Version Control: Git and Gitlab

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22/8/2018

Outline

- Part 1 - A little background
- Part 2 - Basics of Git
- Part 3 - Git for EPOCH - Gitlab and Submodules
- Part 4 - Git merging

Part 1 - A Little Background

Overview

- Version control
  - Record changes that you make to a file or system of files
  - Allows you to keep a log of why/by whom those changes were made
  - Allows you to go back through those changes to get back to old versions
  - Help deal with merging incompatible changes from different sources

Why use version control?

- "I didn't mean to do that!"
    - Can go back to before you made edits that haven't worked
- "What did this code look like when I wrote that?"
    - Can go back as far as you want to look at old versions that you used for papers or talks
- "How can I work on these different things without them interfering?"
    - Branches allow you to work on different bits and then merge them at the end

Why use version control?

- "I want a secure copy of my code"
  - Most version control systems have a client-server functionality. Can easily store an offsite backup.
  - Many suitable free services, and can easily set up your own
- "How do I work with other people collaboratively?"
  - Most modern version control systems include specific tools for working with other people.
  - There are more powerful tools to make it even easier too

How did we get here?

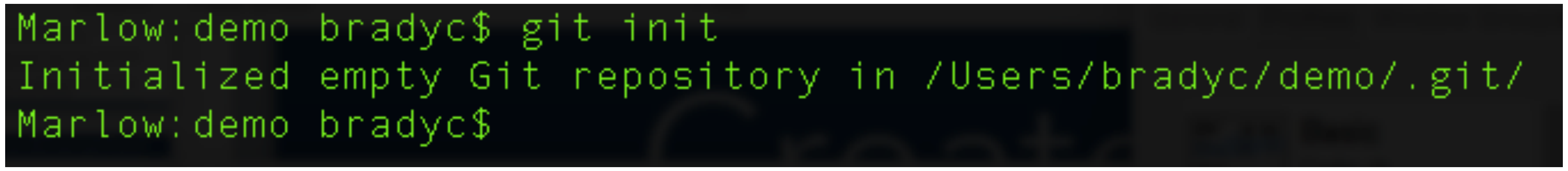
- Version control is literally as old as computers
- United States National Archives Records Service punch card storage warehouse in 1959
- ~100MB / Forklift pallet
- Stored both programs and data
- Important programs would be kept in archives and repunched when changed
- Old versions kept for some time

How did we get here?

- A long lineage of VCS systems eventually produced
- Git (2005 - now)
  - Distributed model - all copies equivalent
  - Push to remote server when needed (if wanted)
  - Very sophisticated branching and merging system
  - Become very popular because of GitHub/Gitlab etc

Part 2 -Basics of Git

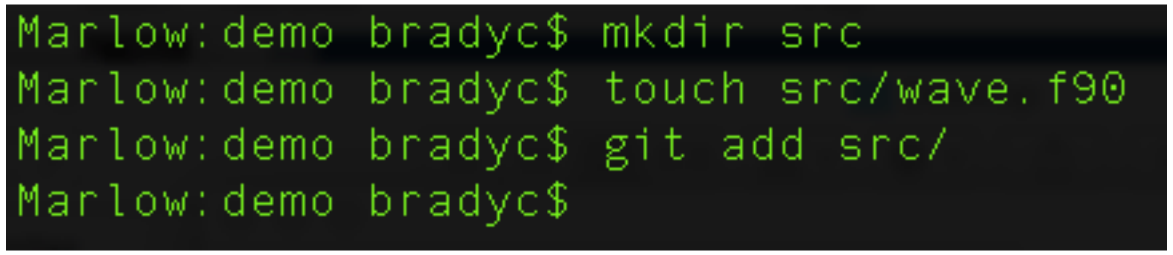
Create a repository



```
Marlow:demo bradyc$ git init
Initialized empty Git repository in /Users/bradyc/demo/.git/
Marlow:demo bradyc$
```

- Simply type “git init”
- Directory is now a working git repository
- Be careful about creating a git repository in a directory that isn’t the bottom of the directory tree!

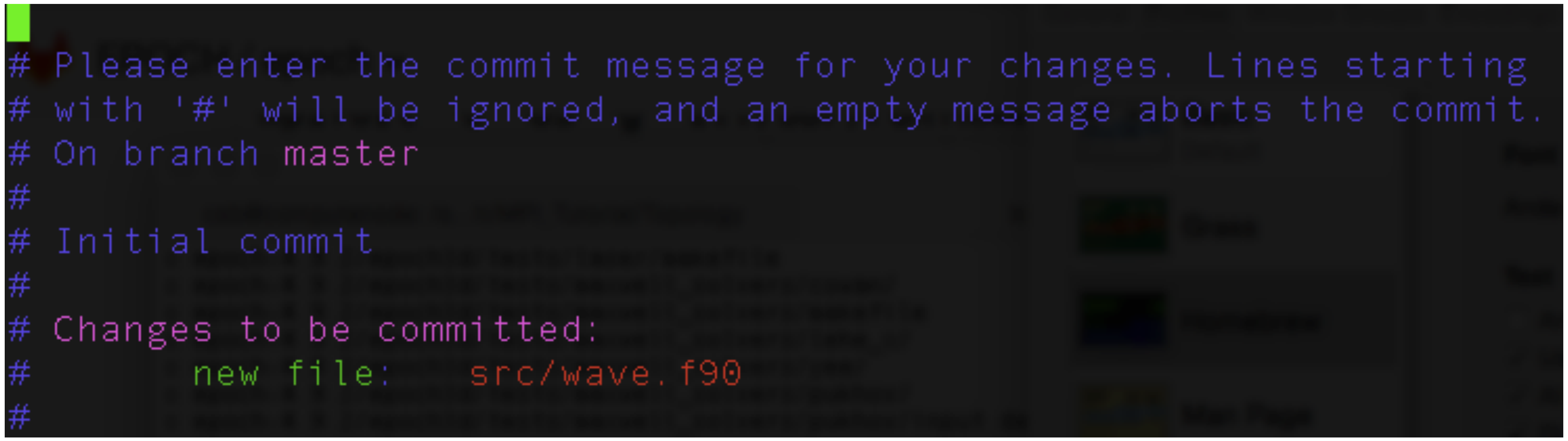
Designate files for repository



```
Marlow:demo bradyc$ mkdir src
Marlow:demo bradyc$ touch src/wave.f90
Marlow:demo bradyc$ git add src/
Marlow:demo bradyc$
```

- Create a directory and put a file in it
- "git add src/" tells git to put the directory src and all files within it under version control
  - Not yet actually in the repository!
- Works pretty well with almost any text based file
  - Best with things like C/C++/Fortran/Python that it understands
  - Sometimes doesn't work as well as you'd hope (see later)

