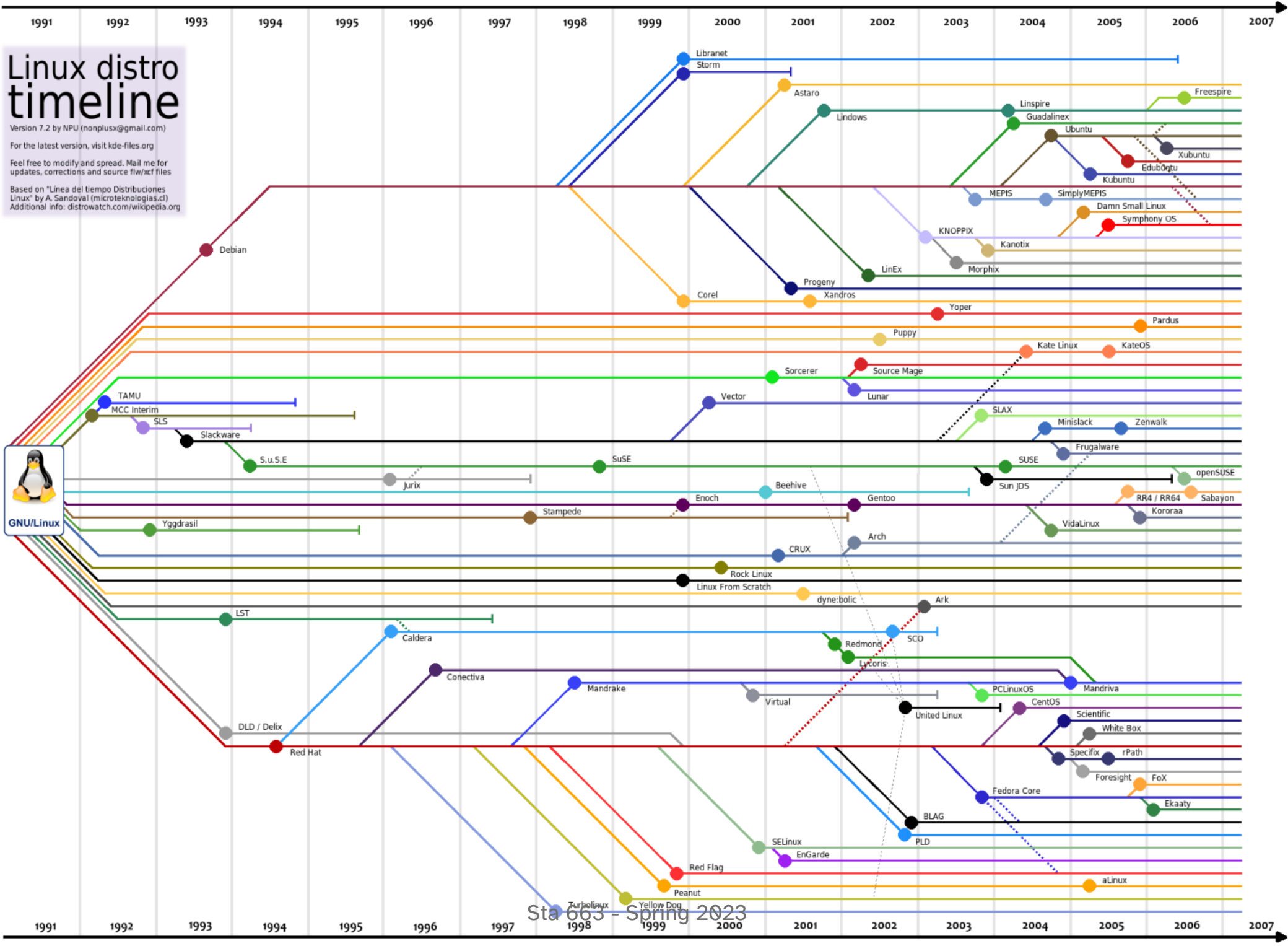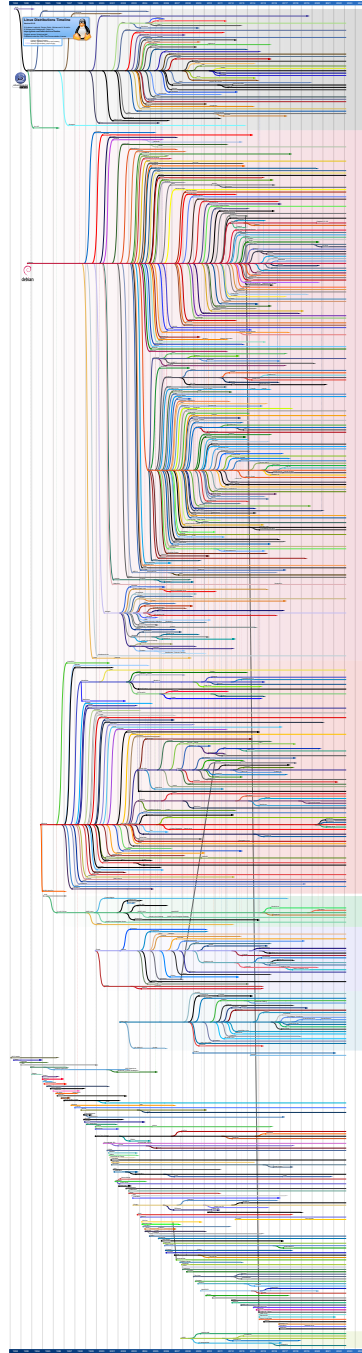# Basic linux admin & Docker

Lecture 26

Dr. Colin Rundel

Linux distro timeline

Version 7.2 by NPU (nonplusx@gmail.com)

For the latest version, visit kde-files.org

Feel free to modify and spread. Mail me for updates, corrections and source flw/xcf files

Based on "Línea del tiempo Distribuciones Linux" by A. Sandoval (microteknologias.cl)
Additional info: distrowatch.com/wikipedia.org

GNU/Linux

1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007

Libranet
Storm
Astaro
Linspire
Lindows
Guadalinex
Freespire
Ubuntu
Xubuntu
Edubuntu
Kubuntu
MEPIS
SimplyMEPIS
Damn Small Linux
Symphony OS
KNOPPIX
Kanotix
LinEx
Morphix
Progeny
Corel
Xandros
Debian
Yoper
Pardus
Puppy
Kate Linux
KateOS
Sorcerer
Source Mage
Vector
Lunar
TAMU
MCC Interim
SLAX
SLS
Minislack
Zenwalk
Slackware
Frugalware
S.u.S.E
SuSE
SUSE
openSUSE
Jurix
Sun JDS
Beehive
Enoch
Gentoo
RR4 / RR64
Sabayon
Stampede
Kororaa
Yggdrasil
VidaLinux
CRUX
Arch
Rock Linux
Linux From Scratch
dyne:bolic
Ark
LST
Caldera
SCO
Redmond
Lycoris
Conectiva
PCLinuxOS
Mandriva
Mandrake
Virtual
CentOS
United Linux
Scientific
DLD / Delix
White Box
Specifix
rPath
Red Hat
Foresight
FoX
Fedora Core
Ekaaty
BLAG
SELinux
PLD
EnGarde
Red Flag
aLinux
Peanut
Turbolinux
Yellow Dog

Sta 663 – Spring 2023

2

Sta 663 - Spring 2023

Duke Virtual Computing Manager

Welcome to Virtual Computing Manager!

Virtual Computing Manager is a service providing the Duke community with easy access to virtual software packages, and semester-long virtual machine (VM) reservations. Access specialized software without installing it on your own computer, host your own server for development projects and coursework, or customize your own environment to use for the semester.

My Reservations

No reserved resources for the current semester

Virtual Machines (aka VMs)

Your Duke VM is like having a second computer that lives in OIT. You can log into and use your VM from your own machine.

- Run Windows or Linux
- Install zero, one or multiple apps for free

Reserve a VM

Virtual Software (aka Containers)

A Container lets you use a desktop software application in your browser without installing it on your machine or your VM.

- Simple to use
- Launch an app in a click!
- Use anywhere you can run a browser

Reserve a Container

Not sure what you need? Check out the Help page or contact vm-manager-help@duke.edu for assistance

vcm.duke.edu

Most Popular

Windows 10

Windows 10 operating system

Ubuntu Server 20.04

Ubuntu Server 20.04 LTS (Focal Fossa)

Fuqua Office 2019 64-Bit

Microsoft Office 2019 Professional Plus 64-bit: Word 2019, Excel 2019, PowerPoint 2019, Outlook, OneNote (2016), Publisher and Access.

Course

COMPSCI 390

Ubuntu 20.04 Mate desktop with Chrome, Java and Ghidra

Everything

All   Linux   Windows

CentOS Stream 8
COMPSCI 390 Ubuntu 20.04 Mate desktop with Chrome, Java and Ghidra
Generic CentOS 7 The CentOS Linux distribution is community-driven free software derived from the sources of Red Hat Enterprise Linux (RHEL).
Lamp Stack Linux, Apache, MySQL, PHP development environment
Linux Matlab MATLAB R2021a numerical computation, visualization, & programming for Linux
Ubuntu Server 20.04 Ubuntu Server 20.04 LTS (Focal Fossa)
Ubuntu Server 22.04 Ubuntu Server 22.04 (Jammy Jellyfish)

VM Management Tools

⏻ Power on	⏻ Power off	📷 Take a current snapshot	⟳ Reload from snapshot	📄 Export this VM

📄 Create an alias	⤫ Transfer ownership	🗑 Delete this reservation	Automatic power downs? ☑

My Reservations

VIRTUAL MACHINES

vcm-26406.vm.duke.edu

Adding your account to your VM. In a few minutes an email will be sent to cr173@duke.edu to let you know it is ready.

THIS VM WILL POWER DOWN AUTOMATICALLY

To make efficient use of the shared VCM resources and reduce our carbon footprint, this VM will be powered down **every morning at 6:00 AM**. Click the Power on button to turn your VM back on before you log into it. If your VM is being used as server or runs very long computations and must remain on continuously, you can un-check the **Automatic power down** check box above to opt out of automatic shutdowns.

