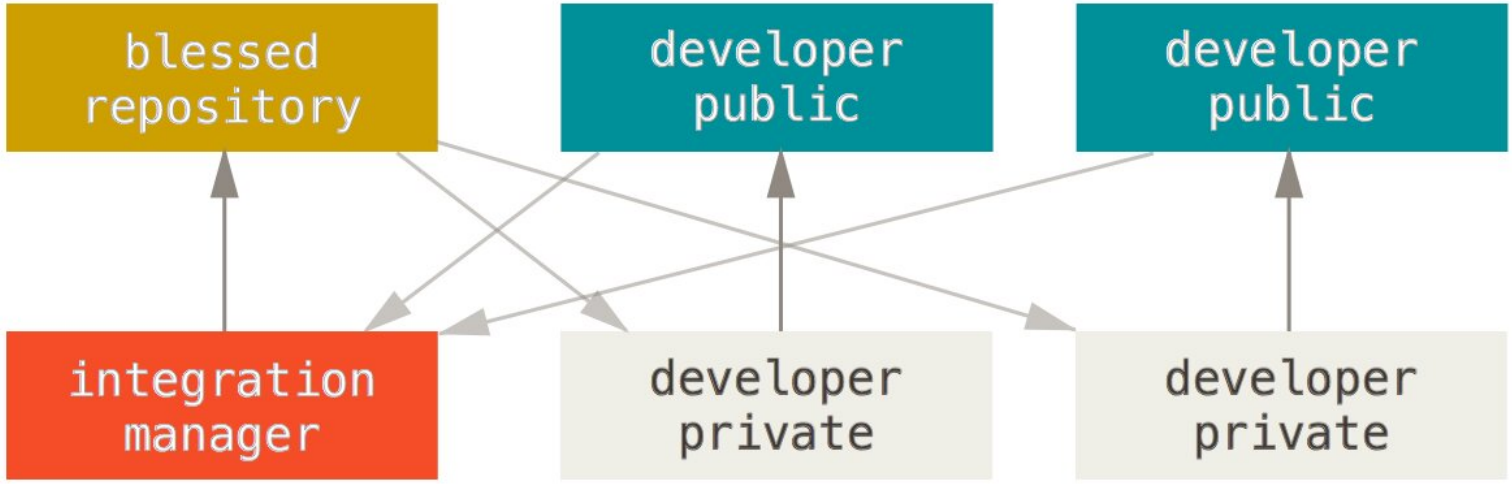
A distributed revision control system

Centralized workflow



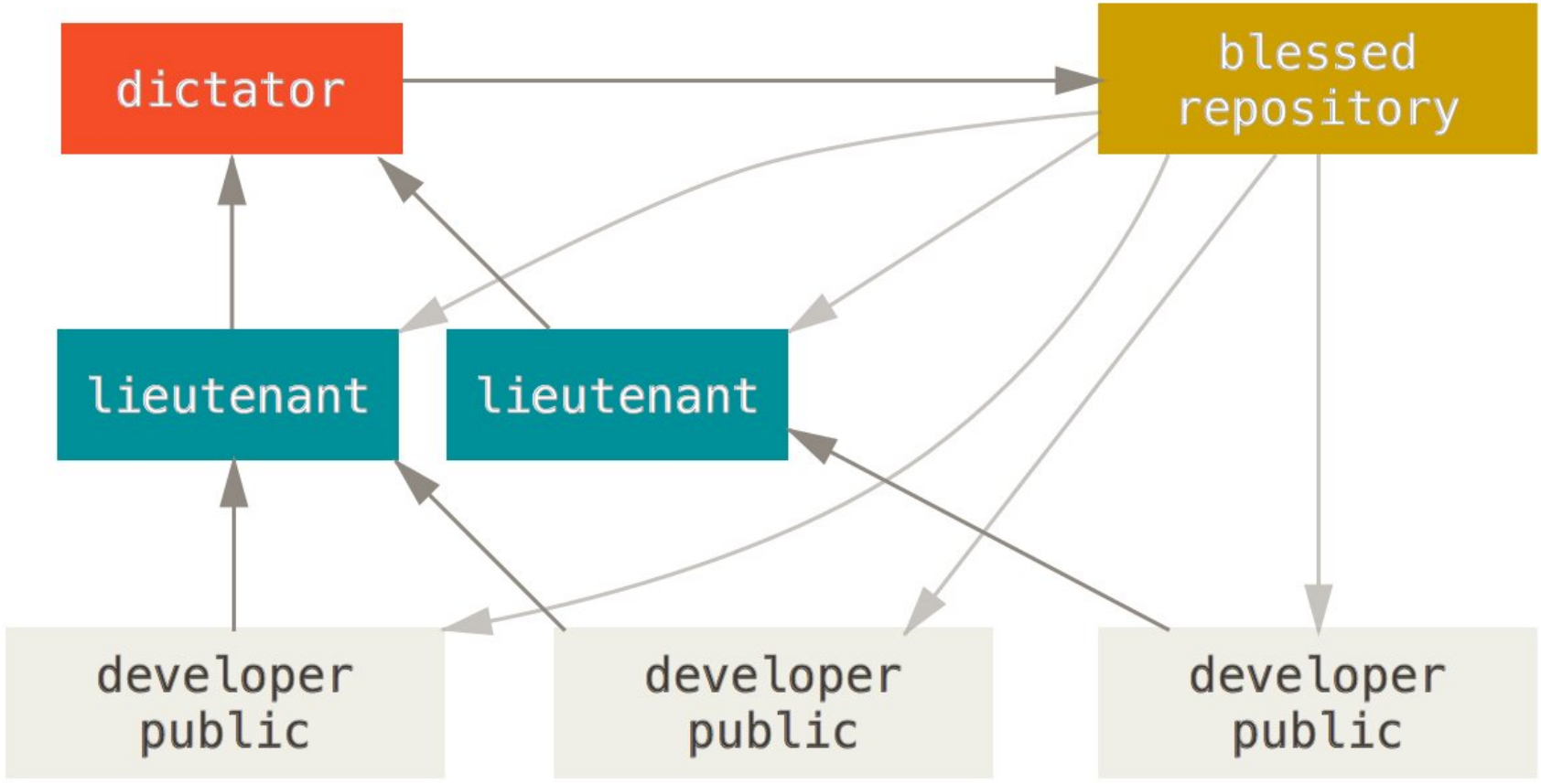
A distributed revision control system

Integration manager workflow



A distributed revision control system

Dictator and Lieutenants workflow



Git basics

[Pro Git, chapter 2]

Start to work

1. Create an empty (sandbox) repository

```
$ git init --bare /tmp/sandbox.git
```

2. Clone the repository

```
$ git clone file:///tmp/sandbox.git
```

3. Start to work in the master branch

```
$ cd /tmp/sandbox
$ git checkout -b master
```

State of the repository

[Pro Git, chapter 2.2]

State of the repository

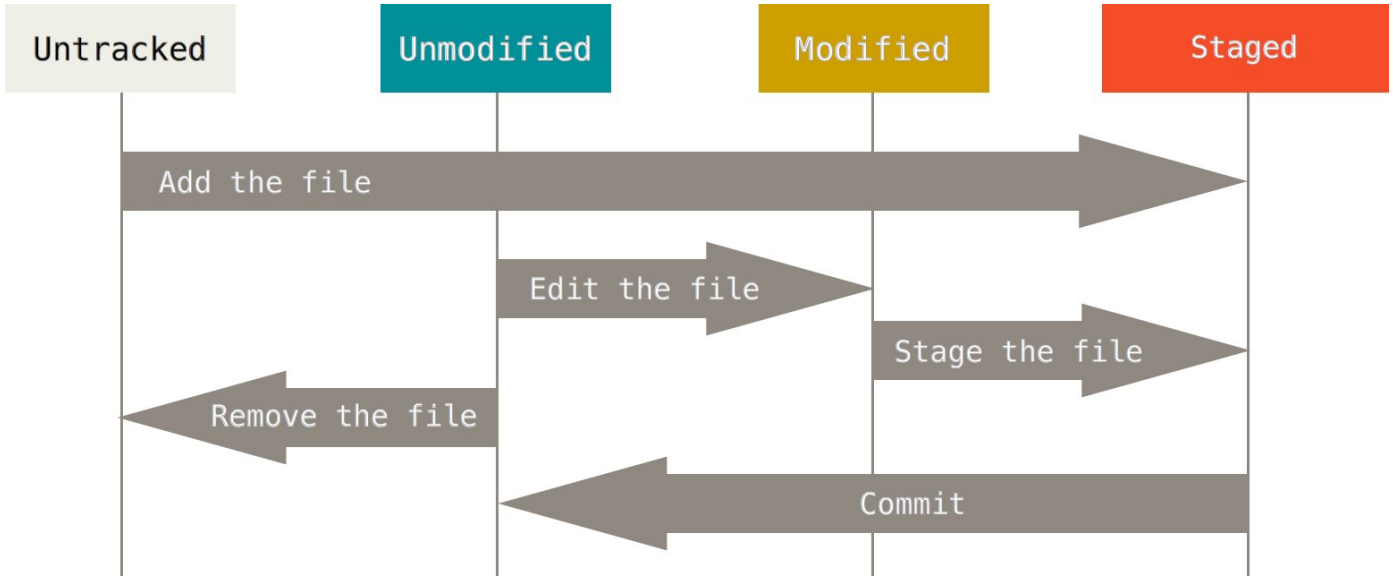
- State of the repository in long format

```
$ git status
Changes to be committed:
    new file:   staged_file
    deleted:    file

Changes not staged for commit:
    modified:   modified_file

Untracked files:
    new_file
```

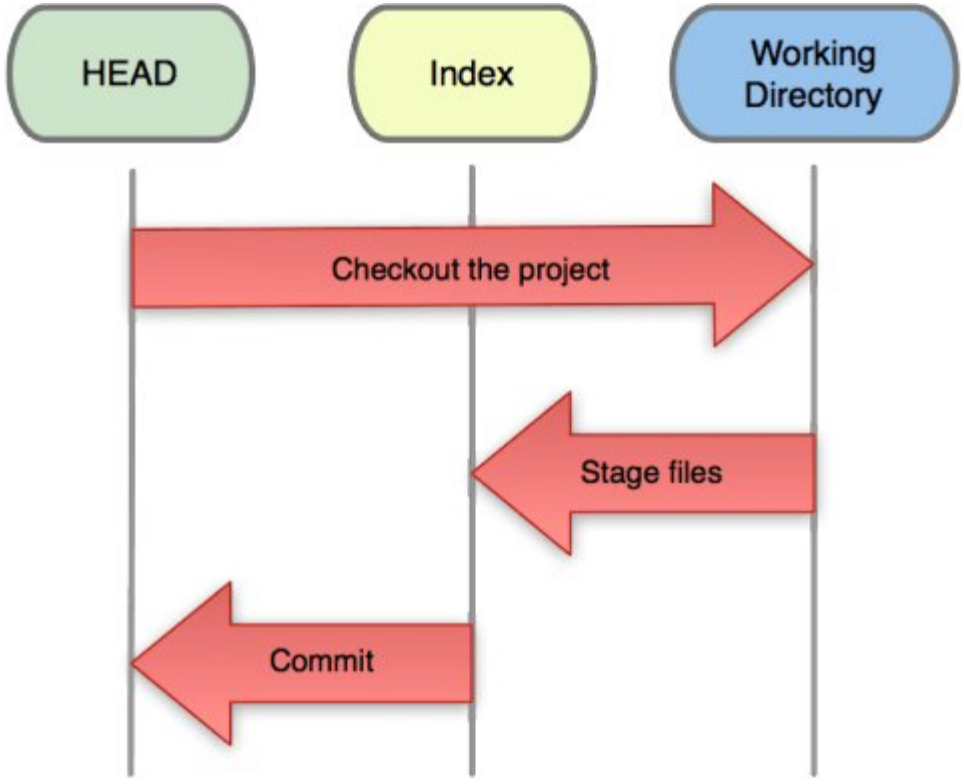
- State of the repository in short format

```
$ git status -s # --short
D  file
 M modified_file
A  staged_file
?? new_file
```

State of files



HEAD, index and working dir.



