Change Management

and

Version Control

CS 35L

Winter 2020 - Lab 1

Software development process

- Involves making a lot of changes to code
  - New features
  - Bug fixes
  - Performance enhancements
- Many people editing code simultaneously need to:
  - Compare different versions
  - Combine different versions into a new version
  - Reference previous versions
- Multiple versions of dependencies, environments

What Changes Are We Managing?

Software

- Planned software development
  - team members constantly add new code
- (Un)expected problems
  - bug fixes
- Enhancements
  - Make code more efficient (memory, execution time)

“The only constant in software development is change”

Features Required to Manage Change

- Backups
- Timestamps
- Who made the change?
- Where was the change made?
- A way to communicate changes with team

How to achieve that

- Big project with multiple files
  - Bug fix required changing multiple files
  - Bug fix didn’t work
  - How to find the problem
  - … Or how to revert to a version before the bug
- Figure out which parts changed (**diff**?)
- Communicate changes with team (**patch**?)
- But diff and patch are not that good

Disadvantages of diff & patch

- Diff requires keeping a copy of old file before changes
- Work with only 2 versions of a file (old & new)
  - Projects will likely be updated more than once
  - store versions of the file to see how it evolved over time

```
index.html
  index-2009-04-08.html
  index-2009-06-06.html
  index-2009-11-04.html
  index-2010-01-23.html
```

- Numbering scheme becomes more complicated if we need to store two versions for the same date

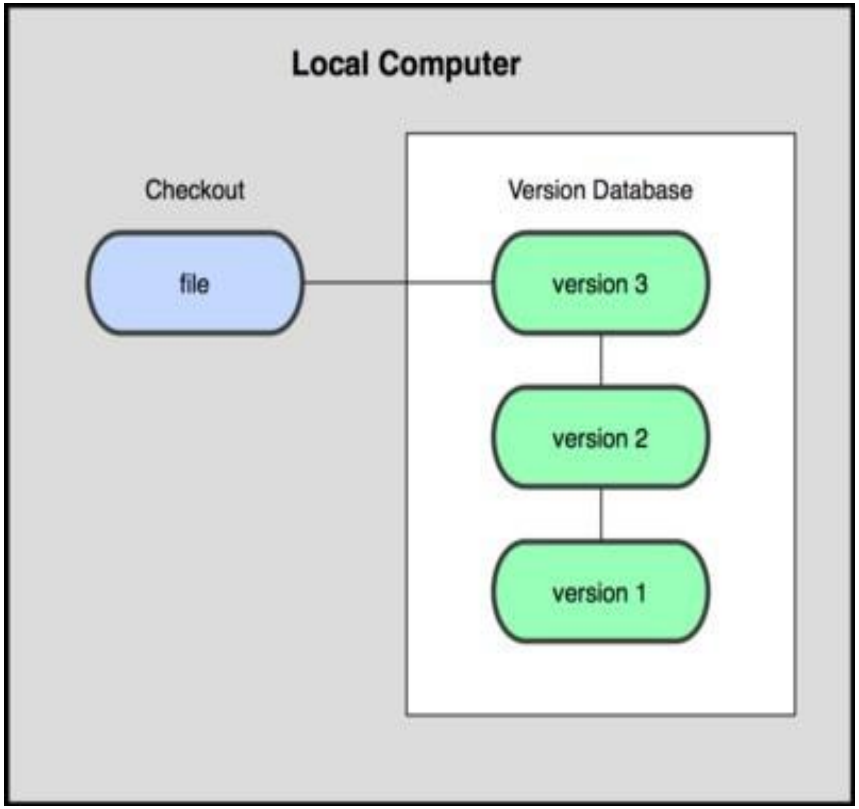
Disadvantages of diff & patch

- Two people may edit the same file on the same date
  - 2 patches need to be sent and merged
- Changes to one file might affect other files (eg. .h & .c)
  - Need to make sure those versions are stored together as a group

Source Control Software (SCS)

- Also called Version Control Software (VCS)
- Track changes to code and other files related to software
  - What new files were added?
  - What changes made to files?
  - Which version had what changes?
  - Which user made the changes?
  - Revert to previous version
- Track entire history of software
- Source control software (SCS)
  - Git, Subversion (SVN), CVS, and others

Local SCS



- Organize different versions as folders on the local machine
- No server involved
- Other users copy with disk/network

