

## Task 01: Basic Docker Virtualization (6 Marks)

- Create a dockerized environment in your computer/ PC (Linux environment preferred. Can be hosted inside a VM) and run at least 3 well-known docker images from the docker hub (i.e., hello-world, BusyBox, Nginx, Redis, Alpine,...etc.).
- Show the running docker containers in your machine. Remove all the running containers and their images and show the list of images in the virtual domain.

Run three images: hello-world, BusyBox and alpine. Because these images are simple examples so it exits automatically after running. I use 'docker ps -a' to show all exited containers.

```
zaiyuanwu -- -zsh -- 85x43
Last login: Tue Apr 25 12:41:59 on ttys000
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker ps
CONTAINER ID   IMAGE     COMMAND   CREATED   STATUS    PORTS   NAMES
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker run busybox
Unable to find image 'busybox:latest' locally
latest: Pulling from library/busybox
4b35f584bb4f: Pull complete
Digest: sha256:b5d6fe0712636ceb7430189de28819e195e8966372edfc2d9409d79402a0dc16
Status: Downloaded newer image for busybox:latest
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker run hello-world

Hello from Docker!
This message shows that your installation appears to be working correctly.

To generate this message, Docker took the following steps:
1. The Docker client contacted the Docker daemon.
2. The Docker daemon pulled the "hello-world" image from the Docker Hub.
   (amd64)
3. The Docker daemon created a new container from that image which runs the
   executable that produces the output you are currently reading.
4. The Docker daemon streamed that output to the Docker client, which sent it
   to your terminal.

To try something more ambitious, you can run an Ubuntu container with:
$ docker run -it ubuntu bash

Share images, automate workflows, and more with a free Docker ID:
https://hub.docker.com/

For more examples and ideas, visit:
https://docs.docker.com/get-started/

[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker run alpine
Unable to find image 'alpine:latest' locally
latest: Pulling from library/alpine
f56be85fc22e: Pull complete
Digest: sha256:124c7d2707904eea7431fffe91522a01e5a861a624ee31d03372cc1d138a3126
Status: Downloaded newer image for alpine:latest
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker ps
CONTAINER ID   IMAGE     COMMAND   CREATED   STATUS    PORTS   NAMES
zaiyuanwu@Zaiyuans-MacBook-Pro ~ %
```

```
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker ps -a
```

CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS	NAMES
4932d0a2707a	alpine	"sh"	About a minute ago	Exited (130) About a minute ago		practical_villani
5f06121d1392	alpine	"/bin/sh"	About a minute ago	Exited (130) About a minute ago		clever_volhard
9dc213db84e9	alpine	"/bin/sh"	2 minutes ago	Exited (130) 2 minutes ago		zen_chaum
1993e1c7519e	busybox	"sh"	2 minutes ago	Exited (0) 2 minutes ago		sweet_beaver
50ef585c6cbb	hello-world	"/hello"	2 minutes ago	Exited (0) 2 minutes ago		bold_mclean
91ee1650a50d	alpine	"/bin/sh"	8 minutes ago	Exited (0) 8 minutes ago		friendly_euclid
060b3f048541	hello-world	"/hello"	8 minutes ago	Exited (0) 8 minutes ago		jovial_nash
90f5296738f7	busybox	"sh"	8 minutes ago	Exited (0) 8 minutes ago		goofy_goldstine
f27a3e639a06	hello-world	"/hello"	15 minutes ago	Exited (0) 15 minutes ago		thirsty_roentgen

```
zaiyuanwu@Zaiyuans-MacBook-Pro ~ %
```

Delete containers using command 'docker rm':

```
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker rm 4932d0a2707a 5f06121d1392 9dc213db84e9 1993e1c7519e 50ef585c6cbb 91ee1650a50d 060b3f048541 90f5296738f7 f27a3e639a06]
4932d0a2707a
5f06121d1392
9dc213db84e9
1993e1c7519e
50ef585c6cbb
91ee1650a50d
060b3f048541
90f5296738f7
f27a3e639a06
```