General Information

Hostname:	vcm-26406.vm.duke.edu
Operating System:	Ubuntu Server 20.04
Base memory:	4 GB
Processors:	2
VM Status:	reserving

Getting Started

Connecting

```
1  rundel@tbBook [~]$ ssh cr173@vcm-26406.vm.duke.edu
```

```
1  The authenticity of host 'vcm-26406.vm.duke.edu (67.159.94.29)' can't be established.
2  ED25519 key fingerprint is SHA256:7Ukmob4JBk3K3Vd2PnlZjy8vgZFN90lmUvs5961kePA.
3  This key is not known by any other names
4  Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
5  Warning: Permanently added 'vcm-26406.vm.duke.edu' (ED25519) to the list of known hosts.
6
7  cr173@vcm-26406.vm.duke.edu's password:
```

```
1  Welcome to Ubuntu 20.04.6 LTS (GNU/Linux 5.4.0-146-generic x86_64)
2
3   * Documentation:  https://help.ubuntu.com
4   * Management:     https://landscape.canonical.com
5   * Support:        https://ubuntu.com/advantage
6
7   * Introducing Expanded Security Maintenance for Applications.
8     Receive updates to over 25,000 software packages with your
9     Ubuntu Pro subscription. Free for personal use.
10
11      https://ubuntu.com/pro
12  New release '22.04.2 LTS' available.
13  Run 'do-release-upgrade' to upgrade to it.
14
15  cr173@vcm-26406:~$
```

Determining Distribution

This does not work 100% of the time but is generally pretty reliable,

System Details

Filesystem Hierarchy Standard

Ubuntu

```
 1  cr173@vcm-26406:~$ tree -d -L 1 /
 2
 3  /
 4  ├── bin
 5  ├── boot
 6  ├── dev
 7  ├── etc
 8  ├── home
 9  ├── lib
10  ├── lib64
11  ├── media
12  ├── mnt
13  ├── opt
14  ├── proc
15  ├── root
16  ├── run
17  ├── sbin
18  ├── srv
19  ├── sys
20  ├── tmp
21  ├── usr
22  └── var
```

Fedora

```
 1  cr173@algebra2 [~]$ tree -d -L 1 /
 2  /
 3  ├── bibtex
 4  ├── bin -> usr/bin
 5  ├── boot
 6  ├── custom-bib
 7  ├── data
 8  ├── dev
 9  ├── doc
10  ├── dvips
11  ├── etc
12  ├── fonts
13  ├── geometry
14  ├── home
15  ├── lib -> usr/lib
16  ├── lib64 -> usr/lib64
17  ├── lost+found
18  ├── media
19  ├── mnt
20  ├── opt
21  ├── pdftex
22  ├── proc
23  ├── proj
```

Secondary, Tertiarty, etc.

Secondary

```
 1  cr173@algebra2 [~]$ tree -d -L 1 /usr
 2  /usr
 3  ├── bin
 4  ├── etc
 5  ├── games
 6  ├── include
 7  ├── lib
 8  ├── lib64
 9  ├── libexec
10  ├── local
11  ├── sbin
12  ├── share
13  ├── src
14  └── tmp -> ../var/tmp
```

Tertiarty

```
 1  cr173@algebra2 [~]$ tree -d -L 1 /usr/local
 2  /usr/local
 3  ├── bin
 4  ├── etc
 5  ├── games
 6  ├── include
 7  ├── lib
 8  ├── lib64
 9  ├── libexec
10  ├── sbin
11  ├── share
12  └── src
```

> Secondary hierarchy for read-only user data; contains the majority of (multi-)user utilities and applications. Should be shareable and read-only
> Tertiary hierarchy for local data, specific to this host.

From Wikipedia Filesystem Hierarchy Standard

Installing packages with apt (Ubuntu, Debian, etc.)

Update the package list

```
1  cr173@vcm-26406:~$ apt update
2
3  Reading package lists... Done
4  E: Could not open lock file /var/lib/apt/lists/lock - open (13: Permission denied)
5  E: Unable to lock directory /var/lib/apt/lists/
6  W: Problem unlinking the file /var/cache/apt/pkgcache.bin - RemoveCaches (13: Permission denied)
7  W: Problem unlinking the file /var/cache/apt/srcpkgcache.bin - RemoveCaches (13: Permission denied)```
```
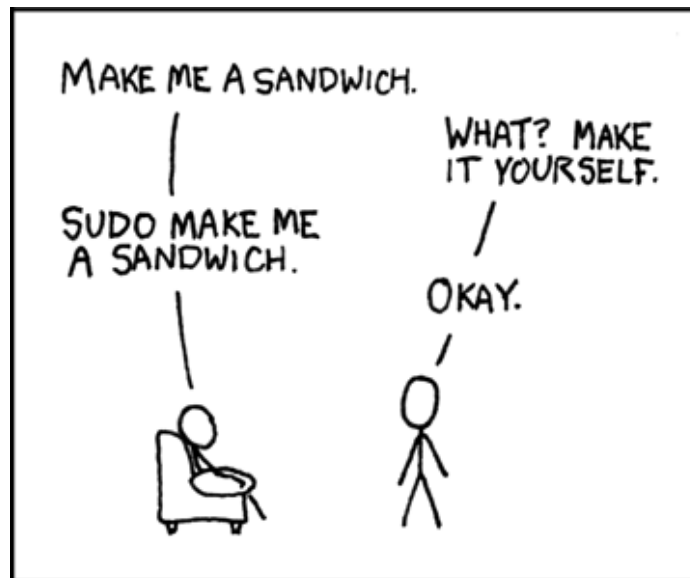

XKCD 149 - Sandwich

Update the package list

```
 1  cr173@vcm-26406:~$ sudo apt update
 2
 3  Hit:1 http://archive.linux.duke.edu/ubuntu focal InRelease
 4  Get:2 http://archive.linux.duke.edu/ubuntu focal-updates InRelease [114 kB]
 5  Hit:3 https://falcon-dl.oit.duke.edu/ubuntu focal InRelease
 6  Get:4 http://archive.linux.duke.edu/ubuntu focal-backports InRelease [108 kB]
 7  Get:5 http://archive.linux.duke.edu/ubuntu focal-security InRelease [114 kB]
 8  Get:6 http://archive.linux.duke.edu/ubuntu focal-updates/main amd64 Packages [1,711 kB]
 9  Get:7 http://archive.linux.duke.edu/ubuntu focal-updates/main i386 Packages [628 kB]
10  Get:8 http://archive.linux.duke.edu/ubuntu focal-updates/main Translation-en [320 kB]
11  Get:9 http://archive.linux.duke.edu/ubuntu focal-updates/restricted amd64 Packages [917 kB]
12  Get:10 http://archive.linux.duke.edu/ubuntu focal-updates/restricted Translation-en [131 kB]
13  Get:11 http://archive.linux.duke.edu/ubuntu focal-updates/universe amd64 Packages [916 kB]
14  Get:12 http://archive.linux.duke.edu/ubuntu focal-updates/universe i386 Packages [676 kB]
15  Get:13 http://archive.linux.duke.edu/ubuntu focal-updates/universe Translation-en [204 kB]
16  Get:14 http://archive.linux.duke.edu/ubuntu focal-updates/universe amd64 c-n-f Metadata [20.4 kB]
17  Get:15 http://archive.linux.duke.edu/ubuntu focal-security/main i386 Packages [416 kB]
18  Get:16 http://archive.linux.duke.edu/ubuntu focal-security/main amd64 Packages [1,383 kB]
19  Get:17 http://archive.linux.duke.edu/ubuntu focal-security/main Translation-en [239 kB]
20  Get:18 http://archive.linux.duke.edu/ubuntu focal-security/restricted amd64 Packages [859 kB]
21  Get:19 http://archive.linux.duke.edu/ubuntu focal-security/restricted Translation-en [122 kB]
22  Get:20 http://archive.linux.duke.edu/ubuntu focal-security/universe i386 Packages [547 kB]
23  Get:21 http://archive.linux.duke.edu/ubuntu focal-security/universe amd64 Packages [696 kB]
```

Installing R

```
 1  cr173@vcm-26406:~$ sudo apt install r-base
 2  [sudo] password for cr173:
 3
 4  Reading package lists... Done
 5  Building dependency tree
 6  Reading state information... Done
 7  The following additional packages will be installed:
 8    build-essential bzip2-doc cpp cpp-9 dpkg-dev fakeroot fontconfig fontconfig-config fonts-dejavu-core
 9    libalgorithm-diff-perl libalgorithm-diff-xs-perl libalgorithm-merge-perl libasan5 libatomic1 libauthe
10    libdata-dump-perl libdatrie1 libdpkg-perl libdrm-amdgpu1 libdrm-intel1 libdrm-nouveau2 libdrm-radeon1
11    libfile-desktopentry-perl libfile-fcntllock-perl libfile-listing-perl libfile-mimeinfo-perl libfont-a
12    libgfortran5 libgl1 libgl1-mesa-dri libglapi-mesa libglvnd0 libglx-mesa0 libglx0 libgomp1 libgraphite
13    libhtml-parser-perl libhtml-tagset-perl libhtml-tree-perl libhttp-cookies-perl libhttp-daemon-perl li
14    libicu-dev libio-html-perl libio-socket-ssl-perl libio-stringy-perl libipc-system-simple-perl libisl2
15    libjpeg8-dev liblapack-dev liblapack3 libllvm12 liblsan0 liblwp-mediatypes-perl liblwp-protocol-https
16    libncurses5-dev libnet-dbus-perl libnet-http-perl libnet-smtp-ssl-perl libnet-ssleay-perl libpango-1.
17    libpciaccess0 libpcre16-3 libpcre2-16-0 libpcre2-32-0 libpcre2-dev libpcre2-posix2 libpcre3-dev libpc
18    libreadline-dev libsensors-config libsensors5 libsm6 libstdc++-9-dev libtcl8.6 libthai-data libthai0
19    libtsan0 libubsan1 liburi-perl libvulkan1 libwayland-client0 libwebp6 libwww-perl libwww-robotrules-p
20    libxcb-glx0 libxcb-present0 libxcb-randr0 libxcb-render0 libxcb-shape0 libxcb-shm0 libxcb-sync1 libxc
21    libxinerama1 libxkbfile1 libxml-parser-perl libxml-twig-perl libxml-xpathengine-perl libxmu6 libxpm4
22    libxxf86dga1 libxxf86vm1 make mesa-vulkan-drivers perl-openssl-defaults pkg-config r-base-core r-base
23    r-cran-foreign r-cran-kernsmooth r-cran-lattice r-cran-mass r-cran-matrix r-cran-mgcv r-cran-nlme r-c
```