Image Source: git-scm.com

Centralized SCS

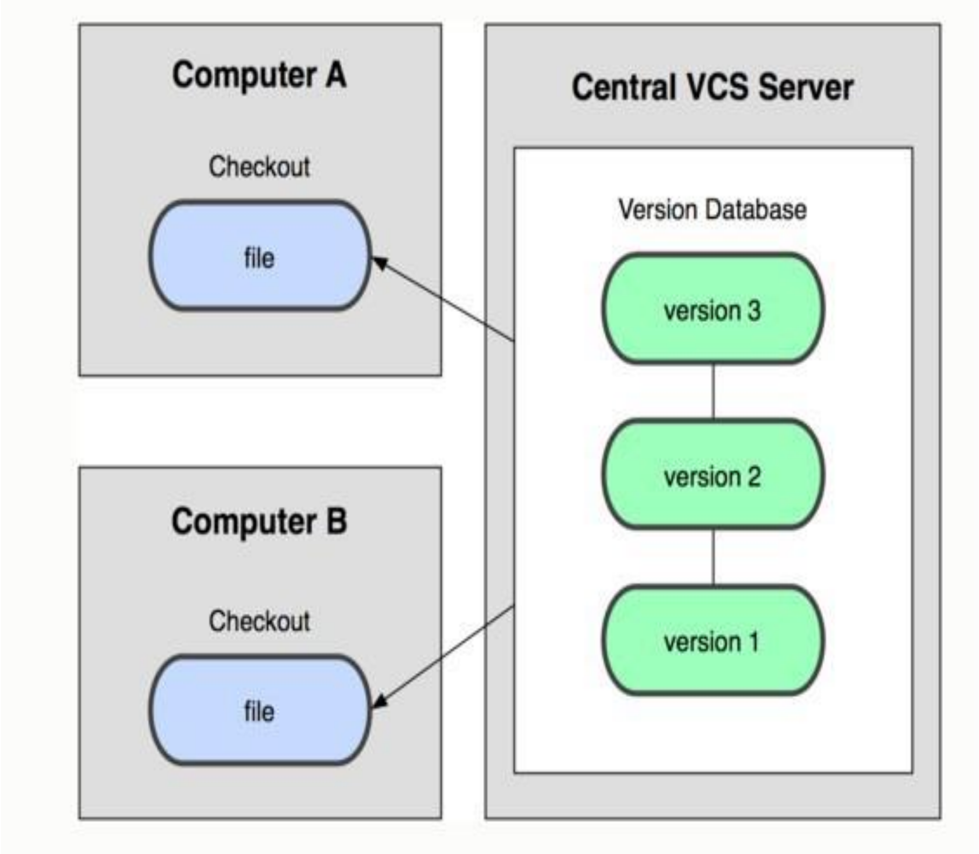


Image Source: git-scm.com

- Version history sits on a central server
- Users will get a working copy of the files
- Changes have to be committed to the server
- All users can get the changes

Distributed SCS

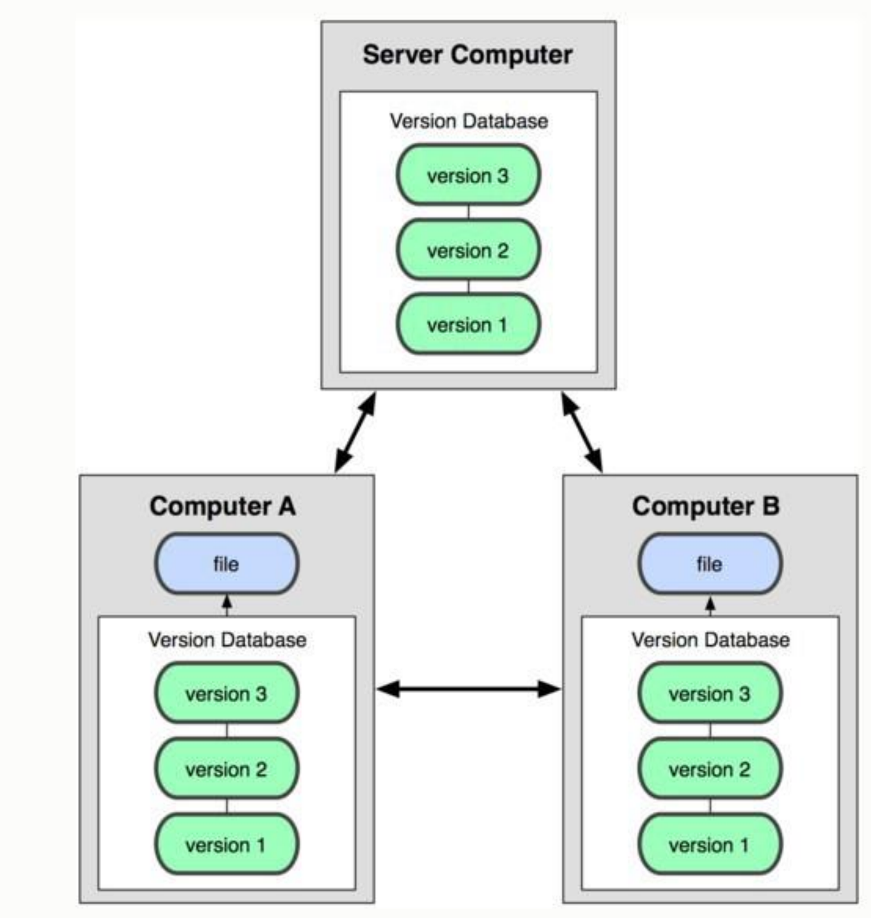


Image Source: git-scm.com

- Version history is replicated on every user’s machine
- Users have version control all the time
- Changes can be communicated between users
- Git is distributed

Terms used

- **Repository**
  - Files and folders related to the software code
  - Full history of the software

- **Working copy**
  - Copy of software's files in the repository

- **Check-out**
  - To create a working copy of the repository

- **Check-in/Commit**
  - Write the changes made in the working copy to the repository
  - Commits are recorded by the SCS

Centralized vs. Distributed SCS

- Single central copy of the project history on a server
- Changes are uploaded to the server
- Other programmers can get changes from the server
- Examples: SVN, CVS

- Each developer gets the full history of a project on their own hard drive
- Developers can communicate changes between each other without going through a central server
- Examples: **Git**, Mercurial, Bazaar, Bitkeeper

Centralized: Pros and Cons

"The full project history is only stored in one central place."