[Git blog, reset]

Planing modifications

[Pro Git, chapter 2.2]

Staging modifications

- Stage only some parts of a file (interactive)

```
$ git add -p FILE # --patch
```

- Stage all indexed files that has changed

```
$ git add -u # --update
```

- Stage both modified and untracked files

```
$ git add -A # --all
```

- Unstage staged files

```
$ git reset HEAD FILE1 FILE2 .. FILEn
```

Discard local modifications

- Discard changes in files

```
$ git checkout -- FILE1 FILE2 .. FILEn
```

- Undo commit and keep modified/new files in index

```
$ git reset --soft HEAD^
```

- Undo commit and remove modified/new files from index

```
$ git reset HEAD^
```

- Undo commit and undo changes to indexed files

```
$ git reset --hard HEAD^
```

[Pro Git, chapter 2.4]

Save repository state w/o commit

- Stash some modifications (saves the current diff)

```
$ git status -s
A  file
 M modified_file
D  removed_file
?? untracked_file

$ git stash save

$ git status -s
?? untracked_file
```

- List current stashed changes

```
$ git stash list
HEAD is now at ce499bc commit
stash@{0}: WIP on test: ce499bc commit
stash@{1}: WIP on master: 0029594 commit2
```

[Pro Git, chapter 7.3]

Save repository state w/o commit

- Display a specific stash

```
$ git stash show stash@{0} # -p to show in diff format
file          | 1 +
modified_file | 2 +-
removed_file  | 0
3 files changed, 2 insertions(+), 1 deletion(-)
```

- Apply stashed changes (apply diff)

```
$ git stash apply # stash@{0}
$ git status -s
A  file
 M modified_file
D  removed_file
?? untracked_file
```

- Create a new branch and apply stashed changes in the top of it

```
git stash branch # stash@{0}
```

Save modifications

Commit changes

- Commit and specify message on the CLI

```
$ git commit -m 'message'
```

- Skip the staging area

```
$ git commit -m "message" -a # ~ git add -a && commit
```

- Select what to commit (interactive)

```
$ git commit -m "message" -p # ~ git add -p && commit
```

- Rewrite (amend) the last commit (staged files will be added in the commit)

```
$ git commit --amend # --no-edit
```

View modifications

View modifications

- View unstaged modifications

```
$ git diff
```

- View staged modifications

```
$ git diff --cached
```

- View modifications between two branches

```
$ git diff master..develop
$ git diff origin/develop..develop
```

- View changes of a specific file

```
$ git diff -- filename
$ git diff master..develop -- filename
```

View modifications

- Summary of changes

```
$ git diff --stat
```

- Show ~bitwise diff

```
$ git diff --color-words
```

- View changes of a specific commit

```
$ git show HEAD~
```

- Show the content of a file in a specified version

```
$ git show HEAD~:filename
$ git show fa616be:filename
```

Explore the history

[Pro Git, chapter 2.3]

Exploring the history

- Show the history of another branch in short version

```
$ git log --oneline branchname
```

- Show the history with branch names

```
$ git log --decorate # git config --global log.decorate true
```

- Show graph version of the history

```
$ git log --graph # --all to display every branches
```

- Summary of history gouped by author

```
$ git shortlog
```

Specifying revisions

- The previous commit: `HEAD^`, `HEAD~`, `HEAD^1`
- The previous commit of the *develop* branch: `develop~1` or `develop^1`
- Two commit before *fa616be*: `fa616be~2` or `fa616be^^`
- Three commit before this commit: `HEAD~3` or `HEAD^^^`

```
Commit tree          Revisions

G   H   I   J        A =      = A^0
 \ /     \ /         B = A^   = A^1     = A~1
  D   E   F          C = A^2  = A^2
   \  |  / \         D = A^^  = A^1^1   = A~2
    \ | /   |        E = B^2  = A^^2
     \|/    |        F = B^3  = A^^3
      B     C        G = A^^^ = A^1^1^1 = A~3
       \   /         H = D^2  = B^^2    = A^^^2  = A~2^2
        \ /          I = F^   = B^3^    = A^^3^
         A           J = F^2  = B^3^2   = A^^3^2
```

[git rev-parse manual, section *SPECIFYING REVISIONS*]

Work in team

[Pro Git, chapter 2.5 and chapter 5.2]

Download and upload changes

- Push the current branch to the remote branch with the same name

```
$ git push origin HEAD
```

- Push several new branches to the remote

```
$ git push origin branchname name:othername HEAD:name HEAD
```

- Delete a branch on the remote

```
$ git push origin :branchname
```

- Delete local branches that track deleted remote branches

```
$ git fetch origin -p # --prune
```

- Fetch changes from a remote branch in a specific local branch

```
$ git fetch origin master:latest_master
```

[Pro Git, chapter 3.5]

Working with remotes

Local view

```
$ find .git/refs -type f
.git/refs/heads/localbranch
.git/refs/heads/master
.git/refs/remotes/origin/master
.git/refs/remotes/origin/remotebranch
```

Classic state

```
                                        C1   C2   C3
uri:///project.git/refs/heads/master ----*----*----*
(remote,read-write)
                                        C1   C2
refs/remotes/origin/master --------------*----*
(local,read-only)
                                        C1
refs/heads/master ------------------------*
(local,read-write)
```

Fetch and Pull

Fetch (`git fetch origin master`)

```
                                    C1   C2   C3
uri:///project.git/refs/heads/master ----*----*----*
(remote,read-write)                                 | update
                                    C1   C2    v
refs/remotes/origin/master ----------------*----*====*
(local,read-only)                                   C3
                                    C1
refs/heads/master ------------------------*
(local,read-write)
```

Pull (`git pull origin master` or `git fetch origin master:master`)

```
                                    C1   C2   C3
uri:///project.git/refs/heads/master ----*----*----*
(remote,read-write)                                 | update
                                    C1   C2    v
refs/remotes/origin/master ----------------*----*====*
(local,read-only)                                   | merge
                                    C1         v
refs/heads/master ------------------------*====*====*
(local,read-write)                              C2   C3
```

Discard remote modifications

- Revert commits (applies the reverse diffs)

```
$ git revert COMMIT1 COMMIT2 .. COMMITn
$ git push origin HEAD
```

- Override a remote branch with a local one

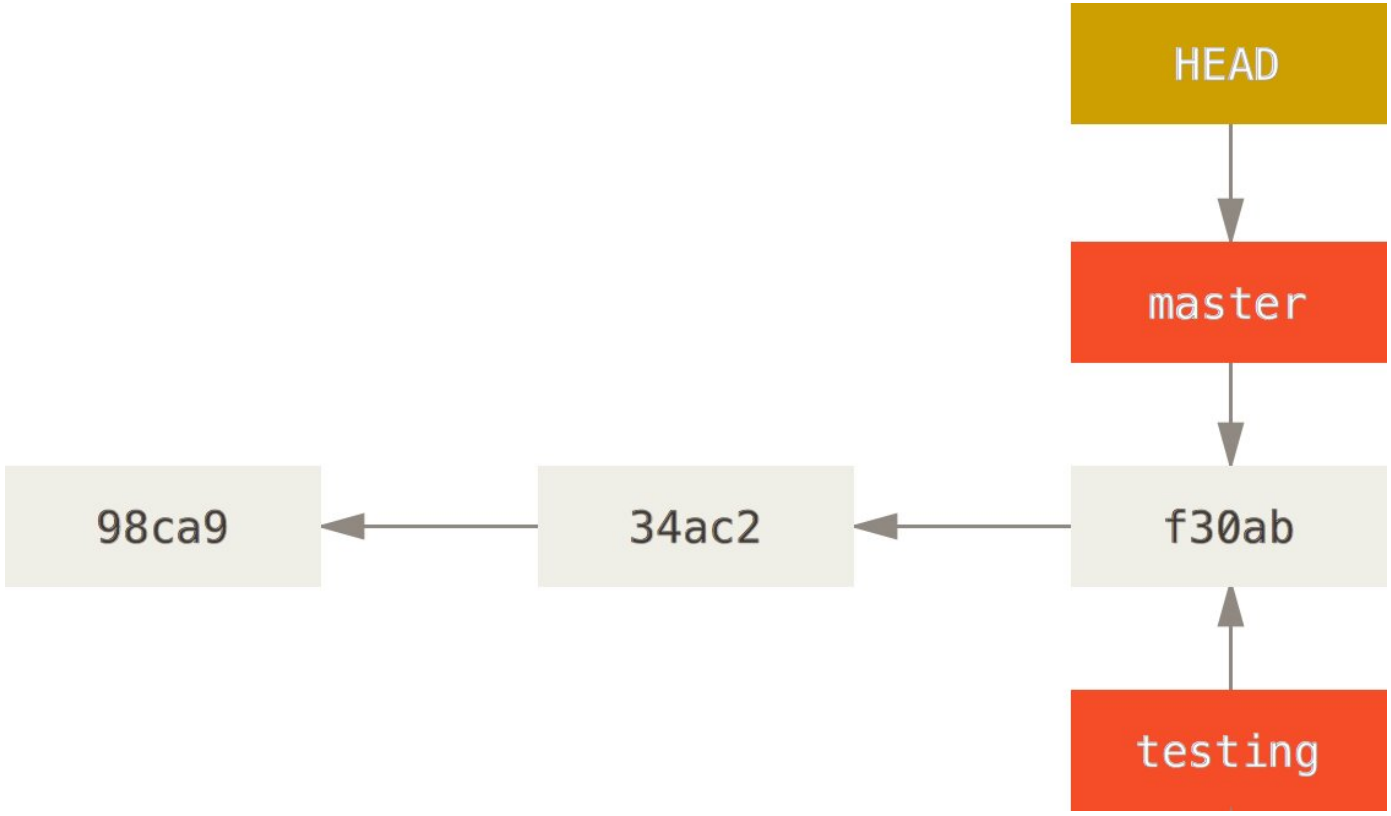
```
$ git rebase -i ... # rewrite history
$ git push --force-with-lease origin HEAD # (to avoid with shared branches)
```

Working with branches

[Pro Git, chapter 3]

