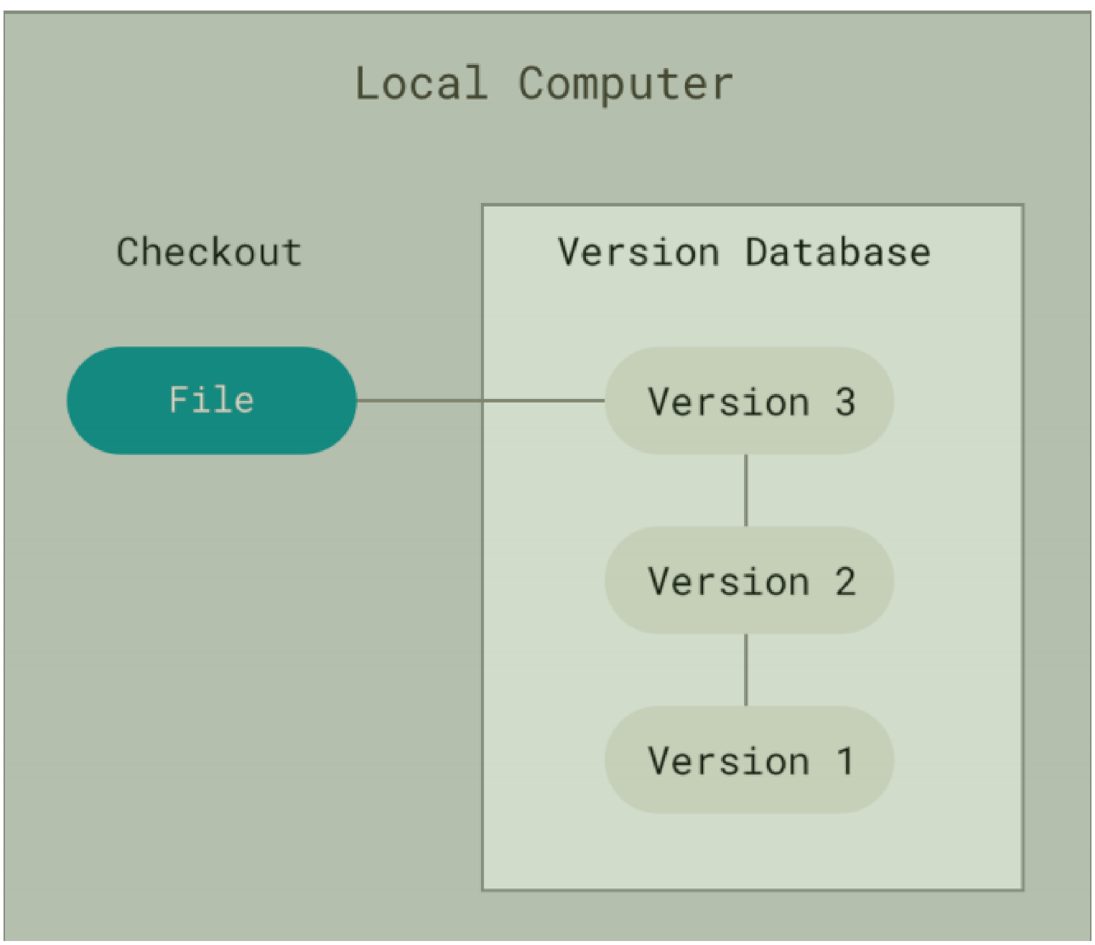
What is version control system?

Version control is a system that records changes to a file or set of files over time so that you can recall specific versions later. It allows you to revert selected files back to a previous state, revert the entire project back to a previous state, compare changes over time, see who last modified something that might be causing a problem, who introduced an issue and when, and more. Using a VCS also generally means that if you screw things up or lose files, you can easily recover. In addition, you get all this for very little overhead.