Pros

- Everyone can see changes at the same time
- Simple to design

Cons

- Single point of failure (no backups!)
- Communicating changes between users requires physical or P2P connection

Distributed: Pros and Cons

“The entire project history is downloaded to the hard drive”

Pros

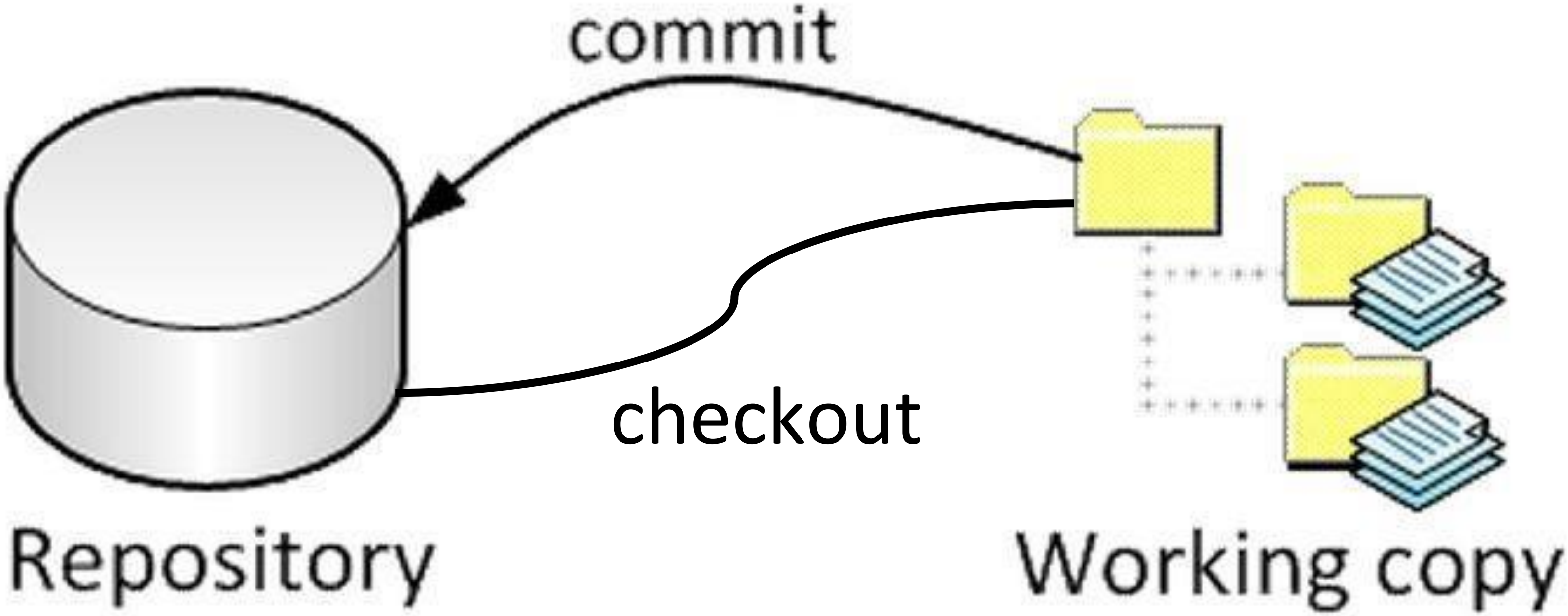
- Commit changes/revert to an old version while offline
- Commands run extremely fast because tool accesses the hard drive and not a remote server
- Share changes with a few people before showing changes to everyone

Cons

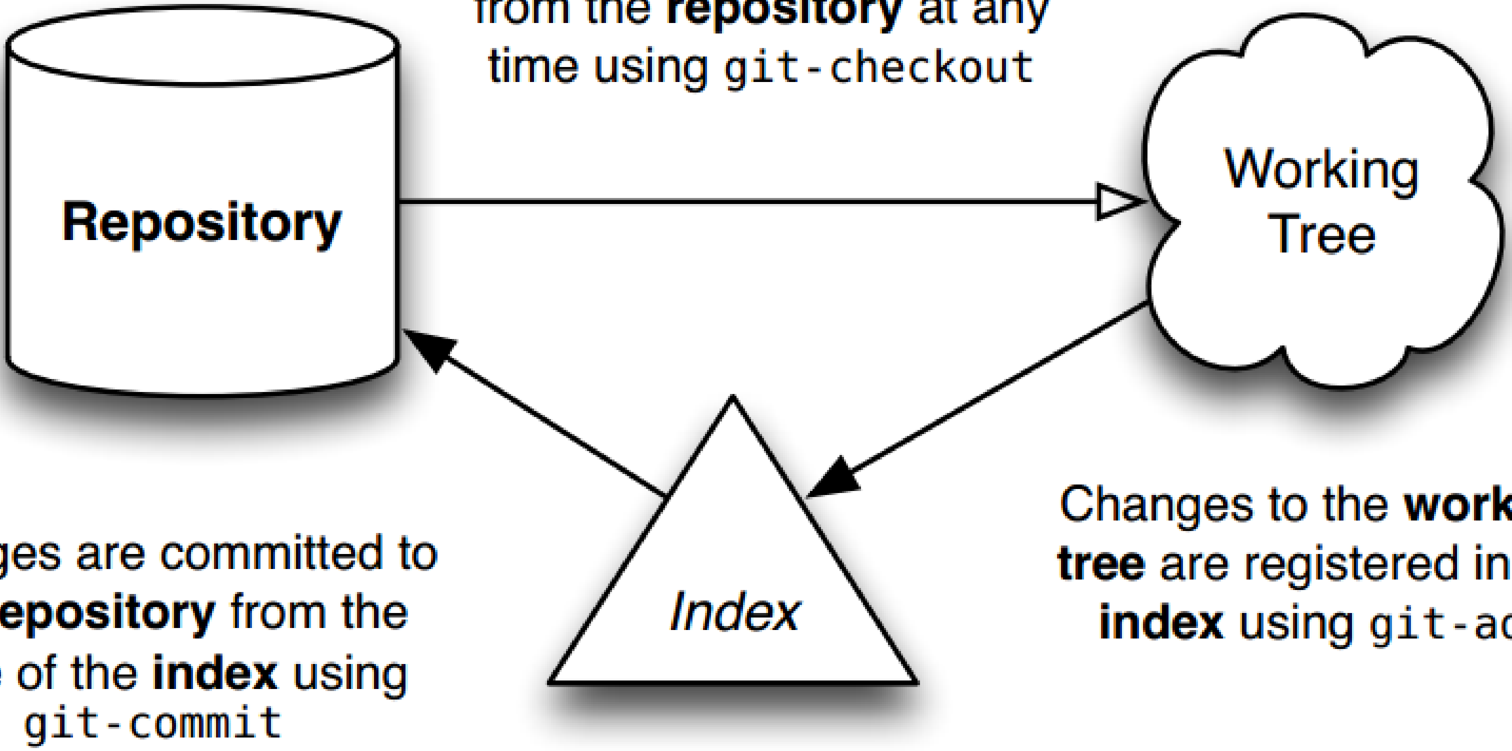
- Long time to download
- A lot of disk space to store all versions