Removing R

```
 1  cr173@vcm-26406:~$ sudo apt remove r-base
 2
 3  Reading package lists... Done
 4  Building dependency tree
 5  Reading state information... Done
 6  The following packages were automatically installed and are no longer required:
 7    fontconfig fontconfig-config fonts-dejavu-core gfortran gfortran-9 icu-devtools libblas-dev libblas3
 8    libdrm-nouveau2 libdrm-radeon1 libfile-basedir-perl libfile-desktopentry-perl libfile-mimeinfo-perl l
 9    libgl1-mesa-dri libglapi-mesa libglvnd0 libglx-mesa0 libglx0 libgraphite2-3 libharfbuzz0b libice6 lib
10    libjpeg-turbo8 libjpeg-turbo8-dev libjpeg8 libjpeg8-dev liblapack-dev liblapack3 libllvm12 liblzma-de
11    libpangocairo-1.0-0 libpangoft2-1.0-0 libpaper-utils libpaper1 libpciaccess0 libpcre16-3 libpcre2-16-
12    libpcrecpp0v5 libpixman-1-0 libpng-dev libpng-tools libreadline-dev libsensors-config libsensors5 lib
13    libvulkan1 libwayland-client0 libwebp6 libx11-protocol-perl libx11-xcb1 libxaw7 libxcb-dri2-0 libxcb-
14    libxcb-shape0 libxcb-shm0 libxcb-sync1 libxcb-xfixes0 libxcomposite1 libxcursor1 libxfixes3 libxft2 l
15    libxml-xpathengine-perl libxmu6 libxpm4 libxrandr2 libxrender1 libxshmfence1 libxss1 libxt6 libxtst6
16    r-base-dev r-base-html r-cran-boot r-cran-class r-cran-cluster r-cran-codetools r-cran-foreign r-cran
17    r-cran-nlme r-cran-nnet r-cran-rpart r-cran-spatial r-cran-survival r-doc-html r-recommended unzip x1
18  Use 'sudo apt autoremove' to remove them.
19  The following packages will be REMOVED:
20    r-base
21  0 upgraded, 0 newly installed, 1 to remove and 1 not upgraded.
22  After this operation, 62.5 kB disk space will be freed.
```

and all of its dependencies

```
 1  cr173@vcm-26406:~$ sudo apt autoremove
 2
 3  Reading package lists... Done
 4  Building dependency tree
 5  Reading state information... Done
 6  The following packages will be REMOVED:
 7    fontconfig fontconfig-config fonts-dejavu-core gfortran gfortran-9 icu-devtools libblas-dev libblas3
 8    libdrm-nouveau2 libdrm-radeon1 libfile-basedir-perl libfile-desktopentry-perl libfile-mimeinfo-perl l
 9    libgl1-mesa-dri libglapi-mesa libglvnd0 libglx-mesa0 libglx0 libgraphite2-3 libharfbuzz0b libice6 lib
10    libjpeg-turbo8 libjpeg-turbo8-dev libjpeg8 libjpeg8-dev liblapack-dev liblapack3 libllvm12 liblzma-de
11    libpangocairo-1.0-0 libpangoft2-1.0-0 libpaper-utils libpaper1 libpciaccess0 libpcre16-3 libpcre2-16-
12    libpcrecpp0v5 libpixman-1-0 libpng-dev libpng-tools libreadline-dev libsensors-config libsensors5 lib
13    libvulkan1 libwayland-client0 libwebp6 libx11-protocol-perl libx11-xcb1 libxaw7 libxcb-dri2-0 libxcb-
14    libxcb-shape0 libxcb-shm0 libxcb-sync1 libxcb-xfixes0 libxcomposite1 libxcursor1 libxfixes3 libxft2 l
15    libxml-xpathengine-perl libxmu6 libxpm4 libxrandr2 libxrender1 libxshmfence1 libxss1 libxt6 libxtst6
16    r-base-dev r-base-html r-cran-boot r-cran-class r-cran-cluster r-cran-codetools r-cran-foreign r-cran
17    r-cran-nlme r-cran-nnet r-cran-rpart r-cran-spatial r-cran-survival r-doc-html r-recommended unzip x1
18  0 upgraded, 0 newly installed, 140 to remove and 1 not upgraded.
19  After this operation, 749 MB disk space will be freed.
20  Do you want to continue? [Y/n]
```

Updating & Upgrading

```
 1  cr173@vcm-26406:~$ sudo apt update
 2
 3  Hit:1 http://archive.linux.duke.edu/ubuntu focal InRelease
 4  Hit:2 http://archive.linux.duke.edu/ubuntu focal-updates InRelease
 5  Hit:3 http://archive.linux.duke.edu/ubuntu focal-backports InRelease
 6  Hit:4 http://archive.linux.duke.edu/ubuntu focal-security InRelease
 7  Hit:5 https://falcon-dl.oit.duke.edu/ubuntu focal InRelease
 8  Reading package lists... Done
 9  Building dependency tree
10  Reading state information... Done
11  1 package can be upgraded. Run 'apt list --upgradable' to see it.
```

```
 1  cr173@vcm-26406:~$ sudo apt upgrade
 2
 3  Reading package lists... Done
 4  Building dependency tree
 5  Reading state information... Done
 6  Calculating upgrade... Done
 7  The following packages will be upgraded:
 8    libfribidi0
 9  1 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
10  1 standard security update
11  Need to get 24.2 kB of archives.
12  After this operation, 0 B of additional disk space will be used.
13  Do you want to continue? [Y/n]
```

Aside - Conflicts

```
 1  ...
 2  update-initramfs: deferring update (trigger activated)
 3  amd64-microcode: microcode will be updated at next boot
 4  Setting up intel-microcode (3.20180807a.0ubuntu0.18.04.1) ...
 5  update-initramfs: deferring update (trigger activated)
 6  intel-microcode: microcode will be updated at next boot
 7  Setting up kmod (24-1ubuntu3.1) ...
 8
 9  *Configuration file '/etc/modprobe.d/blacklist.conf'
10  * ==> Modified (by you or by a script) since installation.
11  * ==> Package distributor has shipped an updated version.
12  *   What would you like to do about it ?  Your options are:
13  *    Y or I  : install the package maintainer's version
14  *    N or O  : keep your currently-installed version
15  *      D     : show the differences between the versions
16  *      Z     : start a shell to examine the situation
17  * The default action is to keep your current version.
18  **** blacklist.conf (Y/I/N/O/D/Z) [default=N] ?
19  Setting up initramfs-tools-core (0.130ubuntu3.6) ...
20  Setting up linux-headers-4.15.0-43-generic (4.15.0-43.46) ...
21  Setting up initramfs-tools (0.130ubuntu3.6) ...
22
23  ...
```

Package Details

```
 1  cr173@vcm-26406:~$ apt show r-base
 2
 3  Package: r-base
 4  Version: 3.6.3-2
 5  Priority: optional
 6  Section: universe/math
 7  Origin: Ubuntu
 8  Maintainer: Ubuntu Developers <ubuntu-devel-discuss@lists.ubuntu.com>
 9  Original-Maintainer: Dirk Eddelbuettel <edd@debian.org>
10  Bugs: https://bugs.launchpad.net/ubuntu/+filebug
11  Installed-Size: 62.5 kB
12  Depends: r-base-core (>= 3.6.3-2), r-recommended (= 3.6.3-2)
13  Recommends: r-base-html, r-doc-html
14  Suggests: elpa-ess, r-doc-info | r-doc-pdf
15  Homepage: http://www.r-project.org/
16  Download-Size: 9,308 B
17  APT-Manual-Installed: yes
18  APT-Sources: http://archive.linux.duke.edu/ubuntu focal/universe amd64 Packages
19  Description: GNU R statistical computation and graphics system
20   R is a system for statistical computation and graphics.  It consists
21   of a language plus a run-time environment with graphics, a debugger,
22   access to certain system functions, and the ability to run programs
23   stored in script files.
```

Package Contents

```
 1  cr173@vcm-26406:~$ dpkg -L r-base
 2
 3  /.
 4  /usr
 5  /usr/share
 6  /usr/share/doc
 7  /usr/share/doc/r-base
 8  /usr/share/doc/r-base/README.Debian
 9  /usr/share/doc/r-base/copyright
10  /usr/share/doc/r-base/changelog.Debian.gz
```

File -> Package

```
1  cr173@vcm-26406:~$ dpkg -S /usr/bin/R
2
3  r-base-core: /usr/bin/R
```

```
1   cr173@vcm-26406:~$ dpkg -L r-base-core
2
3   /.
4   /etc
5   /etc/R
6   /etc/R/Makeconf
7   /etc/R/Renviron.site
8   /etc/R/Rprofile.site
9   /etc/R/ldpaths
10  /etc/R/repositories
11  /etc/ld.so.conf.d
12  /usr
13  /usr/bin
14  /usr/bin/R
15  /usr/bin/Rscript
16  /usr/lib
17  /usr/lib/R
18  /usr/lib/R/SVN-REVISION
19  /usr/lib/R/bin
20  /usr/lib/R/bin/BATCH
21  /usr/lib/R/bin/COMPILE
22  /usr/lib/R/bin/INSTALL
23  /usr/lib/R/bin/LINK
```

Package Manager Comparison

	Ubuntu / Debian	RHEL	Fedora	Requires root
Install	`apt install`	`yum install`	`dnf install`	Yes
Install Local	`dpkg -i pkg.deb`	`yum install pkg.rpm`	`dnf install pkg.rpm`	Yes
Remove	`apt remove`	`yum remove`	`dnf remove`	Yes
Update	`apt update`	`yum check-update`	`dnf check-update`	Yes
Upgrade	`apt upgrade` `apt full-upgrade`	`yum upgrade`	`dnf upgrade`	Yes
Clean Deps.	`apt autoremove`	`yum autoremove`	`dnf autoremove`	Yes
Reinstall	`apt install --reinstall`	`yum reinstall`	`dnf reinstall`	Yes
Details.	`apt show`	`yum info`	`dnf info`	No
Dependencies	`apt show`	`yum deplist`	`dnf repoquery --requires`	No
Pkg -> Files	`dpkg -L`	`rpm -qf`	`rpm -qf`	No
Files -> Pkg	`dpkg -S`	`rpm -ql`	`rpm -ql` or `dnf repoquery -l`	No

