Version Control And Git

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Useful Links

As well as using material from courses I have taught, this talk also borrows from a number of very good sources that go in to much greater detail about git and how to use it:

- Software Carpentry Course:

  http://swcarpentry.github.io/git-novice
- Matthew Brett's 'Curious Coders Guide to Git' Page:

  https://matthew-brett.github.io/curious-git
- Git homepage:

  https://git-scm.com/

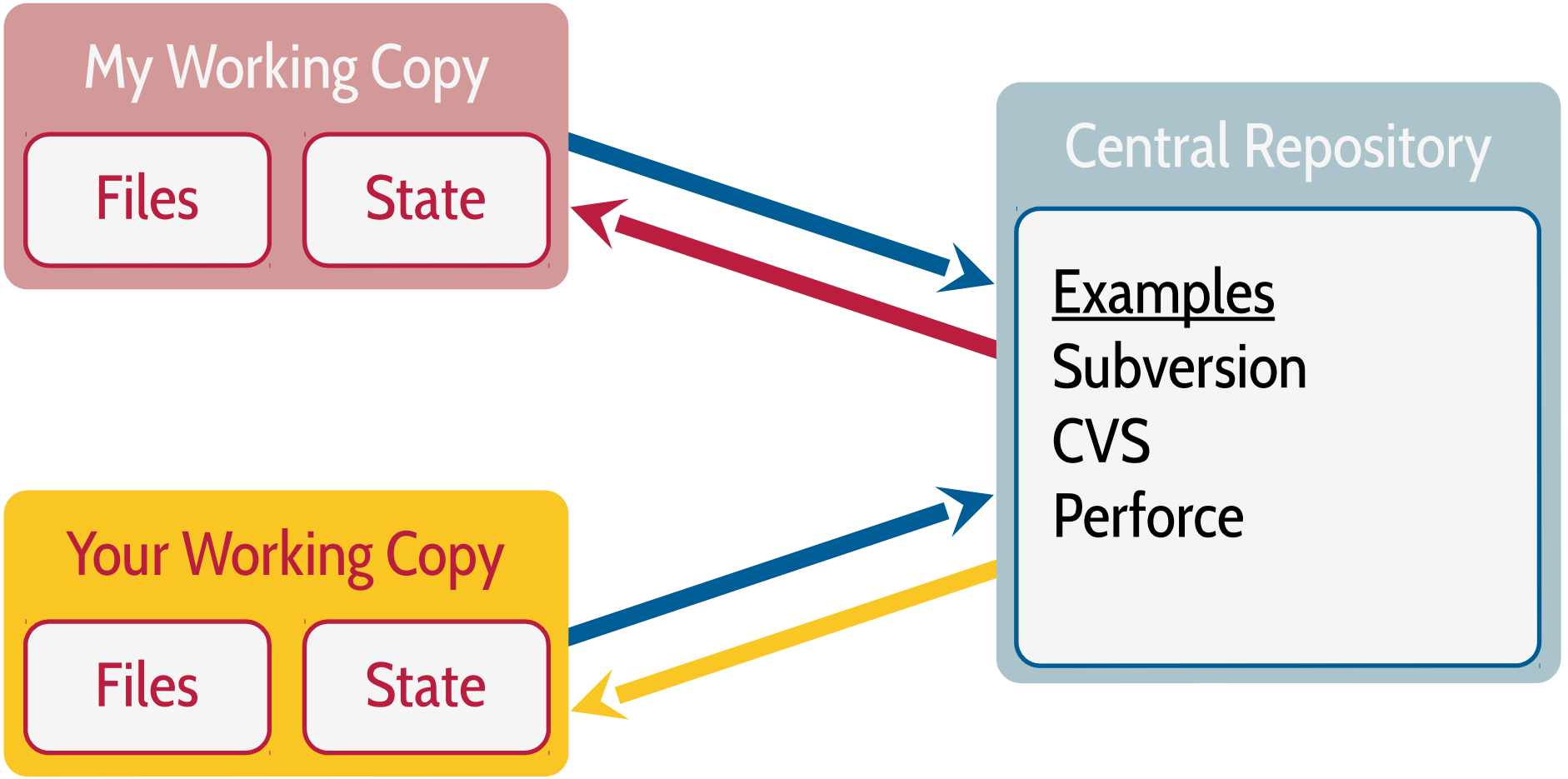
Why do we need Version Control?

