GIT

- Introduction
- Architecture
- Basic Workflows
- Useful Commands
- Discussion

References

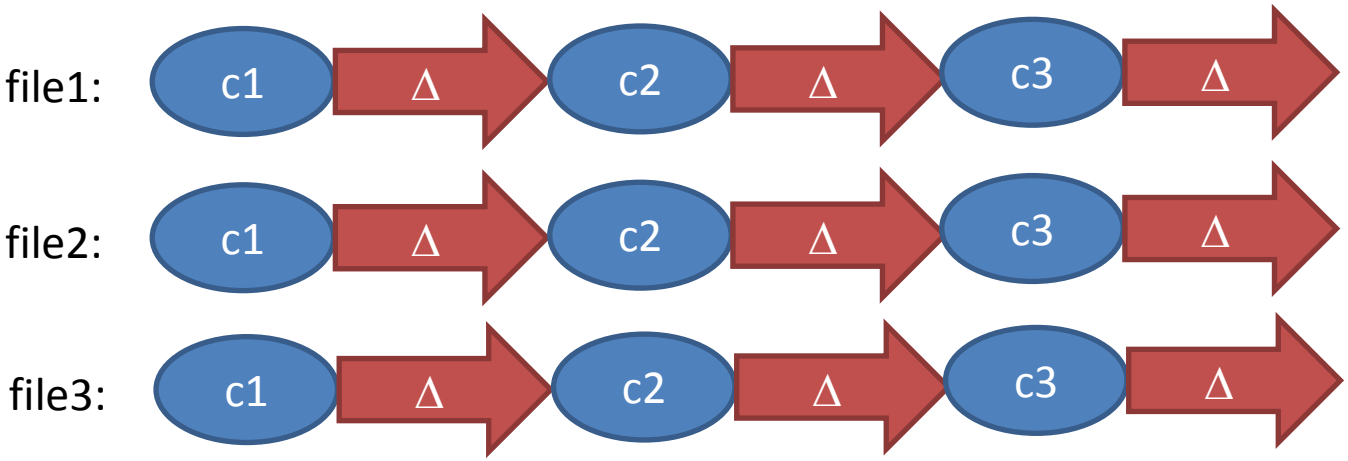
- John Wiegley: Git from the bottom up
  a lot is taken from that source. PDF available online.
- Scott Chacon: Pro Git
  PDF book available online. Complete reference to (almost) all aspects of GIT
- A lot of Git cheat sheets are available online

GIT Advantages

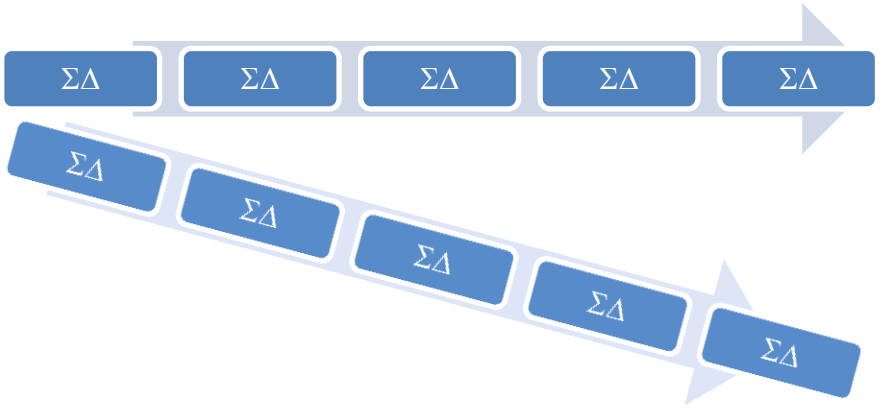
- all metadata in one directory (usualy .git), not one meta-directory in every directory
- simple, consistent, powerful model
- fast, robust
- supports much more workflows than trad vcs (CVS, SVN)