Upgrading R

The R project maintains separate package repositories with the latest version of R - see distribution specific instructions here - the version bundled with your distribution of choice is often *very* outdated.

```
1  sudo apt update -qq
2  sudo apt install --no-install-recommends -y software-properties-common dirmngr
3  wget -qO- https://cloud.r-project.org/bin/linux/ubuntu/marutter_pubkey.asc | sudo tee -a /etc/apt/trust
4  sudo add-apt-repository "deb https://cloud.r-project.org/bin/linux/ubuntu $(lsb_release -cs)-cran40/"
```

```
1  cr173@vcm-26406:~$ cat /etc/apt/sources.list
2
3  ...
4  deb https://cloud.r-project.org/bin/linux/ubuntu focal-cran40/
5  # deb-src https://cloud.r-project.org/bin/linux/ubuntu focal-cran40/
6  ...
```

Updating & Upgrading

```
 1  cr173@vcm-26406:~$ sudo apt update
 2
 3  Hit:1 http://archive.linux.duke.edu/ubuntu focal InRelease
 4  Get:2 http://archive.linux.duke.edu/ubuntu focal-updates InRelease [114 kB]
 5  Hit:3 http://archive.linux.duke.edu/ubuntu focal-backports InRelease
 6  Get:4 http://archive.linux.duke.edu/ubuntu focal-security InRelease [114 kB]
 7  Hit:5 https://falcon-dl.oit.duke.edu/ubuntu focal InRelease
 8  Hit:6 https://cloud.r-project.org/bin/linux/ubuntu focal-cran40/ InRelease
 9  Get:7 http://archive.linux.duke.edu/ubuntu focal-updates/main amd64 Packages [1,711 kB]
10  Get:8 http://archive.linux.duke.edu/ubuntu focal-updates/universe amd64 Packages [916 kB]
11  Fetched 2,854 kB in 1s (2,551 kB/s)
12  Reading package lists... Done
13  Building dependency tree
14  Reading state information... Done
15  22 packages can be upgraded. Run 'apt list --upgradable' to see them.
```

```
 1  cr173@vcm-26406:~$ sudo apt upgrade
 2
 3  Reading package lists... Done
 4  Building dependency tree
 5  Reading state information... Done
 6  Calculating upgrade... Done
 7  The following packages will be upgraded:
 8    libfribidi0 r-base r-base-core r-base-dev r-base-html r-cran-boot r-cran-class r-cran-cluster r-cran-
 9    r-cran-matrix r-cran-mgcv r-cran-nlme r-cran-nnet r-cran-rpart r-cran-spatial r-cran-survival r-doc-h
10  22 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
11  1 standard security update
```

```
12  Need to get 47.9 MB of archives.
13  After this operation, 3,829 kB of additional disk space will be used.
14  Do you want to continue? [Y/n] y
15  Get:1 http://archive.linux.duke.edu/ubuntu focal-updates/main amd64 libfribidi0 amd64 1.0.8-2ubuntu0.1
16  Get:2 https://cloud.r-project.org/bin/linux/ubuntu focal-cran40/ r-cran-lattice 0.20-45-1.2004.0 [1,134
17  Get:3 https://cloud.r-project.org/bin/linux/ubuntu focal-cran40/ r-cran-matrix 1.4-1-1.2004.0 [4,303 kB
18  Get:4 https://cloud.r-project.org/bin/linux/ubuntu focal-cran40/ r-cran-survival 3.2-13-1cran1.2004.0 [
19  Get:5 https://cloud.r-project.org/bin/linux/ubuntu focal-cran40/ r-cran-spatial 7.3-11-2focal0 [127 kB]
20  Get:6 https://cloud.r-project.org/bin/linux/ubuntu focal-cran40/ r-cran-rpart 4.1.16-1.2004.0 [910 kB]
21  Get:7 https://cloud.r-project.org/bin/linux/ubuntu focal-cran40/ r-cran-nnet 7.3-17-1.2004.0 [112 kB]
22  Get:8 https://cloud.r-project.org/bin/linux/ubuntu focal-cran40/ r-cran-nlme 3.1.157-1.2004.0 [2,250 kB
23  Get:9 https://cloud.r-project.org/bin/linux/ubuntu focal-cran40/ r-cran-mgcv 1.8-40-1cran1.2004.0 [3,02
```

System dependencies

```
1  cr173@vcm-26406:~$ R
2
3  R version 4.1.3 (2022-03-10) -- "One Push-Up"
4  Copyright (C) 2022 The R Foundation for Statistical Computing
5  Platform: x86_64-pc-linux-gnu (64-bit)
6
7  ...
8
9  > install.packages("curl")
10   Installing package into '/usr/local/lib/R/site-library'
11   (as 'lib' is unspecified)
12   trying URL 'https://cloud.r-project.org/src/contrib/curl_4.3.2.tar.gz'
13   Content type 'application/x-gzip' length 793345 bytes (774 KB)
14   ==================================================
15   downloaded 774 KB
16
17   * installing *source* package 'curl' ...
18   ** package 'curl' successfully unpacked and MD5 sums checked
19   ** using staged installation
20   Package libcurl was not found in the pkg-config search path.
21   Perhaps you should add the directory containing `libcurl.pc'
22   to the PKG_CONFIG_PATH environment variable
23   No package 'libcurl' found
```

Installing libcurl4-openssl-dev

```
 1  cr173@vcm-26406:~$ sudo apt install libcurl4-openssl-dev
 2
 3  Reading package lists... Done
 4  Building dependency tree
 5  Reading state information... Done
 6  Suggested packages:
 7    libcurl4-doc libidn11-dev libkrb5-dev libldap2-dev librtmp-dev libssh2-1-dev libssl-dev
 8  The following NEW packages will be installed:
 9    libcurl4-openssl-dev
10  0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
11  Need to get 321 kB of archives.
12  After this operation, 1,541 kB of additional disk space will be used.
13  Get:1 http://archive.linux.duke.edu/ubuntu focal-updates/main amd64 libcurl4-openssl-dev amd64 7.68.0-1
14  Fetched 321 kB in 0s (2,051 kB/s)
15  Selecting previously unselected package libcurl4-openssl-dev:amd64.
16  (Reading database ... 126123 files and directories currently installed.)
17  Preparing to unpack .../libcurl4-openssl-dev_7.68.0-1ubuntu2.7_amd64.deb ...
18  Unpacking libcurl4-openssl-dev:amd64 (7.68.0-1ubuntu2.7) ...
19  Setting up libcurl4-openssl-dev:amd64 (7.68.0-1ubuntu2.7) ...
20  Processing triggers for man-db (2.9.1-1) ...
```

Success

```
1  cr173@vcm-26406:~$ R
2  ...
3  > install.packages("curl")
4   Installing package into '/home/cr173/R/x86_64-pc-linux-gnu-library/4.1'
5   (as 'lib' is unspecified)
6   trying URL 'https://cloud.r-project.org/src/contrib/curl_4.3.2.tar.gz'
7   Content type 'application/x-gzip' length 793345 bytes (774 KB)
8   ==================================================
9   downloaded 774 KB
10
11  * installing *source* package 'curl' ...
12  ** package 'curl' successfully unpacked and MD5 sums checked
13  ** using staged installation
14  Found pkg-config cflags and libs!
15  Using PKG_CFLAGS=-I/usr/include/x86_64-linux-gnu
16  Using PKG_LIBS=-lcurl
17  ** libs
18  rm -f curl.so callbacks.o curl.o download.o escape.o fetch.o form.o getdate.o handle.o ieproxy.o init.
19   gcc -I"/usr/share/R/include" -DNDEBUG -I/usr/include/x86_64-linux-gnu -DSTRICT_R_HEADERS    -fvisibili
20   gcc -I"/usr/share/R/include" -DNDEBUG -I/usr/include/x86_64-linux-gnu -DSTRICT_R_HEADERS    -fvisibili
21   gcc -I"/usr/share/R/include" -DNDEBUG -I/usr/include/x86_64-linux-gnu -DSTRICT_R_HEADERS    -fvisibili
22   gcc -I"/usr/share/R/include" -DNDEBUG -I/usr/include/x86_64-linux-gnu -DSTRICT_R_HEADERS    -fvisibili
23   gcc -I"/usr/share/R/include" -DNDEBUG -I/usr/include/x86_64-linux-gnu -DSTRICT_R_HEADERS    -fvisibili
```

What is `libcurl4-openssl-dev`?

```
 1  cr173@vcm-26406:~$ apt show libcurl4-openssl-dev
 2
 3  Package: libcurl4-openssl-dev
 4  Version: 7.68.0-1ubuntu2.7
 5  Priority: optional
 6  Section: libdevel
 7  Source: curl
 8  Origin: Ubuntu
 9  Maintainer: Ubuntu Developers <ubuntu-devel-discuss@lists.ubuntu.com>
10  Original-Maintainer: Alessandro Ghedini <ghedo@debian.org>
11  Bugs: https://bugs.launchpad.net/ubuntu/+filebug
12  Installed-Size: 1,541 kB
13  Provides: libcurl-dev, libcurl-ssl-dev, libcurl3-dev, libcurl3-openssl-dev, libcurl4-dev
14  Depends: libcurl4 (= 7.68.0-1ubuntu2.7)
15  Suggests: libcurl4-doc, libidn11-dev, libkrb5-dev, libldap2-dev, librtmp-dev, libssh2-1-dev, libssl-dev
16  Conflicts: libcurl4-gnutls-dev, libcurl4-nss-dev, libssl-dev (<< 1.1), libssl1.0-dev
17  Homepage: http://curl.haxx.se
18  Download-Size: 321 kB
19  APT-Manual-Installed: yes
20  APT-Sources: http://archive.linux.duke.edu/ubuntu focal-updates/main amd64 Packages
21  *Description: development files and documentation for libcurl (OpenSSL flavour)
22  * libcurl is an easy-to-use client-side URL transfer library, supporting DICT,
23  * FILE, FTP, FTPS, GOPHER, HTTP, HTTPS, IMAP, IMAPS, LDAP, LDAPS, POP3, POP3S,
```