- Recording changes
  - ➔ Being able to record every precise change in a (text) document and record the reasons for that change
- Providing 'backups'
  - ➔ Allowing an easy 'undo' option in case of editing errors
- Reproducibility:
  - ➔ Being able to return to a previous version of a project and know it's exactly as it was when it was originally created
- Collaboration:
  - ➔ By keeping track of the versions of files, it is a lot easier for groups to work on the same project

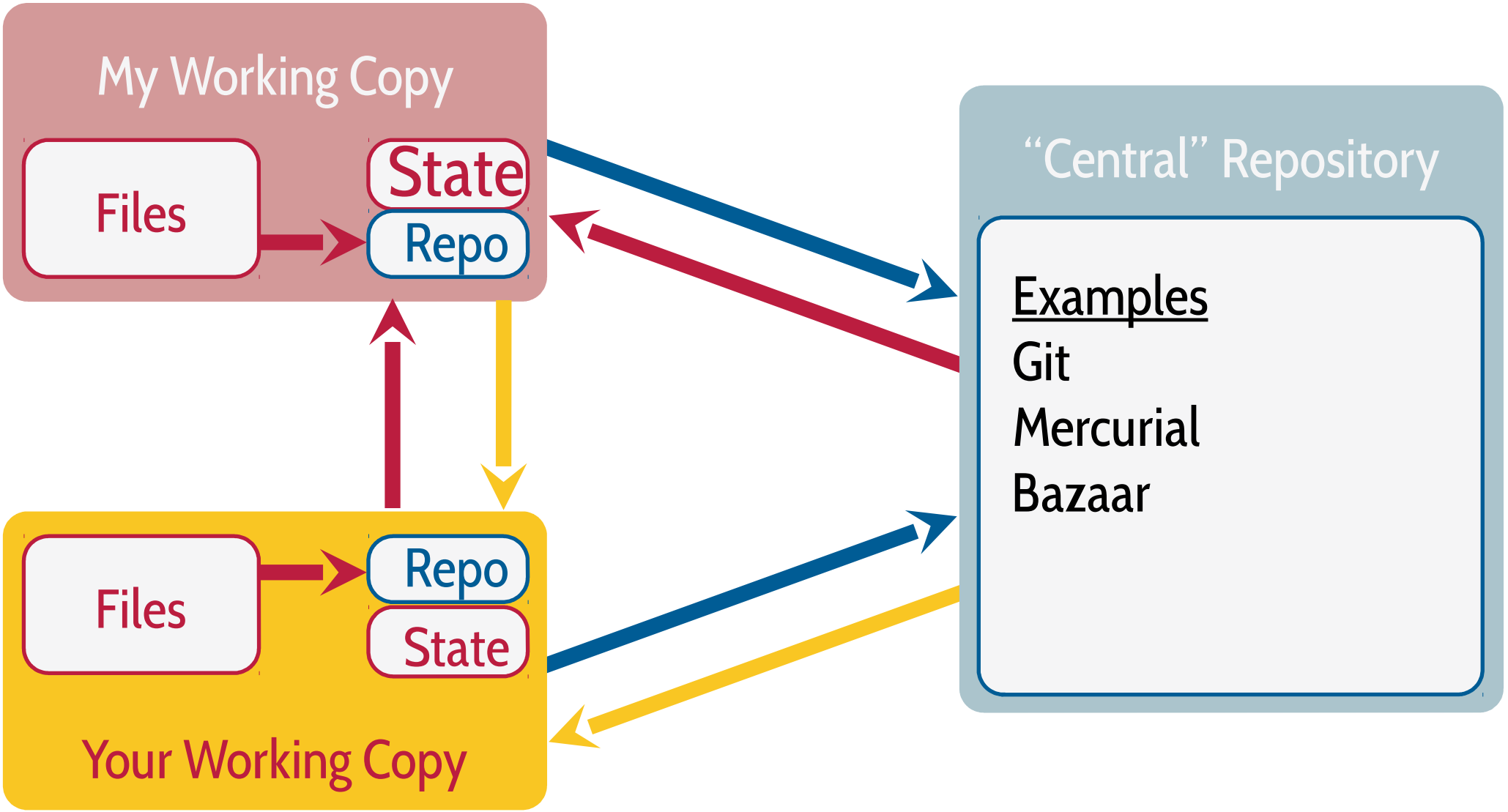
Version Control in Code Development

- The general points in the previous slide can be applied to any files in a project, e.g. bid documents, teaching materials, etc.
- However, where Version Control becomes (arguably) essential is in code development
- Keeping track of changes in code on any significant sized project is very important to:
  - → Tag releases of code
  - → Compare versions of a code base
  - → Identify where bugs have been introduced
  - → Allow parallel and collaborative code development
  - → Etc., etc.

