

## Version Control

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Consider the following simple scenario:

- a software system contains a source code file `x.c`
- system is worked on by several teams of programmers
- Ann in Sydney adds a new feature in her copy of `x.c`
- Bob in Singapore fixes a bug in his copy of `x.c`

Ultimately, we need to ensure that

- all changes are properly recorded (when, who, why)
- both the new feature and the bug fix are in the next release
- if we later find bugs in old release, they can be fixed

## Version Control Systems

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A *version control system* allows software developers to:

- work simultaneously and cooperatively on a system
- document when, who, & why changes made
- discuss and approve changes
- recreate old versions of a system when needed
- multiple versions of system can be distributed, tested, merged

This allows change to be managed/controlled in a systematic way. VCSs also try to minimise resource use in maintaining multiple versions.

## Unix VCS - Generation 1 (Unix)

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1970's ... *SCCS* (source code control system)

- first version control system
- centralized VCS - single central repository
- introduced idea of multiple versions via delta's
- single user model: lock - modify - unlock
- only one user working on a file at a time

1980's ... *RCS* (revision control system)

- similar functionality to *SCCS*  
(essentially a clean open-source re-write of *SCCS*)
- centralized VCS - single central repository
- single user model: lock - modify - unlock
- only one user working on a file at a time
- still available and in use

## Unix VCS - Generation 2 (Unix)

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1990 ... *CVS* (concurrent version system)

- centralized VCS - single central repository
- locked check-out replaced by copy-modify-merge model
- users can work simultaneously and later merge changes
- allows remote development essential for open source projects
- web-accessible interface promoted wide-dist projects
- poor handling of file metadata, renames, links

Early 2000's ... *Subversion* (*svn*)

- depicted as "CVS done right"
- many cvs weakness fixed
- solid, well documented, widely used system
- but essentially the same model as CVS
- centralized VCS - single central repository
- *svn* is suitable for assignments/small-medium projects
- easier to understand than distributed VCSs, well supported
- but Andrew recommends git

## Unix VCS - Generation 3

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Early 2000s... *Bitkeeper*

- distributed VCS - multiple repositories, no "master"
- every user has their own repository
- written by Larry McVoy
- Commercial system but allowed limited use for Linux kernel until dispute over licensing issues
- Linus Torvalds + others then wrote GIT open source distributed VCS
- Other open source distributed VCS's appeared, e.g: bazaar (Canonical!), darcs (Haskell!), Mercurial

## Git

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- distributed VCS - multiple repositories, no "master"
- every user has their own repository
- created by Linus Torvalds for Linux kernel
- external revisions imported as new branches
- flexible handling of branching
- various auto-merging algorithms
- Andrew recommends you use git unless good reason not to
- not better than competitors but better supported/more widely used (e.g. github/bitbucket)
- at first stick with a small subset of commands
- substantial time investment to learn to use Git's full power

## Repository

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Many VCSs use the notion of a *repository*

- store all versions of all objects (files) managed by VCS
- may be single file, directory tree, database,...
- possibly accessed by filesystem, http, ssh or custom protocol
- possibly structured as a collection of *projects*

## Git Repository

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Git uses the sub-directory `.git` to store the repository.

Inside `.git` there are:

- **blobs** file contents identified by SHA-1 hash
- **tree objects** links blobs to info about directories, link, permissions (limited)
- **commit objects** links trees objects with info about parents, time, log message
- Create repository **git init**
- Copy exiting repository **git clone**

## Tracking a Project with Git

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- Project must be in single directory tree.
- Usually don't want to track all files in directory tree
- Don't track binaries, derived files, temporary files, large static files
- Use **.gitignore** files to indicate files never want to track
- Use **git add** *file* to indicate you want to track *file*
- Careful: **git add** *directory* will every file in *file* and sub-directories

## Git Commit

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- A git commit is a snapshot of all the files in the project.
- Can return the project to this state using **git checkout**
- Beware if you accidentally add a file with confidential info to git - need to remove it from all commits.
- **git add** copies file to staging area for next commit
- **git commit -a** if you want commit current versions of all files being tracked
- commits have parent commit(s), most have 1 parent
- merge produce commit with 2 parents, first commit has no parent
- merge commits labelled with SHA-1 hash

## Git Branch

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- Git branch is pointer to a commit
- Allows you to name a series of commits
- Provides convenient tracking of versions of parallel version of projects
- New features can be developed in a branch and eventually merged with other branches
- Default branch is called master.
- **HEAD** is a reference to the last commit in the current branch
- **git branch** *name* creates branch *name*
- **git checkout** *name* changes all project files to their version on this branch

## Git Merge

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- merges branches
- git mergetool shows conflicts
- configure your own mergetool - many choices meld, kdiff3, , p4merge
- kaleidoscope popular on OSX

## Git Push

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- **git push** *repository-name branch* adds commits from your *branch* to remote repository *repository-name*
- Can set defaults, e.g. **git push -u origin master** then run **git push**
- **git remote** lets you give names to other repositories
- Note **git clone** sets origin to be name for cloned repository

## Git Fetch/Pull

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- **git fetch** *repository-name branch* adds commits from *branch* in remote repository *repository-name*
- Usually **git pull** - combines fetch and merge