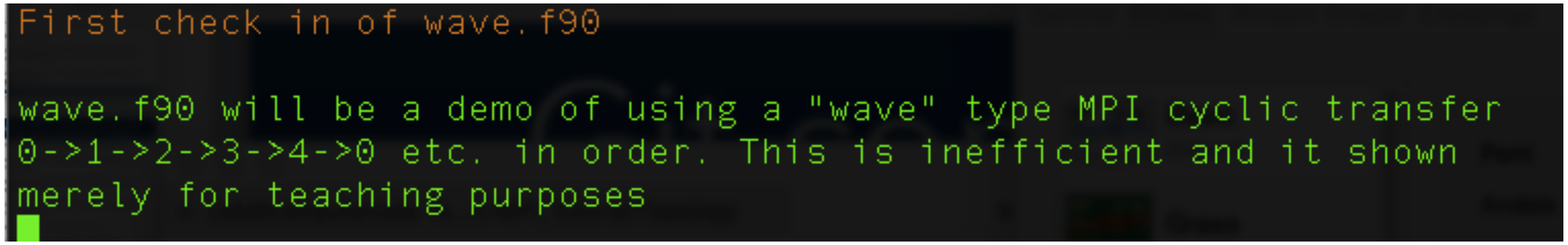
Add files to the repository



```
# Please enter the commit message for your changes. Lines starting
# with '#' will be ignored, and an empty message aborts the commit.
# On branch master
#
# Initial commit
#
# Changes to be committed:
#       new file:   src/wave.f90
#
```

- "git commit" will actually add the file to the repository
- Will open an editor to specify a "commit message"
  - I'm using Vim. Default will depend on your system
- Generally git commit messages should follow standard format

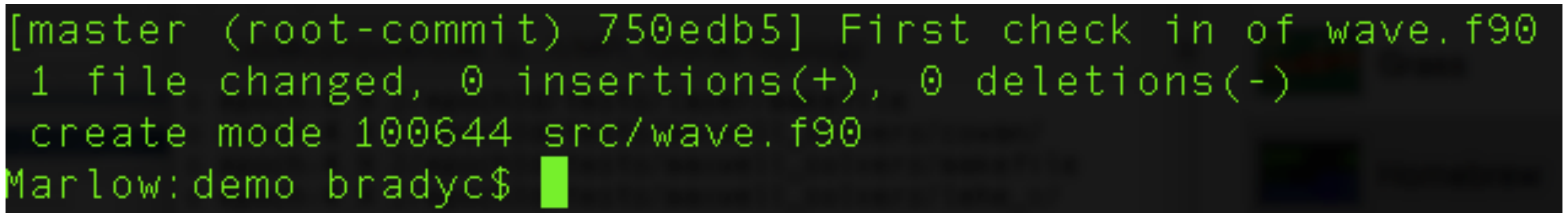
Git commit message



```
First check in of wave.f90

wave.f90 will be a demo of using a "wave" type MPI cyclic transfer
0->1->2->3->4->0 etc. in order. This is inefficient and it shown
merely for teaching purposes
```

- First line is the subject. Keep it to <= 50 characters
- Second line should be blank
- Subsequent lines are the "body" of the message
- Should limit body lines to <=72 characters
- As many as you want, but be concise

After writing message



```
[master (root-commit) 750edb5] First check in of wave.f90
 1 file changed, 0 insertions(+), 0 deletions(-)
 create mode 100644 src/wave.f90
Marlow:demo bradyc$ 
```

- When you save the file and exit your editor git will give you a summary of what's just happened

    - In this case, it's created the file "wave.f90" as I wanted it to

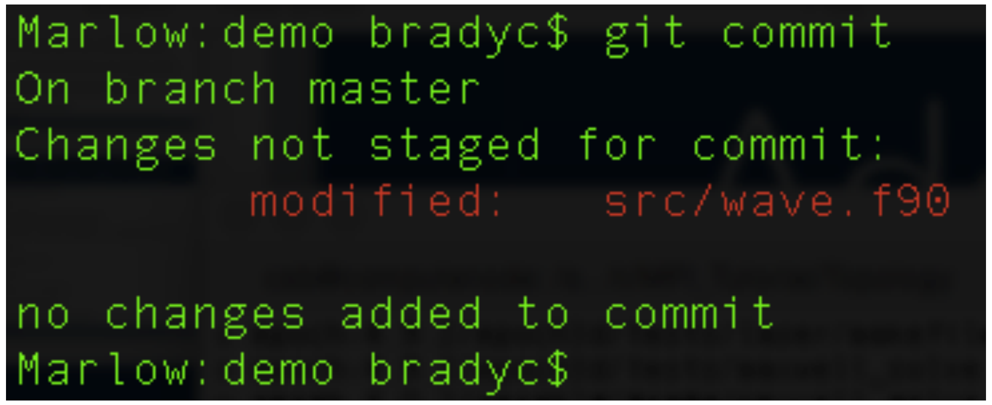
- If you quit your editor without saving this cancels the commit

- "wave.f90" is now under version control, and I can always get back to this version

Editing wave.f90

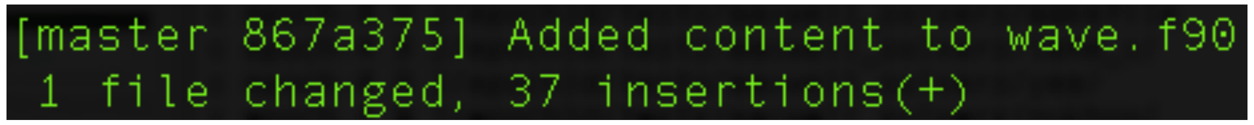
```fortran
PROGRAM wave

  USE mpi
  IMPLICIT NONE

  INTEGER, PARAMETER :: tag = 100

  INTEGER :: rank, recv_rank
  INTEGER :: nproc
  INTEGER :: left, right
  INTEGER :: ierr

  CALL MPI_Init(ierr)

  CALL MPI_Comm_size(MPI_COMM_WORLD, nproc, ierr)
  CALL MPI_Comm_rank(MPI_COMM_WORLD, rank, ierr)

  !Set up periodic domain
  left = rank - 1
  IF (left < 0) left = nproc - 1
  right = rank + 1
  IF (right > nproc - 1) right = 0

  IF (rank == 0)
    CALL MPI_Send(rank, 1, MPI_INTEGER, right, tag, MPI_COMM_WORLD, ierr)
    CALL MPI_Recv(recv_rank, 1, MPI_INTEGER, left, tag, MPI_COMM_WORLD, &
        MPI_STATUS_IGNORE, ierr)
  ELSE
    CALL MPI_Recv(recv_rank, 1, MPI_INTEGER, left, tag, MPI_COMM_WORLD, &
        MPI_STATUS_IGNORE, ierr)
    CALL MPI_Send(rank, 1, MPI_INTEGER, right, tag, MPI_COMM_WORLD, ierr)
  END IF


  CALL MPI_Finalize(ierr)

END PROGRAM wave
```

Adding the changes


```
Marlow:demo bradyc$ git commit
On branch master
Changes not staged for commit:
        modified:   src/wave.f90

no changes added to commit
Marlow:demo bradyc$
```

- Not just “git commit” again!
- That tells me that I have a modified file, but it isn’t “staged for commit”
- Have to “git add” it again, then “git commit”
- Can have as many adds as you want before a commit. That is “staging” the files
- Slightly risky alternative “git commit -a” commits everything changed since last commit