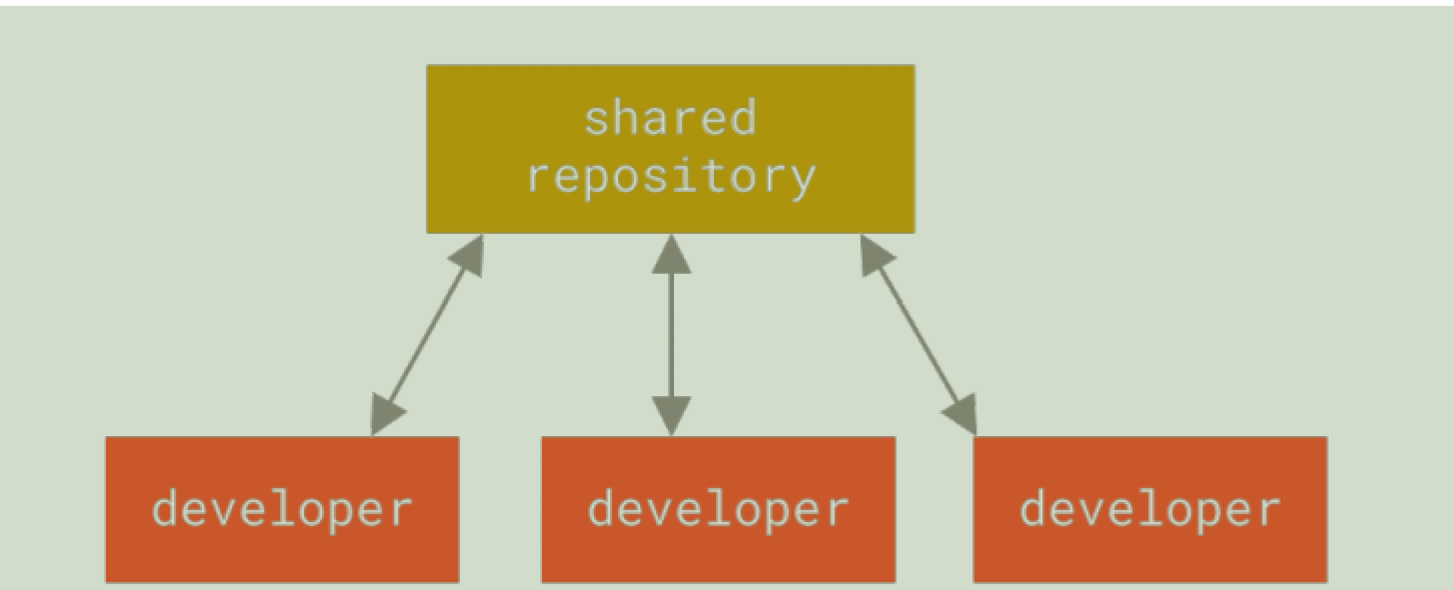
Local Version Control Systems

Many people's version-control method of choice is to copy files into another directory perhaps a time-stamped directory, if they're clever). This approach is very common because it is so simple, but it is also incredibly error prone. It is easy to forget which directory you're in and accidentally write to the wrong file or copy over files you don't mean to. To deal with this issue, programmers long ago developed local VCSs that had a simple database that kept all the changes to files under revision control. One of the most popular VCS tools was a system called RCS, which is still distributed with many computers today. RCS works by keeping patch sets (that is, the differences between files) in a special format on disk; it can then re-create what any file looked like at any point in time by adding up all the patches.



Centralized Version Control Systems

The next major issue that people encounter is that they need to collaborate with developers on other systems. To deal with this problem, Centralized Version Control Systems (CVCSs) were developed. These systems (such as CVS, Subversion, and Perforce) have a single server that contains all the versioned files, and a number of clients that check out files from that central place. For many years, this has been the standard for version control.

