Assignment–1

Group-5

Name	E-mail	PNumber
Sri Harsha Arakatavemula	sraa16@student.bth.se	9501036991
Suman Barua	subr18@student.bth.se	8210133370
Narasimha Krishna Nannuri	nana18@student.bth.se	9208309535
Bing Li	bili18@student.bth.se	8911151242
Guojun Lai	gula18@student.bth.se	9706102572

Architecture:

With the practice of this assignment, one will understand the way to deploy applications with docker containers and to run some of the docker services. The target of this assignment is to construct a simple client/server 3-tire application which can read and write from the database through internet. Image is built and containerize the application by using Dockerfile file. The containers running are pushed into the docker hub repository. The data generated by the application should be safe or persistent even after the container is terminated. This is where volumes and bind mount are used. Finally, after proving the data is persistent, container orchestration is done i.e. docker services like docker swarm is used to cluster the nodes running. Manual scaling is done to check whether load balancing is working properly.

There are few technical terms used in this assignment like docker file, Yaml file, volume, bind mount, docker swarm etc. all the above terms will be explained briefly.

Docker file:

Docker build images by following few instructions written in Docker file. Docker file is a type of text document which contains the instructions or commands to build an image. ¨docker build¨ is a command used to build an image for a application by reading the instructions from docker file.

Yaml file:

Yaml file describes the behavior of the container running. Yaml file contains instructions regarding container while running. File includes son of the instructions like download location of the image and how to deploy a container, replicas needed, what are the ports needed to access the network, replicas needed, load balancing etc.

Volumes:

Volumes are the method or mechanism used to persist the data created by the docker containers. Docker takes the complete hold of volumes to persist the data generated.

Bind mounts:

Bind mounts has the same functionality of volumes but bit less in performance functions when compared to volumes. File or a directory is hosted from the host machine is mounted into a container while using bind mounts.

Docker Swarm:

Swarm mode is one of the services operated by docker. It helps managing a cluster of docker engines running. Swarm provides some of the features like load balancing, scaling, cluster management integrated with docker engine, multi-host networking, decentralized design etc.

Functionality of 3-tire application built:

The application was built in php environment, interacts with user interface, database and backend logic. To interact with above features it runs apache server and mysql server in the background. It is a user registration application where it takes some input data like first name, last name, email, age and location. All the data entered is stored in database file and can be retrieved by searching by location in the application. Thus, the application is reading and writing the data. The following figures explains about the functionality of the application.

It asks to create a new user or search for an existing user.