Git Source Control

Big Picture



Git Workflow



Earlier states of the **working tree** may be checked out from the **repository** at any time using `git-checkout`

Changes are committed to the **repository** from the state of the **index** using `git-commit`

Changes to the **working tree** are registered in the **index** using `git-add`

Git commands

- Repository creation
  - **`git init`** (start a new repository)
  - **`git clone`** (create a copy of an existing repository)
- Branching
  - **`git branch <new_branch_name>`** (creates a new branch)
  - **`git checkout <name>`** (switch to a branch or commit with name)
  - **`git checkout -b <new_branch_name>`** (creates and checks out a new branch)
- Commits
  - **`git add`** (stage modified files)
  - **`git commit`** (check-in changes on the current branch)
- Getting info
  - **`git status`** (shows modified files, new files, etc)
  - **`git diff`** (compares working copy with staged files)
  - **`git log`** (shows history of commits)
- Get help with: **`git help`** (or with git’s online documentation)

Git Repository Objects

- Objects used by Git to implement source control
  - **Blobs**
    - Sequence of bytes
  - **Trees**
    - Groups blobs/trees together
  - **Commit**
    - Refers to a particular “git commit”
    - Contains all information about the commit
  - **Tags**
    - A named commit object for convenience (e.g. versions of software)
- Objects uniquely identified with **hashes**

Terms used

- **Head**
  - Refers to a commit object
  - There can be many heads in a repository
- **HEAD**
  - Refers to the currently active head
- **Detached HEAD**
  - If a commit is not pointed to by a branch
  - This is okay if you want to just take a look at the code and if you don't commit any new changes
  - If the new commits have to be preserved then a new branch has to be created
    - `git checkout v3.0 -b BranchVersion3.1`
- **Branch**
  - Refers to a head and its entire set of ancestor commits
- **Master**
  - Default branch

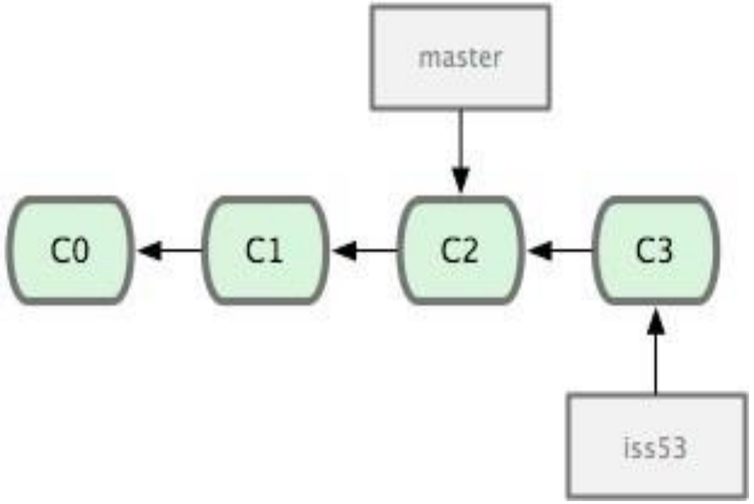
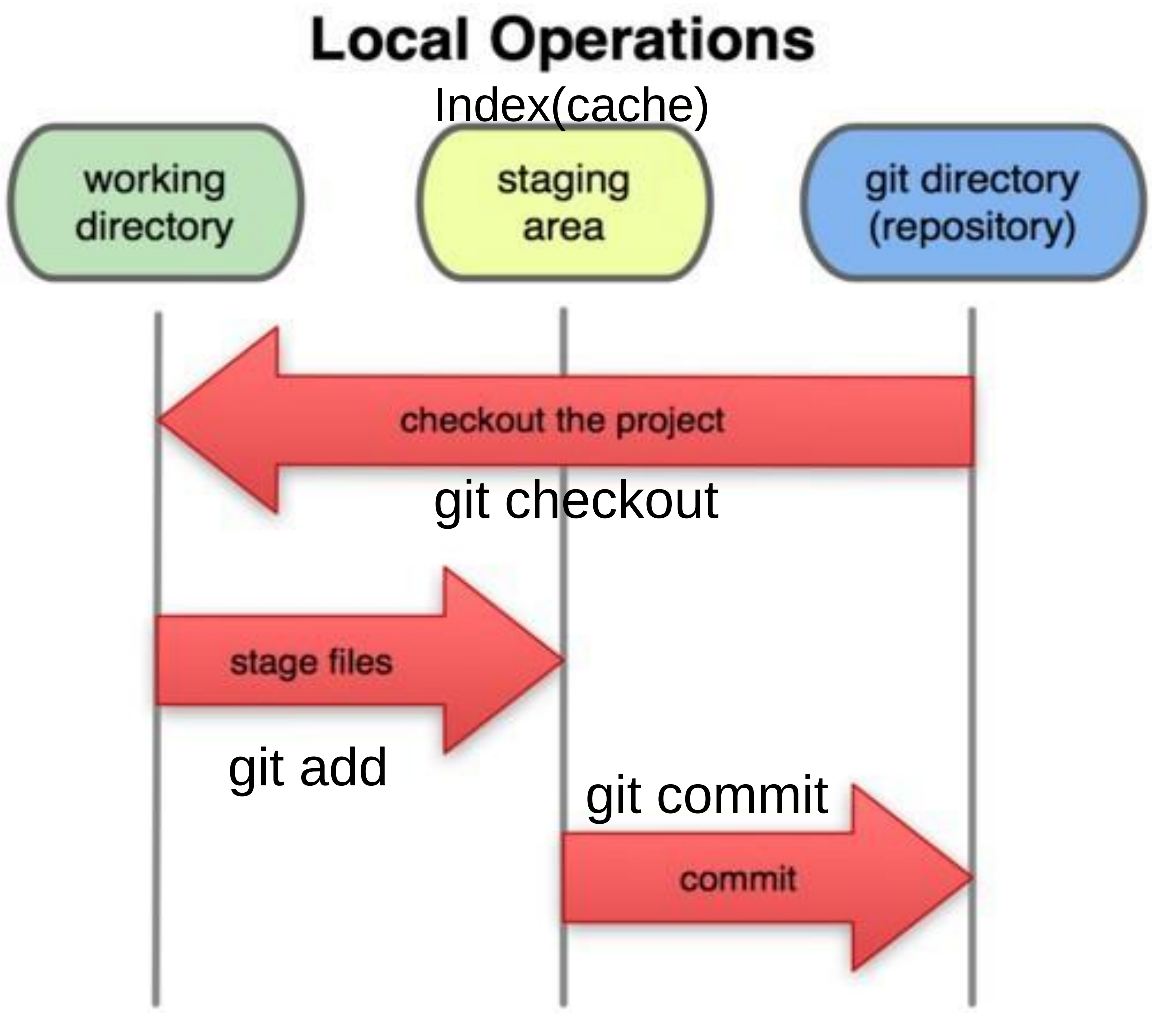


