Working with Git

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2011

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1 Working with Git

This document provides a simple introduction to working with git. Git is a distributed source code management (SCM) system. Although this is a source code management system, you can use it for **any** type of documents that you want to version control and / or work on collaboratively with others.

If you are familiar with SVN, Git is quite similar but adds some new concepts. In particular, Git is distributed, which means there doesnt have to be one single repository that you work against. Git also is ideal for offline work where you still want to do version control. We will explore this more as we go on.

1.1 Installation

Installing Git is easy. Under linux, install like this:

Listing

```
sudo apt-get install git meld gitg
```

The latter two are not actually needed but will prove useful later.

Under windows you can use msysgit - notes on using msys git are provided further down in this document.

1.2 Quick Start

I would like to plunge in with a quick start to using git and then come back to a more systematic coverage of the tool. The idea is to get you familiar with the concepts in the following diagram:

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Working with a local repository
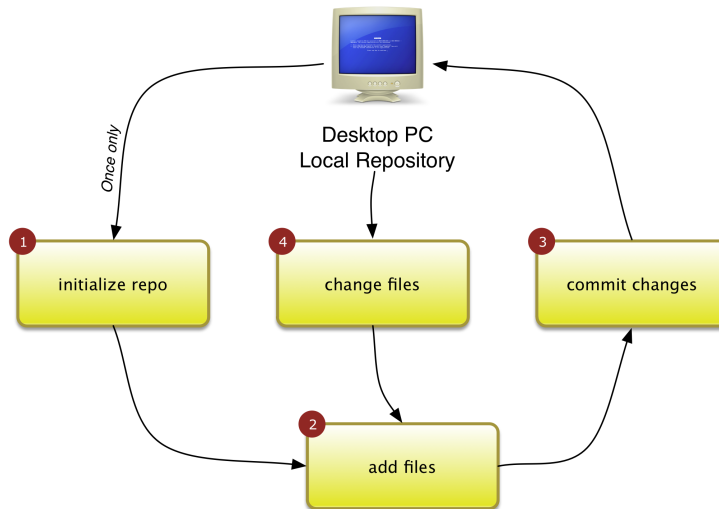
1.2.1 Create a local repository

We start off by creating a local repository. A local repository resides on your own hard dist (its just a directory with some special hidden files in it), and allows you to do all normal SCM activities - check out code, make changes, commit, review your history and so on. We will just make a new directory and initialise it as a git repository:

Listing

```
cd dev
mkdir git-sandbox
cd git-sandbox
git init
```

Ok now we have a repository, lets do some work in it.

1.2.2 Adding a file to the repository

To version any files in the repository, you just need to copy them into your directory (in our example it is called git-sandbox) or create them. Let's create a file called README:

Listing

```
gedit README
```

or

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```
vim README
```

Now we will write a little text to the file:

```
Hello world from my sandbox
```

Then save and close the file. We can use the git *status* command to see the status of our repository:

```
git status
```

Which will return something like this:

```
# On branch master
#
# Initial commit
#
# Untracked files:
#   (use "git add <file>..." to include in what will be committed)
#
#       README
nothing added to commit but untracked files present (use "git add" to track)
```

It tells us that we have one untracked file - the README file we just created. So how do we start tracking the file?

```
git add README
```

Now *git status* will show the file as tracked:

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

Ok, now you can commit your file:

```
git commit -m "First version of README"
```

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```
[master (root-commit) 7ea07e1] First version of README
 1 files changed, 1 insertions(+), 0 deletions(-)
 create mode 100644 README
```

The *-m* option is used to specify the commit message. If you don't provide a *-m* option, git will prompt you for a message using a simple text editor. Once the file is committed, your repository will have a nice clean status:

Listing

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

Let's make a small change to the README file:

Listing

```
Hello world from my sandbox - I'm using Git!
```

Git status will show that the file is now modified:

Listing

```
# On branch master
# Changed but not updated:
#   (use "git add <file>..." to update what will be committed)
#   (use "git checkout -- <file>..." to discard changes in working directory)
#
#       modified:   README
#
no changes added to commit (use "git add" and/or "git commit -a")
```

This change is **unstaged** - it wont be included in your next commit unless you add it.

Listing

```
git add README
```

Now its status is set to **staged** - it will be included in the next commit you make.

Listing

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

Finally you can commit your change using the commit command again:

Listing

```
git commit -m "Improved the README"
[master 983f6fd] Improved the README
```

```
1 files changed, 1 insertions(+), 1 deletions(-)
```

Did you notice that odd looking number in the output? 983f6fd is shortened version
of the unique SHA-1 hash assigned to that commit. Each commit you make will be
assigned such an identifier. The commit numbers are not sequential numbers like SVN
has. The reason for this is that the commits need to be globally unique in a distributed
repository environment (which we will explore later).

