

Making a docker image to run the Waterfox browser

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1 Introduction

This project is about learning how to compose a Dockerfile which runs an X11 application. The Waterfox browser was chosen as an example X11 application, because Waterfox is not available as a package in most Linux distributions, so the result might actually be a useful means of obtaining Waterfox without having to download a tarfile and do a local install.

Getting a running Docker container to talk to the X11 server in the host system is relatively easy. Waterfox is a large and complex X application, and most of the challenge of this project is in setting up in the Docker image a working environment for Waterfox.

2 What is involved in a normal Waterfox install?

There is a document [16] on that. Briefly the steps are

1. Download a tarfile from the Waterfox website [15] or from the Github site [17].
2. Unpack the tarfile in /usr/local/src

```
bzip2 -dc waterfox-G4.1.1.1.en-US.linux-x86_64.tar.bz2 | tar xvf -
```

3. Make a link in /usr/local/bin to point to the Waterfox binary

```
ln /usr/local/src/waterfox/waterfox /usr/local/bin/waterfox
```

4. Define the desktop icon by adding a file waterfox.desktop to the directory /usr/share applications. The file waterfox.desktop does not come with the tarfile, but is available here [16]

We need to implement steps 1 to 3 in a Dockerfile. Step 4 can be omitted, as there will be no icon if running Waterfox in a container. The container will have to be started from the command line.

3 How to run a docker container requiring access to the host Xserver

We assume the host is running X11 (not Wayland). Set up the following primitive Dockerfile.

```
FROM debian
WORKDIR /home/demo
RUN apt-get -y update
RUN apt-get -y upgrade
RUN apt-get -y x11-apps
RUN groupadd -g 1000 demo
RUN useradd -d /home/demo -s /bin/bash -m demo -u 1000 -g 1000
USER demo
ENV HOME /home/demo
CMD /usr/bin/xcalc
```

Build this with

```
docker build -t nevj/test:v2 .
Sending build context to Docker daemon 2.048kB
Step 1/10 : FROM debian
---> 07d9246c53a6
Step 2/10 : WORKDIR /home/demo
---> Running in 2e0e40e0fd4c
.....
Successfully built 517c1937106a
Successfully tagged nevj/test:v2
```

Then run it with

```
[nevj@trinity dtest]$ xhost +
[nevj@trinity dtest]$ docker run -v /tmp/.X11-unix:/tmp/.X11-unix \
-e DISPLAY=$DISPLAY -h $HOSTNAME \
-v $HOME/.Xauthority:/home/nevj/.Xauthority nevj/test:v2
```

and the xcalc app appears in a separate X window, as shown in Figure 1

The *xhost +* statement is needed to give the container permission to communicate with the host X11 server. The purpose of the options included in the *docker run* statement are as follows

-v /tmp/.X11-unix:/tmp/.X11-unix defines a *mount* for a volume. The string */tmp/.X11-unix:/tmp/.X11-unix* is the mount point on the host. The part before ':' is the volume name on the host. The part after ':' is where the file or directory is mounted inside the container. A volume is just a file or directory in the host filesystem.

-e DISPLAY=\$DISPLAY sets the environment variable *DISPLAY* in the container

-h \$HOSTNAME sets the container hostname



Figure 1: Xcalc app started from a Docker container

\$HOME/.Xauthority:/home/nej/.Xauthority sets the `.Xauthority` file of the container to the `.Xauthority` file of the host user who initiated the `run` statement again using a volume mount.

nej/test:v2 is the name of the image, build as above.

Volumes are the mechanism used by Docker containers to share data between the host and the container (and between containers). They are needed in this case because the container is an X11 client, while the host acts as the X11 server, so information has to pass between container and host. A Docker container can only write on the part of the host filesystem defined as a Docker volume. There is also *tmpfs* mount which is a temporary ram disk used for non-permanent data within a container.

4 First attempt at a Waterfox Dockerfile, using a Debian parent image

There is no new principle involved in running Waterfox rather than the simple `xcalc` app, in a Docker container. The Waterfox browser is a large program with many dependencies, so the Dockerfile will have to build up a complete working environment specifically for Waterfox.

I chose Debian parent image for a first attempt, because Debian is familiar and is most likely to be compatible with Waterfox. The Debian parent image is large. We shall try later to repeat the job with a smaller parent image.