Well Known: CVS/SVN

- **sequence of deltas of a file**

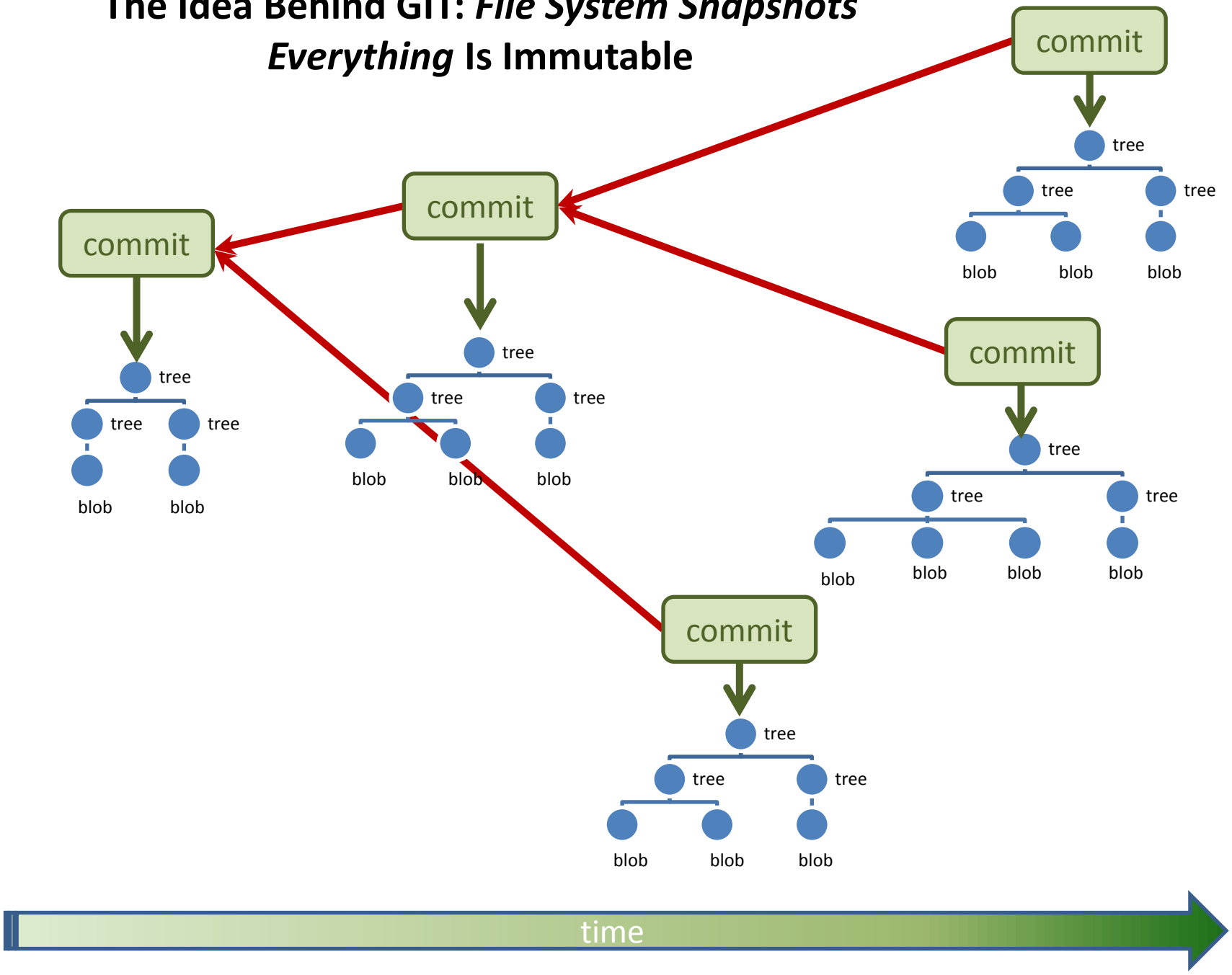


- **branches a complex further construct**



The Idea Behind GIT: *File System Snapshots*

Everything Is Immutable



GIT Terminology 1

Recursive definitions …

working tree:

a directory to which a repository is associated with (usually the sub dir .git).

repository:

a collection of commits. It defines HEAD.

