Tutorial on Version Control and Git

ICERM Workshop on

Reproducibility in Computational and Experimental Mathematics

http://icerm.brown.edu/tw12-5-rcem

Reproducible research

This tutorial is connected with the ICERM workshop,

Reproducibility in Computational and Experimental Mathematics

December 10-14, 2012,

See: **http://icerm.brown.edu/tw12-5-rcem**

There are also slides of talks and good videos at:

www.stodden.net/AMP2011

from a workshop at UBC in July, 2011,

Reproducible Research: Tools and Strategies for Scientific Computing

Outline

Four parts, with hands-on working time after each:

Part 1: Intro to version control, basic Git commands.

Part 2: Branching and merging

Part 3: Using Git for collaboration – basic concepts.

Part 4: Using Git with remote repositories.

Part 1

- Introduction to version control systems (VCS).
- Basic Git commands
- Useful even for working alone:
  - Track changes to documents or programs,
  - Easily revert to earlier versions,
  - Determine where bugs were introduced in code,
  - Archive version of code used to obtain important results.

Version control systems

Originally developed for large software projects with many developers.

Also useful for single user, e.g. to:

- Keep track of history and changes to files,
- Be able to revert to previous versions,
- Keep many different versions of code well organized,
- Easily archive exactly the version used for results in publications,
- Keep work in sync on multiple computers.

Server-client model:

Original style, still widely used (e.g. CVS, Subversion)

One central repository on server.

Developers' workflow (simplified!):

- Check out a working copy,
- Make changes, test and debug,
- Check in (commit) changes to repository (with comments). This creates new version number.
- Run an update on working copy to bring in others' changes.

The system keeps track of diffs from one version to the next (and info on who made the changes, when, etc.)

A changeset is a collection of diffs from one commit.

Server-client model:

Only the server has the full history.

The working copy has:

- Latest version from repository (from last checkout, commit, or update)
- Your local changes that are not yet committed.

Server-client model:

Only the server has the full history.

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Note:

- You can retrieve older versions from the server.
- Can only *commit* or *update* when connected to server.
- When you *commit*, it will be seen by anyone else who does an *update* from the repository.

Often there are trunk and branches subdirectories.

Distributed version control

Examples: Git, Mercurial, Bazaar

These use a distributed model:

When you clone a repository you get all the history too,

All clones are created equal, no “server repository”.

With git, All history stored in .git subdirectory of top directory.
Usually don’t want to mess with this!

Distributed version control

Advantages of distributed model:

- You can commit changes, revert to earlier versions, examine history, etc. without being connected to server.
- Also without affecting anyone else's version if you're working collaboratively. Can commit often while debugging.
- No problem if server dies, every clone has full history.

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For collaboration, will need to fetch changes from other versions and merge into yours.

Distributed version control

Advantages of distributed model:

- You can commit changes, revert to earlier versions, examine history, etc. without being connected to server.
- Also without affecting anyone else's version if you're working collaboratively. Can commit often while debugging.
- No problem if server dies, every clone has full history.

For collaboration, will need to fetch changes from other versions and merge into yours.

May have server version that all developers can fetch from,
and some can push to,
for example hosted on Github.

Using git in solo mode

The following examples will be performed during the tutorial.

Try to work through them on your own computer!

Some Git references

- `http://help.github.com/`
- `http://gitref.org/index.html`
- Git book
  `http://git-scm.com/book/en/Getting-Started-Git-Basics`
- List of 10 recommended tutorials
  `http://sixrevisions.com/resources/git-tutorials-beginners/`
- Github online tutorial
  `http://try.github.com/`

More Git references

- Fernando Perez's blog has many useful links to get started.
  `http://fperez.org/py4science/git.html`
- Git Parable gives a good intro to the concepts.
  `http://tom.preston-werner.com/2009/05/19/the-git-parable.html`
- gitk introduction has a good description of merging.
  `http://lostechies.com/joshuaflanagan/2010/09/03/use-gitk-to-understand-git/`

Using git in solo mode

1. Install git: see **http://git-scm.com/**
2. In any directory:

```
$ git init    # creates .git subdirectory
$ git add .   # track all files
$ git commit -m "initial commit"
```

This takes a snapshop of all files (recursively in subdirectories).

Can selectively add a subset of files instead, e.g.

```
$ git add README.txt  *.tex
```

Important Git concepts

Working directory: The current state of your files.