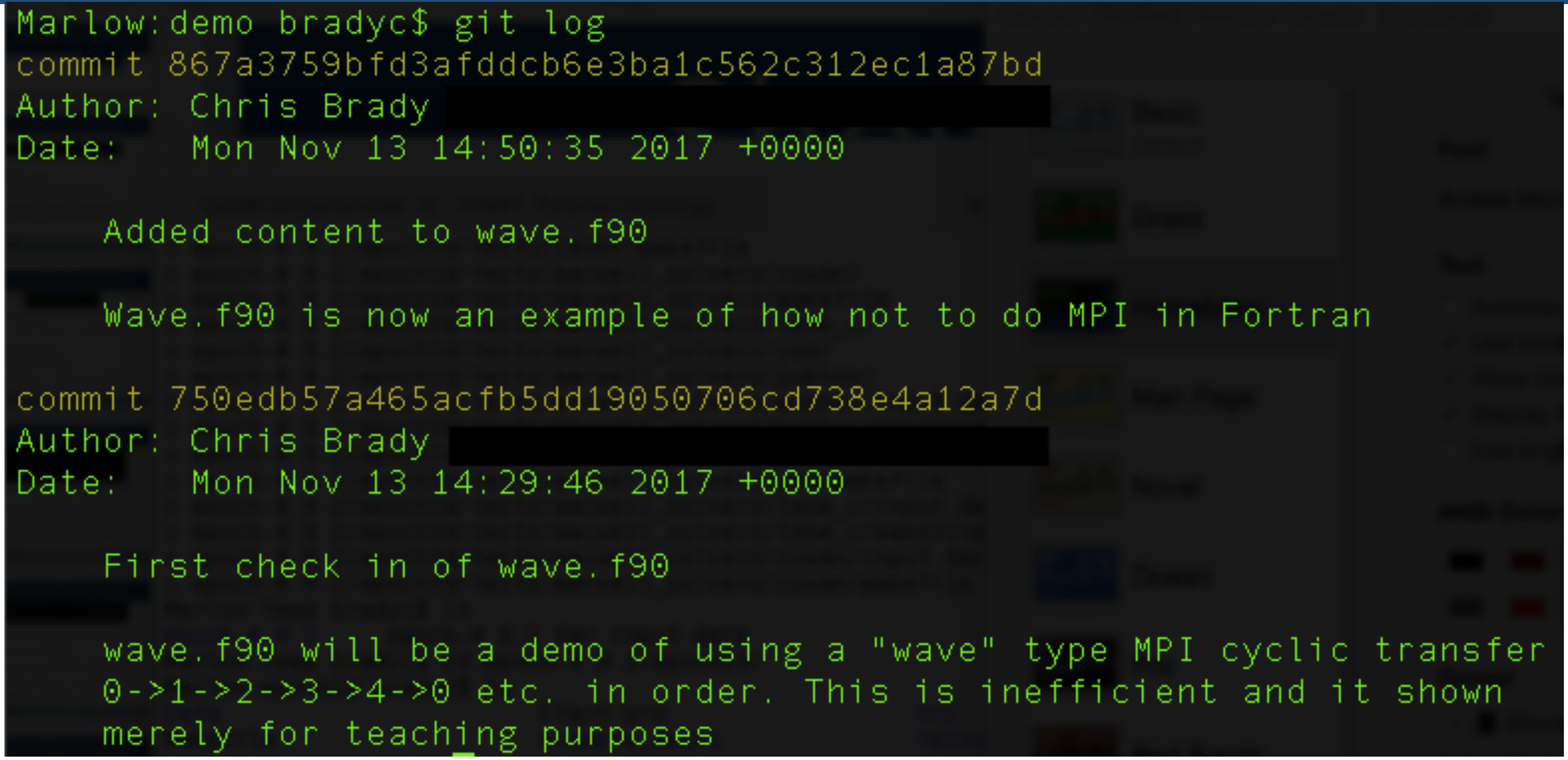
Adding the changes



```
[master 867a375] Added content to wave.f90
 1 file changed, 37 insertions(+)
```

- Once again editor comes up
- Same commit message format
- Should describe the changes that you have made
- On saving the file in the editor see the same commit summary
  - Now telling me that it's added 37 lines

Showing the log



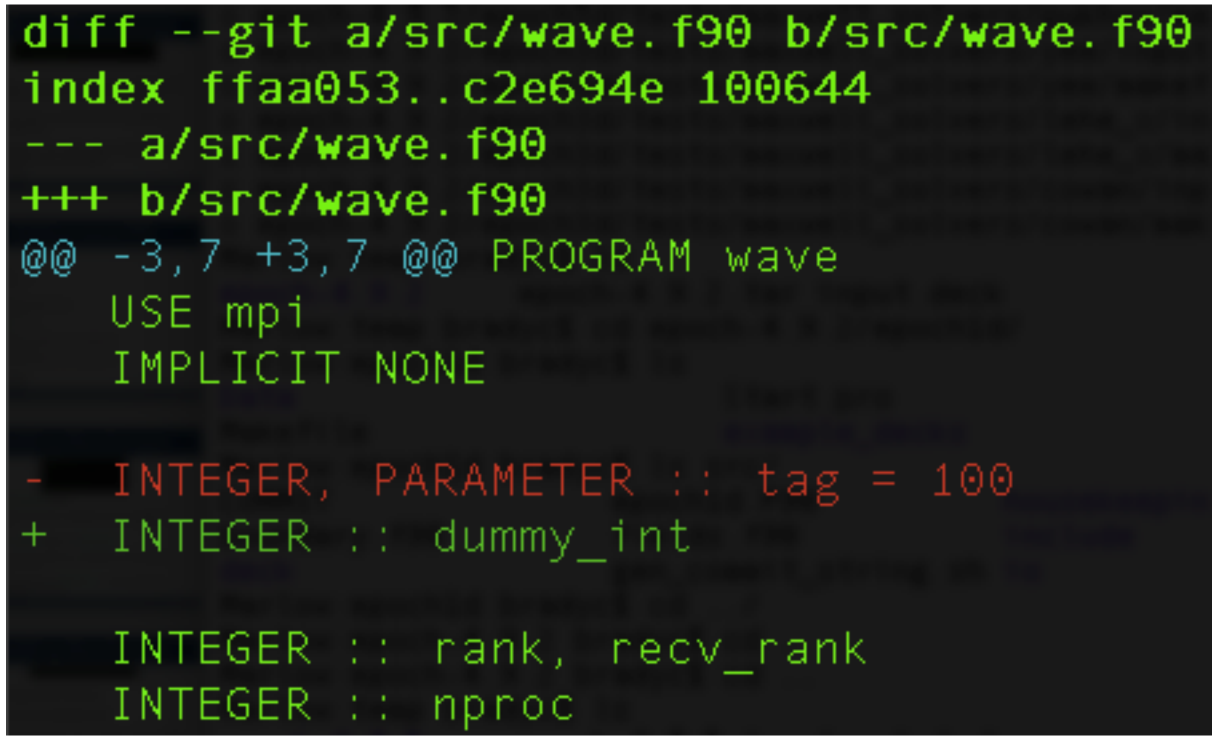
```
Marlow:demo bradyc$ git log
commit 867a3759bfd3afddcb6e3ba1c562c312ec1a87bd
Author: Chris Brady [redacted]
Date:   Mon Nov 13 14:50:35 2017 +0000

    Added content to wave.f90

    Wave.f90 is now an example of how not to do MPI in Fortran

commit 750edb57a465acfb5dd19050706cd738e4a12a7d
Author: Chris Brady [redacted]
Date:   Mon Nov 13 14:29:46 2017 +0000

    First check in of wave.f90

    wave.f90 will be a demo of using a "wave" type MPI cyclic transfer
    0->1->2->3->4->0 etc. in order. This is inefficient and it shown
    merely for teaching purposes
```