Aside: Centralised Version Control

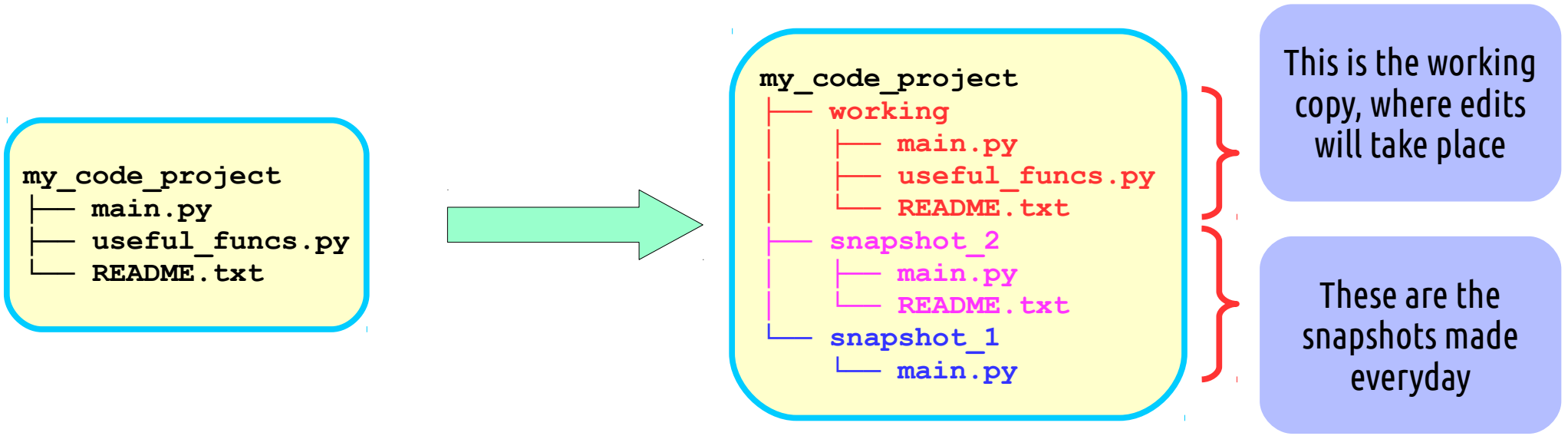


Aside: Distributed Version Control



Developing a VCS: Saving a Copy Everyday

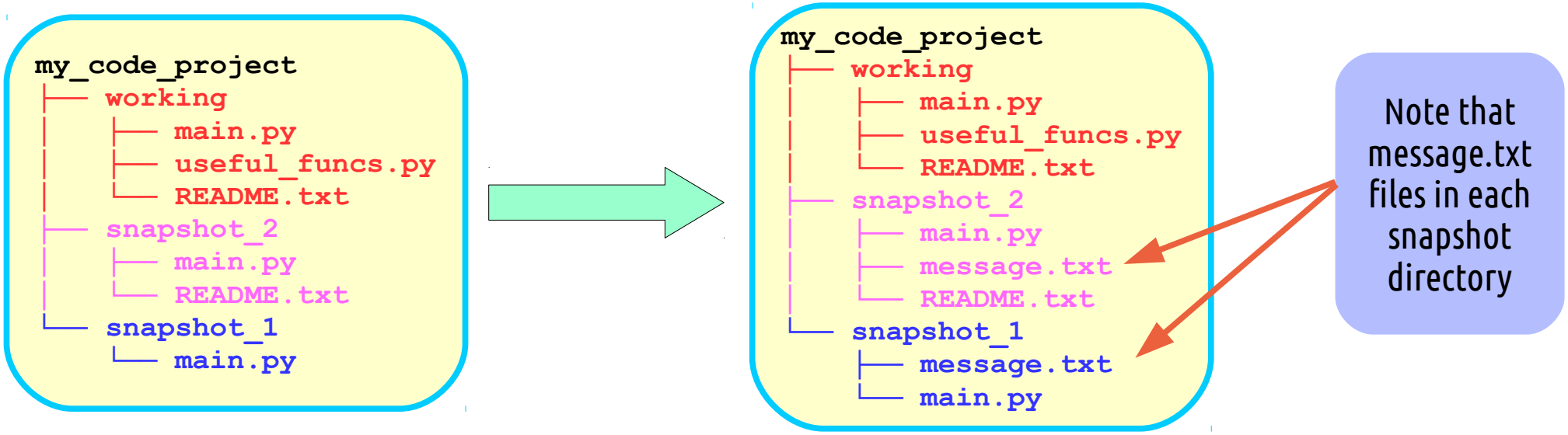
- To try to help explain what Git does, let's go through the steps of essentially coming up with our own VCS
- The most simple VCS is essentially just taking copies (or 'snapshots') of all the project's files and putting them in a separate directory



- This already ticks several of the boxes we wanted for VCS – reproducibility, backup, etc. and at it's core, this is all Git is doing!

Developing a VCS: What did I do again?