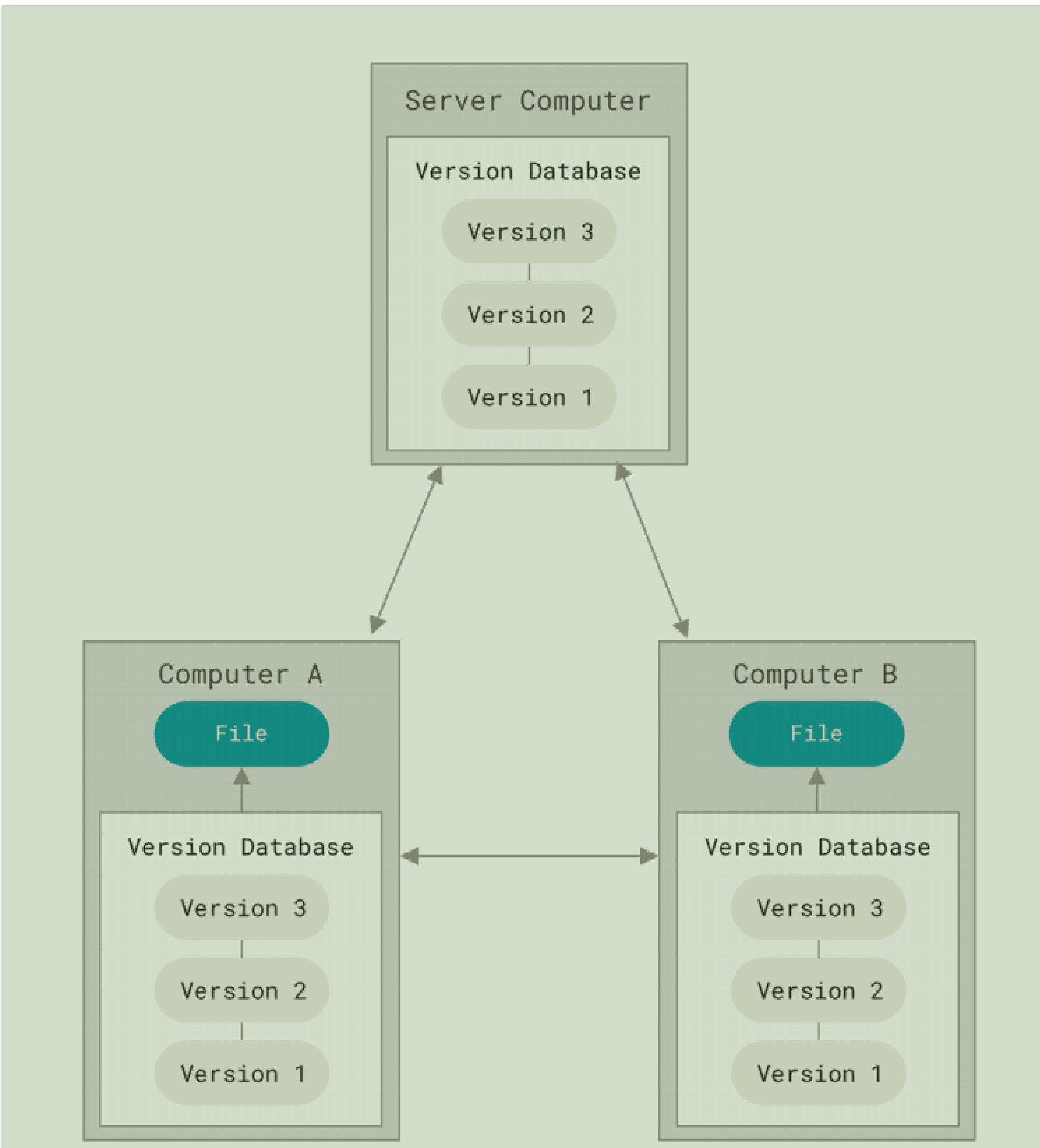


This setup offers many advantages, especially over local VCSs. For example, everyone knows to a certain degree what everyone else on the project is doing. Administrators have fine-grained control over who can do what, and it's far easier to administer a CVCS than it is to deal with local databases on every client. However, this setup also has some serious downsides. The most obvious is the single point of failure

that the centralized server represents. If that server goes down for an hour, then during that hour nobody can collaborate at all or save versioned changes to anything they're working on. If the hard disk the central database is on becomes corrupted, and proper backups haven't been kept, you lose absolutely everything — the entire history of the project except whatever single snapshots people happen to have on their local machines. Local VCSs suffer from this same problem — whenever you have the entire history of the project in a single place, you risk losing everything.

Distributed Version Control Systems

This is where Distributed Version Control Systems (DVCSs) step in. In a DVCS (such as Git, Mercurial or Darcs), clients don't just check out the latest snapshot of the files; rather, they fully mirror the repository, including its full history. Thus, if any server dies, and these systems were collaborating via that server, any of the client repositories can be copied back up to the server to restore it. Every clone is really a full backup of all the data.