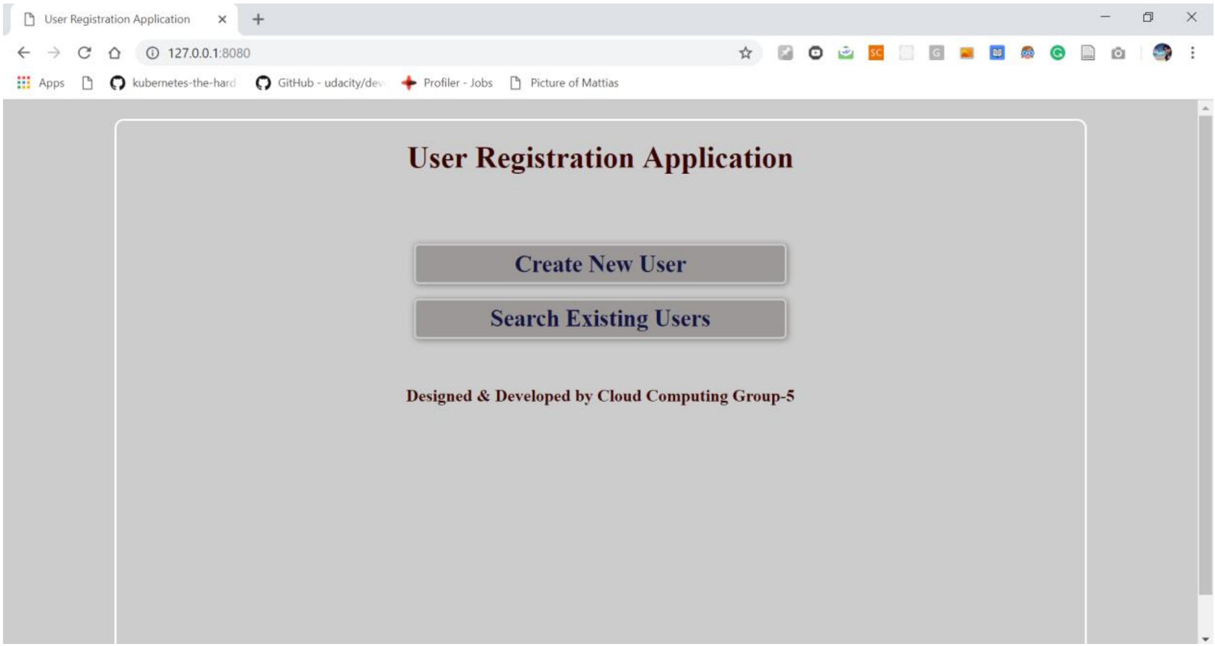


Figure 1: User Interface of the application.

New user is registered by inputting few values mentioned below.

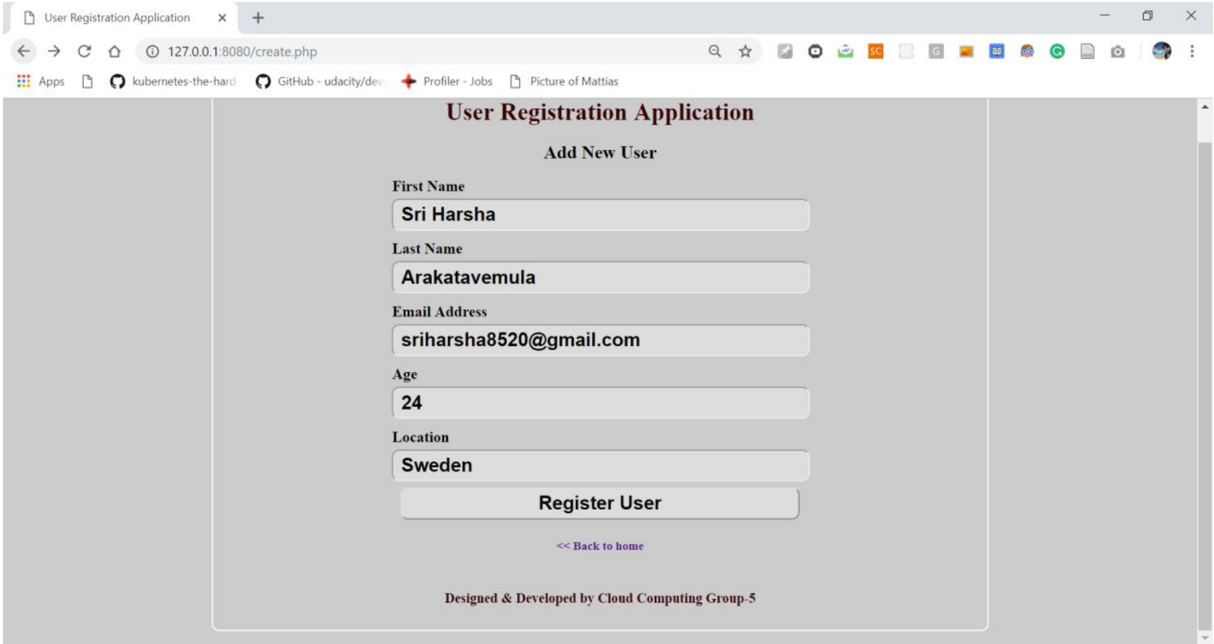


Figure 2: User registration.

A user is registered with location Sweden. To retrieve the existing user search is made according to the location.