It contains branches and tags, which give names to commits.

commit:

a snapshot of the working tree at some point in time. The commit called HEAD, when the commit was made, becomes the commit‘s parent. Thism defines the history of this commit.

HEAD:

the commit the working tree refers to at this moment

GIT Terminology 2

Further definitions …

branch:

a name for a reference to a commit. The parents define the history of the branch: a „branch of development“.

tag:

a name for a commit. Thus always names the same commit.

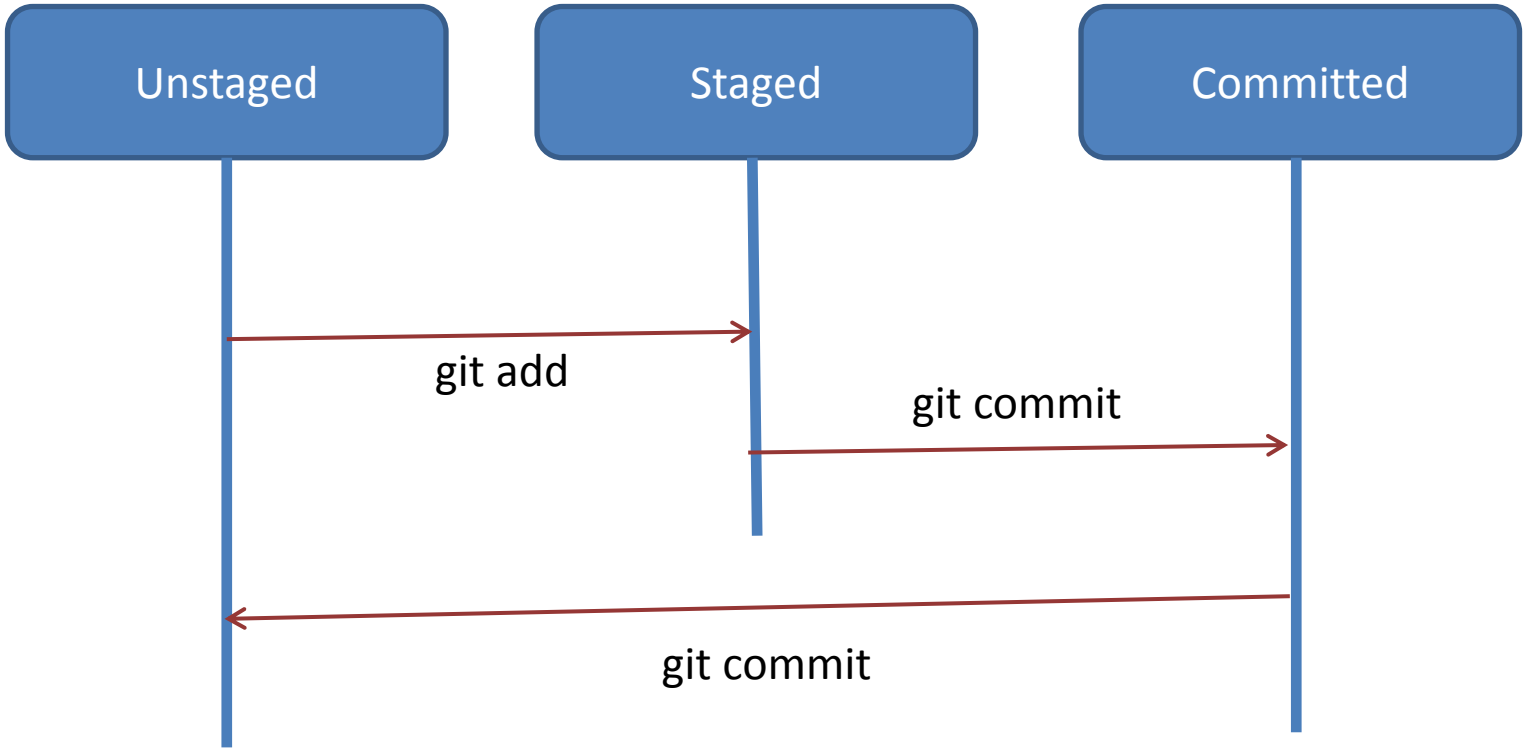
master:

by convention the name of a branch, in which the mainline of development is done. In no way special.