- Can see the list of commit messages using "git log"
- Note the string after the word "commit". It is the commit ID.
  - This uniquely identifies a given commit

Seeing differences

- Using the command "git diff" followed by a commit ID shows you the changes between the current state of the code and the one referred to in the by the commit ID
- Adding a list of filenames at the end allows you to see the differences in only specific files
- The result of the command is in "git-diff" format
  - Lines with a + have been added since the specified commit
  - Lines with a - have been removed
  - Lines without a symbol are only there for context and are unchanged

git diff output



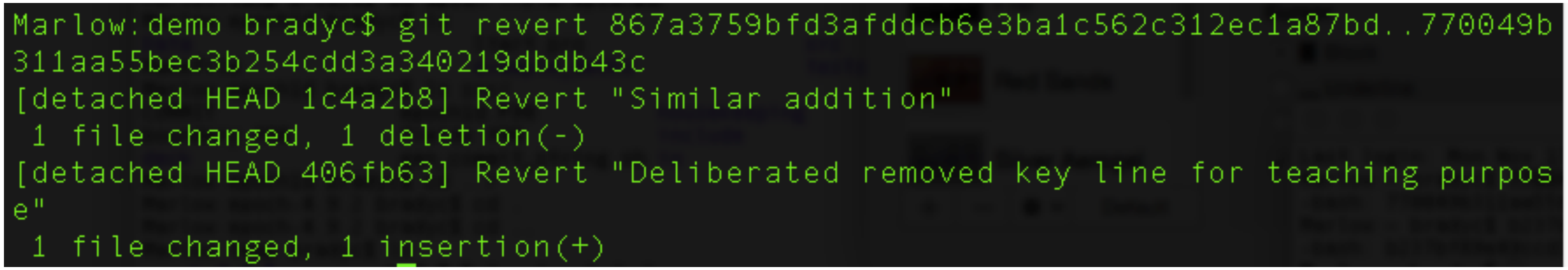
```
diff --git a/src/wave.f90 b/src/wave.f90
index ffaa053..c2e694e 100644
--- a/src/wave.f90
+++ b/src/wave.f90
@@ -3,7 +3,7 @@ PROGRAM wave
   USE mpi
   IMPLICIT NONE

-  INTEGER, PARAMETER :: tag = 100
+  INTEGER :: dummy_int

   INTEGER :: rank, recv_rank
   INTEGER :: nproc
```

- Example git diff
  - I have removed the key line referring to “tag”
  - and replaced it with “dummy_int”

Reverting to undo bad changes

- Undoing changes in git can be a mess
    - Distributed system, so if code has ever been out of your control you can't just go back
    - Reverts are in general simply changes that put things back to how they used to be
    - Git log will show original commits and reverts
- Command is "git revert"

git revert



```
Marlow:demo bradyc$ git revert 867a3759bfd3afddcb6e3ba1c562c312ec1a87bd..770049b
311aa55bec3b254cdd3a340219dbdb43c
[detached HEAD 1c4a2b8] Revert "Similar addition"
 1 file changed, 1 deletion(-)
[detached HEAD 406fb63] Revert "Deliberated removed key line for teaching purpos
e"
 1 file changed, 1 insertion(+)
```

- Lots of flexibility, but mostly you want to do
  - git revert {lower_bound_commit_id}..{upper_bound_commit_id}
- Lower bound is exclusive
- Upper bound is inclusive

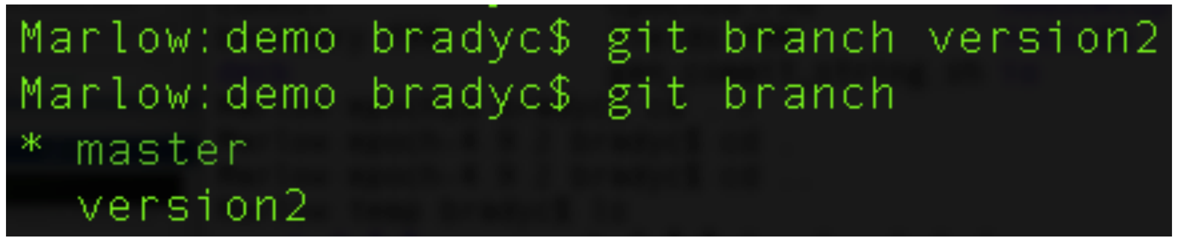
git revert

- When git revert operates, it creates a new commit undoing each commit that you want to revert
- You get an editor pop-up for each with a default message that says
  - Revert “{original commit message}”
  - No real need to change them

git branch

- If you are working on multiple features then branches are useful
- Branches are code versions that git keeps separate for you
- Changes to one branch do not affect any other
- There is a default branch called “master” created when you create the repository
- A git repository is always working on one branch or another (sometime a temporary branch, but ignore this here)
- Adds and commits are always to the branch that you are working on

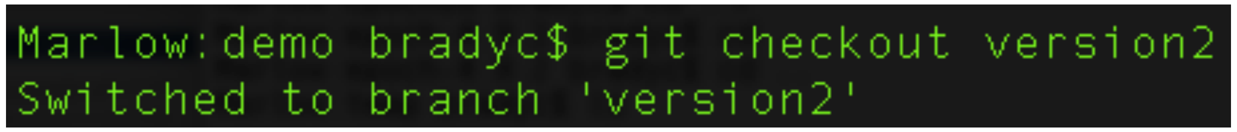
git branch



```
Marlow:demo bradyc$ git branch version2
Marlow:demo bradyc$ git branch
* master
  version2
```

- To create a branch, just type "git branch {name}"
- A new branch is created based on the last commit in the branch that you are on
- Simply creating a branch does not move you to it. You are still exactly where you are before
- You can check what branch you are on by typing "git branch" with no parameters

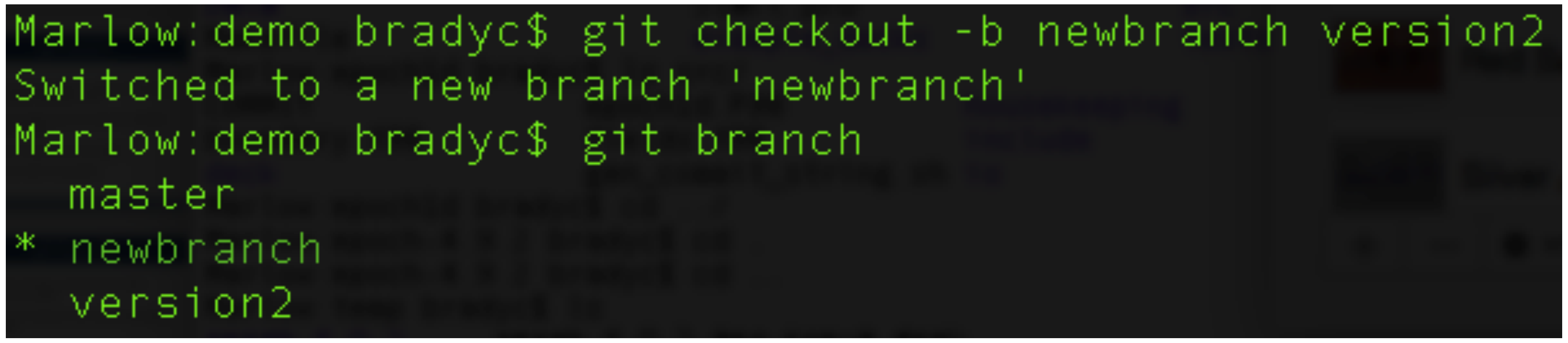
git checkout



```
Marlow:demo bradyc$ git checkout version2
Switched to branch 'version2'
```