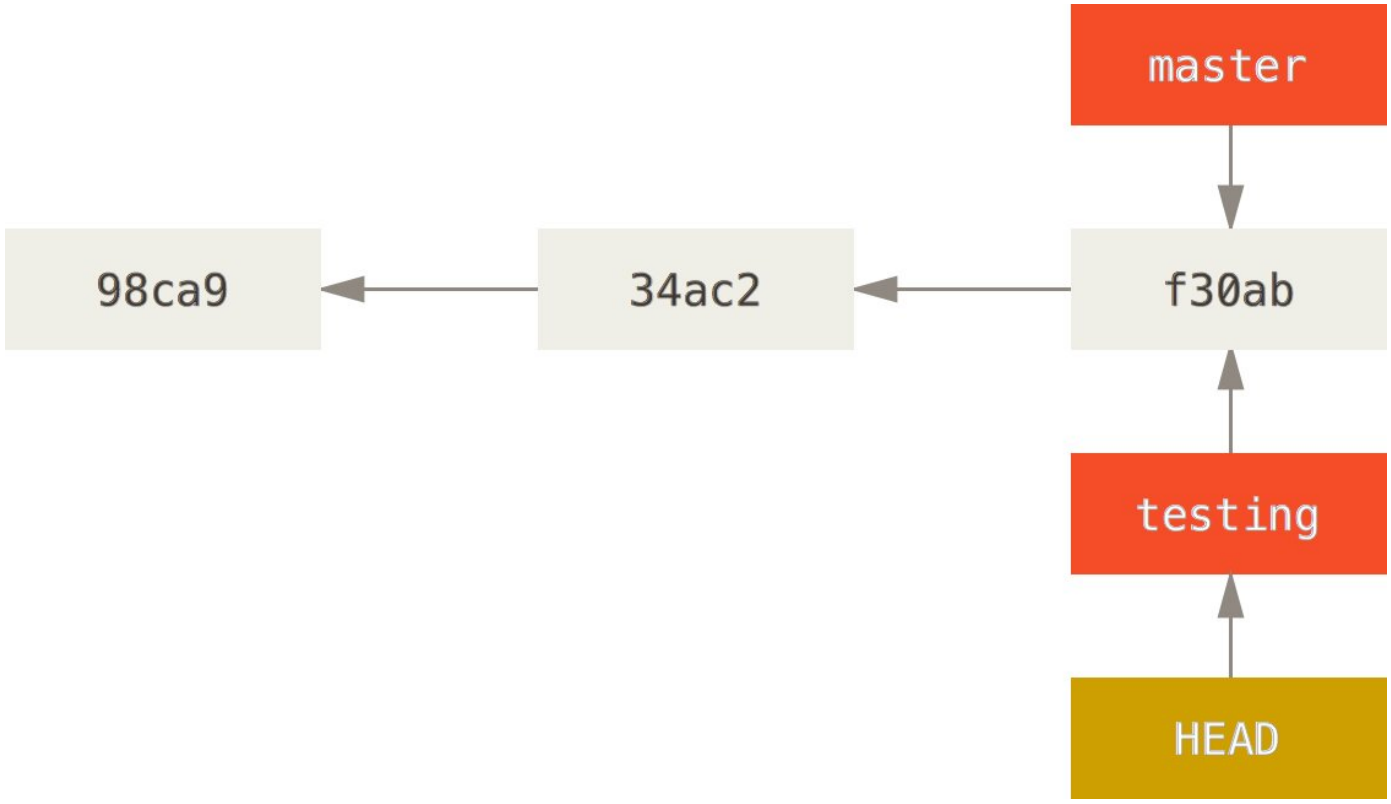
Working in branches

```
$ git branch testing
```



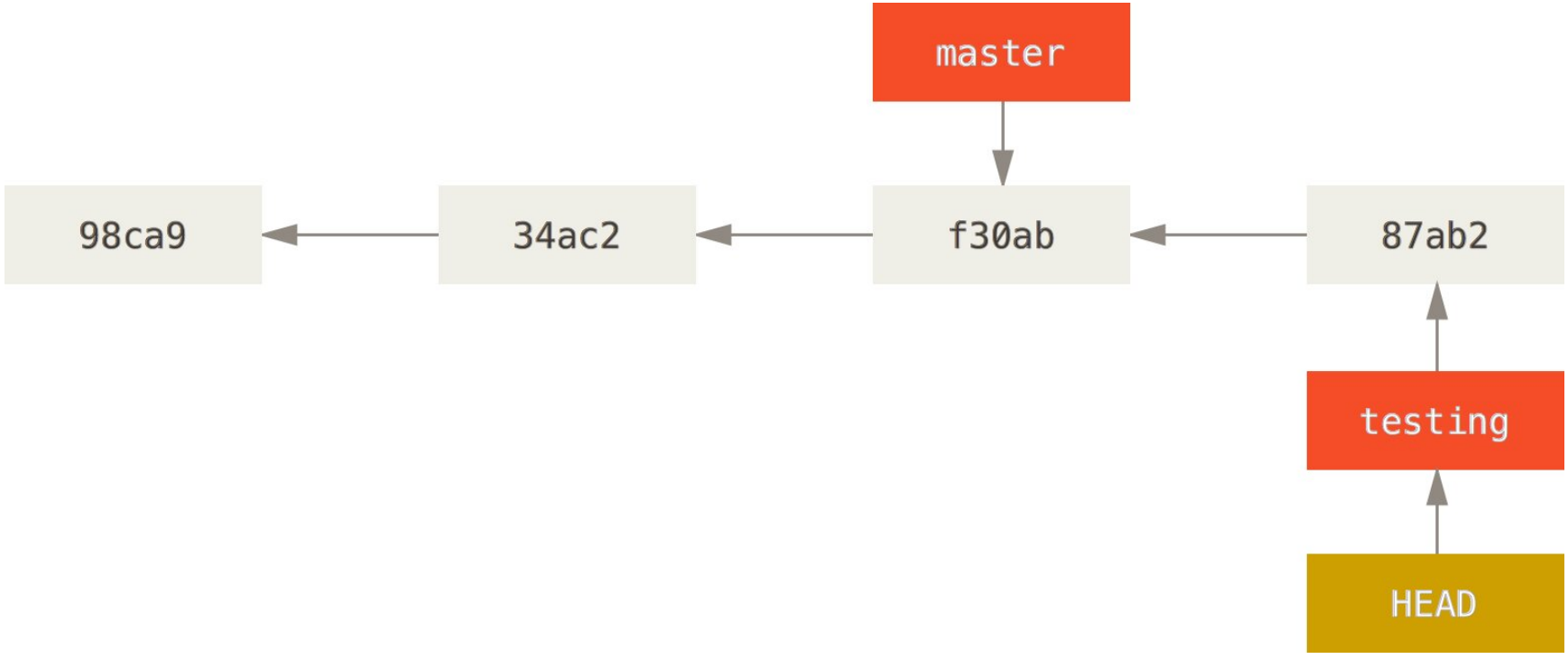
Working in branches

```
$ git checkout testing
```



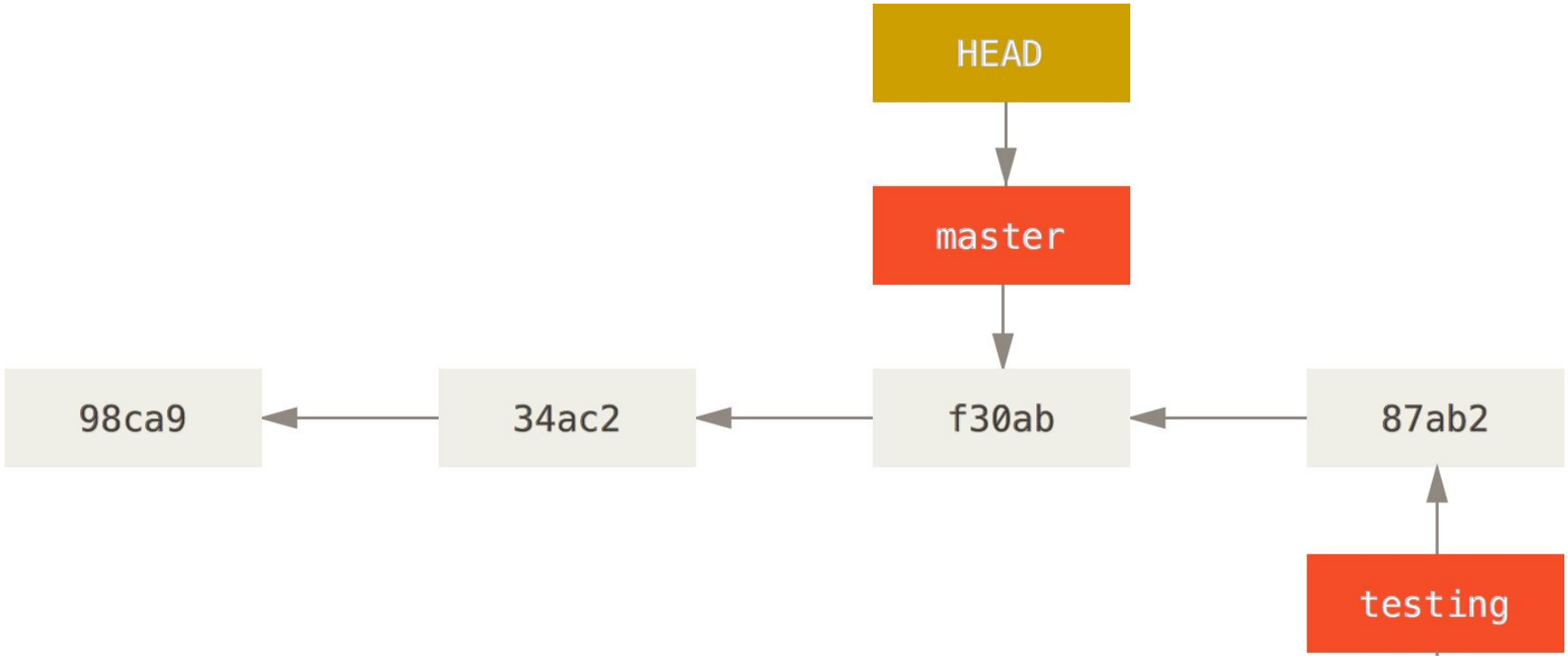
Working in branches

```
$ git add ... && git commit ... # in testing
```



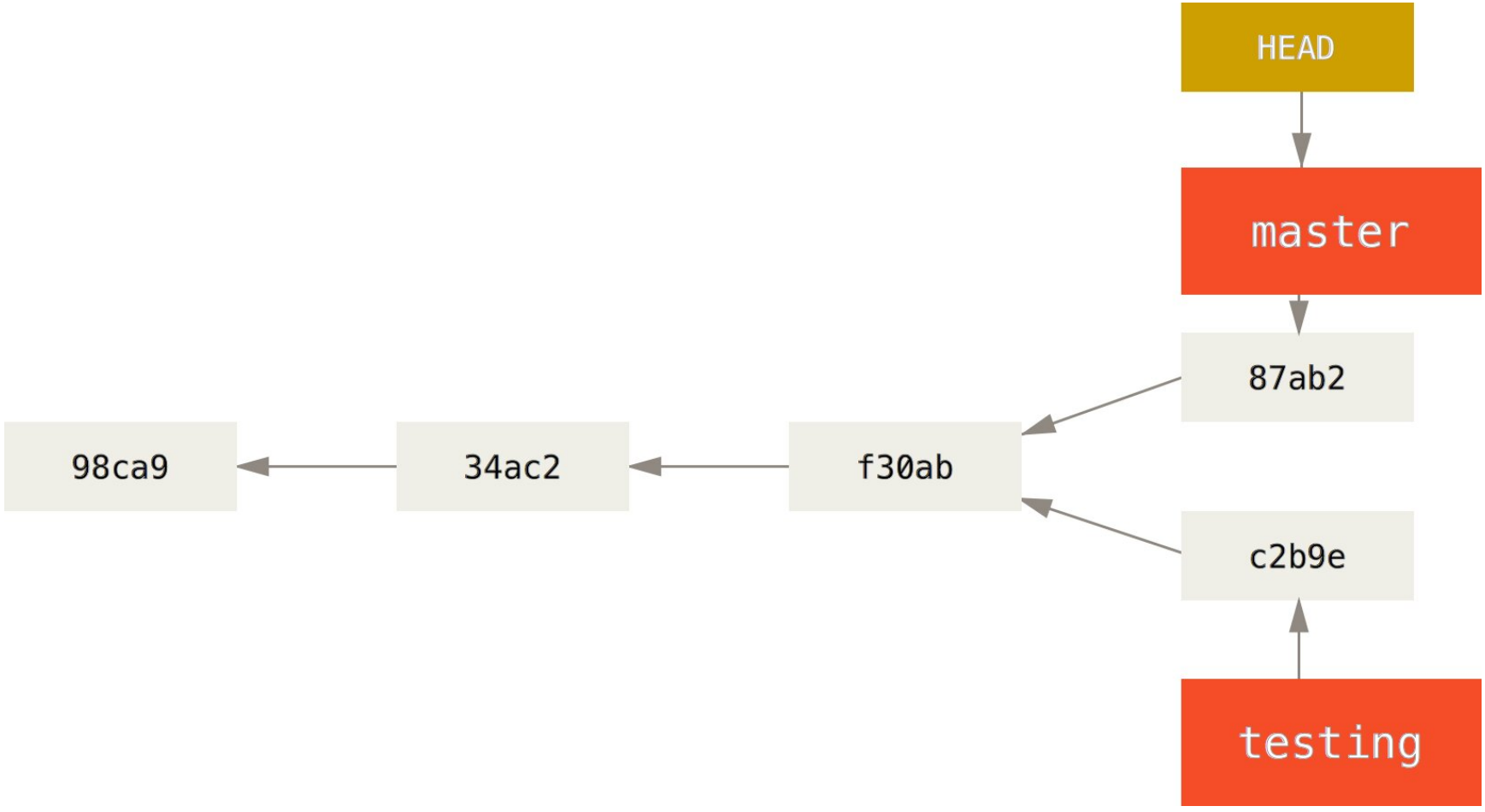
Working in branches

```
$ git checkout master
```