index:

often called „staging area“. GIT commits changes not directly from the working tree, but from the index. Files changed have to be added to the index before they can be committed.

GIT File Workflow

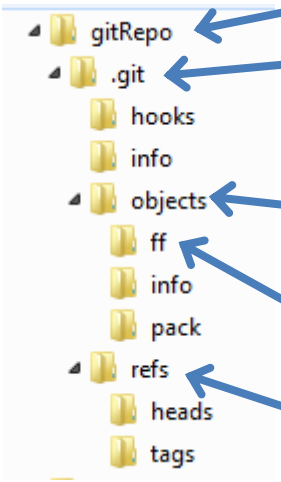


File Content Is Stored In *Blobs*

- file content is stored in *blobs*
- blobs are the *leaves* of the (file system like) tree
- blobs store *no meta-data*. That‘s the responsibility of a tree
- blobs are *immutable*
- the *name* of a blob is the *SHA-1 hash* of (its size concatenated with) its content
- blobs with the same content have the same name – *everywhere* in the world
- files with *identical* content stored in different trees refer to *one* blob only
- GIT uses *content based* adressing

```
$ mkdir gitRepo; cd gitRepo
$ git init
$ echo "Creasy" > names
$ git hash-object –w names
ffef955277e4ad7972740fe9c1fe1fff60e60a27
$ git cat-file –t ffef95
blob
$ git cat-file blob ffef95
Creasy
```

The Structure Of A GIT Repository



the working tree

its repository

content based store (name: SHA-1 hashes of the content, e.g. blobs)

file "names" is here

names for commits (wait some minutes)

```
$ find .git -type f -and -regex '.*/objects/../.*'
.git/objects/ff/ef955277e4ad7972740fe9c1fe1fff60e60a27
```

Directories Are Stored In *Trees*

- blobs have only content (+ their SHA-1 hash name)
- structure and naming is represented in a *tree*
- a tree assembles *(sub-) trees and blobs*
- a tree object is *immutable* and its name is the SHA-1 hash of its content (like blobs)
- trees are created from the files actually in the index ("staged files")

```
$ mkdir descr; cd descr
$ echo "repository for cavy names" > README; cd ..
$ git hash-object -w descr/README
af0ceb86afde8b261a20c32a2d9f82a7e2352bd0
$ find .git -type f -and -regex '.*/objects/../.*'
.git/objects/af/0ceb86afde8b261a20c32a2d9f82a7e2352bd0
.git/objects/ff/ef955277e4ad7972740fe9c1fe1fff60e60a27
$ git ls-files –stage # outputs nothing
$ git add .           # adds all
$ git ls-files –stage # warning: LF CRLF problems --- ignore
100644 af0ceb86afde8b261a20c32a2d9f82a7e2352bd0 0       descr/README
100644 ffef955277e4ad7972740fe9c1fe1fff60e60a27 0       names
```

Directories Are Stored In *Trees* (continued)