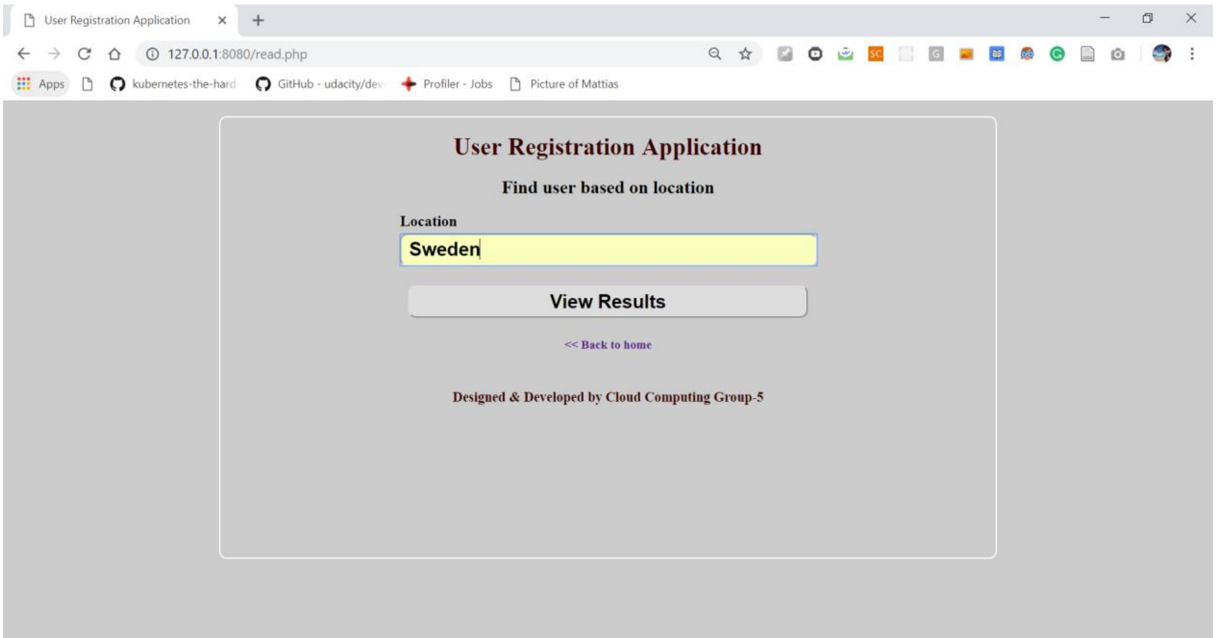


Figure 3: Searching existing user.

Thus, by searching by location existing registered users are retrieved.