Image Source: git-scm.com

Git States



Index(cache)

git checkout

git add

git commit

Image Source: git-scm.com

First Git Repository

- $`mkdir gitroot`
- $`cd gitroot`
- $`git init`
  - – creates an empty git repo (.git directory with all necessary subdirectories)
- $`echo “Hello World” > hello.txt`
- $`git add .`
  - – Adds content to the index
  - – Must be run prior to a commit
- $`git commit –m ‘Check in number one’`

Working With Git

- `$ echo “I love Git” >> hello.txt`
- `$ git status`
  - Shows list of modified files
  - hello.txt
- `$ git diff`
  - Shows changes we made compared to index
- `$ git add hello.txt`
- `$ git diff`
  - No changes shown as diff compares to the index
- `$ git diff HEAD`
  - Now we can see changes in working version
- `$git commit –m ‘Second commit’`

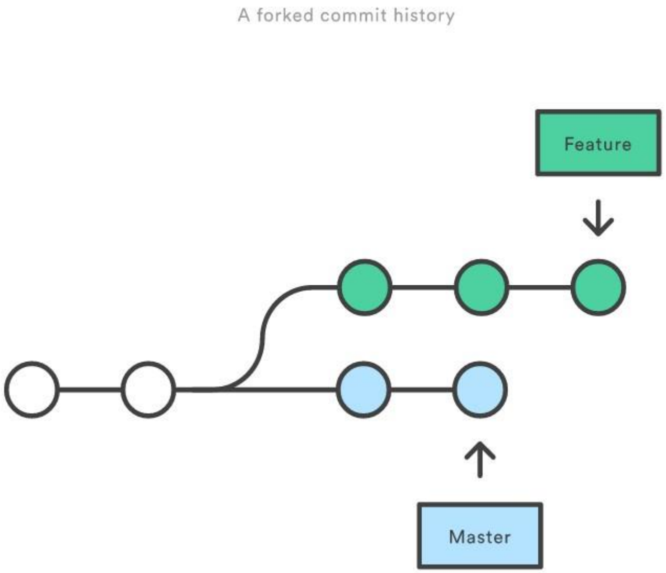
Undoing What Is Done

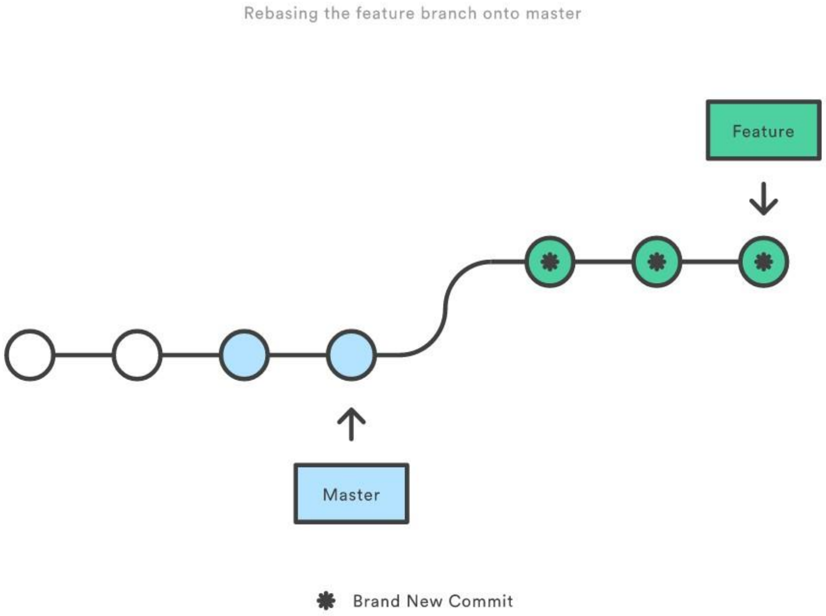
- **git checkout**
  - Used to checkout a specific version/branch of the tree
  - `git rebase master` (returns to current working version)
- **git revert**
  - Reverts a commit
  - Does not delete the commit object, just applies a patch
  - Reverts can themselves be reverted!
- **Git never deletes a commit object**
  - It is very hard to lose data

