Linux Command Line

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Linux

Linux is a Unix-like and mostly POSIX-compliant computer operating system assembled under the model of, and a prime example for concept and practice of, free and open source software development and distribution.

The underlying source code may be used, modified, and distributed – commercially or non-commercially – by anyone under licenses such as the GNU General Public License.

Linux OS is usually packaged in a format known as a *distribution*.

More information: Linux | Linus Torvalds | POSIX compliance | GNU General Public License

The home directory

What is it?

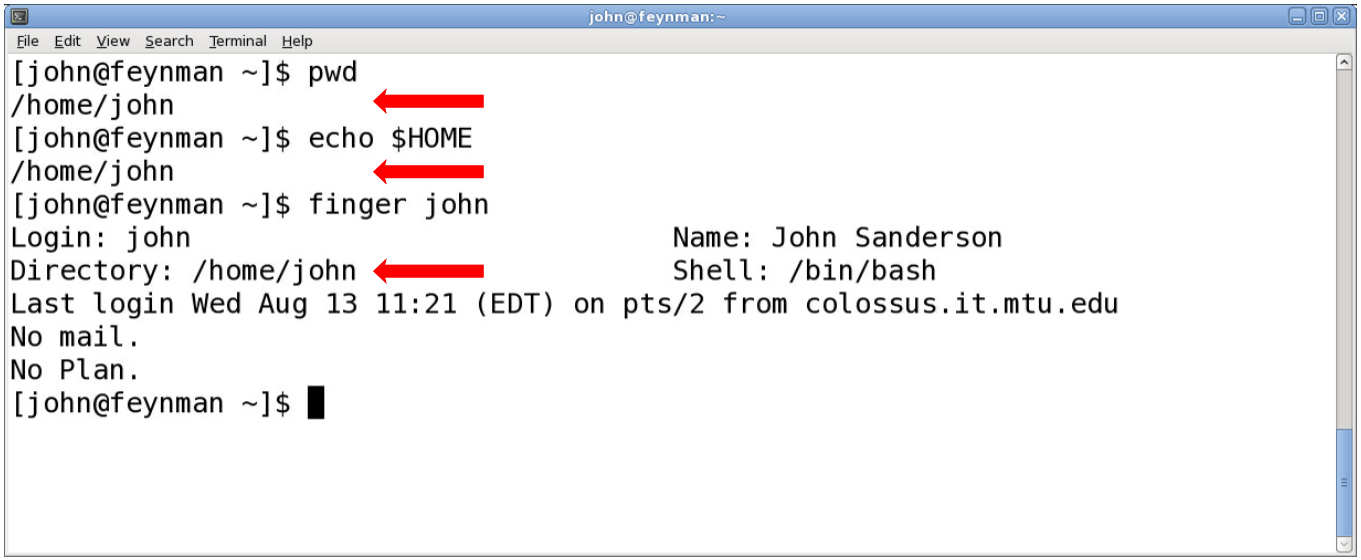
A file system directory in a multi-user operating system that contains files/folders – including configuration files for various applications – for a specified user in the system. The exact location and naming convention used depends on the operating system as well as institutional policies/procedures.

Why use it?

Contents of a user's home directory can be protected by file system permissions. Separating user data from system-wide data makes a backup scheme easier. Cracks (viruses, worms, etc.) running under the ownership of a user will usually be not able to affect system-wide data or that of other users.

Where is the home directory?

* Open a Terminal and type one of the following commands
  * `echo $HOME`
  * `finger john`



Replace `john` with your Michigan ISO username OR appropriate username on personal machines.
`finger` command may not be available. Use the alternate command or contact administrators.
Typing `cd $HOME` or `cd ~/` (or just `cd`) from anywhere in the file system will bring the user back to the home directory.

The shell

What is it?

Although most users think of the shell as an interactive command interpreter, it is really a programming language in which each statement runs as a command. Because it must satisfy both the interactive and programming aspects of command execution, it is a strange language, shaped as much by history as by design.