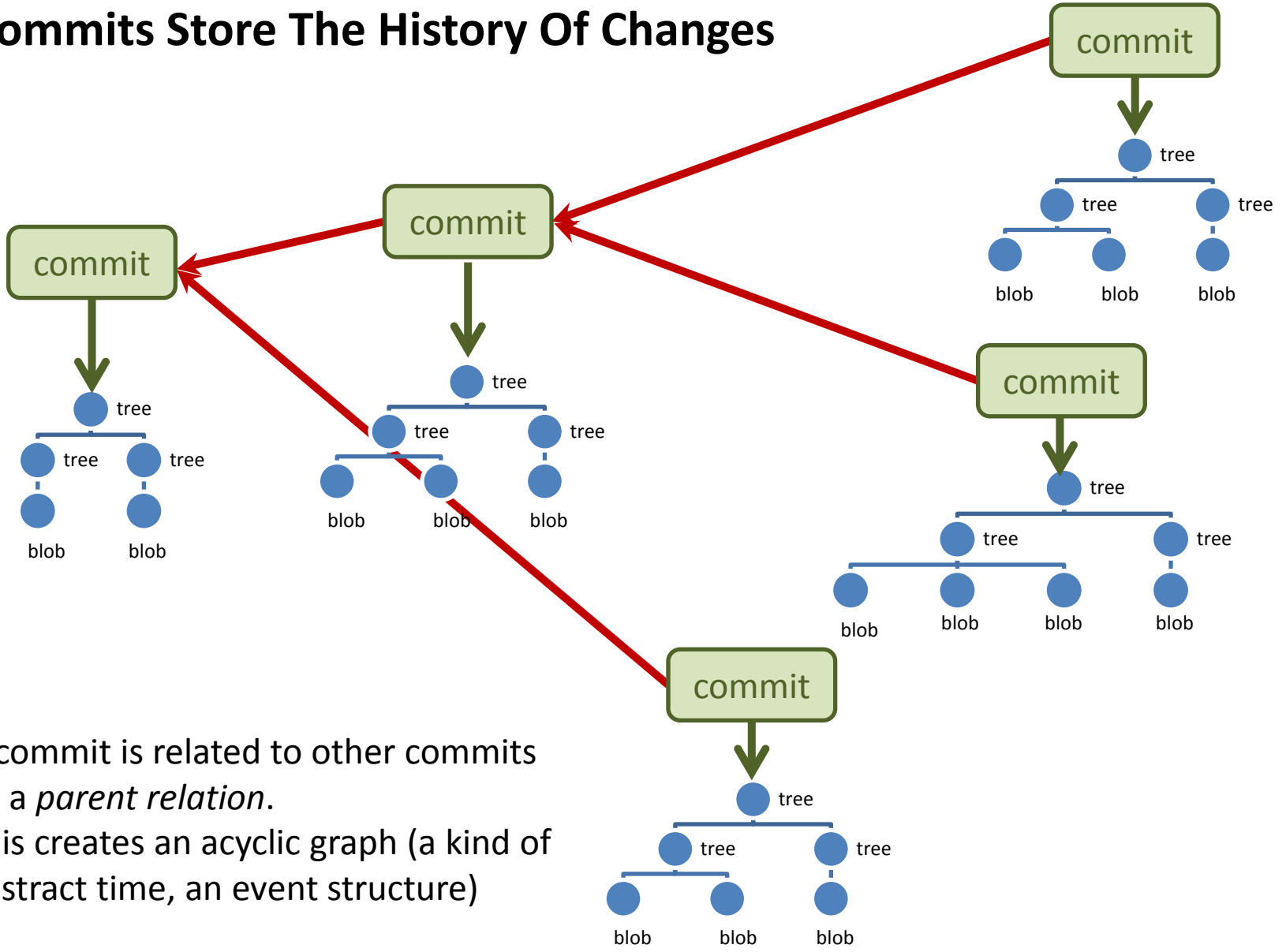
```
$ git write-tree
3cd53c9c80254073be17b2bcf06edb4ac4a85803
$ find .git -type f -and -regex '.*/objects/../.*'
.git/objects/3c/d53c9c80254073be17b2bcf06edb4ac4a85803 # tree
.git/objects/50/ae7f1e28fd1ecf40bfc55c2e92410a49063fed # tree
.git/objects/af/0ceb86afde8b261a20c32a2d9f82a7e2352bd0 # blob
.git/objects/ff/ef955277e4ad7972740fe9c1fe1fff60e60a27 # blob

$ git ls-tree 3cd5
040000 tree 50ae7f1e28fd1ecf40bfc55c2e92410a49063fed    descr
100644 blob ffef955277e4ad7972740fe9c1fe1fff60e60a27    names

$ git ls-tree 50ae
100644 blob 9190600164fe4b0818d230f825efb7bf0bcac269    README
```