- To move between branches, you use "git checkout {branch_name}"
- This will tell you that it has switched to the named branch if it has managed to do so

git checkout



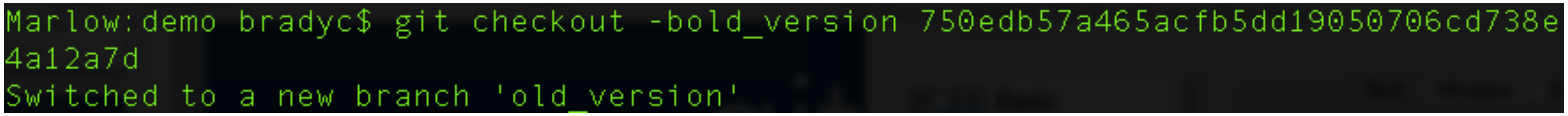
```
Marlow:demo bradyc$ git checkout -b newbranch version2
Switched to a new branch 'newbranch'
Marlow:demo bradyc$ git branch
  master
* newbranch
  version2
```

- You can create a new branch based off an existing branch and check it out in a single command using

- "git checkout -b {new_branch_name} {existing_branch_name}"

- This is very useful when you're working with remote branches (i.e. those you get from a git server)

git checkout



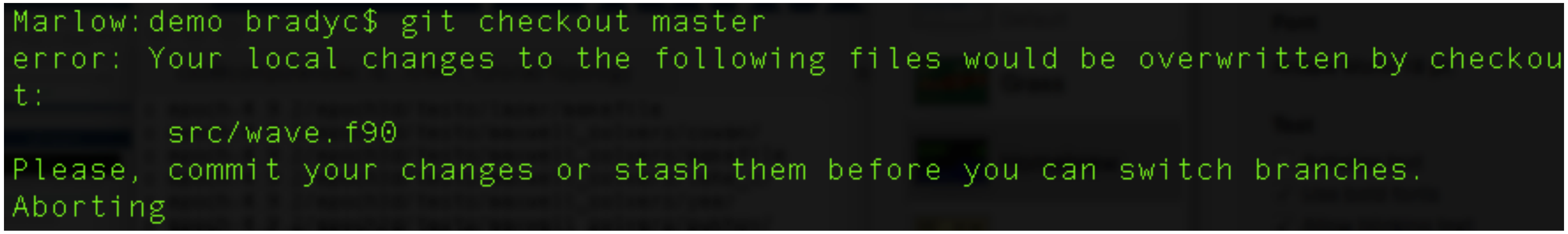
```
Marlow:demo bradyc$ git checkout -bold_version 750edb57a465acfb5dd19050706cd738e
4a12a7d
Switched to a new branch 'old_version'
```

- Sometimes you want to go back to an old version of the code
- "git checkout -b{new_branch_name} {commit ID}"
- This checks out the code in the state that it was in at the specified commit ID.
- If you don't specify a branch, the repository goes into "detached head mode" - temporary branch
  - Probably best to not do it

Checking branches

- You can check that branches are working as you expect by
  - Creating a branch
  - Changing to the branch
  - Making some changes
  - Adding them using “git add” and “git commit”
  - Changing back to master
- Your changes to your branch will not have appeared in master

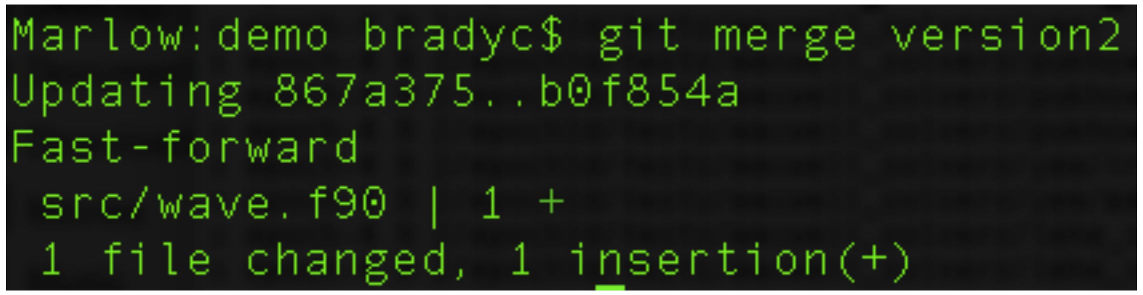
Changing branches



```
Marlow:demo bradyc$ git checkout master
error: Your local changes to the following files would be overwritten by checkou
t:
        src/wave.f90
Please, commit your changes or stash them before you can switch branches.
Aborting
```

- Once branches have changed relative to each other you can no longer carry changes between them
- If you make changes in a branch and then try to move to another branch, without committing the changes you will get an error message
- Either
  - commit the changes in the branch that you are on
  - use git-stash (https://git-scm.com/docs/git-stash)

Bringing branches back



```
Marlow:demo bradyc$ git merge version2
Updating 867a375..b0f854a
Fast-forward
 src/wave.f90 | 1 +
 1 file changed, 1 insertion(+)
```

- If you're using branches to develop features (a very common way of working) you'll want to bring them back together to form a single version with all the features

- Termed "merging"

- "git merge {other_branch_name}" brings the other branch's content into this branch

- If you're lucky, you'll see what's at the top and the merge is automatic

Manual Merge

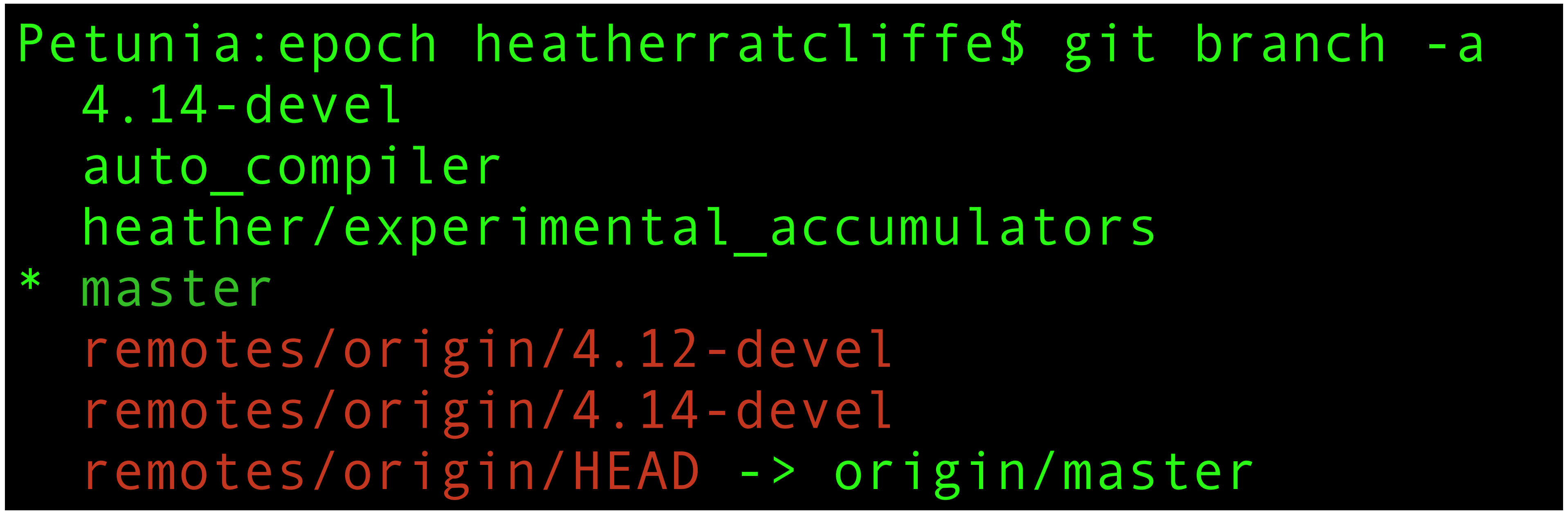
- If git can't work out how to combine the changes between the version then it'll just put diff formatted markers into the file to say what's changed and where
- You have to go through and remove these markers, leaving a single working version of the code
- Commit the finished version using "git commit" as normal (or "git merge -- continue" in newer versions of git)
- There are tools to help, but it's never fun
- Later we'll show a bit more about how to do merges and how they go wrong