Index: List of new or modified files that will be included in next snapshot. Use `git add` to add files to index.

Commit: the command `git commit` takes a snapshot of the current state of your working directory, but only including new or modified files if they are listed in the index.

Useful git commands

```
$ git help
$ git help <topic>

$ git add <filename>
$ git commit -m <message>

$ git status | more
$ git diff | more
$ git diff <filename> | more
```

Git demo

```
$ mkdir gitdemo
$ cd gitdemo

$ git init
Initialized empty Git repository
     in /Users/rjl/gitdemo/.git/


$ cat > file1.txt
First version of file.
<ctrl>-D  # to end entry into file


$ ls -a
./      ../     .git/       file1.txt
```

Git status

```
$ git status

# On branch master
#
# Initial commit
#
# Untracked files:
#   (use "git add <file>..."
#    to include in what will be committed)
#
#   file1.txt

nothing added to commit but untracked
   files present (use "git add" to track)
```

Git status and commit

```
$ git add file1.txt

$ git status

# On branch master
#
# Initial commit
#
# Changes to be committed:
#   (use "git rm --cached <file>..." to unstage)
#
#   new file:   file1.txt
#

$ git commit -m "initial commit"
[master (root-commit) e84a77e] initial commit
 1 files changed, 1 insertions(+), 0 deletions(-)
 create mode 100644 file1.txt
```

Git commit and log

```
$ git commit -m "initial commit"
[master (root-commit) e84a77e] initial commit
 1 files changed, 1 insertions(+), 0 deletions(-)
 create mode 100644 file1.txt
```

```
$ git log
commit e84a77e8afb9c83c37000e698795c350a931b512
Author: Randy LeVeque <rjl@uw.edu>
Date:   Wed Jul 13 08:51:55 2011 -0700

    initial commit
```

The commit has a name which is a 40-digit hexadecimal string.

SHA-1 hash code based on all contents and modification times of files.

Git branch

```
$ git branch
* master
```

There is only one branch named master.

Git diff

```
$ # edit the file...

$ cat file1.txt
Second version of file.
Added a second line.


$ git diff
diff --git a/file1.txt b/file1.txt
index 2ac6b14..6ef2b34 100644
--- a/file1.txt
+++ b/file1.txt
@@ -1 +1,2 @@
-First version of file.
+Second version of file.
+Added a second line.
```

Git demo

```
$ git status
# On branch master
# Changes not staged for commit:
#
#   modified:   file1.txt
#
no changes added to commit
   (use "git add" and/or "git commit -a")
```

Git demo

```
$ git add file1.txt

$ git status
# On branch master
# Changes to be committed:
#   (use "git reset HEAD <file>..." to unstage)
#
#   modified:   file1.txt
#
```

We have added `file1.txt` to the index of files to be committed.

Git demo

```
$ git commit -m "changed line and added second"
[master b1294af] changed line and added second
 1 files changed, 2 insertions(+), 1 deletions(-)


$ git log
commit b1294aff9edb80377096fd861fa53a88af3fb1fc
Author: Randy LeVeque <rjl@uw.edu>
Date:   Wed Jul 13 09:01:57 2011 -0700

    changed line and added second

commit e84a77e8afb9c83c37000e698795c350a931b512
Author: Randy LeVeque <rjl@uw.edu>
Date:   Wed Jul 13 08:51:55 2011 -0700

    initial commit
```

Git demo

```
$ git log --pretty=oneline

b1294aff9edb80377096fd861fa53a88af3fb1fc changed line an
e84a77e8afb9c83c37000e698795c350a931b512 initial commit

$ git help log  # shows many more options
```

Git demo

```
$ cat > file2.txt
Another file
<ctrl>-D
```

```
$ git status
# On branch master
# Untracked files:
#
#   file2.txt
```

Note: Doesn't show file1.txt since it hasn't been modified since last commit.

`file2.txt` is not being tracked.

Git demo

```
$ git add file2.txt

$ git status -s
A  file2.txt

$ # edit file1.txt

$ git status -s
 M file1.txt
A  file2.txt
```

M in column 2: Modified file has not been added to index.