Trees are *shared* based on their SHA-1 hashes

The same tree/blob structure (+ 1 commit object) would have been created by:

```
git commit –a –m "initial commit" # commit coming soon :-)
```

Commits Store The History Of Changes



A commit is related to other commits by a *parent relation*.
This creates an acyclic graph (a kind of abstract time, an event structure)

time

Creating A Commit

- a commit says,
  - *who* committed
  - *when*
  - *what* tree and
  - *why* and
  - from what *commit(-s)* the change was derived (the immediate past, the *parent(s)*)
- *every* commit represents the *whole history* of previous changes (follow its parents

```
$ git commit-tree -m "the first name" 3cd5 # afterwards 5 objects are stored
3cdb74ef7a0a2b847d21d46c251bbb5c71b19ef9
$ git cat-file -t 3cdb
commit
$ git cat-file commit 3cdb
tree 3cd53c9c80254073be17b2bcf06edb4ac4a85803
author Reinhard Budde <reinhard.budde@iais.fraunhofer.de> 1360330438 +0100
committer Reinhard Budde <reinhard.budde@iais.fraunhofer.de> 1360330438 +0100

the first name
```

A Second Commit

```
$ echo "Pid" >> names
$ echo "Mucky" >> names
$ git add names
$ git ls-files --stage
100644 af0ceb86afde8b261a20c32a2d9f82a7e2352bd0 0      descr/README
100644 fd867e53ec91b9b48204214e4d67740a505aea2f 0      names      # neuer SHA-1 hash!!
$ git write-tree
1be52efc1e1daed1c706b60588400487db083fe4
$ git commit-tree -m "2 further names"
  -p 3cdb74ef7a0a2b847d21d46c251bbb5c71b19ef9 1be52
4335220dd169d637b3299363033307f3ef31fc1d
$  git cat-file commit 433522
tree 1be52efc1e1daed1c706b60588400487db083fe4
parent 3cdb74ef7a0a2b847d21d46c251bbb5c71b19ef9
author Reinhard Budde <reinhard.budde@iais.fraunhofer.de> 1360334547 +0100
committer Reinhard Budde <reinhard.budde@iais.fraunhofer.de> 1360334547 +0100

2 further names
```

A Bigger Picture

- you have 1-n *branches* (~~ lines of development) in your repository
- a *branch* has a *name*. That name refers to a SHA-1 hash of a *commit* (see below)
- this commit is the most recent commit of this branch, the *head* of that branch
- this commit contains the whole history of this branch
- **NOTHING ELSE**
- adding a new branch (low level) to a repository:

```
echo "4335220dd169d637b3299363033307f3ef31fc1d" > .git/refs/heads/branch1
```

- by convention you should have the branch master:

```
echo "4335220dd169d637b3299363033307f3ef31fc1d" > .git/refs/heads/master
```

- the head of the branch actually checked out in your working tree is referenced symbolically by HEAD (a top-level file in .git):

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

- this content has been created by git init and is changed by checking out another branch:

```
git checkout branch1
$ git checkout branch1
Switched to branch 'branch1'
$ cat .git/HEAD
ref: refs/heads/branch1
```