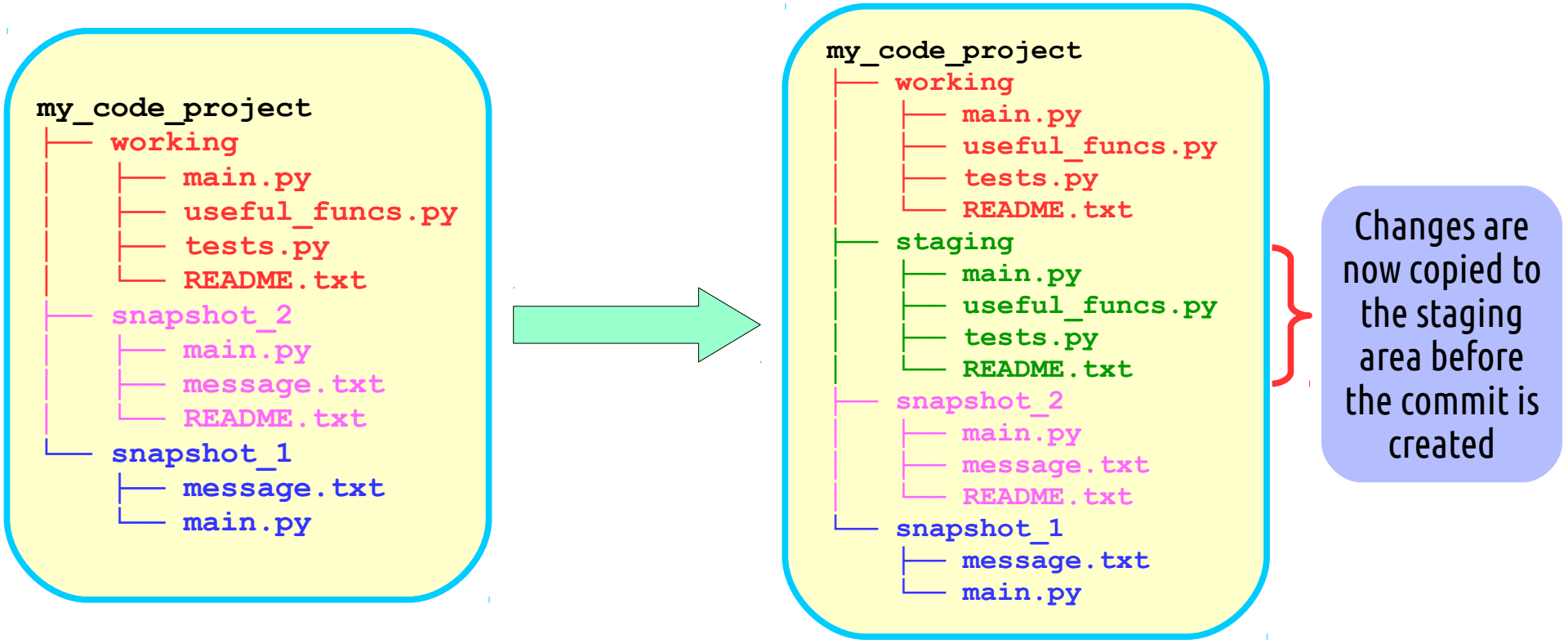
- A significant thing that isn't present when just copying a project's directory is knowing what you did and why
- To get around this, let's add a text file in each snapshot (let's call it a commit from now on) that includes a short message about what has changed since the last commit with the author and date/time info of the commit



- We now have a functional VCS! However, it's not very efficient and is a bit cumbersome to use.

Developing a VCS: One thing at a time

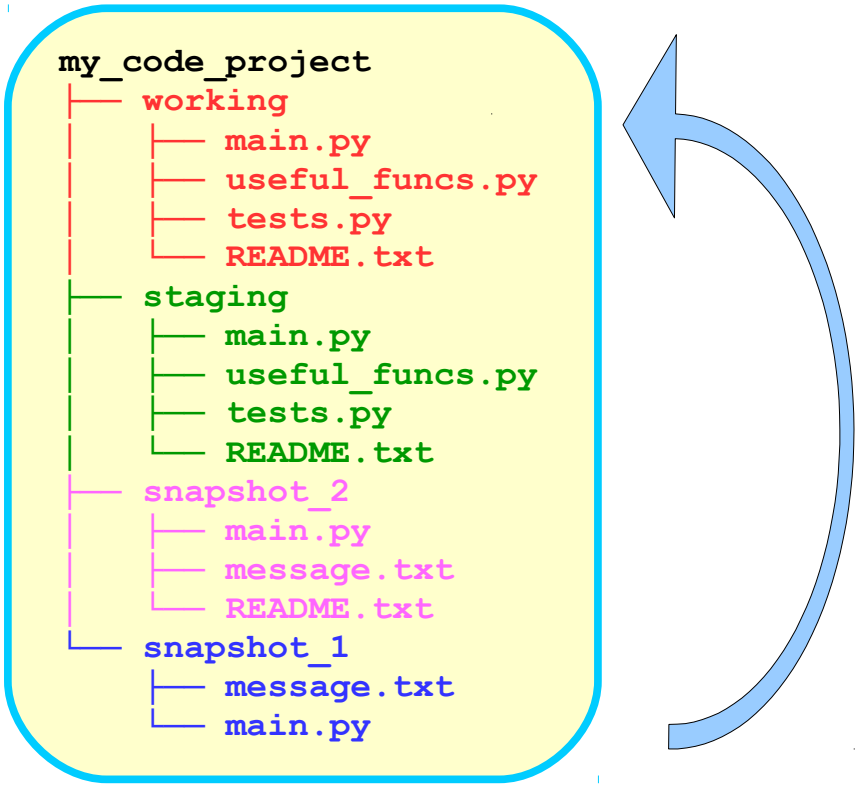
- At present, each commit is just a copy of the working directory every day, no matter what has been done
- But what if you get to the end of the day and have 2 or 3 completely different changes that should go in different commits? Have a staging area!