What is in `libcurl4-openssl-dev`?

```
 1  cr173@vcm-26406:~$ dpkg -L libcurl4-openssl-dev
 2  /.
 3  /usr
 4  /usr/bin
 5  /usr/bin/curl-config
 6  /usr/include
 7  /usr/include/x86_64-linux-gnu
 8  /usr/include/x86_64-linux-gnu/curl
 9  /usr/include/x86_64-linux-gnu/curl/curl.h
10  /usr/include/x86_64-linux-gnu/curl/curlver.h
11  /usr/include/x86_64-linux-gnu/curl/easy.h
12  /usr/include/x86_64-linux-gnu/curl/mprintf.h
13  /usr/include/x86_64-linux-gnu/curl/multi.h
14  /usr/include/x86_64-linux-gnu/curl/stdcheaders.h
15  /usr/include/x86_64-linux-gnu/curl/system.h
16  /usr/include/x86_64-linux-gnu/curl/typecheck-gcc.h
17  /usr/include/x86_64-linux-gnu/curl/urlapi.h
18  /usr/lib
19  /usr/lib/x86_64-linux-gnu
20  /usr/lib/x86_64-linux-gnu/libcurl.a
21  /usr/lib/x86_64-linux-gnu/libcurl.la
22  /usr/lib/x86_64-linux-gnu/pkgconfig
23  /usr/lib/x86_64-linux-gnu/pkgconfig/libcurl.pc
```

Lets try `sf`

```
1  cr173@vcm-26406:~$ R
2  ...
3  > install.packages("sf")
4  Installing package into '/home/cr173/R/x86_64-pc-linux-gnu-library/4.1'
5  (as 'lib' is unspecified)
6  trying URL 'https://cloud.r-project.org/src/contrib/sf_1.0-7.tar.gz'
7  Content type 'application/x-gzip' length 3529597 bytes (3.4 MB)
8  ==================================================
9  downloaded 3.4 MB
10
11 * installing *source* package 'sf' ...
12 ** package 'sf' successfully unpacked and MD5 sums checked
13 ** using staged installation
14 configure: CC: gcc
15 configure: CXX: g++ -std=gnu++11
16 checking for gdal-config... no
17 no
18 configure: error: gdal-config not found or not executable.
19 ERROR: configuration failed for package 'sf'
20 * removing '/home/cr173/R/x86_64-pc-linux-gnu-library/4.1/sf'
21
22 The downloaded source packages are in
23    '/tmp/RtmpAt7DId/downloaded_packages'
```

What next?

r-spatial/sf

or

packagemanager.rstudio.com/

A bit about libraries

System libraries

These are shared common components that are used by a variety of software on a linux system. For the most part they are a collection of compiled code (typically C / C++) that are stored in a single file.

- Allows for code reuse

- Allows for multiple (concurrent) versions

- Avoids reinventing the wheel

- Installed in `/lib`, `/usr/lib`, `/usr/local/lib`, etc.

- Two flavors: static (`.a`) and dynamic (`.so`)

libcurl

```
 1  cr173@vcm-26406:~$ ls -la /usr/lib/x86_64-linux-gnu/libcurl*
 2
 3  -rw-r--r-- 1 root root 1057632 Oct 29 08:10 /usr/lib/x86_64-linux-gnu/libcurl.a
 4  lrwxrwxrwx 1 root root      19 Oct 29 08:10 /usr/lib/x86_64-linux-gnu/libcurl-gnutls.so.3 -> libcurl-gn
 5  lrwxrwxrwx 1 root root      23 Oct 29 08:10 /usr/lib/x86_64-linux-gnu/libcurl-gnutls.so.4 -> libcurl-gn
 6  -rw-r--r-- 1 root root  510408 Oct 29 08:10 /usr/lib/x86_64-linux-gnu/libcurl-gnutls.so.4.5.0
 7  -rw-r--r-- 1 root root     951 Oct 29 08:10 /usr/lib/x86_64-linux-gnu/libcurl.la
 8  lrwxrwxrwx 1 root root      16 Oct 29 08:10 /usr/lib/x86_64-linux-gnu/libcurl.so -> libcurl.so.4.5.0
 9  lrwxrwxrwx 1 root root      16 Oct 29 08:10 /usr/lib/x86_64-linux-gnu/libcurl.so.4 -> libcurl.so.4.5.0
10  -rw-r--r-- 1 root root  518600 Oct 29 08:10 /usr/lib/x86_64-linux-gnu/libcurl.so.4.5.0
```

Getting what you want

The following is a basic heuristic of library package naming schemes for these distro families, there are exceptions and edge cases.

These are the names that would then be used with something like `apt install` or `yum install` respectively.

	Debian	Redhat
Dynamic library (.so)	`lib{name}`	`{name}`
Headers	`lib{name}-dev`	`{name}-devel`
Static library (.a)	`lib{name}-dev`	`{name}-static`
Documentation	`lib{name}-doc`	`{name}-devel`

Troubleshooting dynamic libraries

```
 1  cr173@vcm-26406:~$ ldd /usr/lib/x86_64-linux-gnu/libcurl.so
 2
 3      linux-vdso.so.1 (0x00007ffd98176000)
 4      libnghttp2.so.14 => /usr/lib/x86_64-linux-gnu/libnghttp2.so.14 (0x00007f1e3dc60000)
 5      libidn2.so.0 => /usr/lib/x86_64-linux-gnu/libidn2.so.0 (0x00007f1e3da43000)
 6      librtmp.so.1 => /usr/lib/x86_64-linux-gnu/librtmp.so.1 (0x00007f1e3d827000)
 7      libpsl.so.5 => /usr/lib/x86_64-linux-gnu/libpsl.so.5 (0x00007f1e3d619000)
 8      libssl.so.1.1 => /usr/lib/x86_64-linux-gnu/libssl.so.1.1 (0x00007f1e3d3af000)
 9      libcrypto.so.1.1 => /usr/lib/x86_64-linux-gnu/libcrypto.so.1.1 (0x00007f1e3cf37000)
10      libgssapi_krb5.so.2 => /usr/lib/x86_64-linux-gnu/libgssapi_krb5.so.2 (0x00007f1e3ccec000)
11      libldap_r-2.4.so.2 => /usr/lib/x86_64-linux-gnu/libldap_r-2.4.so.2 (0x00007f1e3ca9a000)
12      liblber-2.4.so.2 => /usr/lib/x86_64-linux-gnu/liblber-2.4.so.2 (0x00007f1e3c88c000)
13      libz.so.1 => /lib/x86_64-linux-gnu/libz.so.1 (0x00007f1e3c66f000)
14      libpthread.so.0 => /lib/x86_64-linux-gnu/libpthread.so.0 (0x00007f1e3c450000)
15      libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6 (0x00007f1e3c05f000)
16      libunistring.so.2 => /usr/lib/x86_64-linux-gnu/libunistring.so.2 (0x00007f1e3bce1000)
17      libgnutls.so.30 => /usr/lib/x86_64-linux-gnu/libgnutls.so.30 (0x00007f1e3b97c000)
18      libhogweed.so.4 => /usr/lib/x86_64-linux-gnu/libhogweed.so.4 (0x00007f1e3b748000)
19      libnettle.so.6 => /usr/lib/x86_64-linux-gnu/libnettle.so.6 (0x00007f1e3b512000)
20      libgmp.so.10 => /usr/lib/x86_64-linux-gnu/libgmp.so.10 (0x00007f1e3b291000)
21      libdl.so.2 => /lib/x86_64-linux-gnu/libdl.so.2 (0x00007f1e3b08d000)
22      libkrb5.so.3 => /usr/lib/x86_64-linux-gnu/libkrb5.so.3 (0x00007f1e3adb7000)
23      libk5crypto.so.3 => /usr/lib/x86_64-linux-gnu/libk5crypto.so.3 (0x00007f1e3ab85000)
```

Python management

```
1  cr173@vcm-26406:~$ pip install torch
2
3  Command 'pip' not found, but can be installed with:
4
5  apt install python3-pip
6  Please ask your administrator.
```

```
1   cr173@vcm-26406:~$ sudo apt install python3-pip
2   [sudo] password for cr173:
3
4   Reading package lists... Done
5   Building dependency tree
6   Reading state information... Done
7   The following additional packages will be installed:
8     libexpat1-dev libpython3-dev libpython3.8-dev python-pip-whl python3-dev python3-wheel python3.8-dev
9   The following NEW packages will be installed:
10    libexpat1-dev libpython3-dev libpython3.8-dev python-pip-whl python3-dev python3-pip python3-wheel py
11  0 upgraded, 8 newly installed, 0 to remove and 0 not upgraded.
12  Need to get 6,651 kB of archives.
13  After this operation, 25.0 MB of additional disk space will be used.
14  Do you want to continue? [Y/n]
```

Package manager vs pip

```
1  cr173@vcm-26406:~$ sudo apt install python3-numpy
2
3  Reading package lists... Done
4  Building dependency tree
5  Reading state information... Done
6  python3-numpy is already the newest version (1:1.17.4-5ubuntu3).
7  python3-numpy set to manually installed.
8  0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

```
1  cr173@vcm-26406:~$ sudo pip install numpy --upgrade
2
3  Collecting numpy
4    Downloading numpy-1.22.3-cp38-cp38-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (16.8 MB)
5       |████████████████████████████████| 16.8 MB 3.6 MB/s
6  Installing collected packages: numpy
7    Attempting uninstall: numpy
8      Found existing installation: numpy 1.17.4
9      Not uninstalling numpy at /usr/lib/python3/dist-packages, outside environment /usr
10     Can't uninstall 'numpy'. No files were found to uninstall.
11 Successfully installed numpy-1.22.3
```

```
1  cr173@vcm-26406:~$ sudo pip install numpy --upgrade --ignore-installed
2
3  Collecting numpy
4    Using cached numpy-1.22.3-cp38-cp38-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (16.8 MB)
5  Installing collected packages: numpy
6  Successfully installed numpy-1.22.3
```

Outdated python libraries