4.1 Finding the dependencies of a binary program file

There is a really good article [14] on identifying dependencies of a runtime binary when making a dockerfile.

If one looks at the unpacked Waterfox distribution tarfile, it contains the files shown in Figure 2

```
[nevj@trinity src]$ cd waterfox
[nevj@trinity waterfox]$ ls
application.ini      libmozavcodec.so    libnssutil3.so      plugin-container
browser              libmozavutil.so     libplc4.so          precomplete
defaults             libmozgtk.so        libplds4.so         removed-files
dependentlibs.list   libmozsandbox.so    libsmime3.so        update-settings.ini
fonts                libmozsqlite3.so    libsoftokn3.so      updater
gmp-clearkey         libmozwayland.so    libssl3.so          updater.ini
icons                libnspr4.so         libxul.so           waterfox
libfreeblpriv3.so    libnss3.so          omni.ja             waterfox-bin
liblgpllibs.so       libnssckbi.so       platform.ini
```

Figure 2: Files contained in the waterfox distribution tarfile

The *.so files shown in green are dynamically loaded libraries. Presumably these are all dependencies of waterfox, but they may not be the only dependencies. There is a file TwemojiMozilla.ttf in the fonts subdirectory, and there are various default configuration files.

An initial check for dependencies can be obtained with *ldd*

```
nevj@mary:/usr/local/src/waterfox$ ldd waterfox
linux-vdso.so.1 (0x00007ffc3eb95000)
libpthread.so.0 => /lib/x86_64-linux-gnu/libpthread.so.0 (0x00007f2a6d46c000)
libdl.so.2 => /lib/x86_64-linux-gnu/libdl.so.2 (0x00007f2a6d466000)
libstdc++.so.6 => /lib/x86_64-linux-gnu/libstdc++.so.6 (0x00007f2a6d299000)
libm.so.6 => /lib/x86_64-linux-gnu/libm.so.6 (0x00007f2a6d155000)
libgcc_s.so.1 => /lib/x86_64-linux-gnu/libgcc_s.so.1 (0x00007f2a6d13b000)
libc.so.6 => /lib/x86_64-linux-gnu/libc.so.6 (0x00007f2a6cf76000)
/lib64/ld-linux-x86-64.so.2 (0x00007f2a6d569000)
```

This is best done in a Debian system in which waterfox has been installed. There are 8 libraries called directly by waterfox, and none of them are present in the distribution tarfile. These are libraries required for waterfox to start up. Note that linux-vdso.so.1 is a virtual library, ie it is built into the kernel and does not exist as a package. The other 7 should each be supplied by a package. We shall leave the problem of finding the package names which supply each library later.