Part 3 -Git for EPOCH

Git remote server

- Git is a distributed, networked version control system.
- Has commands to control this
- Collectively called “git remote” commands
- You probably already cloned the EPOCH gitlab repository
- A local repository can be told that it’s a local copy of an remote repository

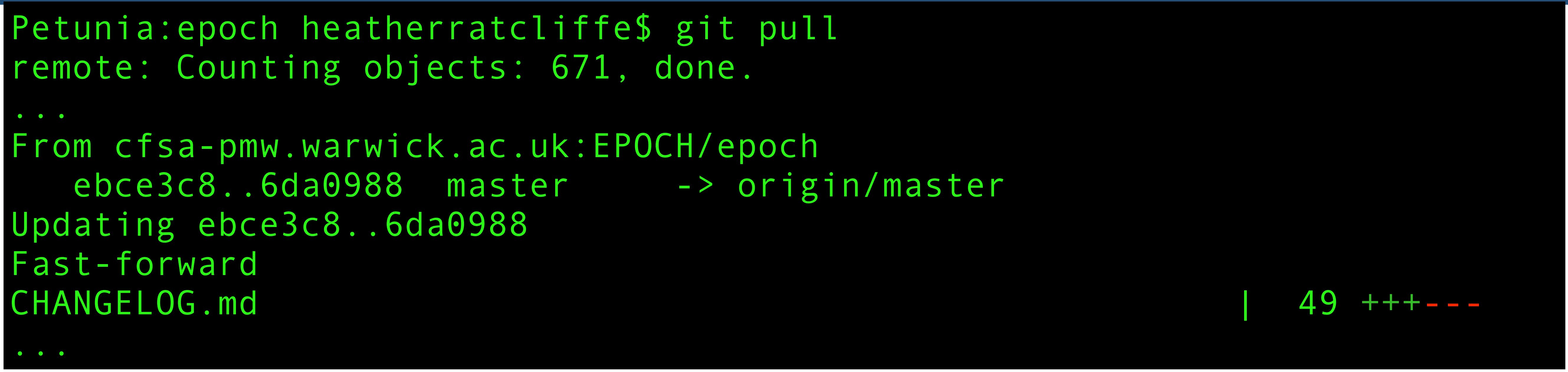
git branch -a



```
Petunia:epoch heatherratcliffe$ git branch -a
  4.14-devel
  auto_compiler
  heather/experimental_accumulators
* master
  remotes/origin/4.12-devel
  remotes/origin/4.14-devel
  remotes/origin/HEAD -> origin/master
```

- Running “git branch -a” also tells you about remote branches
- Once again, there exists a “master” branch, which is now a local reference to “remotes/origin/master”
- You do not by default have copies of all of those remote branches
- You get them using “git checkout -b”

git pull



```
Petunia:epoch heatherratcliffe$ git pull
remote: Counting objects: 671, done.
...
From cfsa-pmw.warwick.ac.uk:EPOCH/epoch
   ebce3c8..6da0988  master     -> origin/master
Updating ebce3c8..6da0988
Fast-forward
CHANGELOG.md                                                  |  49 +++---
...
```

- If you have a copy of a repository that is less recent than the version on the remote server you can update it using "git pull"
- This can happen
  - Because you've changed the code on another machine
  - Another developer has updated the server version
  - Git doesn't care
- Pull is a per branch property. You are pulling the specific branch that you are on

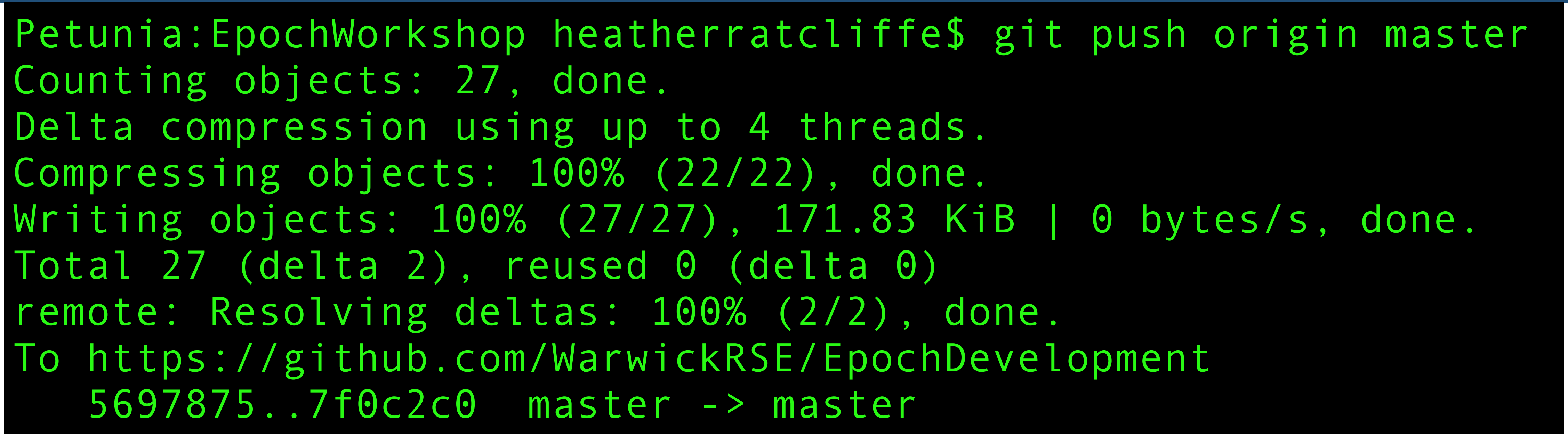
git pull

- Behind the scenes, "git pull" is a combination of
  - "git fetch" - pull data from remote server
  - "git merge" - merge the changes in that data
- All of the problems that can happen in a merge
- Added difficulty that now can be changes due to other developers

git push

- The opposite of pull
  - Pushes your changes to a code to the remote server
  - Will not generally work unless git can automatically merge those changes with the version on the server
    - "git pull" then "git push"
- Be careful! If not your repository people might not like you doing it
  - Shouldn't be able to if you shouldn't
  - For instance, can't push to the gitlab master or devel branch

git push



```
Petunia:EpochWorkshop heatherratcliffe$ git push origin master
Counting objects: 27, done.
Delta compression using up to 4 threads.
Compressing objects: 100% (22/22), done.
Writing objects: 100% (27/27), 171.83 KiB | 0 bytes/s, done.
Total 27 (delta 2), reused 0 (delta 0)
remote: Resolving deltas: 100% (2/2), done.
To https://github.com/WarwickRSE/EpochDevelopment
   5697875..7f0c2c0  master -> master
```