We will finish off our quick start tour by running a few interesting commands on our
repository:

Listing

```
git log README
commit 983f6fda163c09094ef6939b7d4db4af1bfa8c3c
Author: Tim Sutton <tim@linfiniti.com>
Date:   Mon May 9 23:04:08 2011 +0200

    Improved the README

commit 7ea07e1d1e029510a258efebc8cc170cb685803c
Author: Tim Sutton <tim@linfiniti.com>
Date:   Mon May 9 16:35:37 2011 +0200

    First version of README
```

The *git log* command shows you the history of commits made for a file (most recent
changes are shown above older changes). You can see we have made two commits to this
file, and the message associated with each commit.

Finally, lets look at the difference between these two commits:

Listing

```
git diff 7ea07e1 983f6 README
diff --git a/README b/README
index 2d564aa..d85ea56 100644
--- a/README
+++ b/README
@@ -1 +1 @@
-Hello from my sandbox
+Hello from my sandbox - I'm using Git!
```

You can see the two options I passed to the diff command are shortened versions of the
SHA-1 hashes assigned to each commit. You can also see that the text in my README
file was augmented with the phrase "I'm using Git!".

Hopefully this quick look at git has given you the basic concept. In the sections that
follow we will explore with more detail some of the other things you can do with Git.

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1.3 Git Workflows

In this section we are going to walk you through various scenarios to show you how git can be used effectively.

1.3.1 Repository Clones

You can create your repository in one of two ways:

1. Initialise a new one

2. Clone an existing one

We already created our own repository using the 'quick start' section above. Let us see how you can clone the repository we made earlier (we will assume that you are still in the **git-sandbox** directory at this time):

Listing

```
cd ..
git clone git-sandbox git-sandbox-clone
```

You should see a message like this:

Listing

```
Initialized empty Git repository in /tmp/git-sandbox-clone/.git/
```

Now if we enter the cloned repository, we can work in it just like we worked in the original directory. Lets run that *git log* command again:

Listing

```
[git-sandbox-clone] git log
commit 983f6fda163c09094ef6939b7d4db4af1bfa8c3c
Author: Tim Sutton <tim@linfiniti.com>
Date:   Mon May 9 23:04:08 2011 +0200

    Improved the README

commit 7ea07e1d1e029510a258efebc8cc170cb685803c
Author: Tim Sutton <tim@linfiniti.com>
Date:   Mon May 9 16:35:37 2011 +0200

    First version of README
```

You can see our clone has exactly the same commit history as the original repository has - it is an exact clone of the original. Let's make another change to our README file and commit it. I'm going to add this line:

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And then *git add* and *git commit* my changes:

```
git add README
git commit -m "Added a line while in my cloned repo"
```

Which produces output like this:

```
[master 218dfa8] Added a line while in my cloned repo
 1 files changed, 1 insertions(+), 0 deletions(-)
```

Now run the *git log* command again and look at the output:

```
[git-sandbox-clone] git log README
commit 218dfa8474c3213b1a77973df8739ed75120bde5
Author: Tim Sutton <tim@linfiniti.com>
Date:   Mon May 9 23:31:21 2011 +0200

 Added a line while in my cloned repo

commit 983f6fda163c09094ef6939b7d4db4af1bfa8c3c
Author: Tim Sutton <tim@linfiniti.com>
Date:   Mon May 9 23:04:08 2011 +0200

 Improved the README

commit 7ea07e1d1e029510a258efebc8cc170cb685803c
Author: Tim Sutton <tim@linfiniti.com>
Date:   Mon May 9 16:35:37 2011 +0200

 First version of README
```

Well done - you cloned the repository and make a change in your local copy.

== Git conflicts =

Lets go back to our original repository and update the readme file with a new change:

```
cd ../git-sandbox
gedit README
```

And add this line:

```
This is a change in the original.
```

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Now commit your changes and return to the clone directory:

```
[git-sandbox] git add README
git commit -m "A new update from the original repo"
cd ../git-sandbox-clone
```

Now we will merge any changes made in the original repo into our clone:

```
[git-sandbox-clone] git pull
Auto-merging README
CONFLICT (content): Merge conflict in README
Automatic merge failed; fix conflicts and then commit the result.
```

What happened? Git pulled in the changes made in the original repo, but detected that the same line had been changed in both the original repo and the clone, so it doesn't know how to combine them. We can help git to resolve the issues by running *git mergetool*.

```
[git-sandbox-clone] git mergetool
merge tool candidates: meld opendiff kdiff3 tkdiff xxdiff tortoisemerge
        gvimdiff diffuse ecmerge p4merge araxis vimdiff emerge
Merging the files: README

Normal merge conflict for 'README':
  {local}: modified
    {remote}: modified
    Hit return to start merge resolution tool (meld):
```