- You can now choose which changes to add to a particular commit before actually committing them

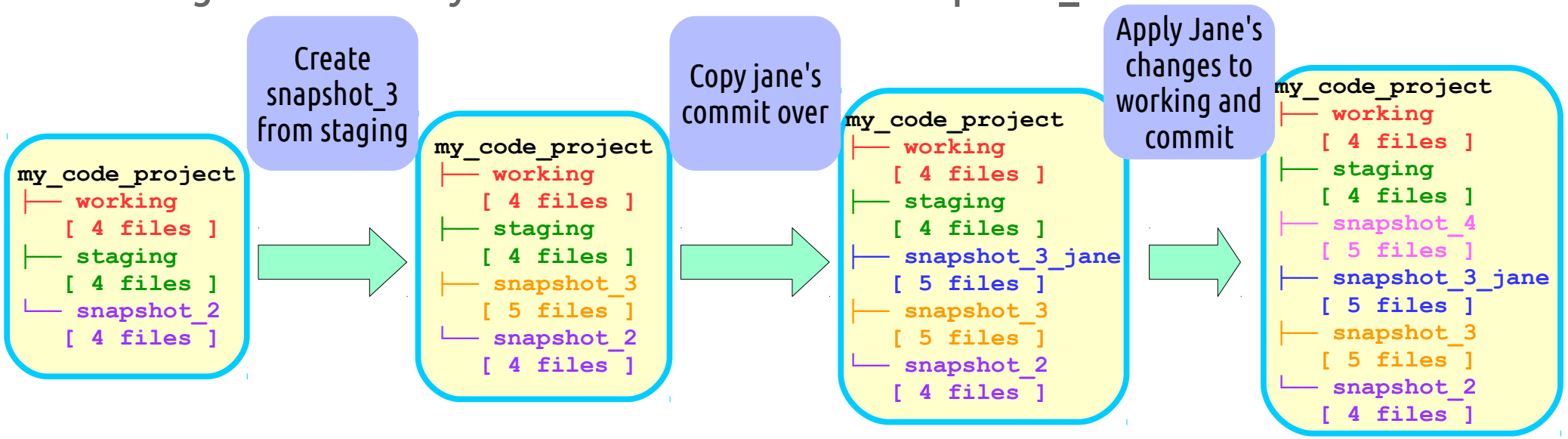
Developing a VCS: Oops - I caused massive breakage

- What happens if you find that 2 commits ago, you managed to break a crucial feature?
- What we need to do is copy the appropriate file from the appropriate commit to our working area ('checkout' the file) and then perform a commit



Developing a VCS: Playing nicely with Others

- Let's say you share your repository with someone ('Jane') and in parallel both develop a 'snapshot_3' commit – what happens?
- After committing your version, you copy Jane's commit directory and call it 'snapshot_3_jane'
- Then you can change your working version (i.e. 'snapshot_3'), apply Jane's changes and finally make the commit as 'snapshot_4'



- Because you are merging two sets of changes, this final commit is called a 'Merge Commit'

Developing a VCS: Making a right hash of things

- As you can probably tell, the names for commits are not scalable so a new naming convention is needed
- Hashing is a very good way to create unique names for things easily as:
  - It will produce an (almost) unique fixed length string for any input
  - Small variations in the data will produce very different hashes
  - It is computationally very quick
- So can we use the only unique file in each commit ('message.txt') to generate a hash and use that as the directory name for the commit?

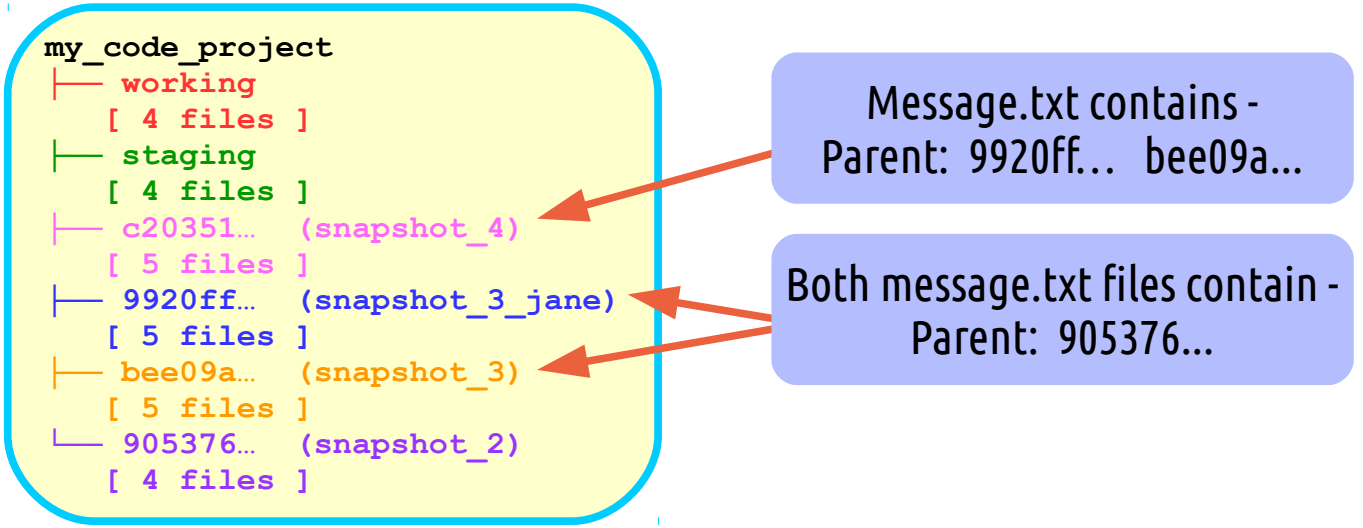
```
my_code_project
├── working
   [ 4 files ]
├── staging
   [ 4 files ]
├── 99b52473039acea4427e13e42b96c78776e2baf5 (snapshot_4)
   [ 5 files ]
├── d396475cc691c8ac7ba7a318726f220c924cf60b (snapshot_3_jane)
   [ 5 files ]
├── d9accd0a27c78b4333d70ee1a9d7dca0bcc3e682 (snapshot_3)
   [ 5 files ]
└── 00d03e9d1bf4ebaea380da3c62e9226189e39ff4 (snapshot_2)
   [ 4 files ]
```