```
1  cr173@vcm-26406:~$ sudo pip list --outdated
2  Package             Version     Latest    Type
3  ------------------  ----------  --------- -----
4  ansible             2.9.6       5.6.0     sdist
5  apache-libcloud     2.8.0       3.5.1     wheel
6  argcomplete         1.8.1       2.0.0     wheel
7  certifi             2019.11.28  2021.10.8 wheel
8  chardet             3.0.4       4.0.0     wheel
9  cryptography        2.8         36.0.2    wheel
10 dbus-python         1.2.16      1.2.18    sdist
11 distro              1.4.0       1.7.0     wheel
12 distro-info         0.23ubuntu1 1.0       wheel
13 dnspython           1.16.0      2.2.1     wheel
14 entrypoints         0.3         0.4       wheel
15 GDAL                3.0.4       3.4.2     sdist
16 httplib2            0.14.0      0.20.4    wheel
17 idna                2.8         3.3       wheel
18 Jinja2              2.10.1      3.1.1     wheel
19 jmespath            0.9.4       1.0.0     wheel
20 keyring             18.0.1      23.5.0    wheel
21 launchpadlib        1.10.13     1.10.16   wheel
22 lazr.restfulclient  0.14.2      0.14.4    sdist
23 lazr.uri            1.0.3       1.0.6     sdist
```

Docker

Docker

Docker can package an application and its dependencies in a virtual container that can run on any Linux, Windows, or macOS computer. This enables the application to run in a variety of locations, such as on-premises, in the public or private cloud. When running on Linux, Docker uses the resource isolation features of the Linux kernel (such as cgroups and kernel namespaces) and a union-capable file system to allow containers to run within a single Linux instance, avoiding the overhead of starting and maintaining virtual machines.

From Wikipedia
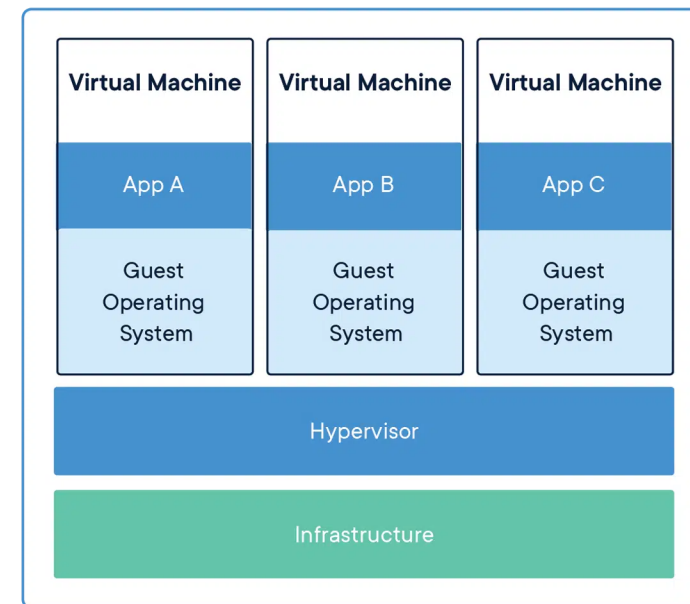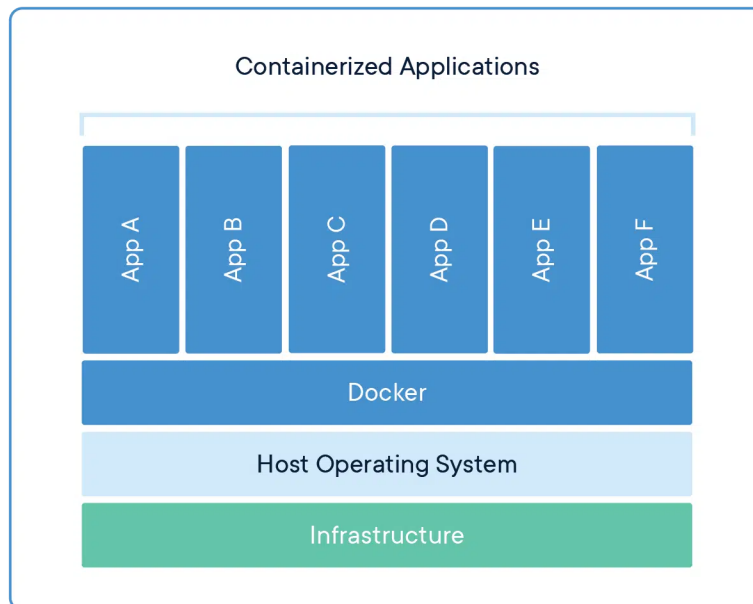
Installation - Ubuntu / Debian

```
1  # Remove system packages
2  sudo apt-get remove docker docker-engine docker.io containerd runc
3
4  # Utililty Packages
5  sudo apt-get update
6  sudo apt-get install \
7    ca-certificates \
8    curl \
9    gnupg \
10   lsb-release
11
12 # Add apt repo signing key
13 curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo gpg --dearmor -o /usr/share/keyrings/doc
14
15 # Add apt repo
16 echo \
17   "deb [arch=$(dpkg --print-architecture) signed-by=/usr/share/keyrings/docker-archive-keyring.gpg] htt
18   $(lsb_release -cs) stable" | sudo tee /etc/apt/sources.list.d/docker.list > /dev/null
19
20 # Install Docker
21 sudo apt-get update
22 sudo apt-get install docker-ce docker-ce-cli containerd.io
```

See docs

Troubleshooting - daemon

```
1  $ sudo docker run hello-world
2  docker: Cannot connect to the Docker daemon at unix:///var/run/docker.sock. Is the docker daemon runnin
3  See 'docker run --help'.
```

This occurs when the docker daemon is not running, this can be fixed by enabling the docker service / daemon,

```
1  # Make sure the daemon runs automatically in the future
2  $ sudo systemctl enable docker
3
4  # Start the daemon
5  $ sudo systemctl start docker
```

Success

```
 1  $ sudo docker run hello-world
 2
 3  Unable to find image 'hello-world:latest' locally
 4  latest: Pulling from library/hello-world
 5  1b930d010525: Pull complete
 6  Digest: sha256:2557e3c07ed1e38f26e389462d03ed943586f744621577a99efb77324b0fe535
 7  Status: Downloaded newer image for hello-world:latest
 8
 9  Hello from Docker!
10  This message shows that your installation appears to be working correctly.
11
12  To generate this message, Docker took the following steps:
13   1. The Docker client contacted the Docker daemon.
14   2. The Docker daemon pulled the "hello-world" image from the Docker Hub.
15      (amd64)
16   3. The Docker daemon created a new container from that image which runs the
17      executable that produces the output you are currently reading.
18   4. The Docker daemon streamed that output to the Docker client, which sent it
19      to your terminal.
20
21  To try something more ambitious, you can run an Ubuntu container with:
22   $ docker run -it ubuntu bash
23
```

Troubleshooting - permissions

```
1  $ docker run hello-world
2
3  docker: Got permission denied while trying to connect to the Docker daemon socket at
4  unix:///var/run/docker.sock: Post http://%2Fvar%2Frun%2Fdocker.sock/v1.39/containers/create:
5  dial unix /var/run/docker.sock: connect: permission denied.
6  See 'docker run --help'.
```

You must either be root or be a member of the docker group to use docker. Currently, your VM may or may not have a docker group and your account is likely not a member. If you are tired of typing sudo + your password there is an easy fix,

```
1  # Make sure the docker group exists
2  $ sudo groupadd docker
3
4  # Add your user to the docker group
5  $ sudo usermod -aG docker $USER
6
7  # Check memberships
8  $ groups
9  # If docker is not listed you should log out and log back in
```

Success

```
1  $ docker run hello-world
2
3  Hello from Docker!
4  This message shows that your installation appears to be working correctly.
5
6  To generate this message, Docker took the following steps:
7   1. The Docker client contacted the Docker daemon.
8   2. The Docker daemon pulled the "hello-world" image from the Docker Hub.
9      (amd64)
10  3. The Docker daemon created a new container from that image which runs the
11     executable that produces the output you are currently reading.
12  4. The Docker daemon streamed that output to the Docker client, which sent it
13     to your terminal.
14
15 To try something more ambitious, you can run an Ubuntu container with:
16  $ docker run -it ubuntu bash
17
18 Share images, automate workflows, and more with a free Docker ID:
19  https://hub.docker.com/
20
21 For more examples and ideas, visit:
22  https://docs.docker.com/get-started/
```

Getting Started
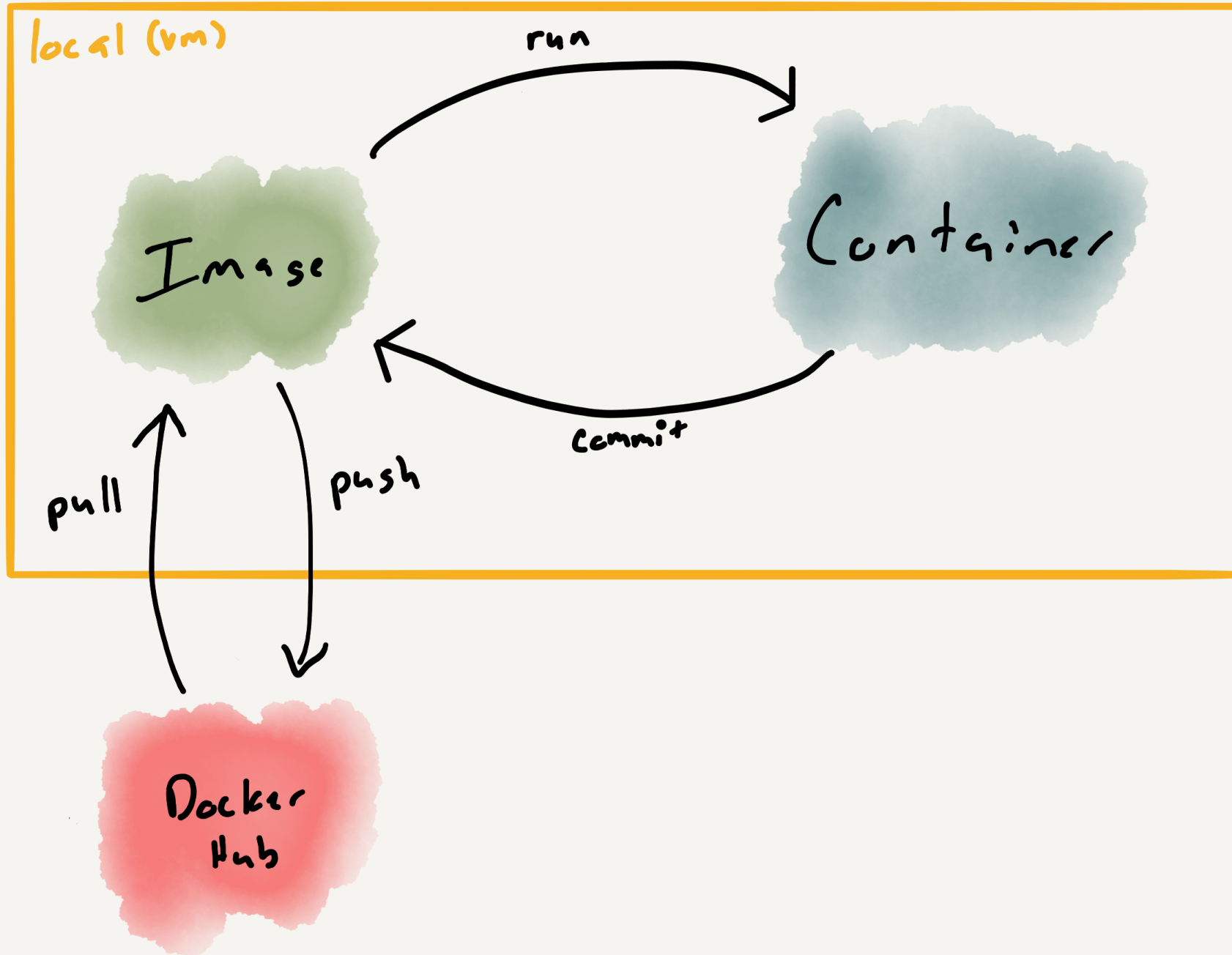
Getting images