Furthermore, many of these systems deal pretty well with having several remote repositories they can work with, so you can collaborate with different groups of people in different ways simultaneously within the same project. This allows you to set up several types of workflows that aren't possible in centralized systems, such as hierarchical models.

Snapshots, Not Differences

The major difference between Git and any other VCS (Subversion and friends included) is the way Git thinks about its data. Conceptually, most other systems store information as a list of file-based changes. These other systems (CVS, Subversion, Perforce, and so on) think of the information they store as a set of files and the changes made to each file over time (this is commonly described as delta-based version control)

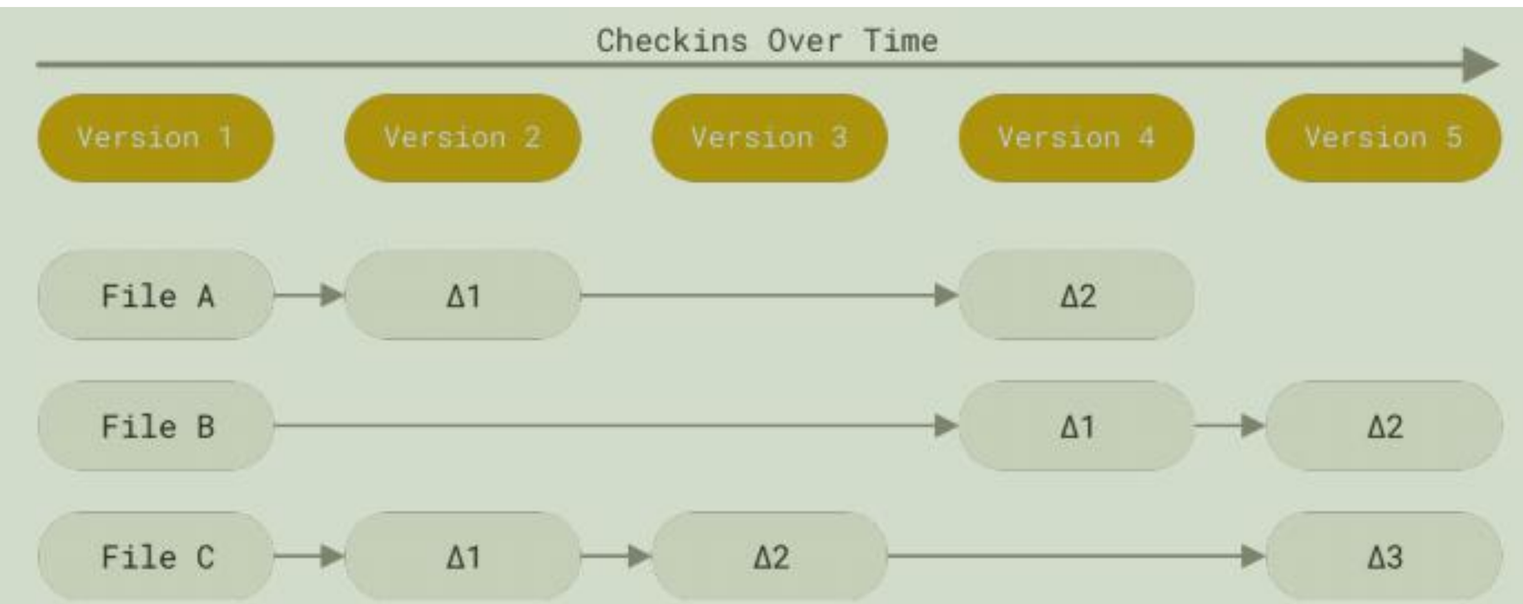


Figure 4. Storing data as changes to a base version of each file

Git doesn't think of or store its data this way. Instead, Git thinks of its data more like a series of snapshots of a miniature filesystem. With Git, every time you commit, or save the state of your project, Git basically takes a picture of what all your files look like at that moment and stores a reference to that snapshot. To be efficient, if files have not changed, Git doesn't store the file again, just a link to the previous identical file it has already stored. Git thinks about its data more like a stream of snapshots.