Note that this is the source of all the strings of hexadecimal numbers you will deal with in git!

- In theory, yes, but now we don't know what order the commits were made in...

Developing a VCS: Linked in

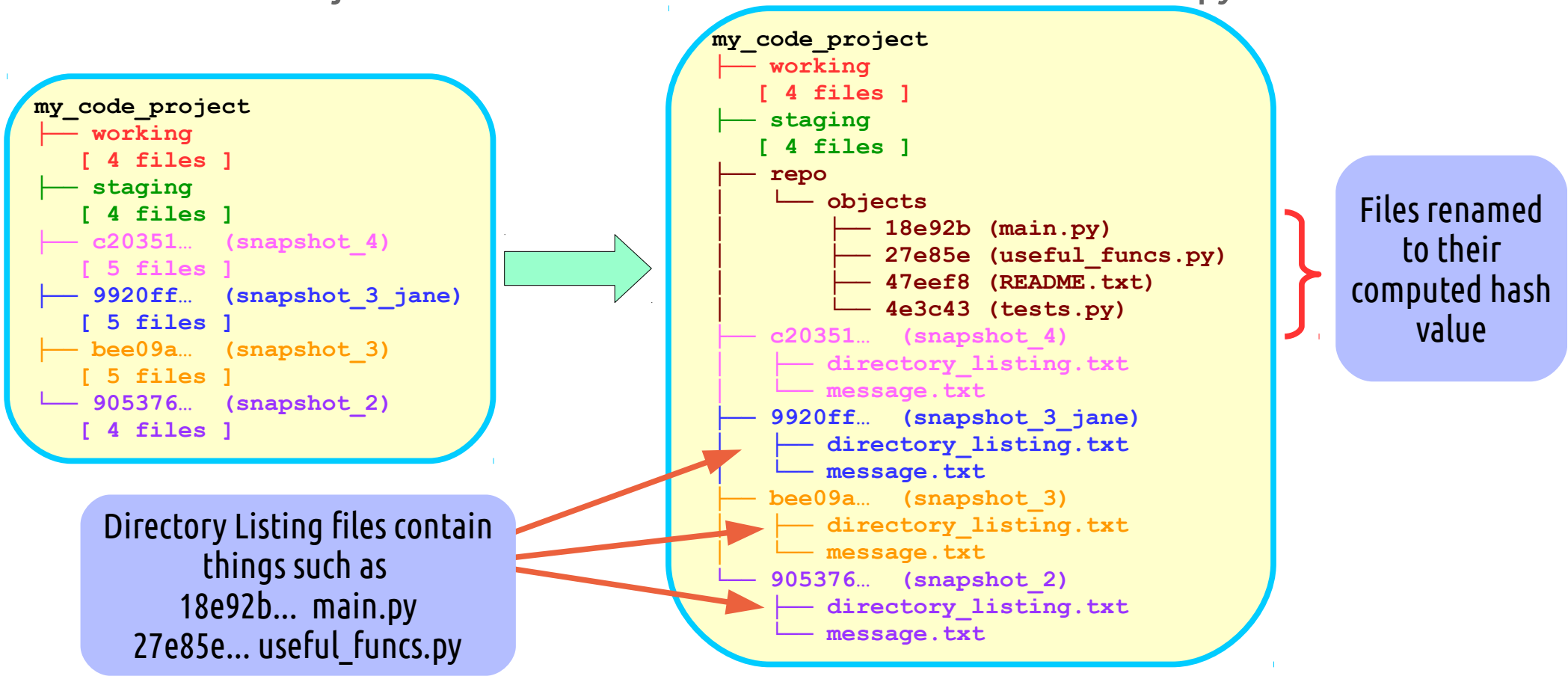
- In order to restore the history, we need each commit message to know what it's parent(s) was
- The hash of the parent can simply be added in a 'Parent' field in the commit message when committing
- You can then reconstruct the history of your project from these commit messages but you still get to use the hashed commit names