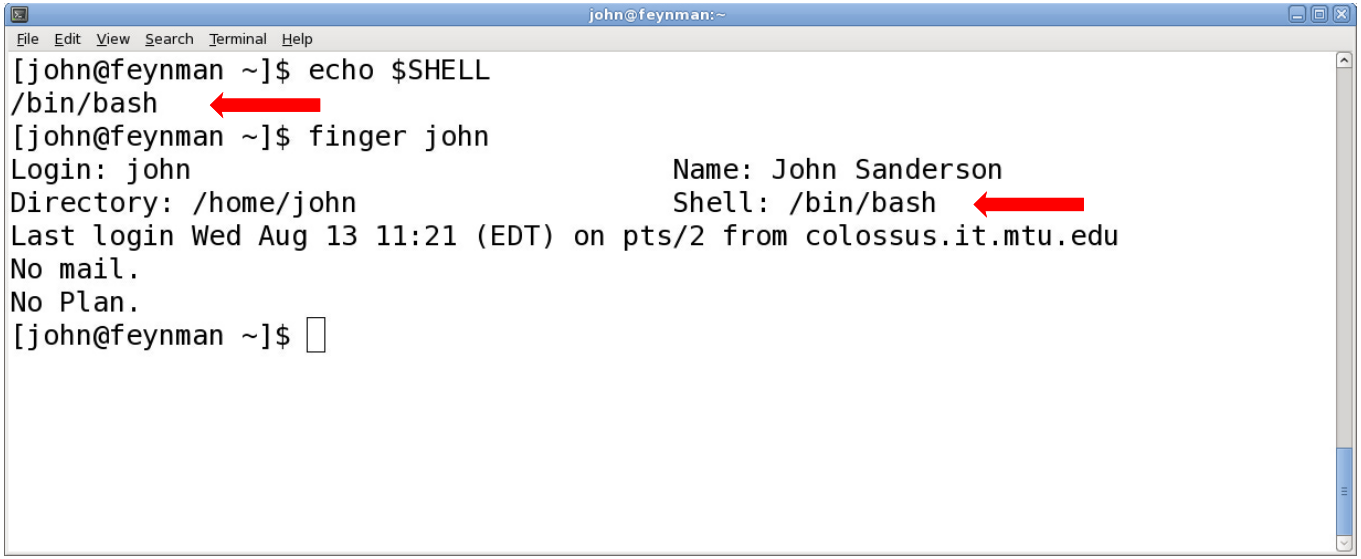
– Brian Kernighan and Robert Pike

Why use it?

While using the GUI seems easier, the often repeated shell commands – which seamlessly interface with a plethora of other utilities – can be saved as a script or a function. This not only saves time and effort, and prevents errors, but also to naturally extends the system's capability.

Which shell?

* Open a Terminal and type one of the following commands
  * `echo $SHELL`
  * `finger john`



Replace `john` with your Michigan ISO username OR appropriate username on personal machines.
`finger` command may not be available. Use the alternate command or contact administrators.
`/bin/tcsh` is the default shell in most campus computers. Request IT to have it changed to `/bin/bash`.

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Login shell vs Interactive shell

Login shell

A BASH shell that is initiated when one of the following commands is executed:

```
sudo su -
bash --login
ssh some-user@some-host
```

When BASH is invoked as a login shell, the following files are executed in the following order: `/etc/profile`, `$HOME/.bash_profile`, `$HOME/.bash_login`, `$HOME/.profile`

Refer to `man bash` for more information.
Although `$HOME/.bashrc` is not explicitly listed, it is run by `$HOME/.bash_profile` in most linux distributions.