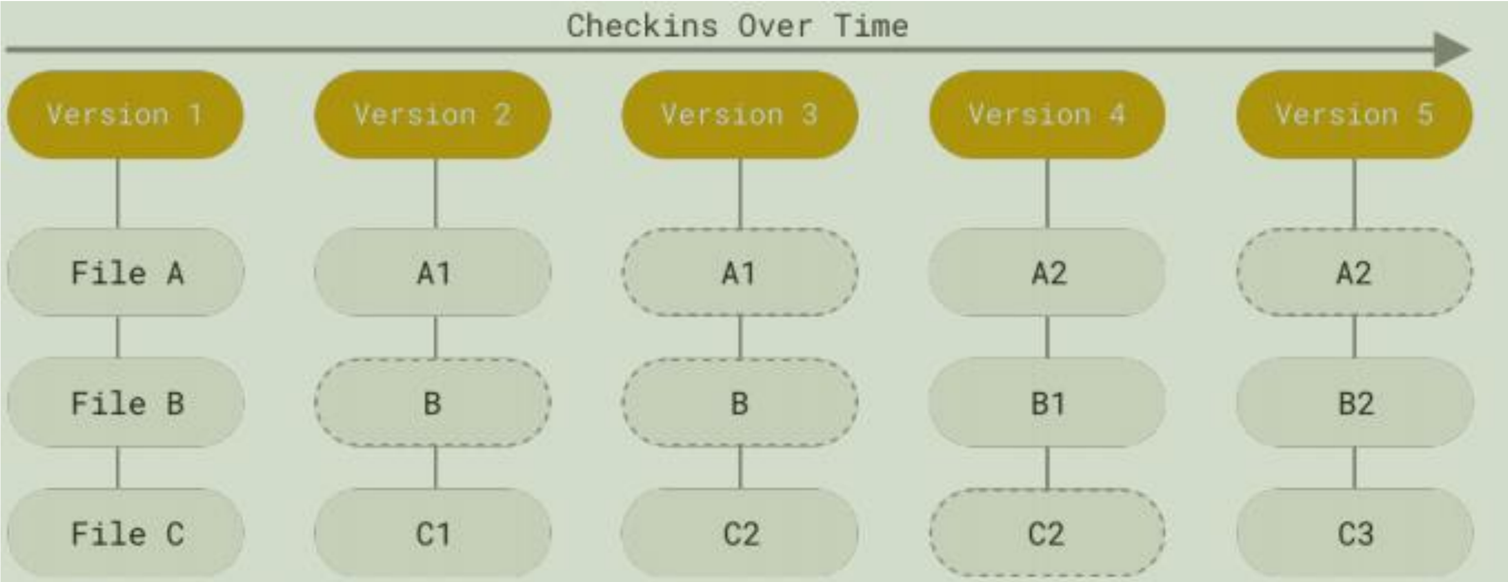


Figure 5. Storing data as snapshots of the project over time

Nearly Every Operation Is Local

Most operations in Git need only local files and resources to operate — generally no information is needed from another computer on your network. If you're used to a CVCS where most operations have that network latency overhead, this aspect of Git will make you think that the gods of speed have blessed Git with unworldly powers. Because you have the entire history of the project right there on your local disk, most operations seem almost instantaneous. For example, to browse the history of the project, Git doesn't need to go out to the server to get the history and display it for you — it simply reads it directly from your local database. This means you see the project history almost instantly. If you want to see the changes introduced between the

current version of a file and the file a month ago, Git can look up the file a month ago and do a local difference calculation, instead of having to either ask a remote server to do it or pull an older version of the file from the remote server to do it locally. This also means that there is very little you can't do if you're offline or off VPN. If you get on an

airplane or a train and want to do a little work, you can commit happily (to your local copy, remember?) until you get to a network connection to upload.

If you go home and can't get your VPN client working properly, you can still work. In many other systems, doing so is either impossible or painful. In Perforce, for example, you can't do much when you aren't connected to the server; in Subversion and CVS, you can edit files, but you can't commit changes to your database (because your database is offline). This may not seem like a huge deal, but you may be surprised what a big difference it can make.

Git Generally Only Adds Data

When you do actions in Git, nearly all of them only add data to the Git database. It is hard to get the system to do anything that is not undoable or to make it erase data in any way. As with any VCS, you can lose or mess up changes you haven't committed yet, but after you commit a snapshot into Git, it is very difficult to lose, especially if you regularly push your database to another repository. This makes using Git a joy because we know we can experiment without the danger of severely screwing things up.