Git demo

```
$ cat file1.txt
Third version of file.
Added a second line.
```

```
$ git diff
diff --git a/file1.txt b/file1.txt
index 6ef2b34..40afc7a 100644
--- a/file1.txt
+++ b/file1.txt
@@ -1,2 +1,2 @@
-Second version of file.
+Third version of file.
 Added a second line.
```

Git demo

```
$ git status -s
 M file1.txt
A  file2.txt

$ git add -u  # add all modified files to index

$ git status -s
M  file1.txt
A  file2.txt
```

Git demo

```
$ git status -s
M  file1.txt
A  file2.txt

$ git diff  # shows diff's between working copy
$           #  and index:  there are none
```

Git demo

```
$ git diff HEAD  # nickname for last commit

diff --git a/file1.txt b/file1.txt
index 6ef2b34..40afc7a 100644
--- a/file1.txt
+++ b/file1.txt
@@ -1,2 +1,2 @@
-Second version of file.
+Third version of file.
 Added a second line.

diff --git a/file2.txt b/file2.txt
new file mode 100644
index 0000000..b0b9fc8
--- /dev/null
+++ b/file2.txt
@@ -0,0 +1 @@
+Another file
```

Git demo

```
$ git commit -m "changed file1 and added another"
[master 5f4e886] changed file1 and added another
 2 files changed, 2 insertions(+), 1 deletions(-)
 create mode 100644 file2.txt

$ mkdir testdir

$ git status
# On branch master
nothing to commit (working directory clean)
```

Note: Tracks only files, not directories!

Git demo

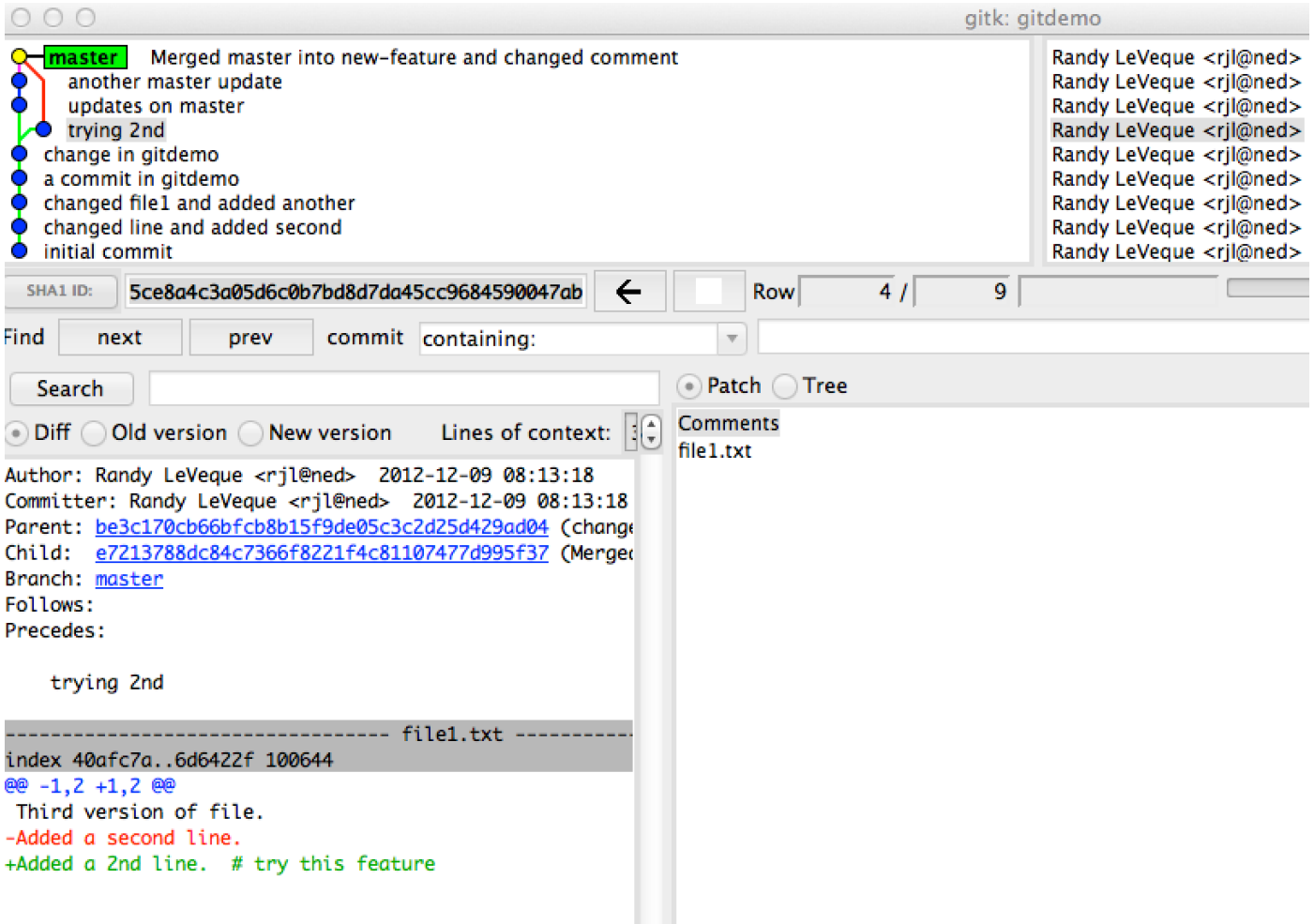
```
$ cat > testdir/file3.txt    # create a new file
In the subdirectory.
<ctrl>-D

$ git status
# On branch master
# Untracked files:
#   testdir/

$ git status -s
?? testdir/

$ git add testdir
$ git status -s
A  testdir/file3.txt

$ git commit -m "testing a subdirectory"
[master 765f3a3] testing a subdirectory
```