Show docker images:

```
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker images]
REPOSITORY      TAG          IMAGE ID       CREATED        SIZE
alpine           latest       9ed4aefc74f6   3 weeks ago    7.05MB
busybox          latest       7cfbbec8963d   5 weeks ago    4.86MB
hello-world      latest       feb5d9fea6a5   19 months ago  13.3kB
zaiyuanwu@Zaiyuans-MacBook-Pro ~ %
```

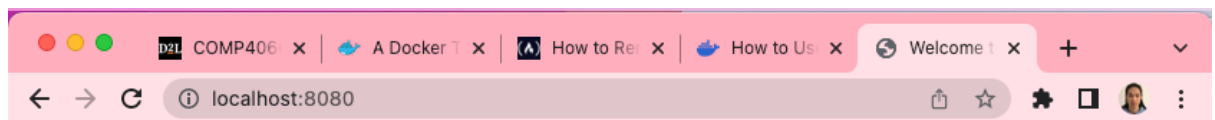
Delete images:

```
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker images]
REPOSITORY      TAG          IMAGE ID       CREATED        SIZE
alpine           latest       9ed4aefc74f6   3 weeks ago    7.05MB
busybox          latest       7cfbbec8963d   5 weeks ago    4.86MB
hello-world      latest       feb5d9fea6a5   19 months ago  13.3kB
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker rmi alpine busybox hello-world]
Untagged: alpine:latest
Untagged: alpine@sha256:124c7d2707904eea7431ffffe91522a01e5a861a624ee31d03372cc1d138a3126
Deleted: sha256:9ed4aefc74f6792b5a804d1d146fe4b4a2299147b0f50eaf2b08435d7b38c27e
Deleted: sha256:f1417ff83b319fbdae6dd9cd6d8c9c88002dcd75ecf6ec201c8c6894681cf2b5
Untagged: busybox:latest
Untagged: busybox@sha256:b5d6fe0712636ceb7430189de28819e195e8966372edfc2d9409d79402a0dc16
Deleted: sha256:7cfbbec8963d8f13e6c70416d6592e1cc10f47a348131290a55d43c3acab3fb9
Deleted: sha256:baacf561cfff825708763ce7ee4a18293716c533e6ece3bd39009a5fb3c804d2
Untagged: hello-world:latest
Untagged: hello-world@sha256:4e83453afed1b4fa1a3500525091dbfca6ce1e66903fd4c01ff015dbcb1ba33e
Deleted: sha256:feb5d9fea6a5e9606aa995e879d862b825965ba48de054caab5ef356dc6b3412
Deleted: sha256:e07ee1baac5fae6a26f30cabfe54a36d3402f96afda318fe0a96cec4ca393359
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker images]
REPOSITORY      TAG          IMAGE ID       CREATED        SIZE
zaiyuanwu@Zaiyuans-MacBook-Pro ~ %
```

- Follow the instructions at <https://www.docker.com/blog/how-to-use-the-official-nginx-docker-image/> to run a basic Nginx web server in your PC/VM. Add a custom HTML message with your Group members' names and run the server. Show the outcomes.

Run the basic Nginx web server:

```
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker run -it --rm -d -p 8080:80 --name web nginx
Unable to find image 'nginx:latest' locally
latest: Pulling from library/nginx
26c5c85e47da: Pull complete
4f3256bdf66b: Pull complete
2019c71d5655: Pull complete
8c767bdbc9ae: Pull complete
78e14bb05fd3: Pull complete
75576236abf5: Pull complete
Digest: sha256:63b44e8ddb83d5dd8020327c1f40436e37a6fffd3ef2498a6204df23be6e7e94
Status: Downloaded newer image for nginx:latest
ee49bfa44585fd4c7d2b7cacc0f7d0d6425be666ac693da6e023a3a5ab305e
zaiyuanwu@Zaiyuans-MacBook-Pro ~ %
```



## Welcome to nginx!

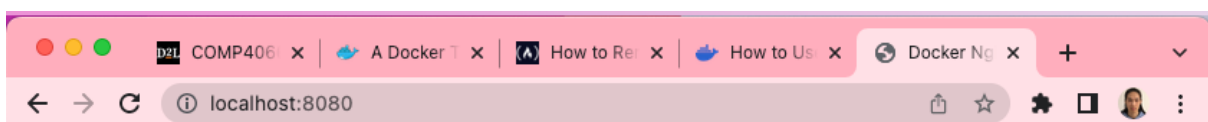
If you see this page, the nginx web server is successfully installed and working. Further configuration is required.