Working in branches

```
$ git add ... && git commit ... # in master
```



Working with branches

- Show history of HEAD's values (find deleted/reseted branch)

```
$ git reflog
```

- Create and checkout a new branch based on an existing one

```
$ git checkout -b feature origin/master
```

- Checkout a new empty branch

```
$ git checkout --orphan newbranch
$ git rm -r --cached .
```

- Clean: remove every local branch that has been merged

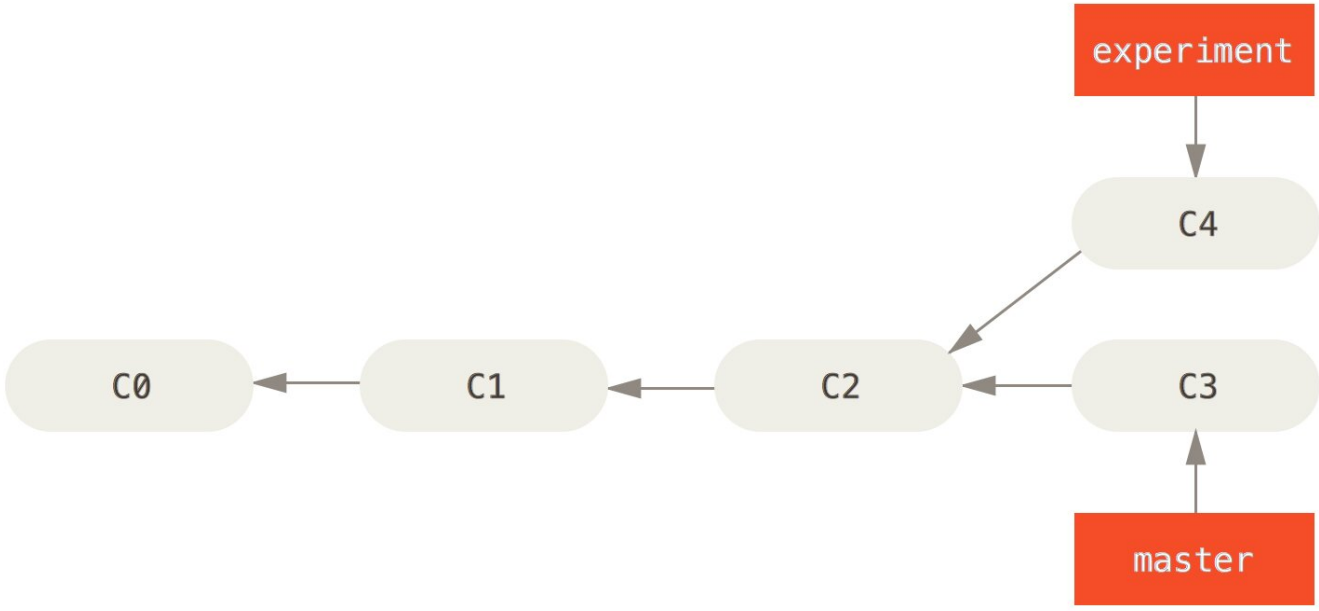
```
git branch --merged master | grep -v '^\*' | xargs -n 1 git branch -d
```

Integrate changes between branches

[Pro Git, chapter 5.3]

Integrate changes between branches

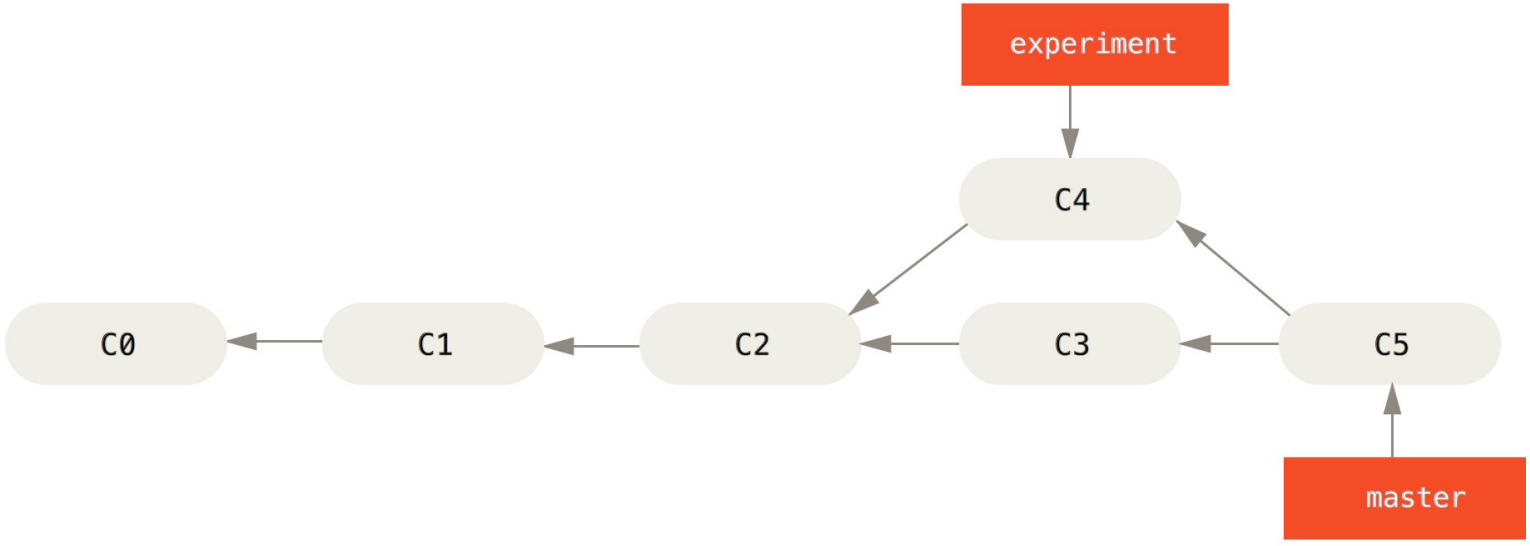
- Simple divergent history



Integrate changes between branches

- Merging

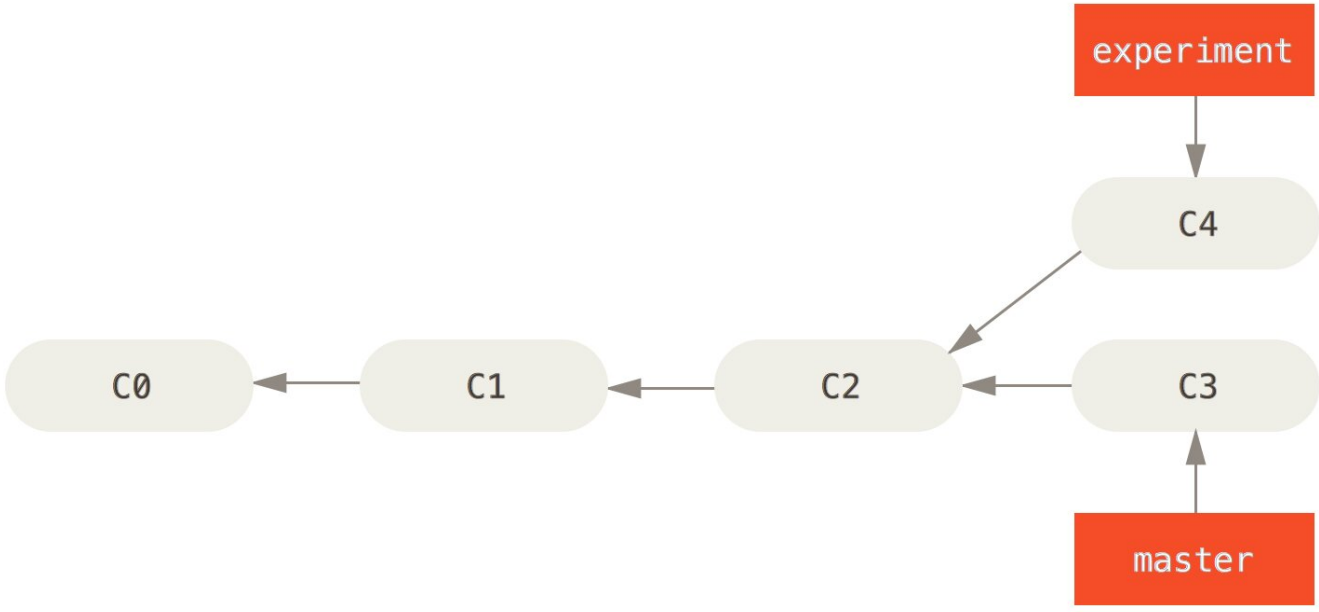
```
$ git checkout master
$ git merge experiment
```



[Pro Git, chapter 3.2]