Git demo

```
$ git commit -m "testing a subdirectory"
[master 765f3a3] testing a subdirectory
```

```
$ git log --pretty=oneline
765f3a3f... testing a subdirectory
5f4e8860... changed file1 and added another
b1294aff... changed line and added second
e84a77e8... initial commit
```

Graphical tools, e.g. `gitk`



Part 2

- Creating branches
- Committing to different branches
- Fetching changes, merging, etc.
- Deleting a branch

Git branches

A new repository has a single branch with named `master`.

Create a new branch:

```
$ git branch new-feature
$ git branch
* master
  new-feature
```

Switch to the branch:

```
$ git checkout new-feature
Switched to branch 'new-feature'

$ git branch
  master
* new-feature
```

Git branches

Any changes committed will now be on this branch until checking out another.

Try the following:

- Make a change on `new-feature`
- Use `git add` and `git commit` to snapshot.
- Check out master branch: `git checkout master`
- Make a different change and commit it.
- Use `gitk` to examine state of repository.

Git branches

Also note that `git log` give different things on each branch.

To see changes since the two diverged...

Commits to new-feature only:

```
$ git log master..new-feature
```

Commits to master since divergence:

```
$ git log new-feature..master
```

Git merge

To merge new changes to `master` into `new-feature`:

```
$ git checkout new-feature
$ git merge --no-commit master
```

This merges changes into working directory.

If there are conflicts then these must be fixed and the files added to the index with `git commit`

Then can do

```
$ git commit -m "Merged master into new-feature"
```

Git merge

Once new feature is fully debugged and incorporates changes to `master`, merge it into `master`:

```
$ git checkout master
$ git merge new-feature
```

This merges changes into working directory.

This should be a “fast-forward” commit.

Now can delete branch:

```
$ git log master..new-feature    # make sure!
$ git branch -d new-feature
```

Part 3

- Collaboration
- Cloning a repository
- Fetching changes, merging, etc.
- Start with two clones on your own computer.

Git clone

```
$ cd ..
$ git clone gitdemo gitdemo2
Cloning into gitdemo2...
done.

$ cd gitdemo2

$ git log --pretty=oneline
765f3a3f... testing a subdirectory
5f4e8860... changed file1 and added another
b1294aff... changed line and added second
e84a77e8... initial commit

$ git remote -v
origin  /Users/rjl/gitdemo (fetch)
origin  /Users/rjl/gitdemo (push)
```

Adding remotes

A cloned repository will have one `remote` named `origin`.

You can add remotes using:

```
$ git remote add <name> <address>
```

where `<name>` is any name you want to use to refer to it.

The `<address>` can be...

- Path to another directory on your computer,
- Another computer, e.g. `rjl@mycomputer.washington.edu:gitrepos/gitdemo`
- A web hosting site, e.g. `git@github.com:rjleveque/gitdemo`

Fetching history from a remote repository

For example, using the remote `origin`...

```
$ git fetch origin
```

This fetches history (all commits) but does not change your version!

You can refer to branches of the remote by, e.g. `origin/master`.