- Note that, because the message.txt has changed for each commit, the hash has also changed
- Also, I will start abbreviating the hashes as git does

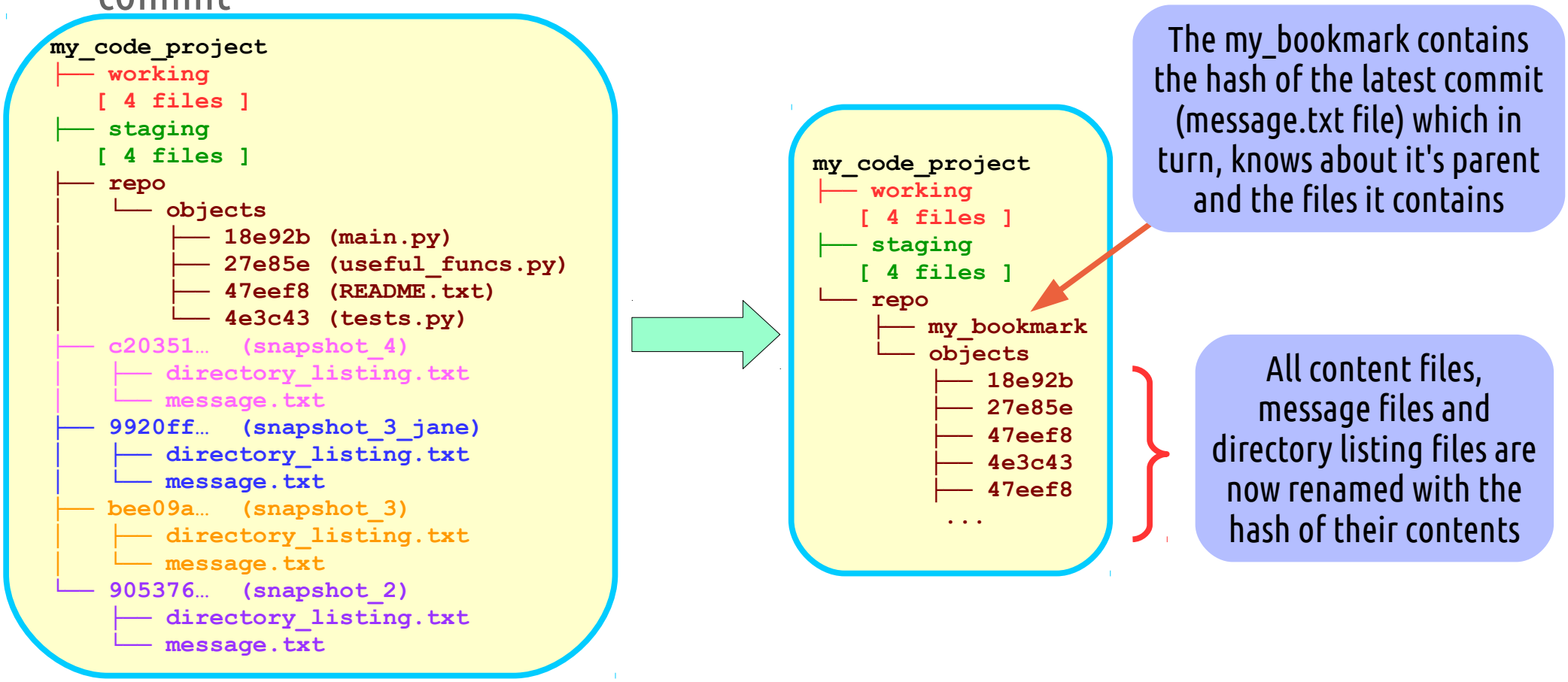
Developing a VCS: Making an even bigger hash of things

- As you make commits, your will notice you get a copy of every file – this means your project directory growing continually due to duplicates
- This is where hashes come in again – if you create a hash from the contents of a file during a commit and it is the same another one, these files are the same
- You can then just save a reference rather than an additional copy of the file



Developing a VCS: Cleaning up

- You can actually take the storing of hashed files even further by hashing the contents of 'message.txt' and 'directory_listing.txt' files and moving to the 'objects' directory as well
- You need to add a reference to the correct 'directory_listing.txt' file in an additional field to 'message.txt' and also an additional file to point to the last commit



Developing a VCS: What we've learned

- This is now a fairly close approximation to what git does
- Most importantly though, hopefully this will help you understand some of the terminology git uses and what it's trying to do:
  - Repository – The folder with all the files associated with the project and git are located
  - Index – What git calls the 'staging area'
  - Commit – creating a copy of the index, adding a message and updating the hash pointers
  - Hash – Used to create unique filenames based on the file contents
  - Branch – Refers to a particular development path, e.g. Jane's changes above
  - Remote – This is a remote copy of the repository that may have different commits to yours, e.g. Jane's copy of the directory
  - HEAD – the hash that points to the last commit of the current branch you're working on, used to compare the index with when committing.