Login shell vs Interactive shell

Interactive shell

A BASH shell that is initiated when one of the following commands is executed:

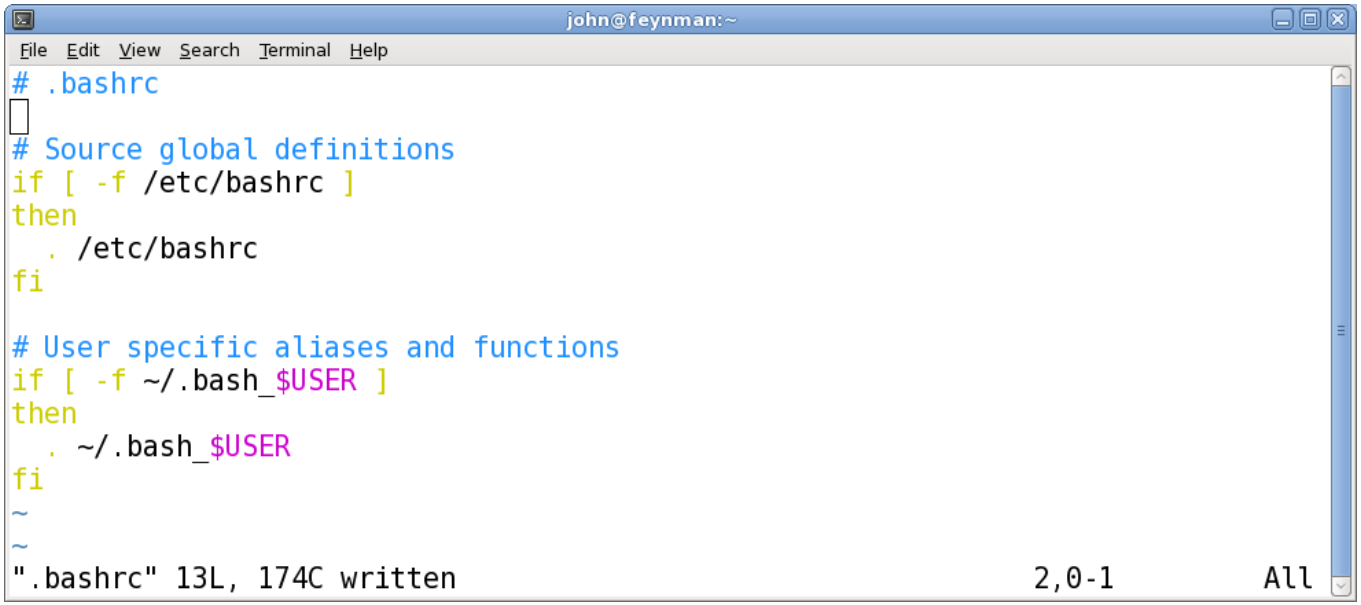
```
sudo su
bash
ssh some-user@some-host some-command
```

When BASH is invoked as an interactive shell, only the `$HOME/.bashrc` is executed.

Refer to `man bash` for more information.
In most linux distributions, `$HOME/.bashrc` runs `/etc/bashrc`.

Customizing the shell

* Open a Terminal
* Edit `$HOME/.bashrc` using `vi` (or other) editor as shown below
* Save and close the file



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Customizing the shell

* Open a Terminal
* Create/Open `$HOME/.bash_$USER` using `vi` (or other) editor
* Add necessary customizations (aliases, variables, functions, etc.)
* Save and close the file
* Run the command `. $HOME/.bashrc`

Reserved shell variables

`EDITOR`, `HOME`, `HOSTNAME`, `IFS`, `LD_LIBRARY_PATH`, `LOGNAME`, `MACHTYPE`, `MANPATH`, `OLDPWD`, `OSTYPE`, `PATH`, `PPID`, `PS1`, `PS2`, `PS3`, `PS4`, `PWD`, `SHELL`, `TMOUT`, `TZ`, `UID`, `USER`

Run `env` to get a complete list of shell variables already in use.
Carefully redefine a variable or extend its definition only if there is a need to do so.