When you press enter a graphical user interface will appear (if you are on linux) which looks something like this.:
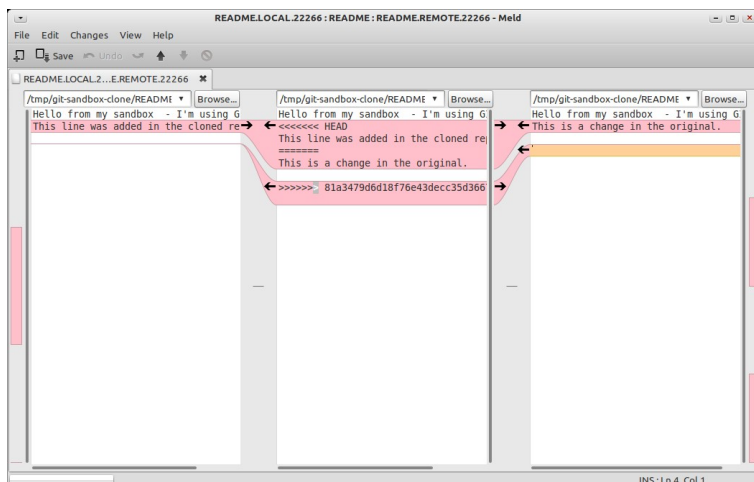
The merge tool shows a side by side view of the version or README in your local repository (clone) and the version of README. Alternatively you can simply open the README in a text editor and resolve the differences. Here is another example of where a merge conflict occurs (before resolving):

Listing

```
Hello from my sandbox  - I'm using Git!
This is a change in the original.
<<<<<<< HEAD
Local Change
=======
Yet another change
>>>>>>> 1386adb6b1b6131d64d18f2bffa877a6687b0073
```

And then after editing the conflicted file it might look like this:

Listing

```
Hello from my sandbox  - I'm using Git!
This is a change in the original.
Local Change
Yet another change
```

Once you have created the final version, you need to commit to indicate to Git that the conflict has been resolved. Doing a *git status* will show you what needs to be committed:

Listing

```
[git-sandbox-clone] git status
# On branch master
# Your branch and 'origin/master' have diverged,
# and have 1 and 1 different commit(s) each, respectively.
#
# Unmerged paths:
#   (use "git add/rm <file>..." as appropriate to mark resolution)
#
#   both modified:      README
#
# Untracked files:
#   (use "git add <file>..." to include in what will be committed)
#
#   README.orig
no changes added to commit (use "git add" and/or "git commit -a")
```

So to finalise the conflict resolution, we can commit our change:

Listing

```
[git-sandbox-clone] git add README
[git-sandbox-clone] git commit -m "Resolved merge conflicts on README"
[master ed30a38] Resolved merge conflicts on README
```

Sidebar: We learnt something else new in this section: When we have a clone of repository, you can synchronise it with the changes in the original repository by doing *git pull*. In our simple sandbox example, the two repositories are just two directories in the same file system, though Git supports synchronising repositories over a network connection too, which is commonly how it is used.

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1.4 Git Topologies

Git is a distributed versioning system. That means there doesnt't have to be one single source for the repository. You can define the topology for your project in a way that is most convenient to you.

1.4.1 Central Repository

If you work in a small team, you may adopt a centralised repository model, similar to SVN. Actually it is a bit of a misnomer, since each client who checks out the repo obtains a copy (with all its version history) on their local machine. This is unlike SVN where you check out only a **snapshot** of the current state of the code. In SVN, any time you want to refer back to an older commit, you need to query the central repository over the network. In Git you have a full copy of the repository stored locally so that network connection is not required. Similarly, with SVN, if you want to commit a change, you need to have a network connection to the repository. Under Git however you commit to your local repository first and then push your changes up to the central repository when you have a connection available. This makes git great for working away from the office, on the plane etc. You just work as per normal and when you get connected to the internet again, you simply sync (push) your local changes too the *origin* repository.

Sidebar: One huge advantage of Git is that you inherantly have a full historised backup for each person who has cloned the repo. If the central repo should be lost, you can simply reinstate it from any of the clones on your developer's desktops.