For online documentation and support please refer to [nginx.org](https://nginx.org).  
Commercial support is available at [nginx.com](https://nginx.com).

*Thank you for using nginx.*

Create a custom html page and run with -v flag to create a bind mount volume:

```
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker stop web
web
[zaiyuanwu@Zaiyuans-MacBook-Pro ~ % cd Desktop
[zaiyuanwu@Zaiyuans-MacBook-Pro Desktop % mkdir site-content
[zaiyuanwu@Zaiyuans-MacBook-Pro Desktop % cd site-content
[zaiyuanwu@Zaiyuans-MacBook-Pro site-content % touch index.html
[zaiyuanwu@Zaiyuans-MacBook-Pro site-content % docker run -it --rm -d -p 8080:80 --name web -v ~/Desktop/site-content:/usr/share/
nginx/html nginx
1e8af908842e2a1c56b35d4f527f829758f0d19f85cddb4a028a2134182ae7fe
[zaiyuanwu@Zaiyuans-MacBook-Pro site-content %
```



## Hello from Zaiyuan and Sophie

- Boot up a basic ubuntu container. Install any Linux package inside the container, such as nano or IP-Utils.

Start container:

```
[zaiyuanwu@Zaiyuans-MacBook-Pro site-content % docker run -it ubuntu  
root@d9ecb15ca619:/# apt-get update
```

Install nano:

```
root@d9ecb15ca619:/# apt install nano  
Reading package lists... Done  
Building dependency tree... Done  
Reading state information... Done  
Suggested packages:  
  hunspell  
The following NEW packages will be installed:  
  nano  
0 upgraded, 1 newly installed, 0 to remove and 5 not upgraded.  
Need to get 280 kB of archives.  
After this operation, 881 kB of additional disk space will be used.  
Get:1 http://archive.ubuntu.com/ubuntu jammy/main amd64 nano amd64 6.2-1 [280 kB]  
Fetched 280 kB in 0s (2326 kB/s)  
debconf: delaying package configuration, since apt-utils is not installed  
Selecting previously unselected package nano.  
(Reading database ... 4395 files and directories currently installed.)  
Preparing to unpack .../archives/nano_6.2-1_amd64.deb ...  
Unpacking nano (6.2-1) ...  
Setting up nano (6.2-1) ...  
update-alternatives: using /bin/nano to provide /usr/bin/editor (editor) in auto mode  
update-alternatives: warning: skip creation of /usr/share/man/man1/editor.1.gz because associated file /usr/share/man/man1/nano.1.gz (of link group editor) doesn't exist  
update-alternatives: using /bin/nano to provide /usr/bin/pico (pico) in auto mode  
update-alternatives: warning: skip creation of /usr/share/man/man1/pico.1.gz because associated file /usr/share/man/man1/nano.1.gz (of link group pico) doesn't exist  
root@d9ecb15ca619:/#
```

```
root@d9ecb15ca619:/# nano --version  
GNU nano, version 6.2  
(C) 1999-2011, 2013-2022 Free Software Foundation, Inc.  
(C) 2014-2022 the contributors to nano  
Compiled options: --disable-libmagic --enable-utf8  
root@d9ecb15ca619:/#
```

- Create a directory with your group name inside the container. Inside the container, create a text file and include the group members' names in it. Show the created directory and the file content.

```
root@d9ecb15ca619:/# ls  
bin boot dev etc home lib lib32 lib64 libx32 media mnt opt proc root run sbin srv sys tmp usr var  
root@d9ecb15ca619:/# mkdir Zaiyuan_Sophie  
root@d9ecb15ca619:/# cd Zaiyuan_Sophie/  
root@d9ecb15ca619:/Zaiyuan_Sophie# touch name.txt  
root@d9ecb15ca619:/Zaiyuan_Sophie# nano name.txt  
root@d9ecb15ca619:/Zaiyuan_Sophie# cat name.txt  
Zaiyuan  
Sophie  
root@d9ecb15ca619:/Zaiyuan_Sophie#
```