## Example: Git & conflicts

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```
$ git init /home/cs2041
Initialized empty Git repository in /home/cs2041/.git/
$ git add main.c
$ git commit main.c
Aborting commit due to empty commit message.
$ git commit main.c -m initial
[master (root-commit) 8c7d287] initial
 1 files changed, 1 insertions(+), 0 deletions(-)
 create mode 100644 main.c
```

## Example: Git & conflicts

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Suppose Fred does:

```
$ cd /home/fred
$ git clone /home/cs2041/.git /home/fred
Cloning into /home/fred...
done.
$ echo >fred.c
$ git commit -m 'created fred.c'
```

## Example: Git & conflicts

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Suppose Jane does:

```
$ cd /home/jane
$ git clone /home/cs2041/.git /home/jane
Cloning into /home/jane...
done.
$ echo '/* Jane Rules */' >>main.c
$ git commit -a -m 'did some documentation'
[master 1eb8d32] did some documentation
1 files changed, 1 insertions(+), 0 deletions(-)
```

## Example: Git & conflicts

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Fred can now get Jane's work like this:

```
$ git pull /home/jane/.git
remote: Counting objects: 5, done.
remote: Total 3 (delta 0), reused 0 (delta 0)
Unpacking objects: 100% (3/3), done.
From /home/jane/.git
 * branch          HEAD          -> FETCH_HEAD
Merge made by recursive.
main.c |      1 +
1 files changed, 1 insertions(+), 0 deletions(-)
```

## Example: Git & conflicts

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And Jane can now get Fred's work like this:

```
$ git pull /home/fred/.git
remote: Counting objects: 7, done.
remote: Compressing objects: 100% (4/4), done.
remote: Total 5 (delta 0), reused 0 (delta 0)
Unpacking objects: 100% (5/5), done.
From /home/fred/.git
 * branch          HEAD          -> FETCH_HEAD
Updating 1eb8d32..63af286
Fast-forward
 fred.c |      1 +
1 files changed, 1 insertions(+), 0 deletions(-)
create mode 100644 fred.c
```

## Example: Git & conflicts

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But if Fred does this:

```
$ echo '// Fred Rules' >fred.c
$ git commit -a -m 'added documentation'
```

And Jane does this:

```
$ echo '// Jane Rules' >fred.c
$ git commit -a -m 'inserted comments'
```

## Example: Git & conflicts

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When Fred tries to get Jane's work:

```
$ git pull /home/jane/.git
remote: Counting objects: 5, done.
remote: Compressing objects: 100% (2/2), done.
remote: Total 3 (delta 0), reused 0 (delta 0)
Unpacking objects: 100% (3/3), done.
From ../jane/
 * branch            HEAD      -> FETCH_HEAD
Auto-merging fred.c
CONFLICT (content): Merge conflict in fred.c
Automatic merge failed; fix conflicts and then commit the result.
$ git mergetool
```

## Example: making Git Repository Public via Github

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Github popular repo hosting site (see competitors e.g. bitbucket)  
Github free for small number of public repos  
Github and competitors also let you setup collaborators, wiki, web pages, issue tracking  
Web access to git repo e.g. <https://github.com/mirrors/linux>

## Example: making Git Repository Public via Github

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Its a week after the 2041 assignment was due and you want to publish your code to the world.

Create github account - assume you choose *2041rocks* as your login

Create a repository - assume you choose *my\_code* for the repo name

Add your ssh key (.ssh/id\_rsa.pub) to github (Account Settings - SSH Public Keys - Add another public key)

```
$ cd ~/cs2041/ass2
$ git remote add origin git@github.com:2041rocks/my_code.git
$ git push -u origin master
```

Now anyone anywhere can clone your repository by

```
git clone git@github.com:2041rocks/my_code.git
```

## Labelling Versions

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How to name an important version? (unique identifier)

Common approach: file name + version "number" (e.g. Perl 5.8.1)

No "standard" for *a.b.c* version numbers, but typically:

- *a* is major version number (changes when functionality/API changes)
- *b* is minor version number (changes when internals change)
- *c* is patch level (changes after each set of bug fixes are added)

Examples: Oracle 7.3.2, 8.0.5, 8.1.5, ...

## Labelling Versions

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How to store multiple versions (e.g. v3.2.3 and v3.2.4)?

We *could* simply store one complete file for each version.

Alternative approach:

- store complete file for version 3.2.3
- store differences between 3.2.3 and 3.2.4

A *delta* is the set of differences between two successive versions of a file.

Many VCSs store a combination of complete versions and deltas for each file.

## Using Deltas

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Creating version  $N$  of file  $F$  ( $F_N$ ) from a collection of

- complete copies of  $F$  whose versions  $< N$
- deltas for all versions in between complete copies

is achieved via:

```
get list of complete copies of F
choose highest complete version V << N
f = copy of F{V}
foreach delta between V .. N {
    f = f + delta
}
# f == F{N} (i.e. version N of F)
```

Programs like patch can apply deltas.

## Delta Bandwidth Efficiency

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An example of why deltas are useful:

- Google Chrome for Windows upgrades in the background almost daily
- Google Chrome is 10MB
- bsdiff delta = 700KB
- google custom delta (Courgette) = 80KB
- 200 full upgrades/year = 2GB/year
- 200 bsdiff upgrades/year = 140Mb/year
- 200 Courgette upgrades/year = 16Mb/year