Working with a central repository
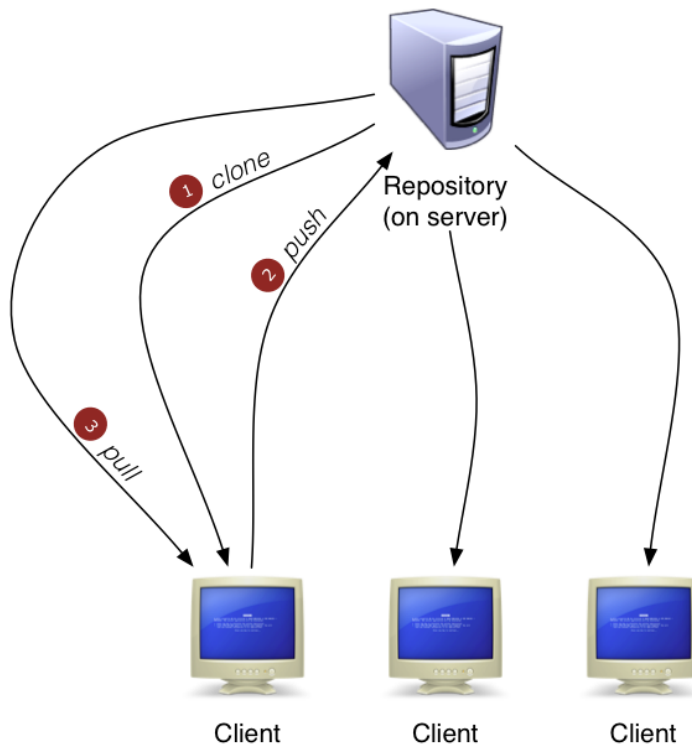
The workflow (as shown in the illustration above) when working with a central repository is simple:

1. Clone the repository initially

2. Make local changes and add them

3. Commit those changes locally

4. Push your changes up to the central repo

1.4.2 Heirarchical Topology

In larger teams, or where you have subteams working on different areas of your code base, you may wish to adopt a heirarchical model - also called the 'captain and luitenants model'.

Working in a hierarchical model
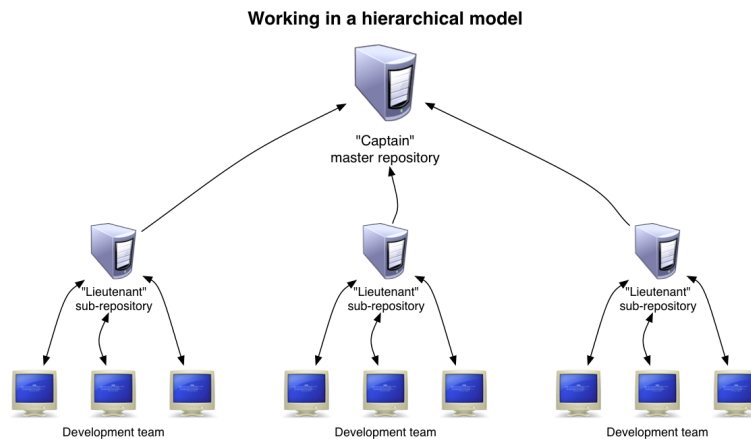
In this arrangement, there is one person (the 'captain') who performs the final integration into the official repository. Under the 'captain', various 'luitenants' take responsibility for different aspects of the code base. Each 'luitenant' has a team of 1 or more developers who push to his repository (or request him to pull from theirs). The 'luitenant' collates all developer's work and when it is ready asks the captain to integrate the work into the official repository. This topology works well for organisations or projects with a well established heirarchy

1.4.3 Decentralised Model

In a decentralised model there is no real 'single point of truth'. Developer's share their work with each other on an *ad hoc* basis.

Working in a decentralized model
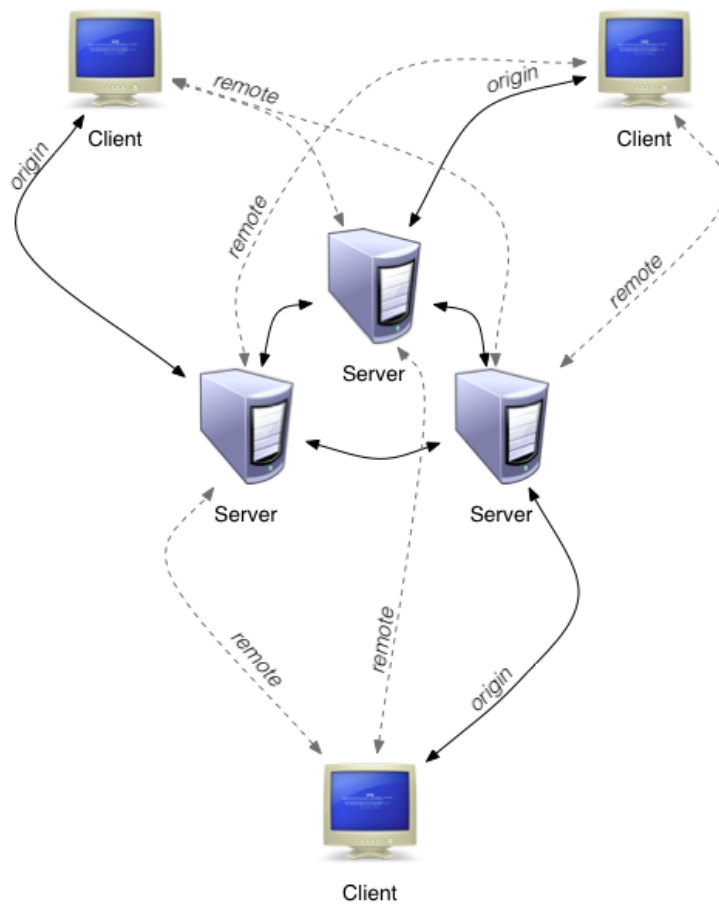
Version history is exchanged between repositories on an *ad hoc* basis. Repository owners add one or more *remotes* to their repository (a *remote* is a reference to another repository). They then *pull* or *push* their changes to these repos as needed. The choice of when to *push* or *pull* and to which *remote* is a social practice defined by the developers themselves and not enforced by any software.