```
1  $ docker pull ubuntu
2
3  Using default tag: latest
4  latest: Pulling from library/ubuntu
5  84ed7d2f608f: Pull complete
6  be2bf1c4a48d: Pull complete
7  a5bdc6303093: Pull complete
8  e9055237d68d: Pull complete
9  Digest: sha256:868fd30a0e47b8d8ac485df174795b5e2fe8a6c8f056cc707b232d65b8a1ab68
10 Status: Downloaded newer image for ubuntu:latest
```

```
1  $ docker images
2
3  REPOSITORY          TAG             IMAGE ID          CREATED          SIZE
4  hello-world         latest          fce289e99eb9      2 weeks ago      1.84kB
5  ubuntu              latest          1d9c17228a9e      3 weeks ago      86.7MB
```

ubuntu ✅ Official Image ☆

Ubuntu is a Debian-based Linux operating system based on free software.

⬇ **1B+**

Linux | 386 | x86-64 | ARM | ARM 64 | PowerPC 64 LE | riscv64 | IBM Z | Official Image

Description | Reviews | Tags

Quick reference

- **Maintained by**: Canonical and Tianon (Debian Developer)

- **Where to get help**: the Docker Community Forums, the Docker Community Slack, or Stack Overflow

Supported tags and respective `Dockerfile` links

- `18.04`, `bionic-20220401`, `bionic`

- `20.04`, `focal-20220404`, `focal`, `latest`

- `21.10`, `impish-20220404`, `impish`, `rolling`

- `22.04`, `jammy-20220404`, `jammy`, `devel`

- `14.04`, `trusty-20191217`, `trusty`

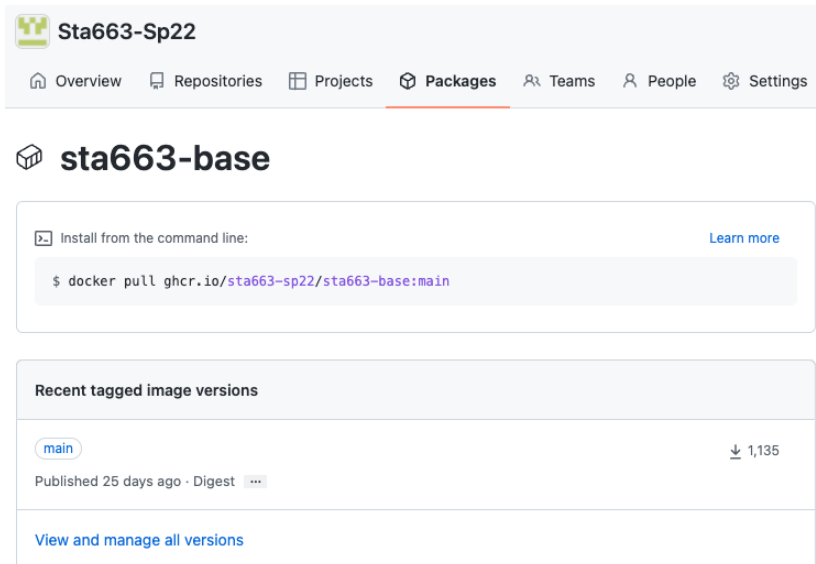- `16.04`, `xenial-20210804`, `xenial`

Tags (Versions)

```
1  $ docker pull ubuntu:18.10
2
3  18.10: Pulling from library/ubuntu
4  d222a4da264e: Pull complete
5  fc8aef08d7f5: Pull complete
6  dc25173478e9: Pull complete
7  860140c5e05a: Pull complete
8  Digest: sha256:79c90229315b26cf37b577db41418874de1c22fb80c3827c80ea624dd993d905
9  Status: Downloaded newer image for ubuntu:18.10
```

```
1  $ docker pull ubuntu:18.04
2
3  18.04: Pulling from library/ubuntu
4  Digest: sha256:868fd30a0e47b8d8ac485df174795b5e2fe8a6c8f056cc707b232d65b8a1ab68
5  Status: Downloaded newer image for ubuntu:18.04
```

```
1  $ docker images
2
3  REPOSITORY          TAG             IMAGE ID            CREATED             SIZE
4  hello-world         latest          fce289e99eb9        2 weeks ago         1.84kB
5  ubuntu              18.10           d4452947e3fa        3 weeks ago         73.7MB
6  ubuntu              18.04           1d9c17228a9e        3 weeks ago         86.7MB
7  ubuntu              latest          1d9c17228a9e        3 weeks ago         86.7MB
```

Other sources

DockerHub is not the only source of images - their are many other possible hosts and all you need to provide is a URL along with the image name.


```
1  $ docker pull ghcr.io/sta663-sp23/sta663-base:la
2  main: Pulling from sta663-sp23/sta663-base
3  7c3b88808835: Pull complete
4  912f6b2ba154: Pull complete
5  dd644c73e3f7: Pull complete
6  443b00f2b587: Pull complete
7  7eed48b59675: Pull complete
8  aaf570891e1e: Pull complete
9  2b816b5489a9: Pull complete
10 15173f034c8a: Pull complete
11 abec7c76a54d: Pull complete
12 bc643c87ba6a: Pull complete
13 05c705c824a9: Pull complete
14 d8d2591a295c: Pull complete
15 b11dc49aa06d: Pull complete
16 eac230728938: Pull complete
17 37972a8150df: Pull complete
18 Digest: sha256:7c769800b08d698cf4e08dfa48f44eb41
19 Status: Downloaded newer image for ghcr.io/sta66
20 ghcr.io/sta663-sp23/sta663-base:latest
```

See on container on GitHub here

```
1  $ docker images
2
3  REPOSITORY                          TAG         IMAGE ID        CREATED         SIZE
4  ghcr.io/sta663-sp23/sta663-base     latest      3ad03e2bb895    15 hours ago    4.87GB
5  ubuntu                              22.04       bab8ce5c00ca    5 weeks ago     69.2MB
```

Running a container

```
1  $ docker run --rm ubuntu cat /etc/os-release
2
3  NAME="Ubuntu"
4  VERSION="18.04.1 LTS (Bionic Beaver)"
5  ID=ubuntu
6  ID_LIKE=debian
7  PRETTY_NAME="Ubuntu 18.04.1 LTS"
8  VERSION_ID="18.04"
9  HOME_URL="https://www.ubuntu.com/"
10 SUPPORT_URL="https://help.ubuntu.com/"
11 BUG_REPORT_URL="https://bugs.launchpad.net/ubunt
12 PRIVACY_POLICY_URL="https://www.ubuntu.com/legal
13 VERSION_CODENAME=bionic
14 UBUNTU_CODENAME=bionic
```

```
1  $ docker run --rm ubuntu:18.10 cat /etc/os-relea
2
3  NAME="Ubuntu"
4  VERSION="18.10 (Cosmic Cuttlefish)"
5  ID=ubuntu
6  ID_LIKE=debian
7  PRETTY_NAME="Ubuntu 18.10"
8  VERSION_ID="18.10"
9  HOME_URL="https://www.ubuntu.com/"
10 SUPPORT_URL="https://help.ubuntu.com/"
11 BUG_REPORT_URL="https://bugs.launchpad.net/ubunt
12 PRIVACY_POLICY_URL="https://www.ubuntu.com/legal
13 VERSION_CODENAME=cosmic
14 UBUNTU_CODENAME=cosmic
```

```
 1  $ docker run --rm fedora:latest cat /etc/os-release
 2
 3  Unable to find image 'fedora:latest' locally
 4  latest: Pulling from library/fedora
 5  0be2a68855d7: Pull complete
 6  Digest: sha256:7b921a4a008ee83c06d2cde9f21d3aa8de4635b0c4ec159f31caee83ad220b21
 7  Status: Downloaded newer image for fedora:latest
 8  NAME=Fedora
 9  VERSION="29 (Container Image)"
10  ID=fedora
11  VERSION_ID=29
12  VERSION_CODENAME=""
13  PLATFORM_ID="platform:f29"
14  PRETTY_NAME="Fedora 29 (Container Image)"
15  ANSI_COLOR="0;34"
16  LOGO=fedora-logo-icon
17  CPE_NAME="cpe:/o:fedoraproject:fedora:29"
18  HOME_URL="https://fedoraproject.org/"
19  DOCUMENTATION_URL="https://docs.fedoraproject.org/en-US/fedora/f29/system-administrators-guide/"
20  SUPPORT_URL="https://fedoraproject.org/wiki/Communicating_and_getting_help"
21  BUG_REPORT_URL="https://bugzilla.redhat.com/"
22  REDHAT_BUGZILLA_PRODUCT="Fedora"
23  REDHAT_BUGZILLA_PRODUCT_VERSION=29
```

docker run - Important options