Integrate changes between branches

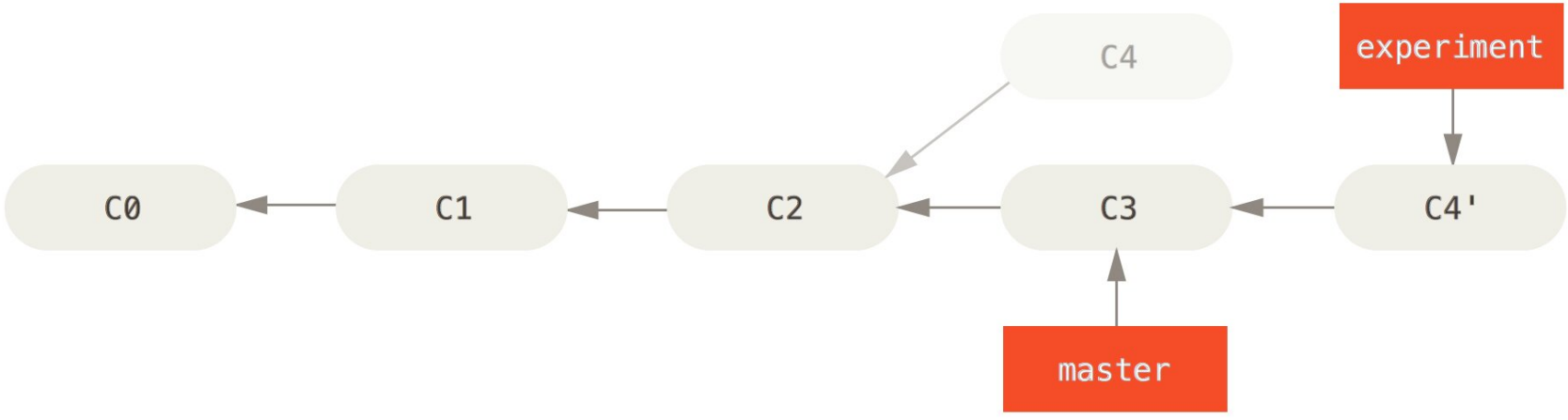
- Simple divergent history



Integrate changes between branches

- Rebasing

```
$ git checkout experiment
$ git rebase master
```

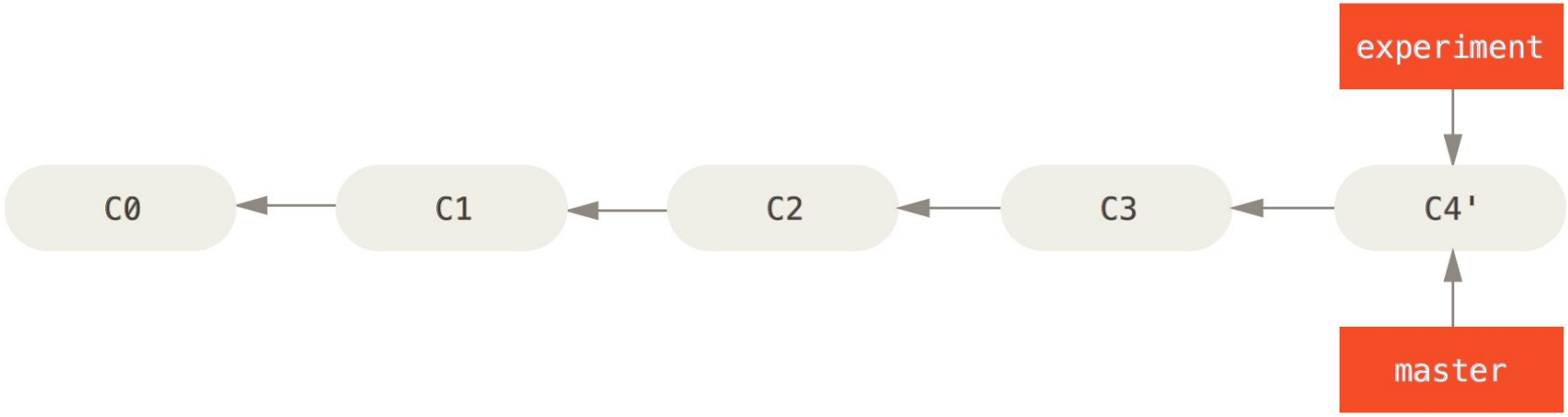


[Pro Git, chapter 3.6]

Integrate changes between branches

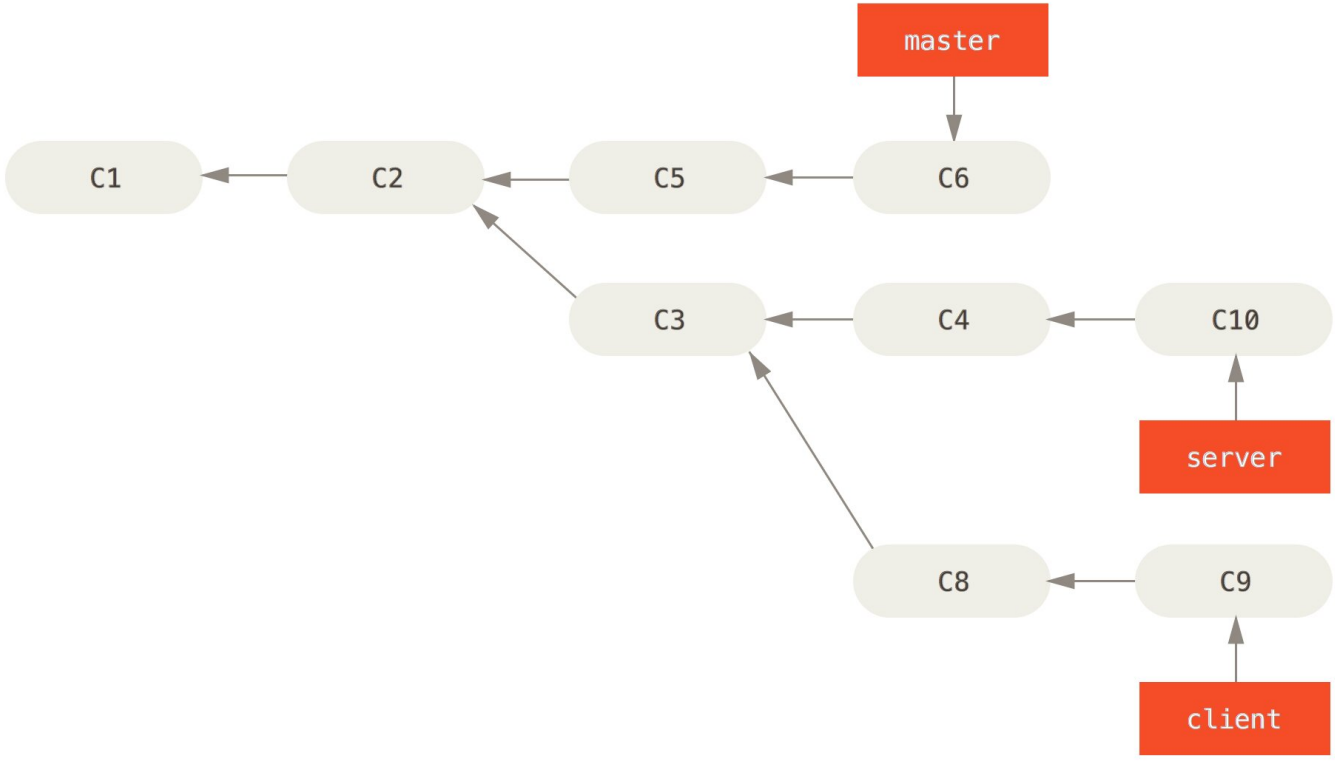
- Rebasing

```
$ git checkout master
$ git merge --ff experiment
```



Integrate changes between branches

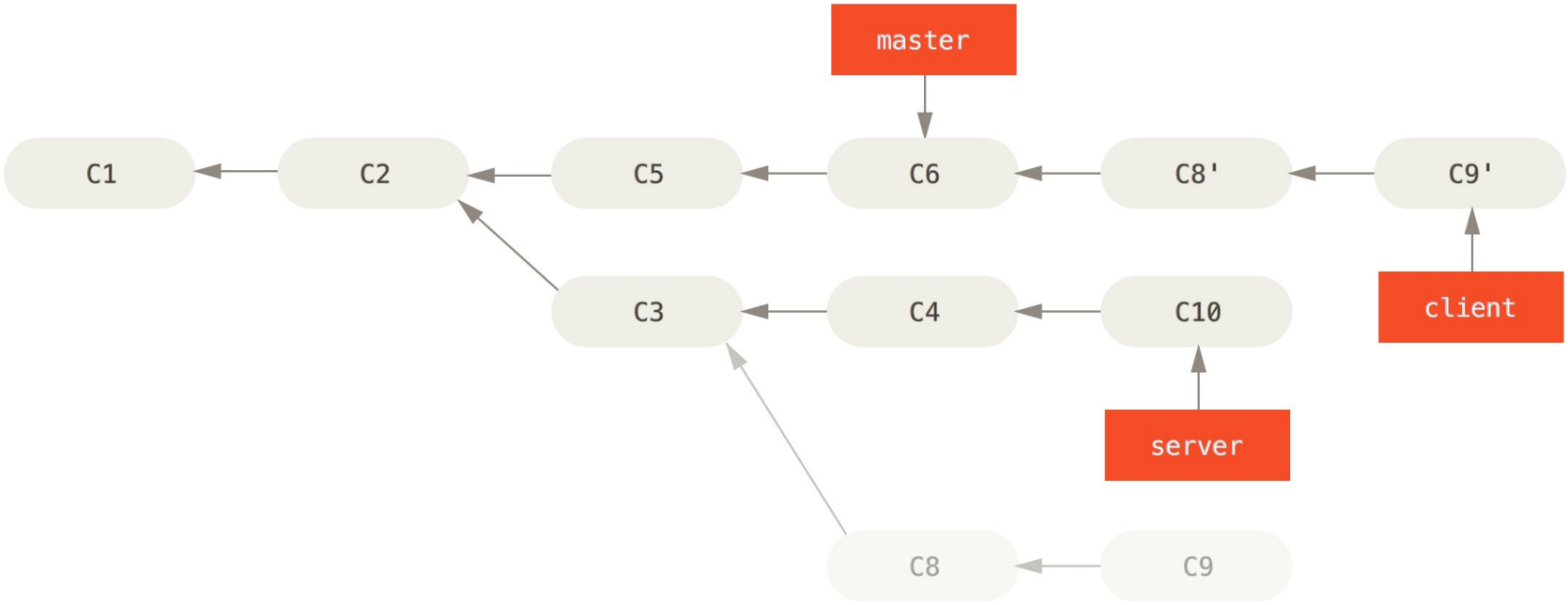
- Complex divergent history



Integrate changes between branches

- Rebase a branch onto another

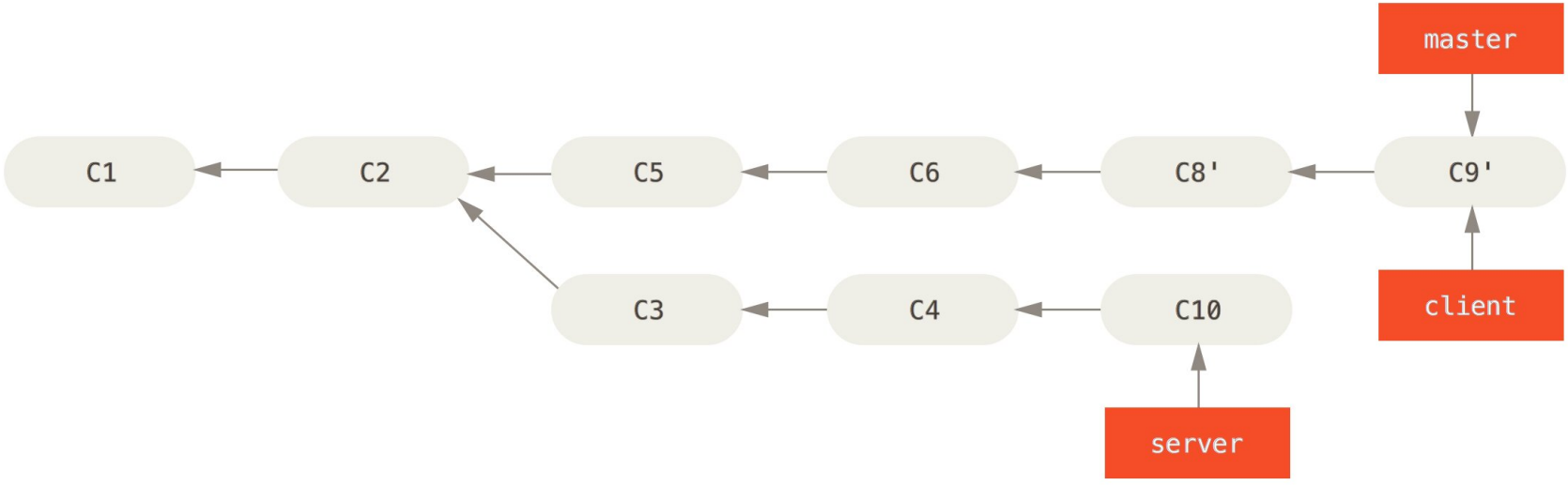
```
$ git rebase --onto master server client
```