There may also be libraries which waterfox loads dynamically while executing. To find these we do the following, again in a Debian system

```
nevj@mary:~$ LD_DEBUG=libs waterfox >&logfile
```

```
nevj@mary:~$ cat logfile
```

```
2572: find library=libpthread.so.0 [0]; searching
2572: search cache=/etc/ld.so.cache
2572: trying file=/lib/x86_64-linux-gnu/libpthread.so.0
2572:
2572: find library=libdl.so.2 [0]; searching
2572: search cache=/etc/ld.so.cache
2572: trying file=/lib/x86_64-linux-gnu/libdl.so.2
2572:
2572: find library=libstdc++.so.6 [0]; searching
2572: search cache=/etc/ld.so.cache
2572: trying file=/lib/x86_64-linux-gnu/libstdc++.so.6
2572:
2572: find library=libm.so.6 [0]; searching
2572: search cache=/etc/ld.so.cache
2572: trying file=/lib/x86_64-linux-gnu/libm.so.6
2572:
2572: find library=libgcc_s.so.1 [0]; searching
2572: search cache=/etc/ld.so.cache
2572: trying file=/lib/x86_64-linux-gnu/libgcc_s.so.1
2572:
2572: find library=libc.so.6 [0]; searching
2572: search cache=/etc/ld.so.cache
2572: trying file=/lib/x86_64-linux-gnu/libc.so.6
2572:
2572:
2572: calling init: /lib/x86_64-linux-gnu/libpthread.so.0
2572:
2572:
2572: calling init: /lib/x86_64-linux-gnu/libc.so.6
2572:
2572:
2572: calling init: /lib/x86_64-linux-gnu/libgcc_s.so.1
2572:
2572:
2572: calling init: /lib/x86_64-linux-gnu/libm.so.6
2572:
2572:
2572: calling init: /lib/x86_64-linux-gnu/libstdc++.so.6
2572:
2572:
2572: calling init: /lib/x86_64-linux-gnu/libdl.so.2
2572:
2572:
```

```

2572:      initialize program: waterfox
2572:
2572:
2572:      transferring control: waterfox
2572:
2572:
2572:      calling init: /usr/local/src/waterfox/libnspr4.so
2572:
2572:
2572:      calling init: /usr/local/src/waterfox/libplc4.so
2572:
2572:
2572:      calling init: /usr/local/src/waterfox/libplds4.so
2572:
2572:      find library=librt.so.1 [0]; searching
2572:      search cache=/etc/ld.so.cache
2572:      trying file=/lib/x86_64-linux-gnu/librt.so.1
2572:
2572:
2572:      calling init: /lib/x86_64-linux-gnu/librt.so.1
2572:
2572:
2572:      calling init: /usr/local/src/waterfox/libmozsandbox.so
2572:
2572:
2572:      calling init: /usr/local/src/waterfox/liblglp1libs.so
2572:
2572:
2572:      calling init: /usr/local/src/waterfox/libnssutil3.so
2572:
2572:
2572:      calling init: /usr/local/src/waterfox/libnss3.so
2572:
.....
2796:      calling init: /lib/x86_64-linux-gnu/libX11-xcb.so.1
2796:
2796:
2796:      calling init: /usr/local/src/waterfox/libxul.so
2796:
2796:      /usr/local/src/waterfox/waterfox: error: symbol lookup error:
undefined symbol: nspr_use_zone_allocator (fatal)
2796:
2796:      calling init: /usr/local/src/waterfox/libsoftokn3.so
2796:
2796:
2796:      calling init: /usr/local/src/waterfox/libfreeblpriv3.so

```

```

2796:
JavaScript error: resource://gre/modules/PartitioningExceptionListService.jsm
, line 69: NS_ERROR_MALFORMED_URI: Component returned failure code: 0x804b000
a (NS_ERROR_MALFORMED_URI) [nsIPartitioningExceptionListObserver.onExceptionL
istUpdate]
console.error: PushService:
  clearOriginData: Error clearing origin data:
    TypeError
JavaScript error: resource:///modules/Interactions.jsm, line 209: NS_ERROR_FA
ILURE: Component returned failure code: 0x80004005 (NS_ERROR_FAILURE) [nsIUse
rIdleService.removeIdleObserver]

```

```

###!!! [Parent][RunMessage] Error: Channel closing: too late to send/recv, me
ssages will be lost

```

Lots of messages, had to truncate it, was 5744 lines. The first 3 lines say it is searching for a system library called *libpthread*. The lines beginning *calling init* indicate the library has been found and give its absolute path. Some libraries may not be found, and they will have no line beginning *calling init*. We can get a list of libraries found with

```

nevj@mary:~$ cat out | grep init > outinit
nevj@mary:~$ wc outinit
  715  2878 45875 outinit
nevj@mary:~$ cat outinit
  2572: calling init: /lib/x86_64-linux-gnu/libpthread.so.0
    2572: calling init: /lib/x86_64-linux-gnu/libc.so.6
    2572: calling init: /lib/x86_64-linux-gnu/libgcc_s.so.1
    2572: calling init: /lib/x86_64-linux-gnu/libm.so.6
    2572: calling init: /lib/x86_64-linux-gnu/libstdc++.so.6
    2572: calling init: /lib/x86_64-linux-gnu/libdl.so.2
    2572: initialize program: waterfox
    2572: calling init: /usr/local/src/waterfox/libnspr4.so
    2572: calling init: /usr/local/src/waterfox/libplc4.so
    2572: calling init: /usr/local/src/waterfox/libplds4.so
    2572: calling init: /lib/x86_64-linux-gnu/librt.so.1
    2572: calling init: /usr/local/src/waterfox/libmozsandbox.so
    2572: calling init: /usr/local/src/waterfox/liblglp1libs.so
    2572: calling init: /usr/local/src/waterfox/libnssutil3.so
    2572: calling init: /usr/local/src/waterfox/libnss3.so
    2572: calling init: /usr/local/src/waterfox/libsmime3.so
    2572: calling init: /usr/local/src/waterfox/libmozsqlite3.so
    2572: calling init: /usr/local/src/waterfox/libssl3.so
    2572: calling init: /lib/x86_64-linux-gnu/libgpg-error.so.0
    .....