- Commit the Ubuntu container and push its image to the docker hub. Mention the link to the exported docker hub image.

```

zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker ps -a
CONTAINER ID   IMAGE     COMMAND                  CREATED        STATUS        PORTS          NAMES
c2c0614293dc   ubuntu   "/bin/bash"             3 minutes ago   Exited (0) 10 seconds ago           dazzling_engelbart
zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker commit c2c0614293dc task1
sha256:074c8d2ed951d42e5c4db8b6b6e371bb4df436a40f5cff9b9974c2be653a5f55

zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker tag task1 willinie/task1
zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker push willinie/task1
Using default tag: latest
The push refers to repository [docker.io/willinie/task1]
d126fb792465: Pushed
b93c1bd012ab: Pushed
latest: digest: sha256:60307d4f4f512df7f0d0e765048b0765e7962719a0a8e20d7b6fcd3c11ad84c3 size: 741
zaiyuanwu@Zaiyuans-MacBook-Pro ~ %

```

Link: <https://hub.docker.com/r/willinie/task1/tags>

## Task 02: Docker Networking (6 Marks)

<https://docs.docker.com/network/>

- Follow the instructions at <https://docs.docker.com/network/network-tutorial-standalone/> use a default bridge to connect three alpine containers and run ping commands to test their connectivity. Show the ping results.

Run 3 alpine containers:

```

zaiyuanwu — -zsh — 80x24
[(base) zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker run -dit --name alpine1 alpine ]
ash
Unable to find image 'alpine:latest' locally
latest: Pulling from library/alpine
f56be85fc22e: Pull complete
Digest: sha256:124c7d2707904eea7431fffe91522a01e5a861a624ee31d03372cc1d138a3126
Status: Downloaded newer image for alpine:latest
7fad0bea9d2eb5837f063bbc956f3d94690e7ada46de06c2fa1f279030478110
[(base) zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker run -dit --name alpine2 alpine ]
ash
0c224cc783afb718c1b3d38c284ffec008a83bbfeeabc9a6e7e6200bcc8f503
[(base) zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker run -dit --name alpine3 alpine ]
ash
8d678885807757d190a02d3f3260a53d6b243dd2ca3c6e84f7ab96f7bdfce9a3
(base) zaiyuanwu@Zaiyuans-MacBook-Pro ~ %

```

Test ping command:

```

[(base) zaiyuanwu@Zaiyuans-MacBook-Pro ~ % docker attach alpine1 ]
[/ # ping alpine2 ]
ping: bad address 'alpine2' ]
[/ # ping -c 2 google.com ]
PING google.com (172.253.116.138): 56 data bytes
64 bytes from 172.253.116.138: seq=0 ttl=36 time=46.491 ms
64 bytes from 172.253.116.138: seq=1 ttl=36 time=65.231 ms

--- google.com ping statistics ---
2 packets transmitted, 2 packets received, 0% packet loss
round-trip min/avg/max = 46.491/55.861/65.231 ms
[/ # ping -c 2 172.17.0.3 ]
PING 172.17.0.3 (172.17.0.3): 56 data bytes
64 bytes from 172.17.0.3: seq=0 ttl=64 time=0.173 ms
64 bytes from 172.17.0.3: seq=1 ttl=64 time=0.144 ms

--- 172.17.0.3 ping statistics ---
2 packets transmitted, 2 packets received, 0% packet loss
round-trip min/avg/max = 0.144/0.158/0.173 ms
/ #

```



- Establish an Inter-Process Communication (IPC) channel between two Ubuntu containers following the instructions at <https://medium.com/techanic/docker-containers-ipc-using-sockets-part-1-2ee90885602c>
- Leveraging the created IPC channel, send parametric values (at least 50) from container 1 to container 2, emulating an offloading scenario; compute the mean, median, and standard deviation of these parameters at container 2. You might have to extend the python script to establish the IPC communication. Send the computed stats to container 1 and display all the results at each container.