Integrate changes between branches

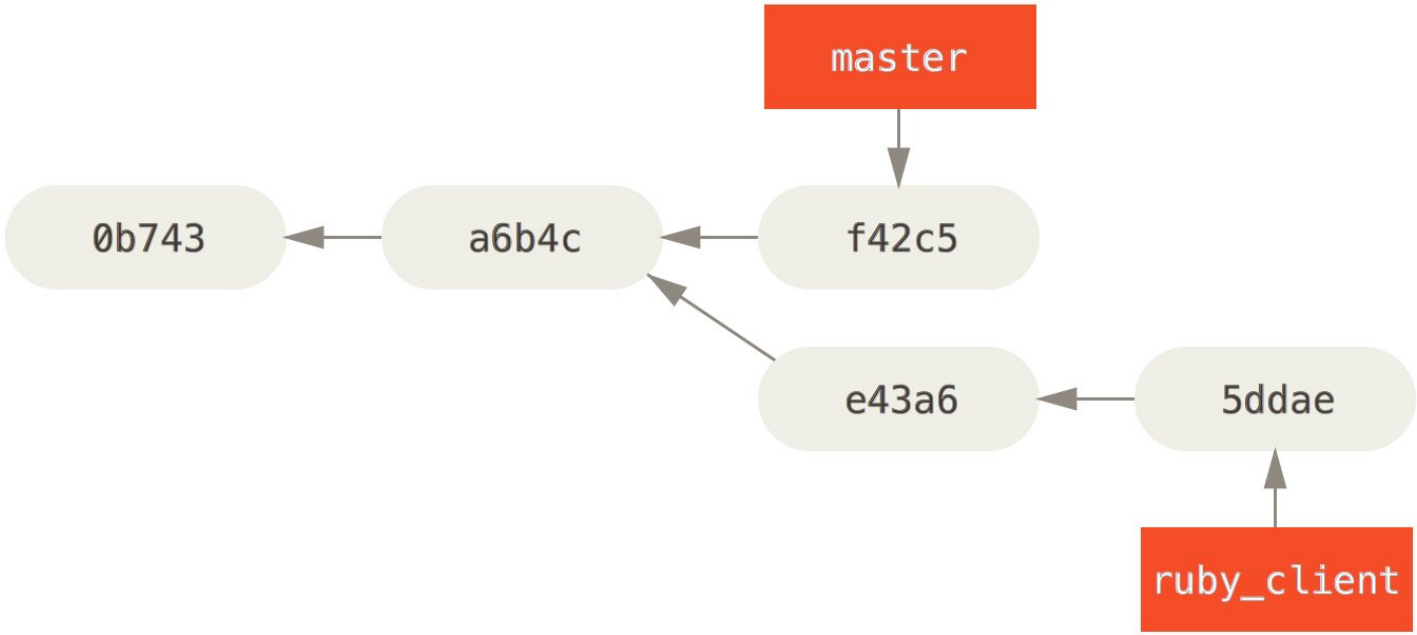
- Rebase a branch onto another

```
$ git checkout master
$ git merge --ff client
```



Integrate changes between branches

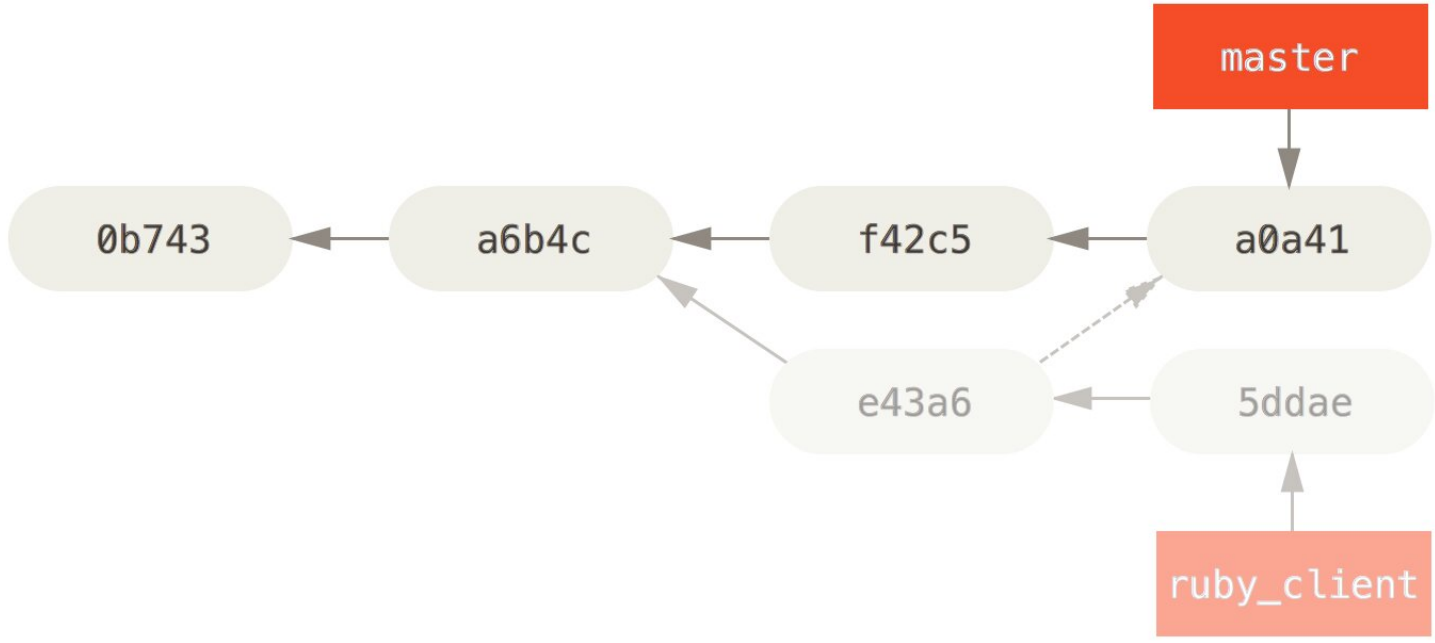
- Another simple divergent history



Integrate changes between branches

- Cherry-Picking (applies the diff of a commit on another branch)

```
$ git checkout master
$ git cherry-pick e43a6
```



[Pro Git, chapter 5.3]

Integrate changes between branches

- Cherry-Picking and keep track of the original commit

```
$ git checkout master

$ git cherry-pick -x db3e256ed4a23c92077aa2f136edab95970e8597

$ git show HEAD
commit 841a4e2375b5dc586c283fd4fb6f1f0a9ee443d3 (HEAD, master)
Author: Luc Sarzyniec <luc.sarzyniec@xilopix.com>
Date:   Tue Feb 24 08:27:00 2015 +0100

    commit4

    (cherry picked from commit db3e256ed4a23c92077aa2f136edab95970e8597)
```

Rewrite history

[Pro Git, chapter 7.6]

Rewrite history

- Rewrite (amend) the last commit

```
$ # git add ...; git rm ...
$ git commit --amend # --no-edit
```

- Rewrite several commits

```
$ git rebase -i HEAD~3
pick f7f3f6d commit 4
pick 310154e commit 5
pick a5f4a0d commit 6

# Rebase 710f0f8..a5f4a0d onto 710f0f8
#
# Commands:
#  p, pick = use commit
#  r, reword = use commit, but edit the commit message
#  e, edit = use commit, but stop for amending
#  s, squash = use commit, but meld into previous commit
#  f, fixup = like "squash", but discard this commit's log message
#  x, exec = run command (the rest of the line) using shell
```

Rewrite history

- Rewrite commit messages only

```
$ git rebase -i HEAD~3
pick f7f3f6d commit 4
reword 310154e commit 5
pick a5f4a0d commit 6
```

- Re-order commits

```
$ git rebase -i HEAD~3
pick 310154e commit 5 # <-
pick f7f3f6d commit 4 # ->
pick a5f4a0d commit 6
```

- Delete commits

```
$ git rebase -i HEAD~3
pick f7f3f6d commit 4
pick a5f4a0d commit 6
```

Rewrite history

Edit several commits

Edit several commits

- Select which commit to edit

```
$ git rebase -i HEAD~3
edit f7f3f6d commit 4
edit 310154e commit 5
pick a5f4a0d commit 6
# Save and quit

Stopped at f7f3f6d ... commit 4
You can amend the commit now, with

    git commit --amend

Once you are satisfied with your changes, run

    git rebase --continue
```

- Rewrite the first commit

```
# edit files
$ git add ... # git rm ...
$ git commit --amend
```

Edit several commits

- Continue with the second commit

```
$ git rebase --continue
Stopped at 310154e ... commit 5

# edit files
$ git add ... # git rm ...
$ git commit --amend

$ git rebase --continue
Successfully rebased and updated refs/heads/master.
```

- Check that everything was done as expected

```
$ git log --oneline -3
53bb260 commit 4 # SHA1 has changed since files were modified
f8765fa new commit 5 # SHA1 has changed since files and message were modified
4fc3652 commit 6 # SHA1 has changed since parents were modified
```

Rewrite history

Mix commits

Mix commits

- Select the commits to be mixed (with the previous commit)

```
$ git rebase -i HEAD~3
pick f7f3f6d commit 4
squash 310154e commit 5
pick a5f4a0d commit 6
```

- Create a new commit message

```
# This is a combination of 2 commits.
# The first commit's message is:
commit 4

# This is the 2nd commit message:
commit 5
```

- Check that everything was done as expected

```
$ git log --oneline -2
pick f7f3f6d commit 4 and 5
pick a5f4a0d commit 6
```

Rewrite history

Insert new commits

Insert new commits

- Select where to insert the commit (after witch existing commit)

```
$ git rebase -i HEAD~3
edit f7f3f6d commit 4
edit 310154e commit 5
pick a5f4a0d commit 6
```

- Add files and create new commits

```
$ git add ... && git commit -m "commit 4-1"
$ git rebase --continue
$ git add ... && git commit -m "commit 5-1"
$ git add ... && git commit -m "commit 5-2"
$ git rebase --continue
```

- Check that everything was done as expected

```
$ git log --oneline -6
f7f3f6d commit 4
0737964 commit 4-1
310154e commit 5
fa96cb9 commit 5-1
26cd81d commit 5-2
cc4ad9a commit 6
```

Rewrite history

Split commits

Split commits

- Select the commits to split

```
$ git rebase -i HEAD~3
pick f7f3f6d commit 4
edit 310154e commit 5
pick a5f4a0d commit 6
```

- Reset the current commit

```
$ git reset HEAD~
```

- Create several new commits

```
$ git add ...
$ git commit -m 'first'

$ git add ...
$ git commit -m 'second'

$ git add ...
$ git commit -m 'third'
```

Split commits

- Continue once it's done

```
$ git rebase --continue
Successfully rebased and updated refs/heads/master.
```