Git Rebase

- Rewrites commit history.
- Loses context
- Never use this on public branches!
- How to rebase?

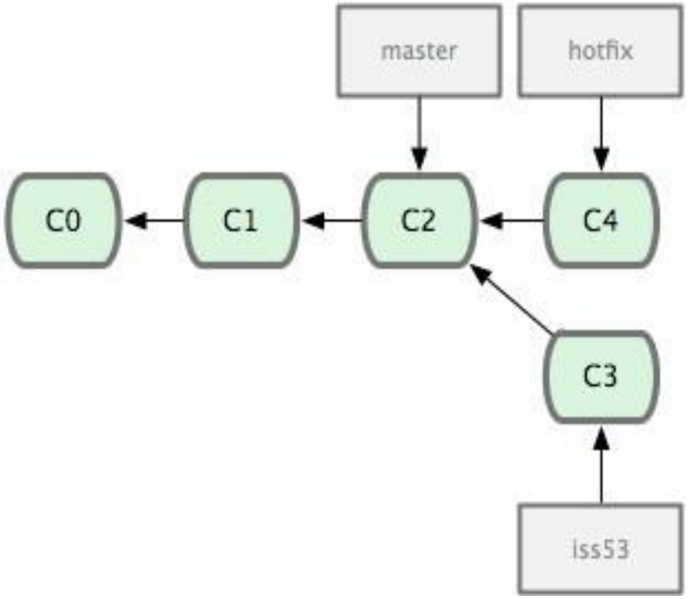
```
$ git checkout feature

$ git rebase master
```





Source - https://www.atlassian.com/git/tutorials

Merging



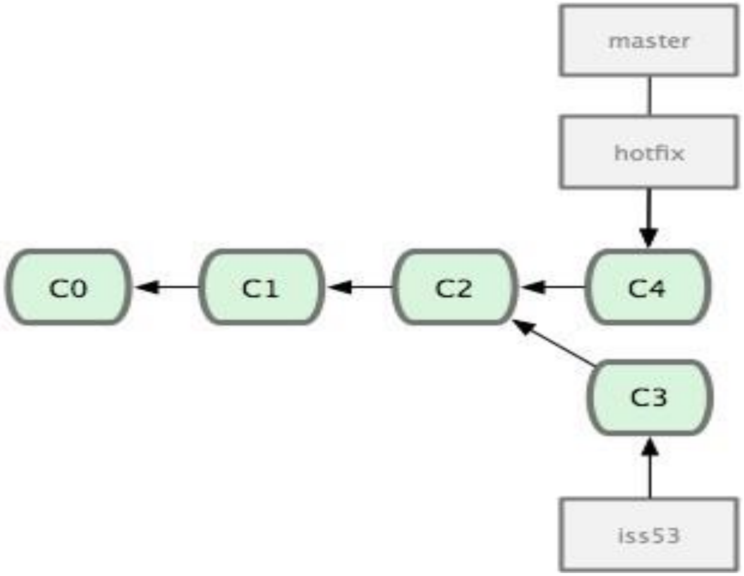


Image Source: git-scm.com

- Merging hotfix branch into master
  - git checkout master
  - git merge hotfix
- Git tries to merge automatically
  - Simple if it is a forward merge
  - Otherwise, you have to manually resolve conflicts