1.4.4 Hybrid topology

The choice of topology is not fixed - you may choose to mix elements together in a way that suites your organisation of project the best. Here it is easiest to illustrate using Quantum GIS, my favourite open source project as an example.

Scenario: The QGIS project has a repository. SANSA is busy building extensions the QGIS project. Linfiniti is creating special software packages for them. Individual devel-

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opers need to be able to work and collaborate and don't want their work to be puclically visible until they are ready. We can create an architecture like the one illustrated below:

Working in a decentralized model (example)
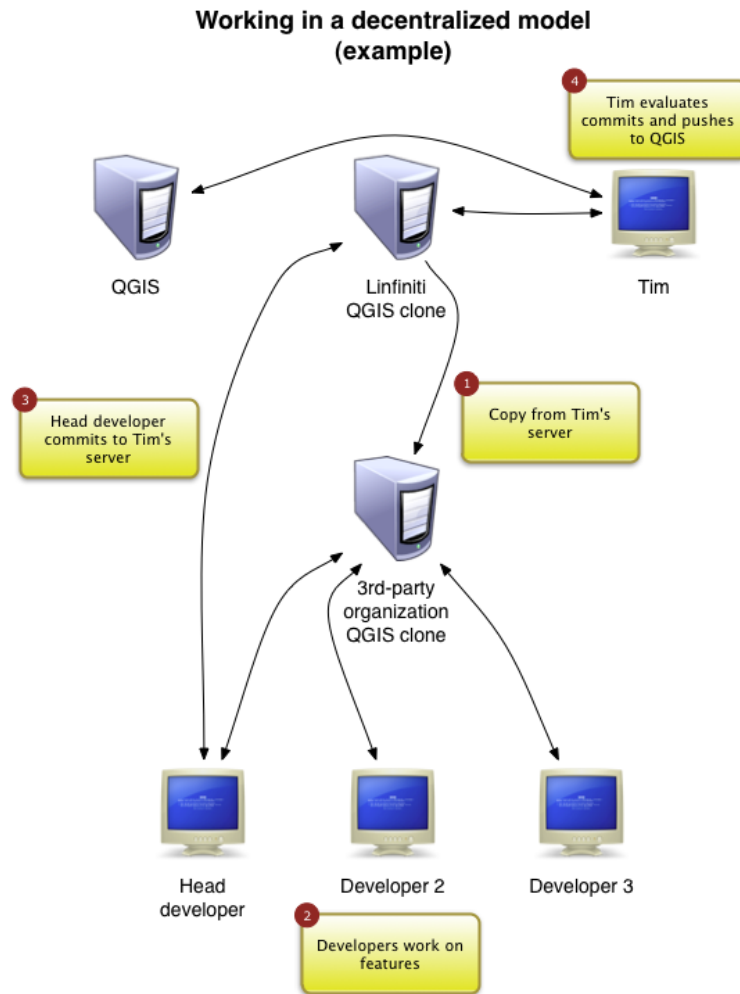
In this architecture, any developer as SANSA can push their changes to the local SANSA GIS Clone. Periodically (e.g. nightly) SANSA will pull changes from the the QGIS official repo into their QGIS clone, so that they can be working against the most up to date QGIS code base. When they have an interesting new feature, they can request Linfiniti to pull their changes to the Linfiniti QGIS Clone, test and package the SANSA version of QGIS. When SANSA are ready, and the code complies with QGIS coding standards etc. Linfiniti can push any improvements created by SANSA into the official QGIS repository for the rest of the world to enjoy.

There are many variations and permutations that can be employed, but the key concept to realise is that SANSA can now independently work on the code base using all the coding best practices available and can share their work in an easy and flexible manner.

1.5 Git Working Practices

In this section we will take a look at Git working practices. There are many git commands and always 10 different ways of doing things, so we will try to cover the basic and commonly used activities.

1.6 Checkout, add, commit, push

We've shown you this in the preceeding sections, but it's worth repeating as it's the essence of working with GIT.