Comparing to branches on a remote repository

You can do things like...

```
$ git log origin/master

$ git log master..origin/master

$ git diff master origin/master -- file1.txt
```

To merge a remote branch into working directory:

```
$ git branch  # see what local branch you're on
$ git checkout ...  # if you want to change
$ git merge origin/master
```

Fetching changes from origin

```
$ cd ../gitdemo
$ #edit file2.txt
$ git add -u
$ git commit -m "a commit in gitdemo"
[master bd166a5] a commit in gitdemo

$ cd ../gitdemo2
$ more file2.txt  # hasn't changed!
Another file

$ git fetch origin
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 /Users/rjl/gitdemo
   765f3a3..bd166a5  master     -> origin/master
```

Git diff

```
$ git diff origin/master

diff --git a/file2.txt b/file2.txt
index 8def468..b0b9fc8 100644
--- a/file2.txt
+++ b/file2.txt
@@ -1,2 +1 @@
 Another file
-Added a line to another file.
```

Note: Would have to delete line from

`origin/master/file2.txt`

to make it agree with working copy.

Git merge

```
$ git diff HEAD origin/master
diff --git a/file2.txt b/file2.txt
index b0b9fc8..8def468 100644
--- a/file2.txt
+++ b/file2.txt
@@ -1 +1,2 @@
 Another file
+Added a line to another file.
```

These are the changes to be made when we merge...

```
$ git merge origin/master
Updating 765f3a3..bd166a5
Fast-forward
 file2.txt |    1 +
 1 files changed, 1 insertions(+), 0 deletions(-)
```

Git merge

Harder case: File has changed in different ways in two places.

git will attempt to merge changes, but cannot if they are on same line...

```
$ cd ../gitdemo
$ #edit file2.txt
$ git add -u
$ git commit -m "change in gitdemo"

$ cd ../gitdemo2
$ #make a different edit to file2.txt
$ git add -u
$ git commit -m "change in gitdemo2"
```

Git merge

```
$ git fetch origin
   bd166a5..76f0bc9  master     -> origin/master

$ git diff HEAD origin/master
diff --git a/file2.txt b/file2.txt
index 17cfc40..c10f444 100644
--- a/file2.txt
+++ b/file2.txt
@@ -1,2 +1,2 @@
 Another file
-Different change in gitdemo2
+Added a line to another file - then change it.
```

Git merge

```
$ git status -s  # make sure no uncommitted changes
$
$ git merge origin/master

Auto-merging file2.txt
CONFLICT (content): Merge conflict in file2.txt
Automatic merge failed;
fix conflicts and then commit the result.
```

Must edit by hand to create proper file.

Git merge

```
$ cat file2.txt

Another file
<<<<<<< HEAD
Different change in gitdemo2
=======
Added a line to another file - then change it.
>>>>>>> origin/master
```

Must edit by hand to create proper file.

Then add to index and commit.

Git merge

Or... to keep local version:

```
$ git checkout HEAD file2.txt

$ cat file2.txt
Another file
Different change in gitdemo2

$ git status -s
$
```

Or.... to take file as in `origin`:

```
$ git checkout origin/master file2.txt
$ cat file2.txt
Another file
Added a line to another file - then change it.

$ git status -s
M  file2.txt
```

Part 4

- Remote repositories
- Public hosting sites, e.g. Github
- Sharing via ssh

Adding remotes

A cloned repository will have one `remote` named `origin`.

You can add remotes using:

```
$ git remote add <name> <address>
```

where `<name>` is any name you want to use to refer to it.

The `<address>` can be...

- Path to another directory on your computer,
- Another computer, e.g. `rjl@mycomputer.washington.edu:gitrepos/gitdemo`
- A web hosting site, e.g. `git@github.com:rjleveque/gitdemo`

Web hosting repositories

Github: `https://github.com`

Repository for open source hosting

Many open sources projects use it, including Linux kernal.

Public repositories free.

Provides wiki, issue tracking, source browsing. See e.g.:

`https://github.com/ipython/ipython`

Bitbucket (**https://bitbucket.org/**)
and Google code (`http://code.google.com/`)
can also be used for hosting git repositories.

ssh repositories

Create a bare repository (no working directory):

```
$ git --bare init
```

Then people can clone it using:

```
$ git clone <user>@<machine>:<path>
```

if they have ssh access set up.