```
docker run [OPTIONS] IMAGE[:TAG|@DIGEST] [COMMAND] [ARG...]
```

Option	Description
`--name`	Give your container a name
`--rm`	Automatically remove the container when it exits
`-i -t`	Allow for interaction with container (STDIN & tty specifically)
`-p host:cont`	Publish a container's port
`-v host:cont`	Share filesystems
`-e "VAR=VAL"`	Define environmental variables

See https://docs.docker.com/engine/reference/run/ for more details

Other useful commands

command	Description
`docker pull NAME[:TAG]`	Pull docker image (usually from DockerHub)
`docker images`	List docker images
`docker rmi IMAGE`	Remove an image
`docker container ls [--all]`	List (all) docker containers
`docker rm CONTAINER`	Remove a container
`docker stop CONTAINER`	Stop a running container
`docker start CONTAINER`	Start a stopped container
`docker attach CONTAINER`	Attach to a running container
`docker commit CONTAINER REPO[:TAG]`	Create an image from a container
`docker rename CONTAINER NAME`	Rename a container

rocker

🐳 + Ⓡ = Rocker

> The rocker project provides a collection of containers suited for different needs. find a base image to extend or images with popular software and optimized libraries pre-installed. Get the latest version or a reproducibly fixed environment.

The versioned stack

image	description
r-ver	Specify R version in docker tag. Builds on `debian:stable`
rstudio	Adds rstudio
tidyverse	Adds tidyverse & devtools
verse	Adds tex & publishing-related packages
geospatial	Adds geospatial libraries

The base stack

image	description
r-base	Current R via apt-get with `debian:testing` & `unstable` repos
r-devel	R-devel added side-by-side onto r-base (using alias `RD`)
drd	lighter r-devel, built not quite daily

rocker-org/rocker-versioned2   **rocker-org/rocker**

Rocker
Versioned

Geospatial

Verse

+ sf, etc.

tidyverse

+ latex

rstudio

+ dplyr, tidyr, etc

r-ver   + server

tags

3.5.2
3.5.1
3.5
3

...

rocker + rstudio

```
 1  $ docker pull rocker/rstudio
 2
 3  Using default tag: latest
 4  latest: Pulling from rocker/rstudio
 5  54f7e8ac135a: Pull complete
 6  021dd68904f6: Pull complete
 7  8d3e964cf18d: Pull complete
 8  81bbbedbef33: Pull complete
 9  c7878d347b3f: Pull complete
10  a7aae3dbd958: Pull complete
11  da950bb11a69: Pull complete
12  Digest: sha256:b9e6acea945ca28ec14b3de9925372bdd6c5e3828a8575b34d4247f619b66dd5
13  Status: Downloaded newer image for rocker/rstudio:latest
```

```
 1  $ docker run -e PASSWORD=SECRET --rm -p 8787:8787 rocker/rstudio
 2  ...
```

rocker + rstudio + tidyverse + latex + sf

```
1  $ docker pull rocker/geospatial
2
3  Using default tag: latest
4  latest: Pulling from rocker/geospatial
5  54f7e8ac135a: Already exists
6  021dd68904f6: Already exists
7  8d3e964cf18d: Already exists
8  81bbbedbef33: Already exists
9  c7878d347b3f: Already exists
10 a7aae3dbd958: Already exists
11 da950bb11a69: Already exists
12 9802011fbe26: Pull complete
13 334f65727953: Pull complete
14 e506f9195a59: Pull complete
15 Digest: sha256:c3158846628b07d4616fafa30ef1d97cdc1b706d1c9aa30d62e7862ffd75703e
16 Status: Downloaded newer image for rocker/geospatial:latest34d4247f619b66dd5
17 Status: Downloaded newer image for rocker/rstudio:latest
```

```
1  $ docker run -e PASSWORD=SECRET --rm -p 8787:8787 rocker/geospatial
2  ...
```

Dockerfile(s)

Common commands

command	Description
FROM	specify a base image
RUN	run commands (e.g. apt or yum), changes saved to image
COPY	copy a local file into the image
ENV	set environment variables for Dockerfile and image
USER	set user to use (affects subsequent RUN, CMD, ENDPOINT)
WORKDIR	set the working directory
EXPOSE	specify which ports will be used (not published automatically)
CMD	specify what (default) action should run when running the image
...	

A tidy example

tidy1/Dockerfile:

```
1  FROM ubuntu:22.02
2
3  ENV DEBIAN_FRONTEND=noninteractive
4
5  RUN apt update
6  RUN apt install -y r-base
7  RUN Rscript -e "install.packages('tibble')"
8
9  CMD ["R"]
```

Building

```
1  $ docker build -t tidy1 .
2
3  Sending build context to Docker daemon  2.048kB
4  Step 1/6 : FROM ubuntu:18.10
5   ---> d4452947e3fa
6  Step 2/6 : ENV DEBIAN_FRONTEND=noninteractive
7   ---> Using cache
8   ---> e0d77908f64a
9  Step 3/6 : RUN apt update
10  ---> Running in fa6969a427d9
11 ...
12  ---> 979edce6cc0b
13 Step 4/6 : RUN apt install -y r-base
14  ---> Running in 1cc3e97a8258
15 ...
16  ---> 87a882be95d7
17 Step 5/6 : RUN Rscript -e "install.packages('tibble')"
18  ---> Running in e9de97c98208
19 ...
20 Removing intermediate container e9de97c98208
21  ---> 5f1666e4e342
22 Step 6/6 : CMD ["R"]
23  ---> Running in 07f9ea769466
```

Images

```
 1  $ docker images
 2
 3  REPOSITORY          TAG                 IMAGE ID            CREATED             SIZE
 4  tidy1               latest              b29115e0a5d2        29 seconds ago      697MB
 5  ubuntu              18.10               d4452947e3fa        3 weeks ago         73.7MB
 6  ubuntu              latest              1d9c17228a9e        3 weeks ago         86.7MB
 7
 8  $ docker images -a
 9
10  REPOSITORY          TAG                 IMAGE ID            CREATED             SIZE
11  <none>              <none>              598100ea4878        25 seconds ago      697MB
12  tidy1               latest              b29115e0a5d2        25 seconds ago      697MB
13  <none>              <none>              75296565d476        56 seconds ago      690MB
14  <none>              <none>              d82af2f4083b        2 minutes ago       96.3MB
15  <none>              <none>              6bb4e2b36ade        2 minutes ago       73.7MB
16  ubuntu              18.10               d4452947e3fa        3 weeks ago         73.7MB
17  ubuntu              latest              1d9c17228a9e        3 weeks ago         86.7MB
```

A better tidy example

tidy2/Dockerfile:

```
1  FROM ubuntu:21.10
2
3  ENV DEBIAN_FRONTEND=noninteractive
4
5  RUN apt update \
6   && apt install -y r-base \
7   && Rscript -e "install.packages('tibble')"
8
9  CMD ["R"]
```

Building

```
 1  $ docker build -t tidy2 .
 2
 3  Sending build context to Docker daemon   2.048kB
 4  Step 1/4 : FROM ubuntu:18.10
 5   ---> d4452947e3fa
 6  Step 2/4 : ENV DEBIAN_FRONTEND=noninteractive
 7   ---> Running in be9c52bb8db9
 8  Removing intermediate container be9c52bb8db9
 9   ---> e0d77908f64a
10  Step 3/4 : RUN apt update  && apt install -y r-base  && Rscript -e "install.packages('tibble')"
11  ...
12  Step 4/4 : CMD ["R"]
13   ---> Running in d98129eb112c
14  Removing intermediate container d98129eb112c
15   ---> be418f99be82
16  Successfully built be418f99be82
17  Successfully tagged tidy2:latest
```

Images

```
1  $ docker images
2  REPOSITORY          TAG             IMAGE ID          CREATED            SIZE
3  tidy2               latest          be418f99be82      7 seconds ago      697MB
4  ubuntu              18.10           d4452947e3fa      3 weeks ago        73.7MB
5  ubuntu              latest          1d9c17228a9e      3 weeks ago        86.7MB
6
7  $ docker images -a
8  REPOSITORY          TAG             IMAGE ID          CREATED            SIZE
9  tidy2               latest          be418f99be82      9 seconds ago      697MB
10 <none>              <none>          7869e0549108      10 seconds ago     697MB
11 <none>              <none>          e0d77908f64a      About a minute ago 73.7MB
12 ubuntu              18.10           d4452947e3fa      3 weeks ago        73.7MB
13 ubuntu              latest          1d9c17228a9e      3 weeks ago        86.7MB
```

Dangling images

```
1 $ docker images -a
2 REPOSITORY          TAG            IMAGE ID          CREATED           SIZE
3 <none>              <none>         83384d4f0d1c      14 minutes ago    714MB
4 <none>              <none>         b656b4674ab9      15 minutes ago    209MB
5 <none>              <none>         c02c49f3aed2      15 minutes ago    96.3MB
6 <none>              <none>         cff3a89309ff      15 minutes ago    73.7MB
7 ubuntu              18.10          d4452947e3fa      3 weeks ago       73.7MB
8 ubuntu              latest         1d9c17228a9e      3 weeks ago       86.7MB
```

```
1  $ docker image prune
2  WARNING! This will remove all dangling images.
3  Are you sure you want to continue? [y/N] y
4  Deleted Images:
5  deleted: sha256:83384d4f0d1c6989ad492aee44dd44ca0a6aa013c0b80a78294d2d63e13c6d0c
6  deleted: sha256:ada707994b5f0aacd91d44b221e78fb4674c2f53afed87ac9c8f3db39b993d48
7  deleted: sha256:b656b4674ab989f57e1dc3dab682bcbfe6b8634206935cb630e09cfcecf5f645
8  deleted: sha256:8769da78ba480413ba7b3ee505008b88e549214a96238744bc328901367c38c1
9  deleted: sha256:c02c49f3aed2b3131f4e636745f713aab28ba870e9ec2ac2c0b13b008e9a2fd3
10 deleted: sha256:095edb1ee39242ed717542420ab9a4911f7cd805713bfd94b321d52d25091eda
11 deleted: sha256:cff3a89309ffcc08fe80a3558e1c6715574a4ec3ac926bbd49cd90519aa62241
12
13 Total reclaimed space: 640.4MB
```

Course docker images

Sta523-fa22/docker-base

Sta663-sp23/docker-base