- Check that everything was done as expected

```
$ git log --oneline -5
f7f3f6d commit 4
66b1120 first
afcd336 second
4fc3652 third
a5f4a0d commit 6
```

Automatically rewrite history

- Automatically rewrite **all** the history

```
git filter-branch --tree-filter 'rm -f passwords.txt' HEAD
```

- Change your email address

```
git filter-branch --commit-filter '
if [ "$GIT_AUTHOR_EMAIL" = "schacon@localhost" ];
then
      GIT_AUTHOR_NAME="Scott Chacon";
      GIT_AUTHOR_EMAIL="schacon@example.com";
      git commit-tree "$@";
else
      git commit-tree "$@";
fi' HEAD
```

Debugging

[Pro Git, chapter 7.10]

Code introspection

- Read the code annotated with commit/line

```
$ git blame -L 1,10 zlib.c
b0613ce0 (Jonathan Nieder 2010-11-06 06:47:34 -0500  1) /*
b0613ce0 (Jonathan Nieder 2010-11-06 06:47:34 -0500  2)  * zlib wrappers to make sure we don't
b0613ce0 (Jonathan Nieder 2010-11-06 06:47:34 -0500  3)  * at init time.
b0613ce0 (Jonathan Nieder 2010-11-06 06:47:34 -0500  4)  */
b0613ce0 (Jonathan Nieder 2010-11-06 06:47:34 -0500  5) #include "cache.h"
b0613ce0 (Jonathan Nieder 2010-11-06 06:47:34 -0500  6)
1a507fc1 (Junio C Hamano  2011-06-10 10:31:34 -0700  7) static const char *zerr_to_string(int s
b0613ce0 (Jonathan Nieder 2010-11-06 06:47:34 -0500  8) {
1a507fc1 (Junio C Hamano  2011-06-10 10:31:34 -0700  9)         switch (status) {
b0613ce0 (Jonathan Nieder 2010-11-06 06:47:34 -0500 10)         case Z_MEM_ERROR:
1a507fc1 (Junio C Hamano  2011-06-10 10:31:34 -0700 11)                 return "out of memory";
b0613ce0 (Jonathan Nieder 2010-11-06 06:47:34 -0500 12)         case Z_VERSION_ERROR:
1a507fc1 (Junio C Hamano  2011-06-10 10:31:34 -0700 13)                 return "wrong version";
1a507fc1 (Junio C Hamano  2011-06-10 10:31:34 -0700 14)         case Z_NEED_DICT:
1a507fc1 (Junio C Hamano  2011-06-10 10:31:34 -0700 15)                 return "needs dictionar
1a507fc1 (Junio C Hamano  2011-06-10 10:31:34 -0700 16)         case Z_DATA_ERROR:
1a507fc1 (Junio C Hamano  2011-06-10 10:31:34 -0700 17)                 return "data stream err
1a507fc1 (Junio C Hamano  2011-06-10 10:31:34 -0700 18)         case Z_STREAM_ERROR:
1a507fc1 (Junio C Hamano  2011-06-10 10:31:34 -0700 19)                 return "stream consiste
b0613ce0 (Jonathan Nieder 2010-11-06 06:47:34 -0500 20)         default:
```

Code introspection

- In short format

```
$ git blame -L 1,10 -s zlib.c
b0613ce0  1) /*
b0613ce0  2)  * zlib wrappers to make sure we don't silently miss errors
b0613ce0  3)  * at init time.
b0613ce0  4)  */
b0613ce0  5) #include "cache.h"
b0613ce0  6)
1a507fc1  7) static const char *zerr_to_string(int status)
b0613ce0  8) {
1a507fc1  9)    switch (status) {
b0613ce0 10)    case Z_MEM_ERROR:
1a507fc1 11)            return "out of memory";
b0613ce0 12)    case Z_VERSION_ERROR:
1a507fc1 13)            return "wrong version";
1a507fc1 14)    case Z_NEED_DICT:
1a507fc1 15)            return "needs dictionary";
1a507fc1 16)    case Z_DATA_ERROR:
1a507fc1 17)            return "data stream error";
1a507fc1 18)    case Z_STREAM_ERROR:
1a507fc1 19)            return "stream consistency error";
b0613ce0 20)    default:
```

Code introspection

- See where sections of code originally came from

```
$ git blame -s -C -L 1,20 zlib.c
b0613ce0 zlib.c     1) /*
39c68542 wrapper.c  2)  * zlib wrappers to make sure we don't silently miss errors
39c68542 wrapper.c  3)  * at init time.
39c68542 wrapper.c  4)  */
b0613ce0 zlib.c     5) #include "cache.h"
b0613ce0 zlib.c     6)
1a507fc1 zlib.c     7) static const char *zerr_to_string(int status)
b0613ce0 zlib.c     8) {
1a507fc1 zlib.c     9)  switch (status) {
b0613ce0 zlib.c    10)  case Z_MEM_ERROR:
1a507fc1 zlib.c    11)          return "out of memory";
b0613ce0 zlib.c    12)  case Z_VERSION_ERROR:
1a507fc1 zlib.c    13)          return "wrong version";
1a507fc1 zlib.c    14)  case Z_NEED_DICT:
1a507fc1 zlib.c    15)          return "needs dictionary";
1a507fc1 zlib.c    16)  case Z_DATA_ERROR:
1a507fc1 zlib.c    17)          return "data stream error";
1a507fc1 zlib.c    18)  case Z_STREAM_ERROR:
1a507fc1 zlib.c    19)          return "stream consistency error";
b0613ce0 zlib.c    20)  default:
```

Track a bug using binary search

- Start to search, specify the commit of the last working version

```
$ git bisect start HEAD v2.2.0
Bisecting: 150 revisions left to test after this (roughly 7 steps)
```

- At each step specify if the current snapshot is working or not

```
# Do some tests
$ git bisect good
Bisecting: 75 revisions left to test after this (roughly 6 steps)

# Do some tests
$ git bisect bad
Bisecting: 37 revisions left to test after this (roughly 5 steps)

# ...
```

- Find the version that introduced the bug (-> read the diff to understand)

```
# ...
bcbdeb1a1256f777e52192fa7da0f7dbad680162 is the first bad commit

$ git show -p bcbdeb1a1256f777e52192fa7da0f7dbad680162
```

Track a bug automating binary search

- Find a command or create a script to reproduce the bug

```
rake test # ?
```

- Start the binary search

```
$ git bisect start HEAD v2.2.0
```

- Use the script to automatically run the binary search

```
$ git bisect run rake test
```

- Stop the binary search procedure

```
$ git bisect reset
```

[See http://lwn.net/Articles/317154/]

Other useful commands

[Pro Git, chapter 7]

Other useful commands

- Grep in a specific commit

```
git grep test 49e4c29
49e4c29:lib/disco/common/service.rb:      test_connect()
49e4c29:lib/disco/common/service.rb:    def test_connect()
```

- Find in which tag a commit was included

```
$ git describe --tag 49e4c299dc390698724da5d21de853c44737c65c
0.1.0
```

- Remove untracked files from the working directory

```
$ git clean # -d to remove directories too
```

- Create an archive of the repository (a commit/tag can be specified)

```
$ git archive -o soft-2.2.0.tar.gz v2.2.0
```

Other useful commands

- Resolve conflicts using an external (GUI?) tool

```
$ git mergetool
```

[Pro Git, chapter 3.2]

- Share changes saving commits in a bundle file (can be sent by mail, ...)
  - Create the bundle file

```
$ git bundle create repo.bundle HEAD master
```

  - Load the downloaded bundle file

```
$ git clone repo.bundle repo
```

```
$ git fetch ../commits.bundle master:other-master
```

[Pro Git, chapter 7.12]

Memo

```
$ git add -p
$ git checkout -- FILE
$ git reset REV # --soft/--hard
$ git stash
$ git commit --amend
$ git diff REV -- FILE
$ git diff --color-words
$ git show REV:FILE
$ git log --decorate --graph
$ git fetch origin BRANCH:OTHER_BRANCH
$ git revert REV
$ git rebase -i REV
$ git cherry-pick -x REV
$ git blame FILE
$ git bisect REV_END REV_START
$ git grep STR REV
$ git clean
$ git archive -o FILE.tar.gz REV
```

Internals

[Pro Git, chapter 10]

Git: content-addressable filesystem

- Object database, index = SHA1 hash
- Objects are stored in the filesystem under the `.git/objects` directory
- Several kind of objects: commit, tree, blob, ...
- Objects linking each-other (commits, trees)
- Compression on demand or when files are too big

Git objects: blobs

- Create and store a new blob (file) object:

```
$ echo "Awesome!" | git hash-object --stdin -w
6d4ed2c98c4fbe835280634af0cbddefffaf7ee6

$ touch file && git hash-object -w file
e69de29bb2d1d6434b8b29ae775ad8c2e48c5391
```

- Find this object in the filesystem

```
$ find .git/objects/
.git/objects/6d/
.git/objects/6d/4ed2c98c4fbe835280634af0cbddefffaf7ee6
```

- Get information about the object

```
$ git cat-file -t 6d4ed2c98c4fbe835280634af0cbddefffaf7ee6
blob

$ git cat-file -p 6d4ed2c98c4fbe835280634af0cbddefffaf7ee6
Awesome!
```

Git objects representation

- Content of the file associated to the object

```
$ cat .git/objects/6d/4ed2c98c4fbe835280634af0cbddefffaf7ee6
xKÊÉOR°dp,O-ÎÏMUä,S
```

- *deflate* (zip,gzip,zlib,...) decompressed content

```
$ cat .git/objects/6d/4ed2c98c4fbe835280634af0cbddefffaf7ee6 | \
openssl zlib -d | od -vtc -tx1
0000000   b   l   o   b       9  \0   A   w   e   s   o   m   e   !  \n
     62  6c  6f  62  20  39  00  41  77  65  73  6f  6d  65  21  0a
```

- Calculation of the SHA1 hash associated of the object

```
$ printf %b 'blob 9\0Awesome!\n' | sha1sum
6d4ed2c98c4fbe835280634af0cbddefffaf7ee6 *-
```