Customizing the shell

```
# .bash_$USER
# User specific aliases, variables, functions, environment and startup programs

export HISTCONTROL=ignoreboth
export HISTSIZE=100000
export HISTFILESIZE=100000
export HISTTIMEFORMAT="%b %d %H:%M:%S "
export TMOUT=360000

export PATH="/bin:/usr/bin:/sbin:/usr/sbin:/usr/kerberos/bin"
export PATH="$PATH:/usr/local/bin:$HOME/bin"
export LD_LIBRARY_PATH="/lib64:/usr/lib64:/usr/kerberos/lib64:$HOME/lib"
export MANPATH="/usr/share/man:$HOME/man"

export COLOSSUS="colossus.it.mtu.edu"
export GUARDIAN="guardian.it.mtu.edu"

alias cl="clear"
alias ll="ls -lh"
alias lr="ls -ltrh"
alias la="ls -a"
alias colossus="ssh -Y $COLOSSUS"
alias guardian="ssh -Y $GUARDIAN"
~
".bash_john" 23L, 676C written                                3,0-1         All
```

Open a Terminal and create `$HOME/bin`, `$HOME/lib`, `$HOME/man` directories using `mkdir` command.
Save and close `$HOME/.bash_$USER` after making the changes, and run `. $HOME/.bashrc` for the changes to take effect.
OS looks for commands, libaries and manual pages in `PATH`, `LD_LIBRARY_PATH` and `MANPATH` respectively.

Files, folders, symbolic links

```
[john@feynman ~]$ ls
[john@feynman ~]$ ls -l
total 0
[john@feynman ~]$ touch file_01.txt
[john@feynman ~]$ touch file_02.txt
[john@feynman ~]$ mkdir folder_01
[john@feynman ~]$ mkdir folder_02
[john@feynman ~]$ ln -s file_01.txt file.txt
[john@feynman ~]$ ln -s folder_02 folder
[john@feynman ~]$ touch .hidden_file
[john@feynman ~]$ mkdir .hidden_folder
[john@feynman ~]$
```

Open a Terminal and type the above commands.
Entities that start with a `.` are hidden, and don't appear in `ls` or `ls -l`. Use `man ls` to learn how to list all entities.

Ownership and permission

```
[john@feynman ~]$ ls -l
total 8
-rw-r--r-- 1 john users    0 Aug 20 14:27 file_01.txt
-rw-r--r-- 1 john users    0 Aug 20 14:28 file_02.txt
lrwxrwxrwx 1 john users   11 Aug 20 14:28 file.txt -> file_01.txt
lrwxrwxrwx 1 john users    9 Aug 20 14:29 folder -> folder_02
drwxr-xr-x 2 john users 4096 Aug 20 14:28 folder_01
drwxr-xr-x 2 john users 4096 Aug 20 14:28 folder_02
[john@feynman ~]$
```

- Entity type: normal file (-), directory (d), link (-), socket (s)
- Ownership levels: user (u), group (g), others (o)
- Permission levels: read (4, r), write (2, w), execute (1, x)

Open a Terminal and type `ls -l`.
Permission level values add up at each ownership level.
Ownership and permission can be changed using `chown` and `chmod` commands respectively.
`file_01.txt` and `file_02.txt` have 644, `folder_01` and `folder_02` have 755, and `folder` and `file.txt` have 777.

Ownership and permission

Using alphabet approach

```
chmod u=rwx file_01.txt
chmod g+rw,o-rwx file_02.txt
chmod g+x,o-x folder_01
chmod u-x folder_02
```

Using number approach

```
chmod 744 file_01.txt
chmod 660 file_02.txt
chmod 754 folder_01
chmod 655 folder_02
```

Open a Terminal and type the above commands. Run `ls -l` after each command to observe the changes. Reset the permission to original values after each approach by using `chmod 644 file_01.txt file_02.txt` and `chmod 755 folder_01 folder_02`.

Commands

Basic

`cat`, `cd`, `clear`, `cp`, `date`, `echo`, `finger`, `grep`, `head`, `history`, `less`, `ls`, `man`, `mkdir`, `more`, `mv`, `pwd`, `rm`, `rmdir`, `tail`, `touch`, `vim`

Intermediate

`awk`, `basename`, `bc`, `bzip2`, `chmod`, `chown`, `comm`, `crontab`, `cut`, `df`, `diff`, `du`, `env`, `expect`, `expr`, `file`, `find`, `free`, `gzip`, `hostname`, `id`, `kill`, `killall`, `ln`, `locate`, `paste`, `ping`, `ps`, `rsync`, `scp`, `sdiff`, `sed`, `seq`, `sleep`, `sort`, `ssh`, `tar`, `time`, `top`, `tr`, `ulimit`, `uniq`, `wc`

Advanced

`chgrp`, `groupadd`, `groupmod`, `groupdel`, `ifconfig`, `mount`, `passwd`, `poweroff`, `reboot`, `su`, `uptime`, `umount`, `useradd`, `usermod`, `userdel`

To learn more about a command (e.g., `mkdir`), use `man mkdir`.