Git workflow: checkout, add, commit & push
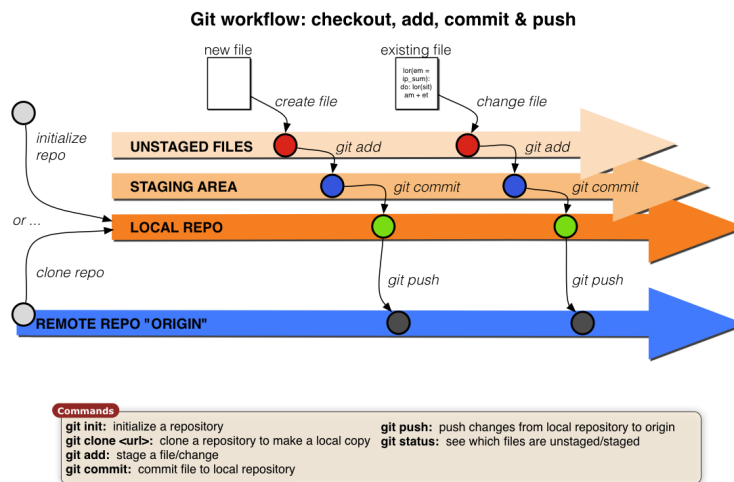
When you work with Git, you changes go through a routine:

1. Initially when you change a file or create a file, it changes are **unstaged**. Unstaged is just another way of saying 'will not form part of the next commit'.

2. To stage a file (or group of files) you *git add* them, moving them from the unstaged area to the **staging area**.

3. One files are staged, you can *git commit* them to your local repository. A **commit** will be accompanied by a short log message and it also stores the name and email address of the committer.

4. You can pass your commits from your local repository over to a remote repository by doing a *git push.* All the commits in your local repository that don't yet exist in the upstream repo are **pushed** to it.

1.6.1 Working with remote repositories

From Git's point of view, a **remote** repository is anyone that you are not currently in. In other words a remote might be on the same local filesystem, just in a different place in the file system tree.

Git workflow: checkout, add, commit & push
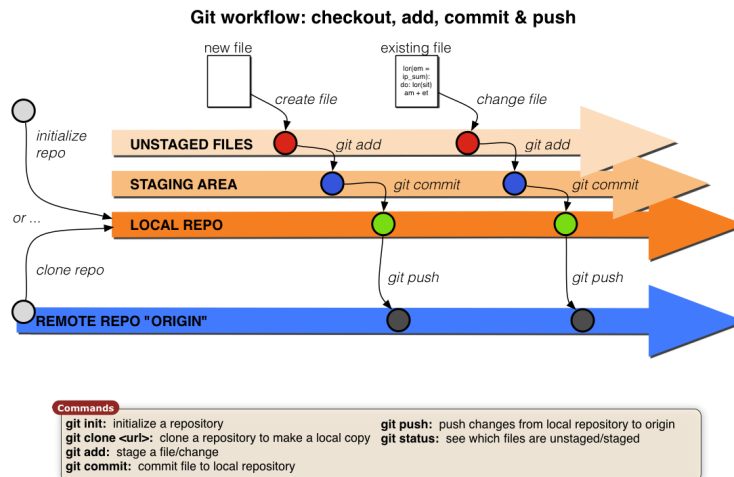
You can push and pull commits to and from a remote (depending on permissions). When you clone from a remote repository, a remote repository entry pointing from your clone to the original repository is automatically made in your remotes list. You can see which remote repositories you have set up for your repository by doing:

Listing

```
git remote -v
```

Which might return something like this:

Listing

```
[git-sandbox-clone] git remote -v
origin  /tmp/git-sandbox (fetch)
origin  /tmp/git-sandbox (push)
```

You can add a new remote reference at any time (and you can have as many as you need). Lets test this by doing a little experiment. First we will make another clone of the git-sandbox:

Listing

```
cd ..
git clone git-sandbox git-sandbox-clone2
cd git-sandbox-clone2
git checkout master
echo "From clone2 : a new message" >> README
git add README
```

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```
git commit -m "Added a new message to readme from clone 2"
```

By now the above commands should be starting to make sense to you. Basically, we created a clone and committed a change to the README file in it. Lets go back to our first clone and add the second as a remote to it.

Listing

```
cd ..
cd git-sandbox-clone
git remote add clone2 ../git-sandbox-clone2
git remote -v
```

The last command will show you your now longer list of clones - it should look something like this:

Listing

```
clone2  ../git-sandbox-clone2 (fetch)
clone2  ../git-sandbox-clone2 (push)
origin  /tmp/git-sandbox (fetch)
origin  /tmp/git-sandbox (push)
```

Once you have added the new remote, you should call *git fetch* on it to obtain a list of its branches and its commit history.

Listing