Build images:

```
[(base) zaiyuanwu@Zaiyuans-MacBook-Pro server % docker build -t my_ipc_server .
[+] Building 0.8s (8/8) FINISHED
```

```
[(base) zaiyuanwu@Zaiyuans-MacBook-Pro client % docker build -t my_ipc_client .
[+] Building 1.2s (9/9) FINISHED
```

Define bridge network:

```
[(base) zaiyuanwu@Zaiyuans-MacBook-Pro server % docker network create my_socket_ipc_network
463b5a28568c13adeeb9d465a7bb9ce17a9ce4f7726cabaa9b0f149b63cfa203
[(base) zaiyuanwu@Zaiyuans-MacBook-Pro server % docker network ls
NETWORK ID          NAME                DRIVER              SCOPE
1ecd11d54ebe        bridge              bridge              local
0f8e5189eb24        host                host                local
463b5a28568c        my_socket_ipc_network bridge              local
8ef9ffea9575        none                null                local
(base) zaiyuanwu@Zaiyuans-MacBook-Pro server %
```

Run containers separately:

```
[(base) zaiyuanwu@Zaiyuans-MacBook-Pro server % docker run --rm --network=my_socket_ipc_network --name ipc_server_dns_name my_ipc_server
Connected by ('172.19.0.3', 40698)
Sent Average: 24.5, Median: 24.5, Stdev: 14.577379737113251
(base) zaiyuanwu@Zaiyuans-MacBook-Pro server %
```

```
(base) zaiyuanwu@Zaiyuans-MacBook-Pro client % docker run --rm --network=my_socket_ipc_network my_ipc_client
Received '0'
Received '1'
Received '2'
Received '3'
```

```
Received '48'
Received '49'
Received Average: 24.5, Median: 24.5, Stdev: 14.577379737113251
(base) zaiyuanwu@Zaiyuans-MacBook-Pro client %
```

- Emulate another offloading scenario that is relevant for future applications.

Another scenario we implemented in this task in asymmetrical encryption with rsa-key pair. In the Part2 of this task, we emulated a client-server transmission, including the following steps:

1. server generate an rsa-key pair, sending public key to client
2. client receive public key, then encrypt a secret message with it
3. client send encrypted message to server
4. server decrypt message with private key

Presentation:

1. Similar to last part, build two images:

```

[...]\...
((base) zaiyuanwu@Zaiyuans-MacBook-Pro server % docker build -t my_ipc_server .
[+] Building 3.5s (10/10) FINISHED

```

```

((base) zaiyuanwu@Zaiyuans-MacBook-Pro client % docker build -t my_ipc_client .
[+] Building 0.5s (9/9) FINISHED

```

2. Run containers separately:

```

((base) zaiyuanwu@Zaiyuans-MacBook-Pro server % docker run --rm --network=my_socket_ipc_network --name ipc_server_dns_name my_ipc_server
[rsa-key]generated
[rsa-key]saved to files
Connected by ('172.19.0.3', 45056)
[socket]HEADER sent
[socket]public key sent
[socket]encrypted message received
[message]decrypted -- This is a secret message! Don't share it with anyone.
(base) zaiyuanwu@Zaiyuans-MacBook-Pro server %

```

```

((base) zaiyuanwu@Zaiyuans-MacBook-Pro client % docker run --rm --network=my_socket_ipc_network my_ipc_client
Connected by 172.19.0.2
[socket]HEADER received
public key info: public.pem -- 251bytes
[socket]public key received
-----BEGIN RSA PUBLIC KEY-----
MIGJAoGBALiP2iUVYJSNiM/5A3F3NrEq6ADhTU1RTuyw3mPd35Ifpb742brEkV/H
QhlFZ7wDOrT8Pj7dzhhZgS88JQdFakoZFpkJnW7IwIaZvx7j6C2gJ0aOW4KJ7xcw
6h7vh/YuEl7B4nBjBD7rC3YAzNF6aLSECyIqMdvS04GR7o16o3pDAgMBAAE=
-----END RSA PUBLIC KEY-----

[message] -- This is a secret message! Don't share it with anyone.
[message]encrypted with public key
[socket]encrypted message sent to server
(base) zaiyuanwu@Zaiyuans-MacBook-Pro client %

```