The Three States

Pay attention now — here is the main thing to remember about Git if you want the rest of your learning process to go smoothly. Git has three main states that your files can reside in: modified, staged, and committed:

• Modified means that you have changed the file but have not committed it to your database yet.

• Staged means that you have marked a modified file in its current version to go into your next commit snapshot.

• Committed means that the data is safely stored in your local database.

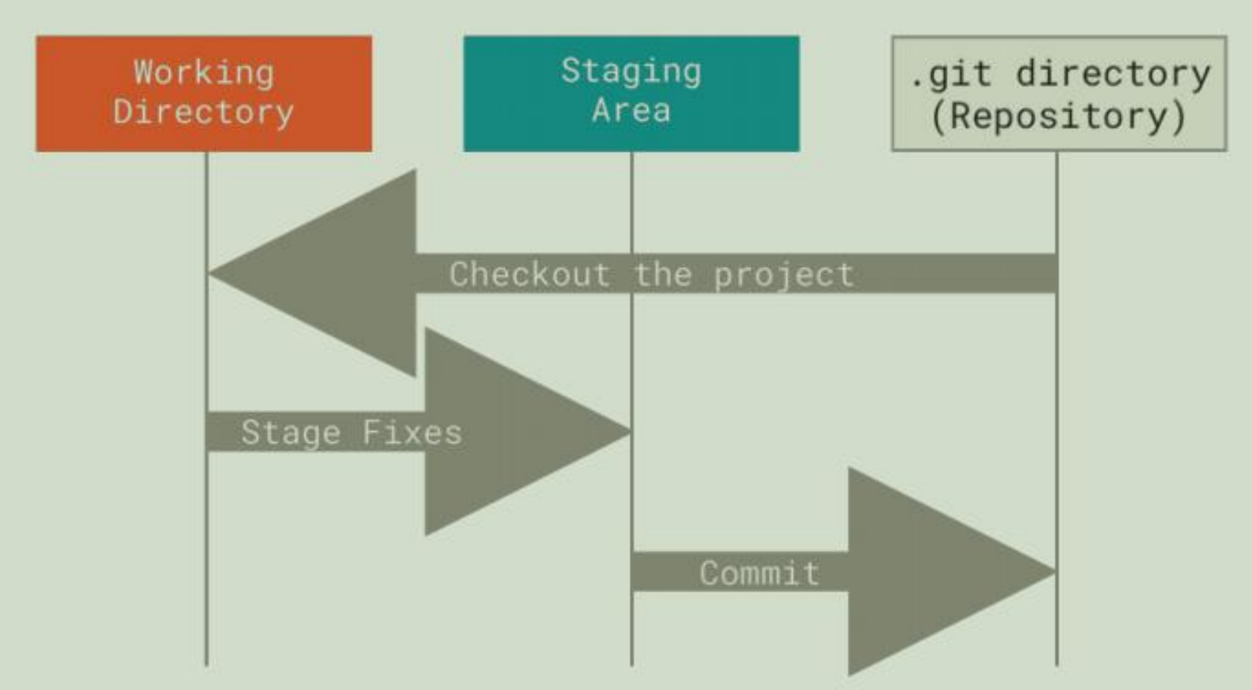


Figure 6. Working tree, staging area, and Git directory

This leads us to the three main sections of a Git project: the working tree, the staging area, and the Git directory.

1. The working tree is a single checkout of one version of the project. These files are pulled out of the compressed database in the Git directory and placed on disk for you to use or modify.
2. The staging area is a file, generally contained in your Git directory, that stores information about what will go into your next commit. Its technical name in Git parlance is the “index”, but the phrase “staging area” works just as well.
3. The Git directory is where Git stores the metadata and object database for your project. This is the most important part of Git, and it is what is copied when you clone a repository from another computer.

The basic Git workflow goes something like this:
1. You modify files in your working tree.
2. You selectively stage just those changes you want to be part of your next commit, which adds only those changes to the staging area.
3. You do a commit, which takes the files as they are in the staging area and stores that snapshot permanently to your Git directory.

If a particular version of a file is in the Git directory, it's considered committed. If it has been modified and was added to the staging area, it is staged. And if it was changed since it was checked out but has not been staged, it is modified.