```

So there are still 715 of them. The first 6 are the startiup dependencies, and the rest are runtime dependencies

There is also the question of configuration files. Most of these are hopefully included in the Waterfox tarfile. We can check

```
strace --trace=open,openat /usr/local/bin/waterfox >&strace.out
```

Lots of libraries which we can ignore

```
....
Conf files
openat(AT_FDCWD, "/etc/host.conf", O_RDONLY|O_CLOEXEC) = 7
openat(AT_FDCWD, "/etc/resolv.conf", O_RDONLY|O_CLOEXEC) = 7
openat(AT_FDCWD, "/etc/nsswitch.conf", O_RDONLY|O_CLOEXEC) = 7
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 7
.....
openat(AT_FDCWD, "/home/nevj/.Xauthority", O_RDONLY) = 5
openat(AT_FDCWD, "/usr/share/X11/locale/locale.alias", O_RDONLY) = 5
openat(AT_FDCWD, "/usr/share/X11/locale/locale.alias", O_RDONLY) = 5
openat(AT_FDCWD, "/usr/share/X11/locale/locale.dir", O_RDONLY) = 5
openat(AT_FDCWD, "/usr/share/X11/locale/en_US.UTF-8/XLC_LOCALE", O_RDONLY) =
5
openat(AT_FDCWD, "/home/nevj/.Xdefaults-mary", O_RDONLY) = -1 ENOENT (No such
file or directory)
....
openat(AT_FDCWD, "/home/nevj/.waterfox/profiles.ini", O_RDONLY) = 8
openat(AT_FDCWD, "/home/nevj/.Xauthority", O_RDONLY) = 9
....
openat(AT_FDCWD, "/usr/local/src/waterfox/omni.ja", O_RDONLY) = 14
openat(AT_FDCWD, "/usr/local/src/waterfox/browser/omni.ja", O_RDONLY) = 15
openat(AT_FDCWD, "/sys/devices/system/cpu", O_RDONLY|O_NONBLOCK|O_CLOEXEC|O_D
IRECTORY) = 16
openat(AT_FDCWD, "/usr/local/src/waterfox/defaults/pref", O_RDONLY|O_NONBLOCK
|O_CLOEXEC|O_DIRECTORY) = 16
openat(AT_FDCWD, "/usr/local/src/waterfox/defaults/pref/channel-prefs.js", O_
RDONLY) = 17
.....
openat(AT_FDCWD, "/usr/share/fontconfig/conf.avail/11-lcdfilter-default.conf"
, O_RDONLY|O_CLOEXEC) = 38
openat(AT_FDCWD, "/etc/fonts/conf.avail/20-unhint-small-dejavu-lgc-sans-mono.
conf", O_RDONLY|O_CLOEXEC) = 38
.....
openat(AT_FDCWD, "/etc/os-release", O_RDONLY) = 37
openat(AT_FDCWD, "/sys/devices/system/cpu/present", O_RDONLY) = 37
openat(AT_FDCWD, "/usr/share/locale/locale.alias", O_RDONLY) = 38
openat(AT_FDCWD, "/usr/share/icons/Tango/index.theme", O_RDONLY) = 38
openat(AT_FDCWD, "/usr/share/icons/Tango/icon-theme.cache", O_RDONLY) = 38
.....
openat(AT_FDCWD, "/usr/share/icons/index.theme", O_RDONLY) = -1 ENOENT (No su
```



```

ch file or directory)
openat(AT_FDCWD, "/usr/share/pixmaps/cursors/e-resize", O_RDONLY) = -1 ENOENT
(No such file or directory)
....
penat(AT_FDCWD, "/home/nej/.icons/Adwaita/cursors/e-resize", O_RDONLY) = -1
ENOENT (No such file or directory)
openat(AT_FDCWD, "/home/nej/.icons/Adwaita/index.theme", O_RDONLY) = -1 ENOE
NT (No such file or directory)
.....
openat(AT_FDCWD, "/home/nej/.config/xfce-mimeapps.list", O_RDONLY) = -1 ENOE
NT (No such file or directory)
openat(AT_FDCWD, "/home/nej/.config/mimeapps.list", O_RDONLY) = 80
....
openat(AT_FDCWD, "/usr/local/share/applications/xfce-mimeapps.list", O_RDONLY
) = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/local/share/applications/mimeapps.list", O_RDONLY) = -
1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/local/share/applications/defaults.list", O_RDONLY) = -
1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/usr/local/share/applications/mimeinfo.cache", O_RDONLY) =
-1 ENOENT (No such file or directory)
.....
openat(AT_FDCWD, "/usr/share/fonts/truetype/dejavu/DejaVuSans-Bold.ttf", O_RD
ONLY) = 88
JavaScript error: resource:///actors/AboutNewTabParent.jsm, line 23: InvalidS
tateError: An attempt was made to use an object that is not, or is no longer,
usable
.....
JavaScript error: resource://gre/modules/PartitioningExceptionListService.jsm
, line 69: NS_ERROR_MALFORMED_URI: Component returned failure code: 0x804b000
a (NS_ERROR_MALFORMED_URI) [nsIPartitioningExceptionListObserver.onExceptionL
istUpdate]
....
penat(AT_FDCWD, "/home/nej/.icons/Adwaita/cursors/hand2", O_RDONLY) = -1 EN
OENT (No such file or directory)
openat(AT_FDCWD, "/home/nej/.icons/Adwaita/index.theme", O_RDONLY) = -1 ENOE
NT (No such file or directory)
.....