```
[git-sandbox-clone] git fetch clone2
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 ../git-sandbox-clone2
 * [new branch]      newfeature -> clone2/newfeature
```

You can see that our local repository has now been told about the existance of another remote branch in the clone2 repo.

Origin is your 'default' remote - whenever you make a *push* or *pull* request, it will be made against that remote. However you can qualify a *pull* or *push* request by specifying the remote after it, and then the request will be routed to the correct repository. Lets finish off this section by pulling the change we made in our second clone into our first clone:
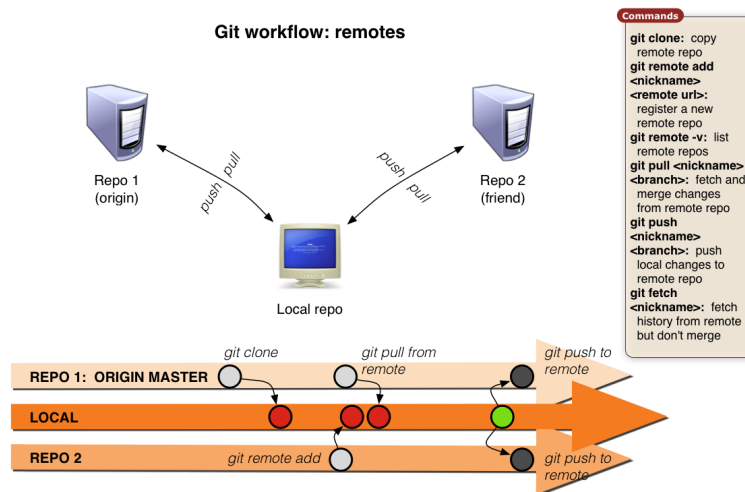
Listing

```
git pull clone2 master
```

This will fetch any commits present in clone2's master which are not present in clone's master.

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```
[git-sandbox-clone] git pull clone2 master
From ../git-sandbox-clone2
 * branch            master     -> FETCH_HEAD
 Auto-merging README
 Merge made by recursive.
  README |    1 +
   1 files changed, 1 insertions(+), 0 deletions(-)
```

Remotes are a powerful feature - the let you tap into the distributed nature of Git, absorbing changes from any repository that interestes you. The next illustration shows a typical use of multiple remotes.

Git workflow: remotes

Repo 1
(origin)

Repo 2
(friend)

push pull

push pull

Local repo

Commands

git clone: copy
remote repo
**git remote add
<nickname>
<remote url>:**
register a new
remote repo
git remote -v: list
remote repos
**git pull <nickname>
<branch>:** fetch and
merge changes
from remote repo
**git push
<nickname>
<branch>:** push
local changes to
remote repo
**git fetch
<nickname>:** fetch
history from remote
but don't merge

	git clone		git pull from		git push to
REPO 1: ORIGIN MASTER	○		○ remote		● remote
LOCAL		●	● ●		●
REPO 2	git remote add		○		● git push to

1.6.2 Working in branches

One of the principles of Git is to work in branches. SVN also support branches - the concept is the same in Git. However, Git's design (in particular the fact that it assigns SHA-1 globally unique id's to each commit) makes it very easy to create branches and merge their changes back and forth between other branches or the master branch.

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Git workflow: branch & merge

UNSTAGED FILES

STAGING AREA

LOCAL REPO: MASTER BRANCH

git branch   *merge master*

         merge feature

{ **FEATURE**

git checkout

Commands

git branch: create a local branch in your repository
git checkout <branch>: start working in a branch
git checkout master: return to master branch (staging area must be clean)

git merge <other branch>: bring changes from "other branch" into your branch **git branch -D <unwanted branch>:** delete a branch
git branch: list branches (current shown with A)

If you create a branch your work in that branch is isolated from the main code store (the *master* branch) - allowing you to safely experiment without impacting anything else. In Git branches and features are often used synonymously - the idea being that a branch is a place where you develop a new feature. While you are working on the feature, changes are probably taking place in the *master* branch. To prevent your branch becoming too different to the *master branch* you will regularly *git merge* the changes from master in to your branch. Once your work on your feature is complete, you then merge your feature branch into the master branch.

You can obtain a list of branches in your local branch (and see which branch you are currently in) by using the *git branch* command. If you want to also see which branches are in a remote repository, you can use the //git branch -r// command.

After you have merged a branch into the *master* branch, usually you will throw away the branch - you can use //git branch -D <branch name> for this. Just make sure you are not currently in the branch that you are deleting or you will evaporate :-).