Merging

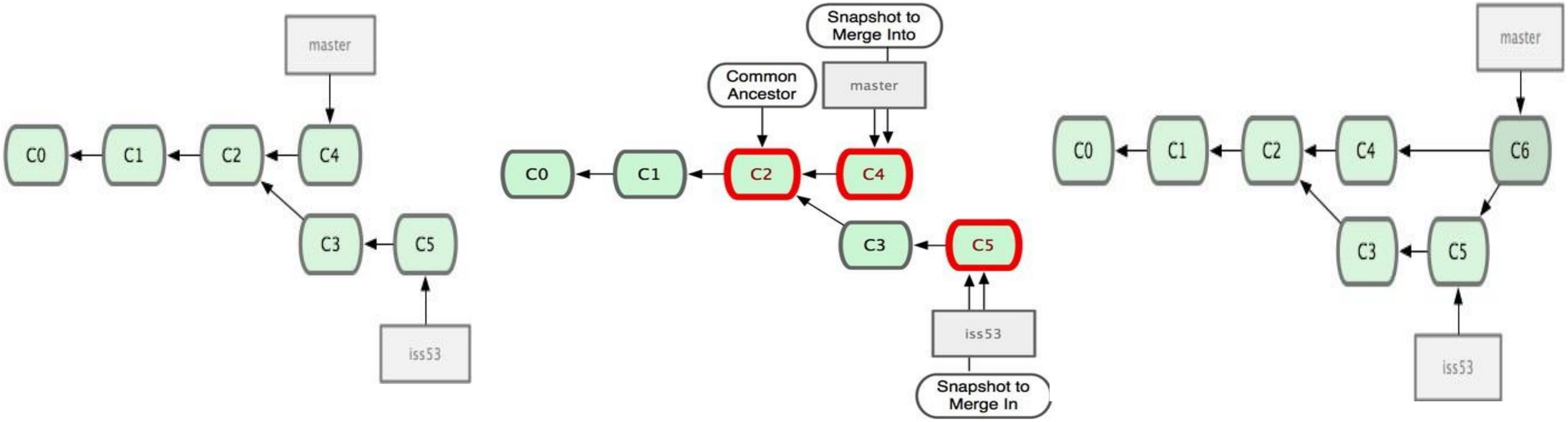


Image Source: git-scm.com

- Merge iss53 into master
- Git tries to merge automatically by looking at the changes since the common ancestor commit
- Manually merge using 3-way merge or 2-way merge
    - Merge conflicts - Same part of the file was changed differently

Merging

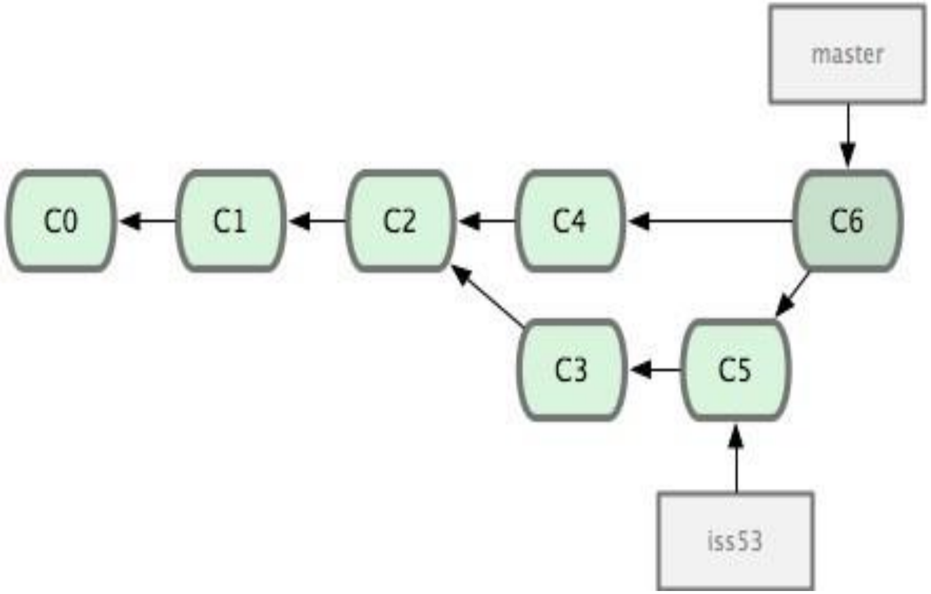


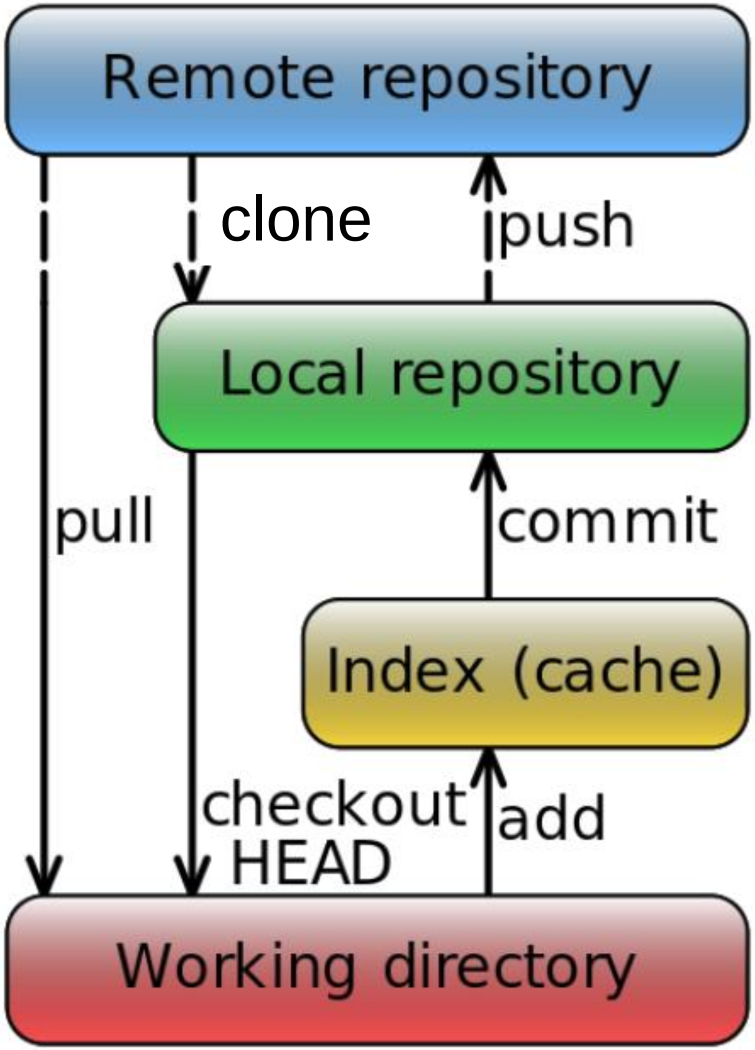
Image Source: git-scm.com

- Refer to multiple parents
  - git show hash
  - git show hash^2 (shows second parent)
- HEAD^^ == HEAD~2