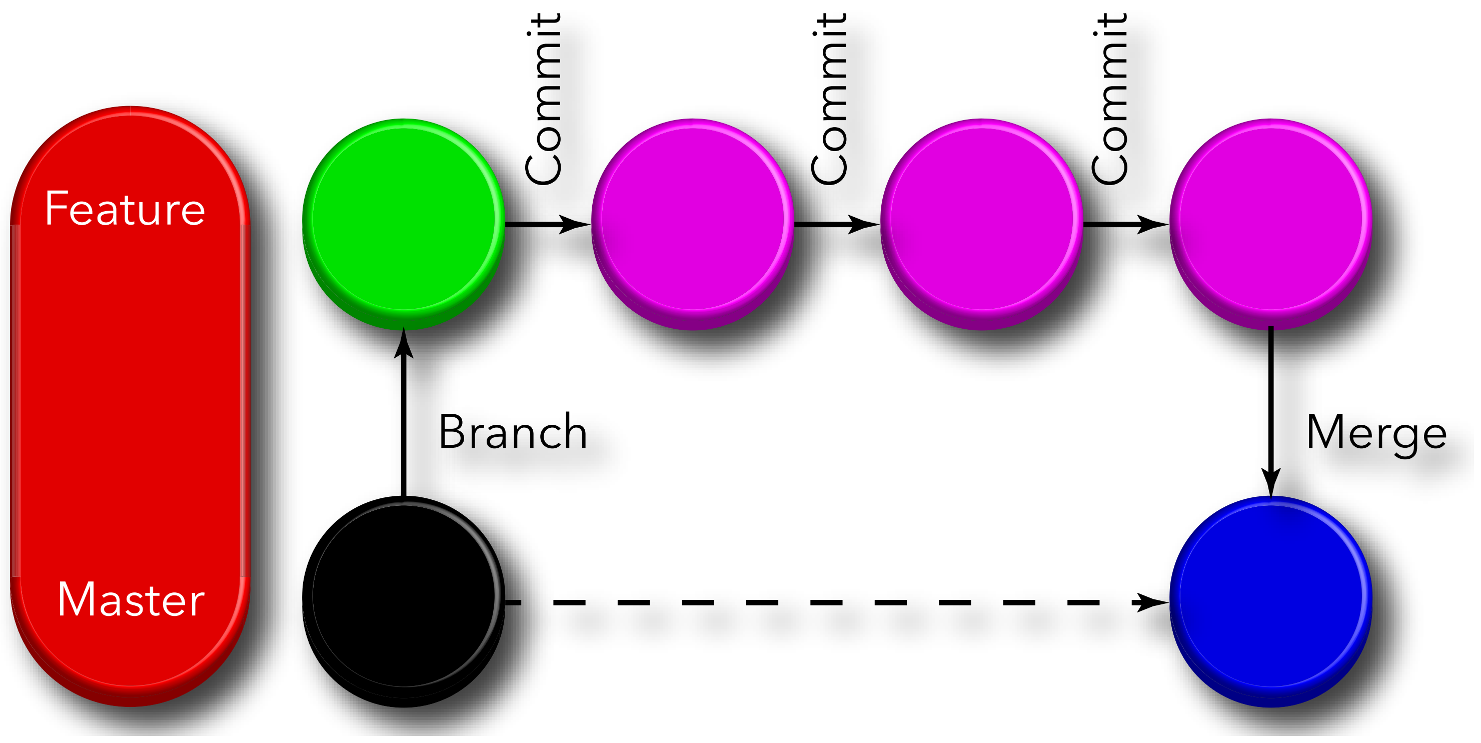
- If it works, should see something like that
- Push can be a much more complicated command if you want to push different local branches or the name of the local branch and the remote branch are different
- Read the documentation

Forking

- Important when using remote servers collaboratively
- Epoch uses mostly uses a simple flow model with branches and merge requests for small contributions but can also *fork*
  - Make a copy of it that you control
  - You control access too
    - Use this for personal versions that you don't want to share
    - Features etc can be merged back into core repository
- Use the "fork" button on Epoch project main page https://cfsa-pmw.warwick.ac.uk/EPOCH/epoch