Git objects: commits and trees

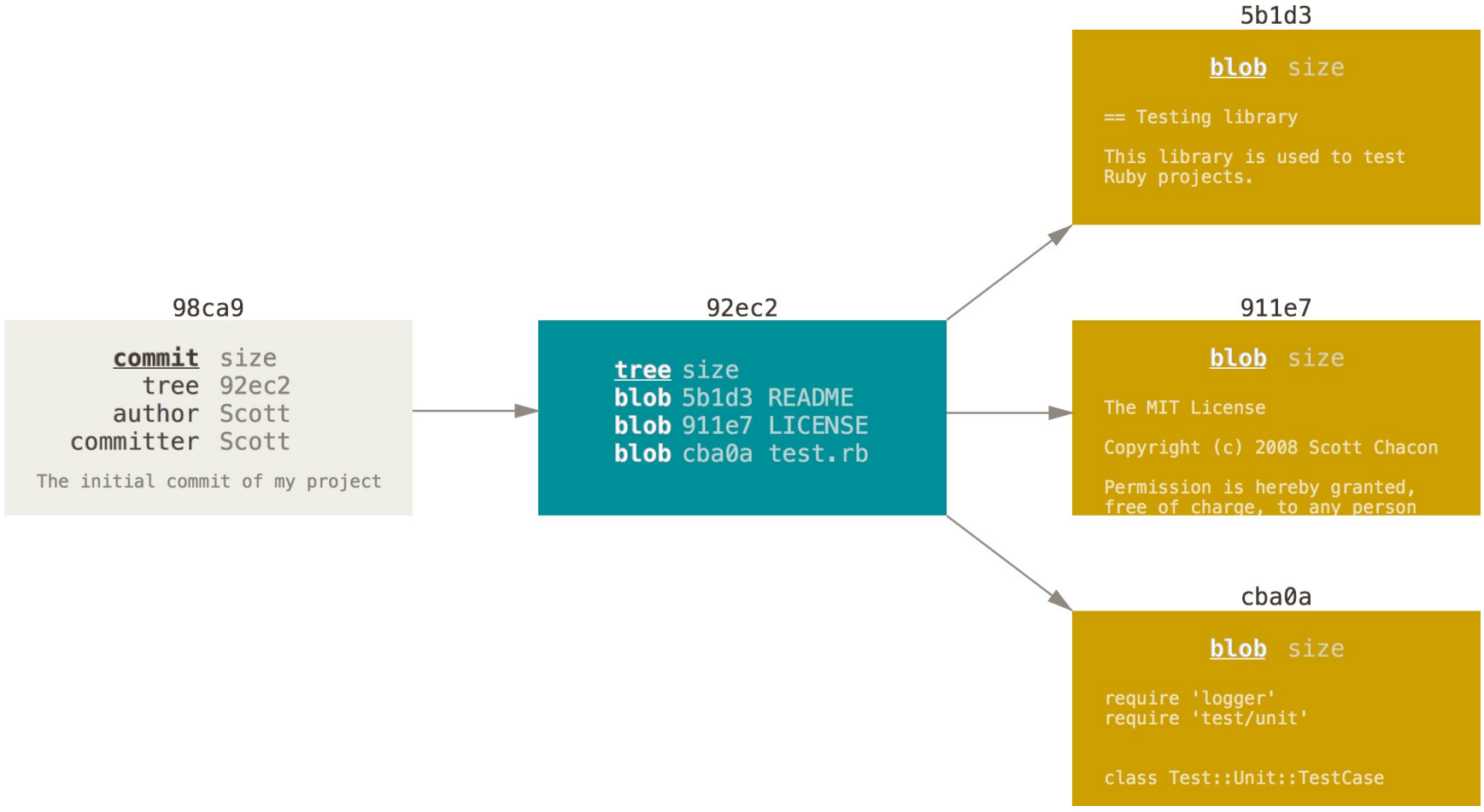
- Content of a commit object

```
$ git cat-file -p $(git rev-parse HEAD) # 00c4dfee3c28787870d2574a50c5de3725d5fcfb
tree 4814e377c18f2da9cce56631f24e0d09181b0feb
parent e8a0d201e0b701d7c2de28cb33fa03ef59b22506
author Luc Sarzyniec <luc.sarzyniec@xilopix.com> 1424853891 +0100
committer Luc Sarzyniec <luc.sarzyniec@xilopix.com> 1424853895 +0100

Commit message
```

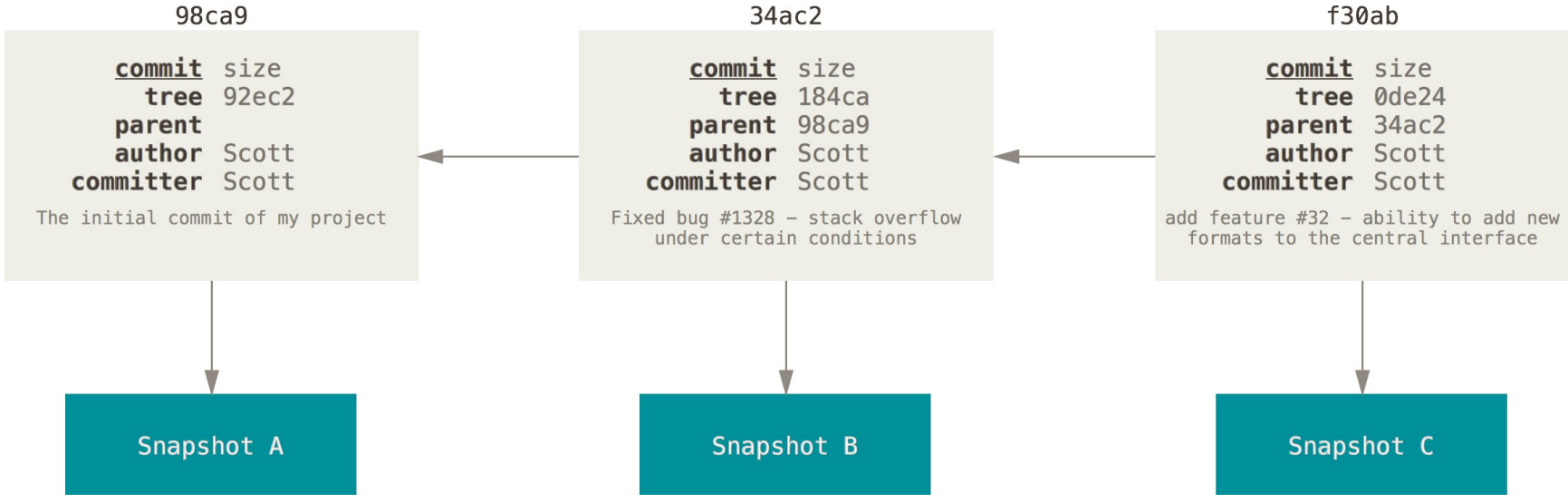
- Content of a tree object

```
$ git cat-file -p $(git rev-parse HEAD^{tree}) # 4814e377c18f2da9cce56631f24e0d09181b0feb
040000 tree e4af7700f8c091d18cc15f39c184490125fb0d17    dir
100644 blob e69de29bb2d1d6434b8b29ae775ad8c2e48c5391    file1
100644 blob e69de29bb2d1d6434b8b29ae775ad8c2e48c5391    file3
$ git cat-file -p e4af7700f8c091d18cc15f39c184490125fb0d17
100644 blob e69de29bb2d1d6434b8b29ae775ad8c2e48c5391    file2
```

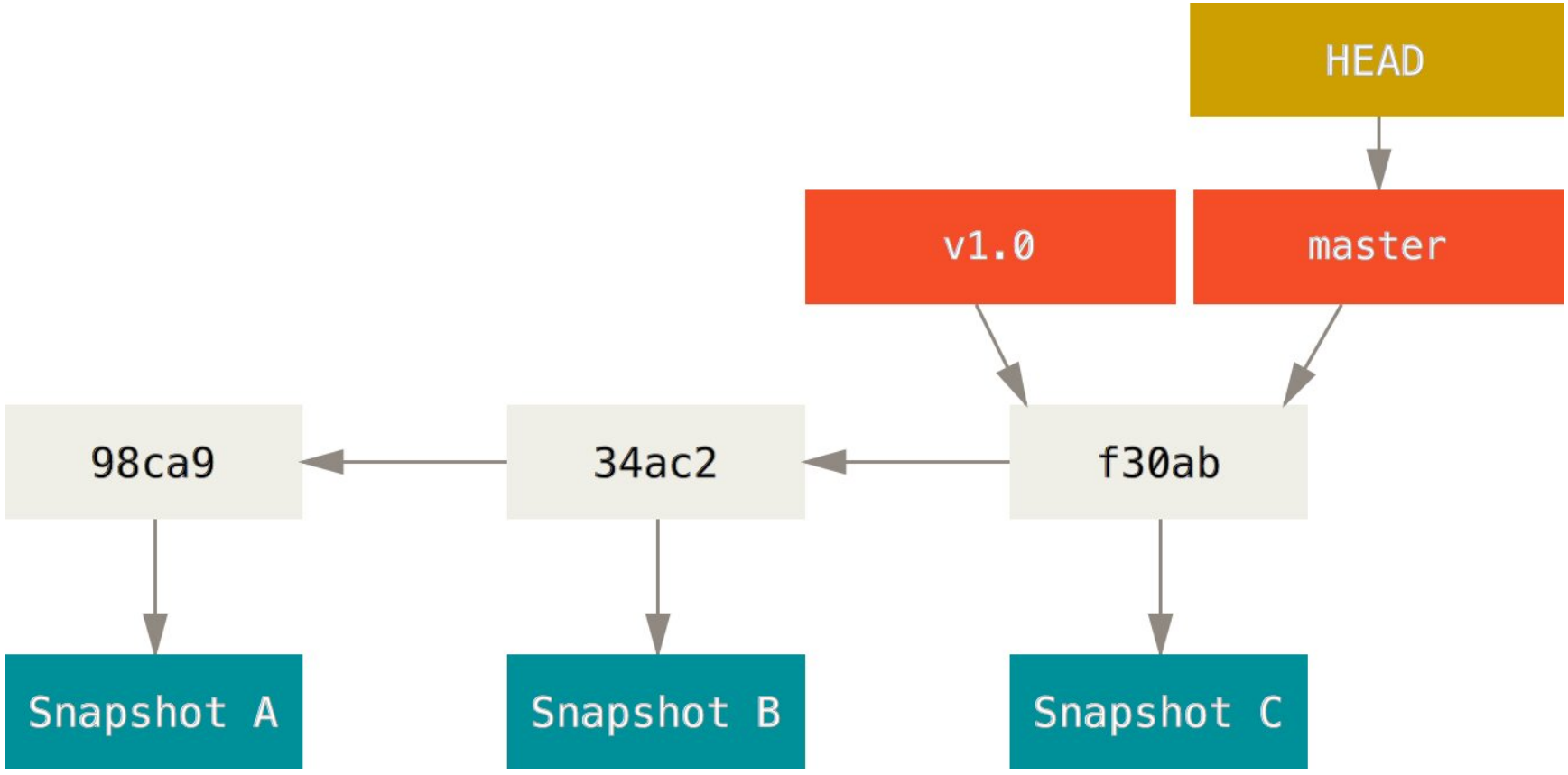
A commit


98ca9
commit size
tree 92ec2
author Scott
committer Scott
The initial commit of my project
92ec2
tree size
blob 5b1d3 README
blob 911e7 LICENSE
blob cba0a test.rb
5b1d3
blob size
== Testing library
This library is used to test
Ruby projects.
911e7
blob size
The MIT License
Copyright (c) 2008 Scott Chacon
Permission is hereby granted,
free of charge, to any person
cba0a
blob size
require 'logger'
require 'test/unit'
class Test::Unit::TestCase

History


98ca9
commit size
tree 92ec2
parent
author Scott
committer Scott
The initial commit of my project
34ac2
commit size
tree 184ca
parent 98ca9
author Scott
committer Scott
Fixed bug #1328 – stack overflow under certain conditions
f30ab
commit size
tree 0de24
parent 34ac2
author Scott
committer Scott
add feature #32 – ability to add new formats to the central interface
Snapshot A
Snapshot B
Snapshot C

Branches


HEAD
v1.0
master
98ca9
34ac2
f30ab
Snapshot A
Snapshot B
Snapshot C

Branches

- Branch = pointer on a commit object

```
$ cat .git/refs/heads/master
7f4ba4b6e3ba7075ca6b379ba23fd3088cbe69a8
```

- HEAD = pointer on the current branch

```
$ cat .git/HEAD
ref: refs/heads/master
```

- Create a branch

```
$ echo 7f4ba4b6e3ba7075ca6b379ba23fd3088cbe69a8 > .git/refs/heads/test
```

- Local and remote branches

```
$ find .git/refs -type f
.git/refs/remotes/origin
.git/refs/remotes/origin/HEAD
.git/refs/remotes/origin/master
.git/refs/heads/master
```

Thank you !