1.6.3 Tracking branches

Some times you will want to work collaboratively on a feature with other developers. When the branch for that feature is in a remote repository, you can create a local branch that **tracks** the remote branch. This is illustrated below:

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Git workflow: tracking branches
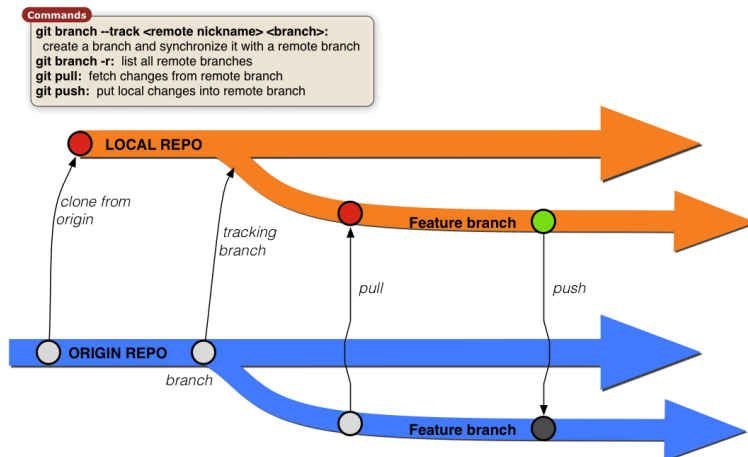
To illustrate, lets first create a branch in our sandbox, check it out, make some changes and then commit them.

Listing

```
[git-sandbox] git branch newfeature
[git-sandbox] git checkout newfeature
Switched to branch 'newfeature'
[git-sandbox] echo "Hello from upstream newfeature branch" > README
[git-sandbox] git add README
[git-sandbox] git commit -m "Added new feature to readme in upstream branch"
[newfeature 56ee8af] Added new feature to readme in upstream branch
 1 files changed, 1 insertions(+), 4 deletions(-)
```

Now let's go to our clone directory. You create a tracking branch by doing the following:

Listing

```
cd ../git-sandbox-clone
git fetch
git branch -r
```

The above commands will update the list of remote branches available and then display it to you. In this case they show this output:

"" [git-sandbox] cd ../git-sandbox-clone [git-sandbox-clone] git fetch remote: Counting objects: 5, done. remote: Compressing objects: 100% (1/1), done. remote: Total 3 (delta 0), reused 0 (delta 0) Unpacking objects: 100% (3/3), done. From /tmp/git-sandbox * new newfeature -> origin/newfeature [git-sandbox-clone] git branch -r origin/HEAD -> origin/master origin/master origin/newfeature

Listing

```
You can see when we did a //git fetch//, the new branch was found in git-sandbox. When we
ran //git branch// the branches from **origin** (the original repo that we cloned) are
listed, including our newfeature branch. Now you can actually check out the branch:
```

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git branch –track newfeature origin/newfeature git pull git checkout newfeature

---
Listing

```
When you check out the newfeature branch, you will see it contains the changes
we made a moment ago.
```

[git-sandbox-clone] git branch –track newfeature origin/newfeature Branch newfeature set up to track remote branch newfeature from origin. [git-sandbox-clone] git pull Already up-to-date. [git-sandbox-clone] git checkout newfeature Switched to branch 'newfeature' [git-sandbox-clone] cat README Hello from upstream newfeature branch

---
Listing

```
When you do a //git pull// on a tracking branch it will fetch changes from the
origin repository and merge them into your copy of the branch. You can go ahead
and make changes to your branch and then pull updates regularly from the origin
repository.

=== Some useful git commands ===

There are many many commands available for git. The resources section at the end of
this document points to some good sites where you can learn more after this primer.
Here are a couple of other commands you may find useful in your day to day work:

[img/git09.png]

Any discussion of Git would be lacking if we did not mention [github
http://github.com]. Github provide a free git hosting facility for your online
git repositories. The free repositories must be public. For a fee you can also
purchase space for hosting private repositories.

== Git under windows ==

Here are some generic notes on using git under windows you should install [msys
git app http://code.google.com/p/msysgit/]. In windows explorer go to
c:\Documents and Settings\<your user>\

Make a directory called .ssh

In that directory create a text file called 'config' (note it has no extension)
and put the following content into it:
```

Host <host name> User <user name> HostName <host name> Port <port>

Listing

```
Replace items in angle brackets above as appropriate.

Now copy your id_dsa into this directory (it should be a unix style one so you
may need to convert from putty style private key, though just try with your
existing one first).

Open the msys git shell then go to the directory where you want to check out
your project to. For example to check it out to c:\dev\foo do
```
---

cd /c/ mkdir dev cd dev

Listing

```
Now clone the directory:
```

git clone git@foo:bar.git bar

Listing

```
Make sure to type 'yes' in full when it asks you if you are sure you want to
continue connecting.

Then enter your passphrase when prompted.

Wait a few minutes while it checks out.

Thereafter you use the git commands from the msys shell as normal. There is
also a tortoisegit explorer integration for windows you can try but I havent
used it and don't know how well it works.


== Further Reading ==

http://gitref.org
http://progit.org
http://gitready.com
```