Good Git Practise

- When working with git (and any VCS actually), there are few general rules:
  1. Only include source files
     - You shouldn't add anything that can be created from the source files (e.g. *.pyc, *.o, etc.)
  2. Write good commit messages
     - The commit messages can be long so don't just put 'made some changes'
  3. Commits should be related
     - Only include changes that are related in any one commit
  4. Keep commits small
     - Large changes in single commits con be confusing and difficult to solve conflicts
  5. Only commit completed work
     - Git isn't a backup system – only commit things that are complete and tested

Live Coding Demo (!)

Web Clients

- Git has several web based servers to provide a central repository for your project:
  - Github
  - Gitlab (See BEAR's version!)
  - Bitbucket
- They all allow similar functionality that extend that of git itself, notably with:
  - Issue Tracking
  - Release Tracking
  - Integrated Testing
  - Etc.

Graphical Clients

- In addition to the web options, there are also graphical clients that have all the git functionality but have a GUI
  - Github has it's own client
  - GitKraken
  - Git-gui
  - SourceTree

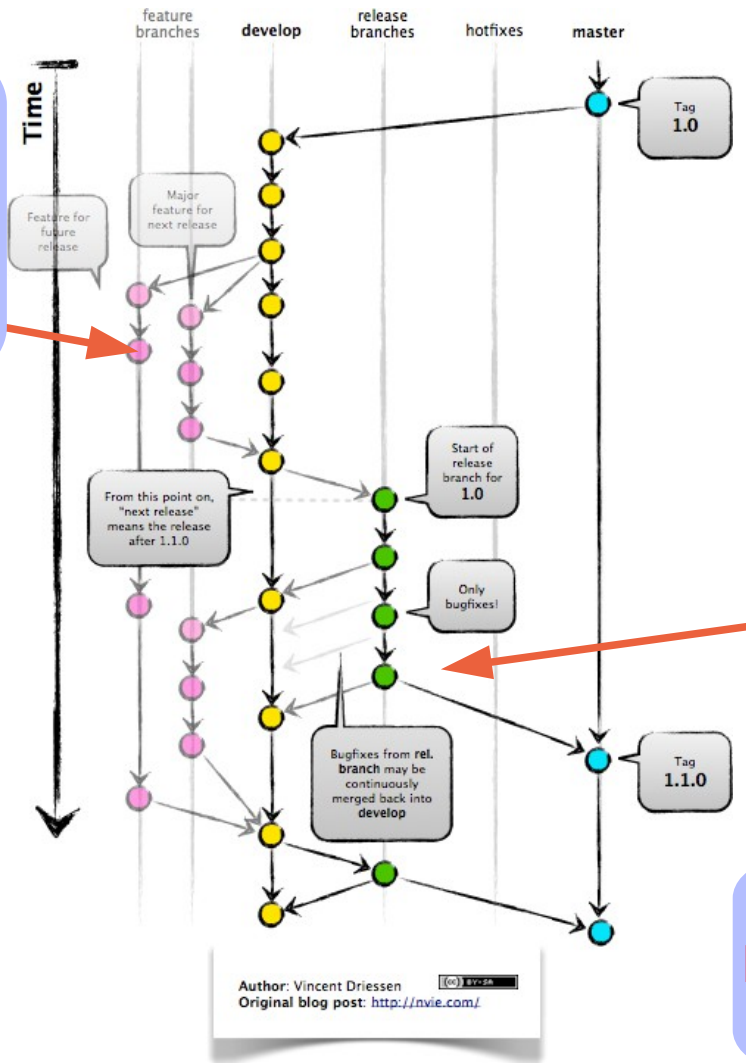
Going Further (1)

- Forking
  - This is associated with the web clients and is similar to a 'git clone'
  - It allows you to make a clone of a repo into your account to enable you to work on it
  - You can then request your changes be merged from your fork with a 'Pull Request'
- Tagging
  - If you hit a point that you want to make a 'release' or take a named 'snapshot', you can use tagging
  - All this does is create a pointer to a specific commit that you can refer to later

Going Further (2)

- Using branches
  - The way git handles branches is one of it's main selling points and it's encouraged to use them in development. Gitflow is a typical model:

ALL features developed in their own separate branches and merged to develop when complete



3 Main branches:
Master – Just contains releases
Develop – feature branches are added
Release – release candidates tested

Only when a release candidate has passed all tests, it gets tagged on the master branch any bugfixes added back in to develop

For more info:
https://datasift.github.io/gitflow/IntroducingGitFlow.html

Summary

Hopefully that has demystified some of what git is, does and how it works if you haven't used it before. For more info, do please have a loot at:

- Software Carpentry Course:

  http://swcarpentry.github.io/git-novice
- Matthew Brett's 'Curious Coders Guide to Git' Page:

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