More Git commands

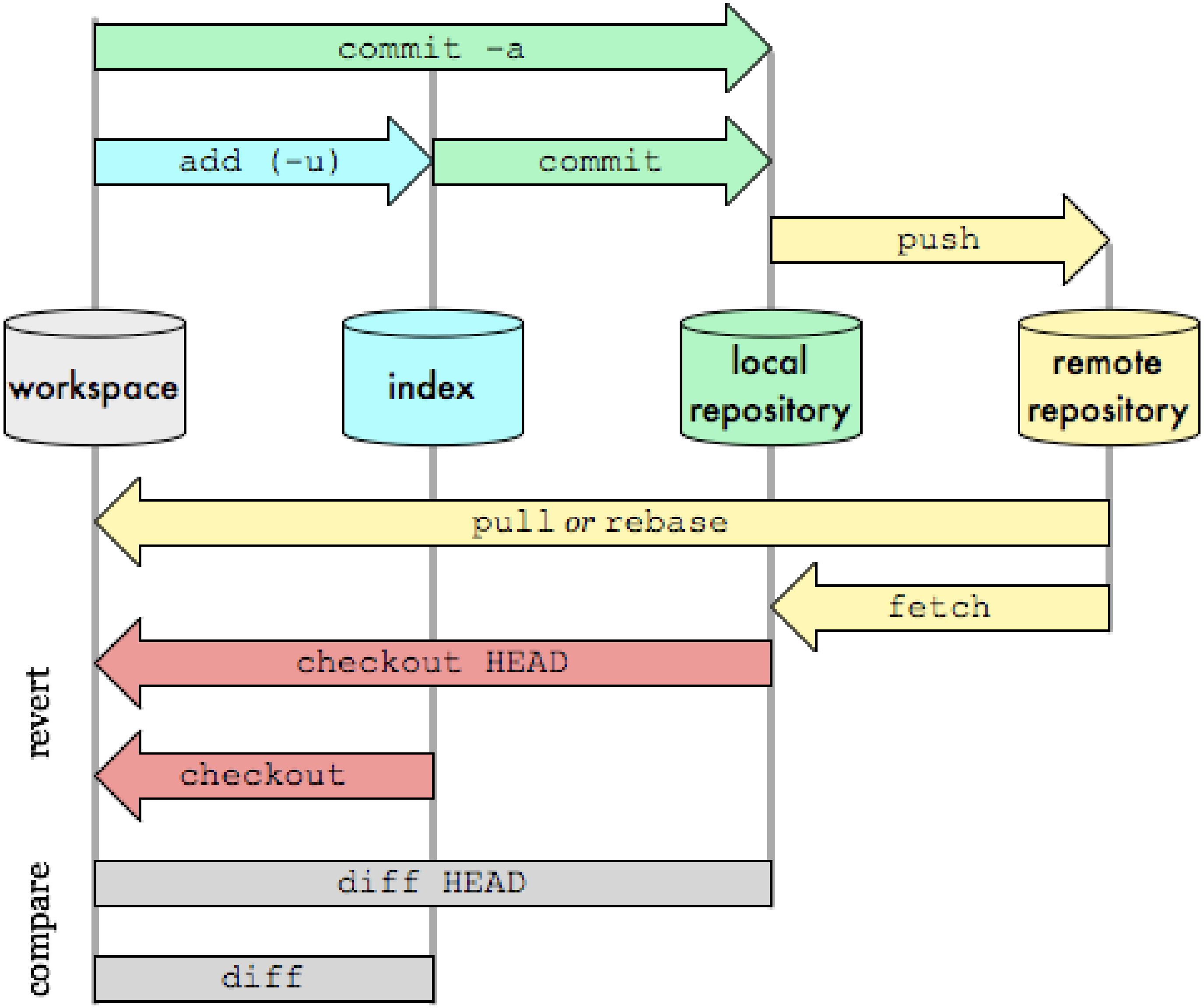
- Reverting
  - **`git checkout HEAD main.cpp`**
    - Gets the HEAD revision for the working copy
  - **`git checkout -- main.cpp`**
    - Reverts changes in the working directory
  - **`git revert`**
    - Reverts commits (this creates new commits)
- Cleaning up untracked files
  - **`git clean`**
- Tagging
  - Human readable pointers to specific commits
  - **`git tag -a v1.0 -m ‘Version 1.0’`**
    - This will name the HEAD commit as v1.0

Overview


Remote repository
clone
push
Local repository
pull
commit
Index (cache)
checkout
HEAD
add
Working directory

Git Data Transport Commands

http://osteele.com



commit -a

add (-u)

commit

push

workspace

index

local repository

remote repository

pull *or* rebase

fetch

revert

checkout HEAD

checkout

compare

diff HEAD

diff

Assignment 7

- GNU Diffutils uses " ` " in diagnostics
  - Example: `diff . -`
  - Output: diff: cannot compare `– ' to a directory
  - Want to use apostrophes only
- Diffutils maintainers have a patch for this problem called “maint: quote 'like this' or "like this", not `like this'”
- Problem: You are using Diffutils version 3.0, and the patch is for a newer version

Backporting

Taking a certain software modification (patch) and **applying it to an older version** of the software than it was initially created for.

Useful Links

- Git Tutorial
  - By topic
- Git Beginner’s Tutorial (alternative)
  - Step by step tutorial + testing terminal
- Git Visual Guide
  - For visualizing what each command does
- Git From The Bottom Up
  - For understanding how Git is structured and the details of how it tracks changes

More Git hints

- Git beginner's tutorial (highly recommended):
  - Click here
- Git cheat sheet:
  - Click here
- gitk introduction/tutorial:
  - Click here

X11 forwarding must be configured properly for gitk!