Piping

The act of treating the output of one command as the input for a subsequent command. | character represents the pipe.

Prevents creation and keeping track of temporary files to store the output of each command, and is a segue to elegant shell scripting.

Examples

```
du | sort -nr
ls -l | tail -n +2
ps aux | grep $USER
ls -l | sed '1d' | wc -l
last | awk '{ print $1 }' | sort | uniq -c | sort -nr
seq 1 1 100 | awk '{ sum += $1 } END { print sum }'
```

Open a Terminal and type the above commands. Refer to `man` pages to learn what each command (and its option) is doing.

Shell script

A set of (piped) commands, to accomplish a given task, saved in a file for easier execution – helps automate the work flow, reduce chances of errors, and make time for more productive activities.

```
john@feynman:~/bin
File  Edit  View  Search  Terminal  Help
#! /bin/bash
#
# BASH script to count the number of login attempts.
#
# Usage:
# login_counter.sh

last | awk '{ print $1 }' | sort | uniq -c | sort -nr
~
~
~
~
~
~
"login_counter.sh" 8L, 153C written                          7,0-1         All
```

Save all shell scripts in `$HOME/bin` folder. A shell script requires 755 (or at least 700) permission to run.

SSH keys

```
[john@feynman ~]$ cd $HOME
[john@feynman ~]$ ssh-keygen -t rsa -b 1024 -C "john@mtu.edu"
Generating public/private rsa key pair.
Enter file in which to save the key (/home/john/.ssh/id_rsa):
Created directory '/home/john/.ssh'.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/john/.ssh/id_rsa.
Your public key has been saved in /home/john/.ssh/id_rsa.pub.
The key fingerprint is:
a3:e4:82:2d:29:bf:21:25:60:e2:e1:73:f8:92:86:b2 john@mtu.edu
The key's randomart image is:
+--[ RSA 1024]----+
|                 |
|                 |
|oo               |
|* o              |
|.=..   . S       |
|.o=+ o . .       |
|=+=.o o          |
|o=.o .           |
|E o.             |
+-----------------+
[john@feynman ~]$
```

Replace `john` with your Michigan ISO username.
Accept the default location for `$HOME/.ssh/id_rsa`, and set a passphrase (different from Michigan Tech ISO password).
When completed successfully, it will result in two files in `$HOME/.ssh` folder: `id_rsa` and `id_rsa.pub`.
Do not ever share/distribute `id_rsa`.
Copy the contents of `id_rsa.pub` into `$HOME/.ssh/authorized_keys` of a remote server.

SSH keys

```
[john@feynman ~]$ eval $(ssh-agent -s)
Agent pid 14031
[john@feynman ~]$ ssh-add
Enter passphrase for /home/john/.ssh/id_rsa:
Identity added: /home/john/.ssh/id_rsa (/home/john/.ssh/id_rsa)
[john@feynman ~]$
```

Replace `john` with your Michigan ISO username.
`eval $(ssh-agent -s)` followed by `ssh-add` may only need to be run once per session (or day). Check the system settings.
`ssh`, `scp`, and `rsync` over `ssh` from local machine to remote server will no longer prompt for the password.

Additional references

* The Linux Command Line
* The Command Line Crash Course
* BASH Guide for Beginners
* BASH Scripting/Programming: Introduction | Advanced
* Vi editor: Interactive tutorial | Reference
* Tip of the Week: Michigan Tech HPC | GitHub repository
* Twitter: @UNIXToolTip | @Linux_Tips | @RegExTip

A really good and effective way to learn Linux command line quickly is imposing upon yourself to use it for accomplishing as many, if not all, tasks every single day until it starts becoming second nature.

Need help?

https://servicedesk.mtu.edu

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