```

Some of the files have the message (*No such file or directory*). They are probably not serious issues... the above was done in a Waterfox install which works satisfactorily. I have only shown a selection. The full output above was 1402 lines.

4.2 Which Debian packages provide these files?

We have a long list of files which are dependencies. We need to convert this into a list of *.deb* packages which supply the necessary files. That should reduce the information to a much shorter list of packages. The tool for finding which package supplies a file is *apt-file*.

apt-file is not part of a standard Debian system. We need to install it

```
root@trinity:/home/nevj# apt-get install apt-file
.....
The following additional packages will be installed:
  libapt-pkg-perl libexporter-tiny-perl liblist-moreutils-perl
  liblist-moreutils-xs-perl libregexp-assemble-perl
The following NEW packages will be installed:
  apt-file libapt-pkg-perl libexporter-tiny-perl liblist-moreutils-perl
  liblist-moreutils-xs-perl libregexp-assemble-perl
0 upgraded, 6 newly installed, 0 to remove and 6 not upgraded.
Need to get 322 kB of archives.
After this operation, 901 kB of additional disk space will be used.
The following additional packages will be installed:
  libapt-pkg-perl libexporter-tiny-perl liblist-moreutils-perl
  liblist-moreutils-xs-perl libregexp-assemble-perl
The following NEW packages will be installed:
  apt-file libapt-pkg-perl libexporter-tiny-perl liblist-moreutils-perl
  liblist-moreutils-xs-perl libregexp-assemble-perl
0 upgraded, 6 newly installed, 0 to remove and 6 not upgraded.
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  libapt-pkg-perl libexporter-tiny-perl liblist-moreutils-perl
  liblist-moreutils-xs-perl libregexp-assemble-perl
The following NEW packages will be installed:
  apt-file libapt-pkg-perl libexporter-tiny-perl liblist-moreutils-perl
  liblist-moreutils-xs-perl libregexp-assemble-perl
0 upgraded, 6 newly installed, 0 to remove and 6 not upgraded.
Need to get 322 kB of archives.
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The following additional packages will be installed:
  libapt-pkg-perl libexporter-tiny-perl liblist-moreutils-perl
  liblist-moreutils-xs-perl libregexp-assemble-perl
The following NEW packages will be installed:
  apt-file libapt-pkg-perl libexporter-tiny-perl liblist-moreutils-perl
  liblist-moreutils-xs-perl libregexp-assemble-perl
0 upgraded, 6 newly installed, 0 to remove and 6 not upgraded.
Need to get 322 kB of archives.
After this operation, 901 kB of additional disk space will be used.
```

```

The following additional packages will be installed:
  libapt-pkg-perl libexporter-tiny-perl liblist-moreutils-perl
  liblist-moreutils-xs-perl libregexp-assemble-perl
The following NEW packages will be installed:
  apt-file libapt-pkg-perl libexporter-tiny-perl liblist-moreutils-perl
  liblist-moreutils-xs-perl libregexp-assemble-perl
0 upgraded, 6 newly installed, 0 to remove and 6 not upgraded.
Need to get 322 kB of archives.
After this operation, 901 kB of additional disk space will be used.
.....