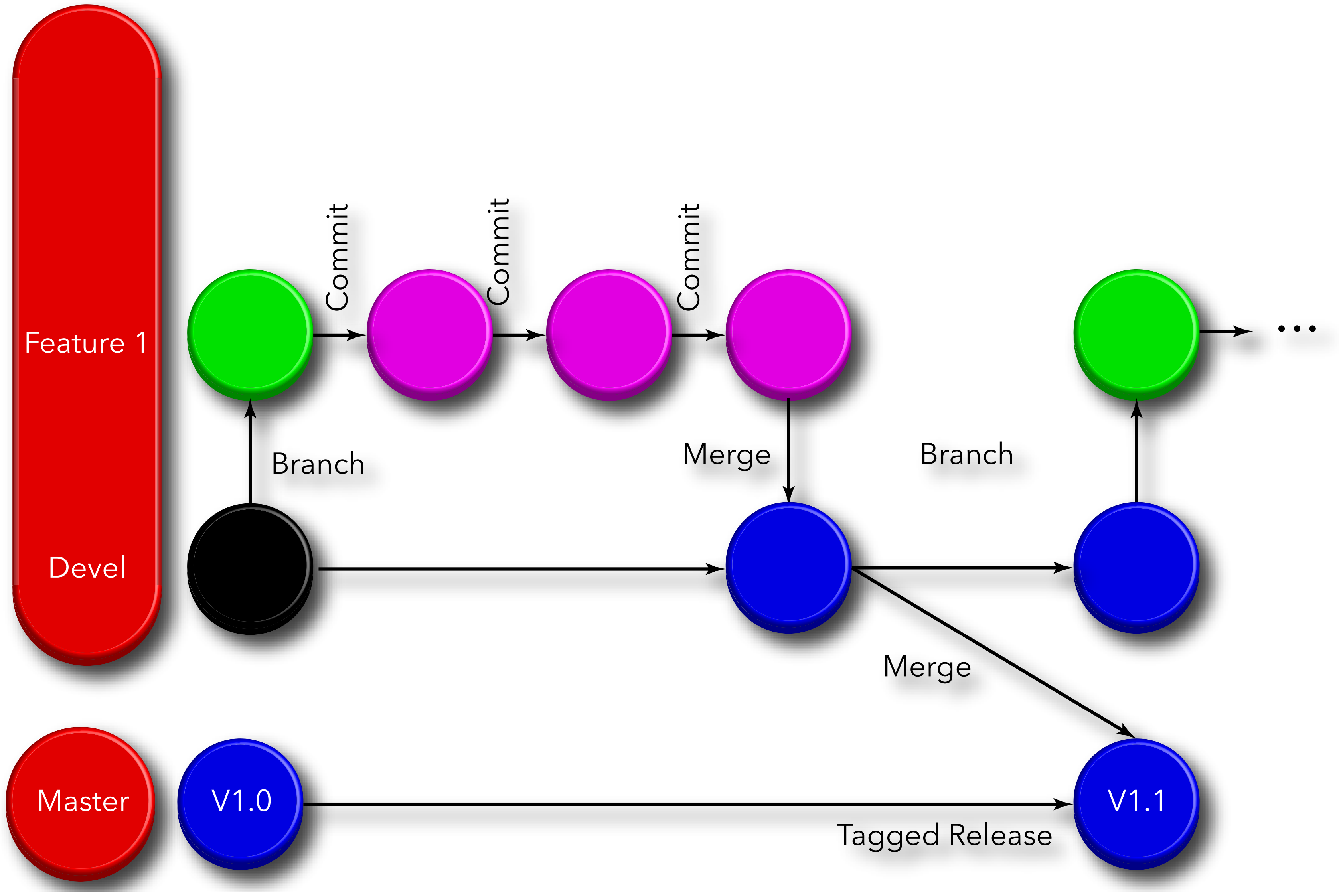
Flow Models

- Simplest robust ``flow'' model for git is:
  - Master is always in a working state
  - All work is on ``feature branches'', merge when done
  - Single developer so just one feature at a time



Flow Models

- EPOCH adds a “devel” branch and periodic “releases”
  - Features merge to devel; when ready and documented merge devel onto master, add version number and prepare docs



Flow Models

- EPOCH adds a "devel" branch and periodic "releases"
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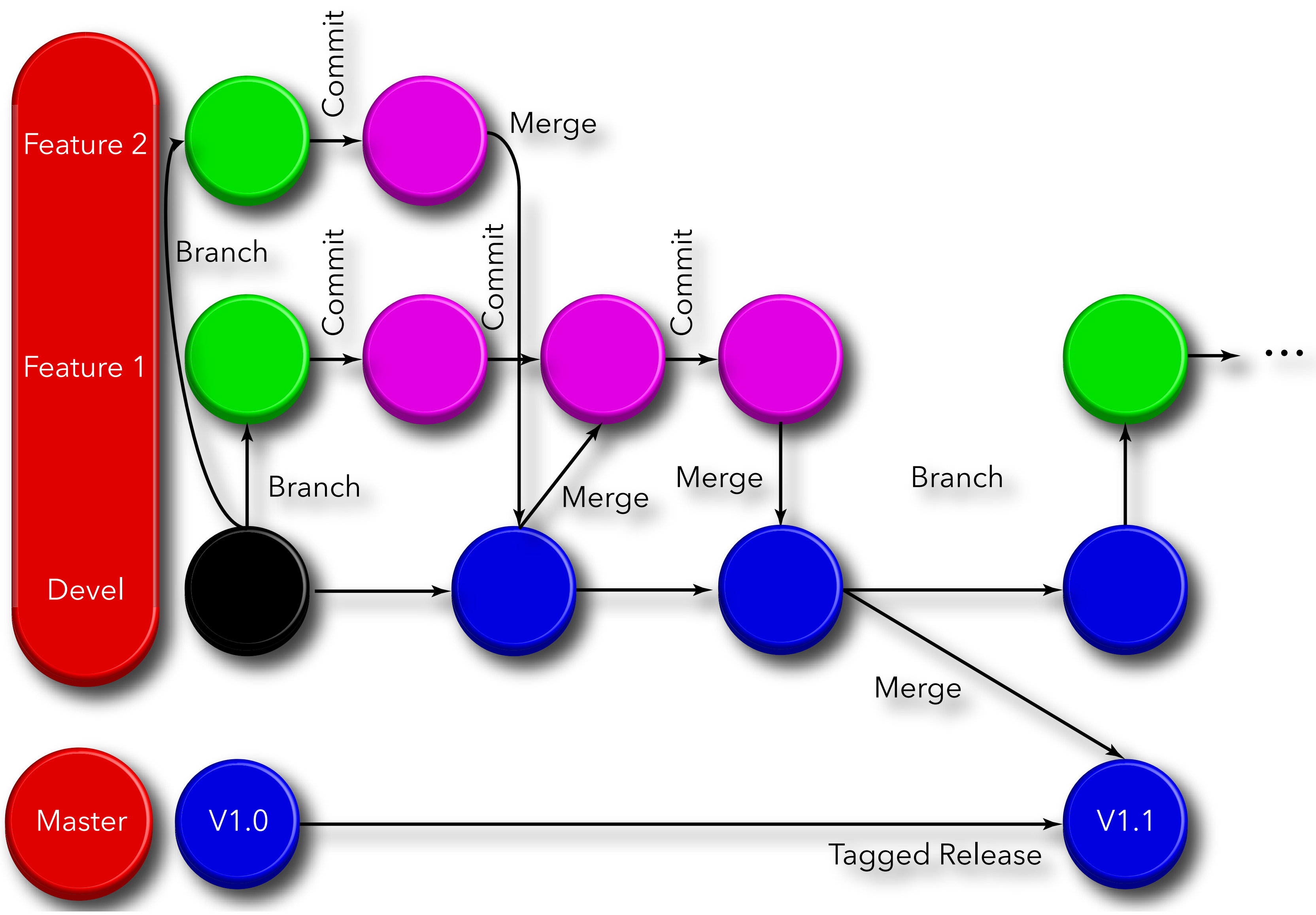

Merge requests

- To contribute code:
  - From a branch
    - Push the branch to gitlab, named something like <myname>/<featurename> and create a merge request against devel
  - From a forked copy
    - Almost the same, but make sure to give access to your fork to the epoch dev team first
    - Create a new merge request, selecting your personal fork as the “Source” branch and the main EPOCH devel branch as the “Target”

Submodules

- EPOCH shares its IO code with several other Warwick codes
- SDF is a ***submodule***
  - Has it’s own standalone repository
  - Can be included in other projects
    - These then recursively clone the submodules
  - Actually… SDF has submodules inside it for C, FORTRAN etc
- If contributing to SDF, this must be done against the main repository - don’t work on the module within EPOCH

Submodules

- Mostly don’t need to know much about submodules
- Most important command -
  - `git submodule update --recursive`
  - Use this whenever `git status` shows changes to SDF
- If you edit inside SDF might also have to `reset` in SDF and whichever subdirectory was changed before this

Part 4 - Git Merging

Merging

- In theory, git will help you merge two sets of code changes together
- If changes are in different files this works well
- If they're in the same file but don't interleave much, it works pretty well
- If they're intermixed it can be OK
- If they touch the same code lines, it can go …

  "badly"

Merge Failures

- Two sorts of merge “failure”
- The OK sort is when git recognises it can’t merge changes and makes you do it
- The bad sort is when it tries anyway

Merge Failures - type 1

If you get something like

```
Auto-merging eg.f90
CONFLICT (content): Merge conflict in eg.f90
Automatic merge failed; fix conflicts and then commit the result.
```

then you have to open up eg.f90 and look for merge indicators

```
<<<<<<< HEAD
  ELSE IF (first_char == 'e') THEN
    PRINT*, ‘E'
    convert = 5
=======
  ELSE IF (first_char == 'd') THEN
    PRINT*, ‘D'
    convert = 4
>>>>>>> feature
```

Merge Failures - type 2

This sort of failure you probably wont notice until the code wont compile. There's an example of this in the exercises.

ALWAYS compile and CHECK after a merge. And read the code - does it look correct? Is anything missing? Does the logic still work?