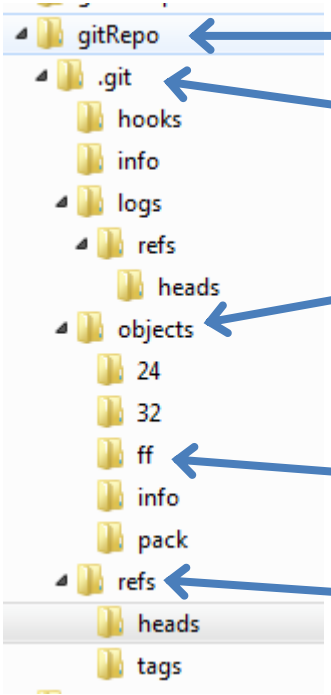
Fom Plumbing To Porcelain

- Setting up a repository as before shows the elegance of GIT, but is no elegant work
- low-level commands: plumbing
- user-level commands: porcelain
- **Don't forget: if you understand commits, you master version control easily**
- working with porcelain commands:

```
$ git add …
$ git status
$ git branch –v
$ git log
$ git log --oneline
$ git checkout …
$ git commit –m "…"
```

- … more later …

The Structure Of A GIT Repository



the working tree

its repository

content based store (name: SHA-1 hashes of the content, e.g. blobs)

file content of "names" is found here

names for commits (wait some minutes)

```
$ find . -type f -and ! -name '*.sample'
./COMMIT_EDITMSG
./config
./description
./HEAD
./index
./info/exclude
./logs/HEAD
./logs/refs/heads/master
./objects/24/6bf44b5432c7a982e9fd0f44f1b9a480c1495f
./objects/32/f81177700a7d16640b019d5ffbe52563643090
./objects/ff/ef955277e4ad7972740fe9c1fe1fff60e60a27
./refs/heads/master

rbudde@ILYA /c/gitHome/gitRepo/.git (GIT_DIR!)
```

configuration

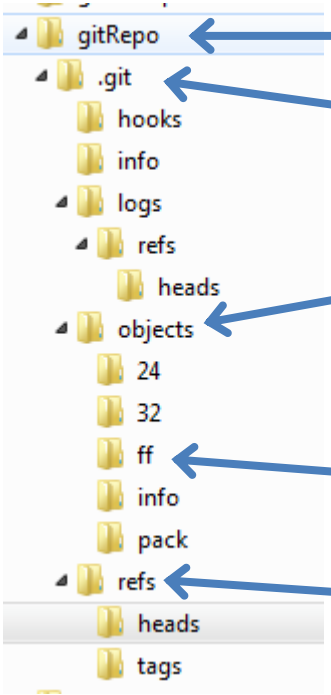
the commit checked out

working tree image (added files!)

the objects stored

the last commit of the branch "master"

The Structure Of A GIT Repository



the working tree

its repository

content based store (name: SHA-1 hashes of the content, e.g. blobs)

file "names" is here

names for commits (wait some minutes)

```
--- cd to .git and then:
$ find . -type f -and -regex './objects/../.*'
./objects/24/6bf44b5432c7a982e9fd0f44f1b9a480c1495f # hash is 246bf.....
./objects/25/ae680dccc76c1e67ceb52886cdcabaf94186b1
./objects/32/f81177700a7d16640b019d5ffbe52563643090
./objects/48/33b56499eae2332773f2fce8784861dcb91e69
./objects/8f/38871a7d5599bdd54d8ec6ccd733afa94b0a16
./objects/91/90600164fe4b0818d230f825efb7bf0bcac269
./objects/ff/ef955277e4ad7972740fe9c1fe1fff60e60a27
```

File Content Is Stored In *Blobs*

- file content is stored in *blobs*
- blobs are the *leaves* of the (file system like) tree
- blobs store *no meta-data*. That‘s the responsibility of a tree
- blobs are *immutable*
- the *name* of a blob is the *SHA-1 hash* of (its size concatenated with) its content
- blobs with the same content have the same name – *everywhere* in the world
- files with *identical* content stored in different trees refer to *one* blob only
- GIT uses *content based* adressing

```
$ mkdir gitRepo; cd gitRepo
$ git init
$ echo "Creasy" > names
$ git hash-object names
ffef955277e4ad7972740fe9c1fe1fff60e60a27
$ git add names
$ git commit –m "first of 6 names"
$ git cat-file –t ffef95
blob
$ git cat-file blob ffef95
Creasy
```