```

Then we need to generate apt-file's database

```
root@trinity:/home/nevj# apt-file update
```

Then we can search

```

nevj@trinity:~$ apt-file search libpthread.so.0
libc6: /lib/x86_64-linux-gnu/libpthread.so.0
.....
Lots of other libraries .... it is better to use the full path
nevj@trinity:~$ apt-file search /lib/x86_64-linux-gnu/libpthread.so.0
libc6: /lib/x86_64-linux-gnu/libpthread.so.0
So we just get the relevant one

```

There is an alternative to apt-file

```

nevj@trinity:~$ dpkg -s libpthread.so.0
dpkg-query: package 'libpthread.so.0' is not installed and no information is available
Use dpkg --info (= dpkg-deb --info) to examine archive files.

```

So *dpkg -s* only works for installed library files, *apt-file* works for all available packages.

Now we have the tools, it is a mere matter of feeding several hundred library files to *apt-file search*.

```

# a bit of hand editing
$ cp outinit outinit.edit
$ vi outinit.edit

# make a simple awk script to extract the 4th field
$ vi field4.awk
{print $4}

# run the script
$ awk -f field4.awk < outinit.edit > libfiles.txt

# and the output is
$ more libfiles.txt

```

```

/lib/x86_64-linux-gnu/libpthread.so.0
/lib/x86_64-linux-gnu/libc.so.6
/lib/x86_64-linux-gnu/libgcc_s.so.1
/lib/x86_64-linux-gnu/libm.so.6
/lib/x86_64-linux-gnu/libstdc++.so.6
/lib/x86_64-linux-gnu/libdl.so.2
/usr/local/src/waterfox/libnspr4.so
/usr/local/src/waterfox/libplc4.so
..... too many to list

```

```

$ wc libfiles.txt
711 711 26829 libfiles.txt
So 711 libraries in total

```

So now we have out list of libraries, we need a shell script to feed it to apt-file.

```

#!/bin/csh
foreach lib (`cat libfiles.txt`)
  apt-file --fixed-string -l search $lib >>& package.txt
end

```

Now if we run that script we get

```

chmod 755 packages.csh
./packages.csh
wc package.txt
125 125 1124 package.txt

```

So we have reduced from 711 libraries to 125 packages. However there are duplicates so

```

sort <package.txt | uniq >uniqupackage.txt
wc uniqupackage.txt
21 21 249 uniqupackage.txt
cat uniqupackage.txt
dconf-gsettings-backend
gvfs
gvfs-libs
libc6
libcom-err2
libdbus-1-3
libelogind0
libexpat1
libgcc-s1
libgdk-pixbuf-2.0-0
libgl1-mesa-dri
libgpg-error0
libkeyutils1
liblzma5

```

```
libnss-mdns
libpcre3
libpulse0
libselinux1
libtirpc3
python3-minimal
zlib1g
```

There are 21 unique packages required. Now we can write the Dockerfile with some confidence that it will supply an suitable environment for Waterfox.

4.3 First Debian parent Dockerfile

References

- [1] Docker tutorial. URL <https://www.guru99.com/docker-tutorial.html>
- [2] Docker get started URL <https://docs.docker.com/get-started/>
- [3] Docker Desktop URL <https://docs.docker.com/desktop/install/linux-install/>
- [4] Docker Hub URL <https://hub.docker.com/>
- [5] Official Dockerfile documnet URL https://docs.docker.com/develop/develop-images/dockerfile_best-practices/
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