Installing Git

Before you start using Git, you have to make it available on your computer. Even if it's already installed, it's probably a good idea to update to the latest version. You can either install it as a package or via another installer or download the source code and compile it yourself.

First-Time Git Setup

Now that you have Git on your system, you'll want to do a few things to customize your Git environment. You should have to do these things only once on any given computer; they'll stick around between upgrades. You can also change them at any time by running through the commands again. Git comes with a tool called git config that lets you get and set configuration variables that control

all aspects of how Git looks and operates. These variables can be stored in three different places:

1. [path]/etc/gitconfig file: Contains values applied to every user on the system and all their repositories. If you pass the option --system to git config, it reads and writes from this file specifically. Because this is a system configuration file, you would need administrative or superuser privilege to make changes to it.
2. ~/.gitconfig or ~/.config/git/config file: Values specific personally to you, the user. You can make Git read and write to this file specifically by passing the --global option, and this affects all of the repositories you work with on your system.
3. config file in the Git directory (that is, .git/config) of whatever repository you're currently using: Specific to that single repository. You can force Git to read from and write to this file with the --local option, but that is in fact the

default. Unsurprisingly, you need to be located somewhere in a Git repository for this option to work properly.

Each level overrides values in the previous level, so values in .git/config trump those in [path]/etc/gitconfig.
On Windows systems, Git looks for the .gitconfig file in the $HOME directory (C:\Users\$USER for most people). It also still looks for [path]/etc/gitconfig, although it's relative to the MSys root, which is wherever you decide to install Git on your Windows system when you run the installer. If you are using version 2.x or later of Git for Windows, there is also a system-level config file at C:\Documents and Settings\All Users\Application Data\Git\config on Windows XP, and in
C:\ProgramData\Git\config on Windows Vista and newer. This config file can only be changed by git config -f <file> as an admin.
You can view all of your settings and where they are coming from using:

```
$ git config --list --show-origin
```

Your Identity

The first thing you should do when you install Git is to set your user name and email address. This is important because every Git commit uses this information, and it's immutably baked into the commits you start creating:

```
$ git config --global user.name "John Doe"
$ git config --global user.email johndoe@example.com
```

Again, you need to do this only once if you pass the --global option, because then Git will always use that information for anything you do on that system. If you want to override this with a different name or email address for specific projects, you can run the command without the --global option when you're in that project.

Your Editor

Now that your identity is set up, you can configure the default text editor that will be used when Git needs you to type in a message. If not configured, Git uses our system's default editor.
If you want to use a different text editor, such as Emacs, you can do the following:

```
$ git config --global core.editor emacs
```

On a Windows system, if you want to use a different text editor, you must specify the full path to its executable file. This can be different depending on how your editor is packaged. In the case of Notepad++, a popular programming editor, you are likely to want to use the 32-bit version, since at the time of writing the 64-bit version doesn't support all plug-ins. If you are on a 32-bit Windows system, or you have a 64-bit editor on a 64-bit system, you'll type something like this:

```
$ git config --global core.editor "'C:/Program
Files/Notepad++/notepad++.exe'
-multiInst -notabbar -nosession -noPlugin"
```

Your default branch name

By default Git will create a branch called master when you create a new repository with git init. From Git version 2.28 onwards, you can set a different name for the initial branch.
To set main as the default branch name do:

```
$ git config --global init.defaultBranch main
```

Checking Your Settings

If you want to check your configuration settings, you can use the git config --list command to list all the settings Git can find at that point:

```
$ git config --list
user.name=John Doe
user.email=johndoe@example.com
```

color.status=auto

color.branch=auto

color.interactive=auto

color.diff=auto

...

You may see keys more than once, because Git reads the same key from different files ([path]/etc/gitconfig and ~/.gitconfig, for example). In this case, Git uses the last value for each unique key it sees.

You can also check what Git thinks a specific key's value is by typing git config <key>:

```
$ git config user.name
John Doe
```

Getting Help

If you ever need help while using Git, there are three equivalent ways to get the comprehensive manual page (manpage) help for any of the Git commands:

```
$ git help <verb>
$ git <verb> --help
$ man git-<verb>
```

For example, you can get the manpage help for the git config command by running this:

```
$ git help config
```

, you can ask for the more concise "help" output with the -h Option.