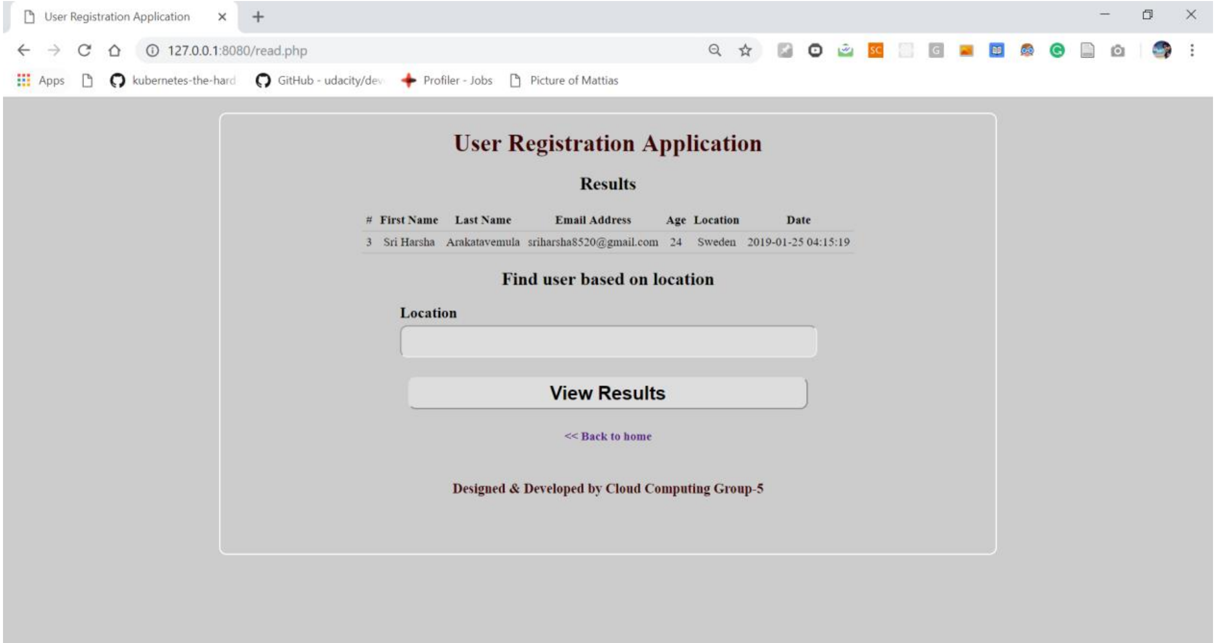


Figure 4: Results for existing user search.

Dockerfile:

```
ARG APACHE_VERSION=""
FROM httpd:${APACHE_VERSION:+${APACHE_VERSION}-}alpine

RUN apk update; \
    apk upgrade;

# Copy apache vhost file to proxy php requests to php-fpm container
COPY demo.apache.conf /usr/local/apache2/conf/demo.apache.conf
RUN echo "Include /usr/local/apache2/conf/demo.apache.conf" \
    >> /usr/local/apache2/conf/httpd.conf
```

Figure 5: Dockerfile

Yaml file:

```yaml
version: "3.2"
services:
  php:
    build: './php/'
    networks:
      - backend
    volumes:
      - ./html/:/var/www/html/
  apache:
    build: './apache/'
    depends_on:
      - php
      - mysql
    networks:
      - frontend
      - backend
    ports:
      - "8080:80"
    volumes:
      - ./public_html/:/var/www/html/
  mysql:
    image: mysql:5.6.40
    networks:
      - backend
    environment:
      - MYSQL_ROOT_PASSWORD=rootpassword
networks:
  frontend:
  backend:
```

Figure 6: Yaml file

Apache Config:

```
ServerName localhost

LoadModule deflate_module /usr/local/apache2/modules/mod_deflate.so
LoadModule proxy_module /usr/local/apache2/modules/mod_proxy.so
LoadModule proxy_fcgi_module /usr/local/apache2/modules/mod_proxy_fcgi.so

<VirtualHost *:80>
    # Proxy .php requests to port 9000 of the php-fpm container
    ProxyPassMatch ^/(.*\.php(/.*)?)$ fcgi://php:9000/var/www/html/$1
    DocumentRoot /var/www/html/
    <Directory /var/www/html/>
        DirectoryIndex index.php
        Options Indexes FollowSymLinks
        AllowOverride All
        Require all granted
    </Directory>

    # Send apache logs to stdout and stderr
    CustomLog /proc/self/fd/1 common
    ErrorLog /proc/self/fd/2
</VirtualHost>
```

Figure 7: Apache Config

Init.sql:

```sql
CREATE DATABASE abc;

use abc;

CREATE TABLE users (
    id INT(11) UNSIGNED AUTO_INCREMENT PRIMARY KEY,
    firstname VARCHAR(30) NOT NULL,
    lastname VARCHAR(30) NOT NULL,
    email VARCHAR(50) NOT NULL,
    age INT(3),
    location VARCHAR(50),
    date TIMESTAMP
);
```

Figure 8: Init.sql

Initially, image is built and containerize the application with a single command.

- docker-compose up

The path is set to the docker compose.yml file in the terminal and the above command is executed. The following figure explains the execution of above command.

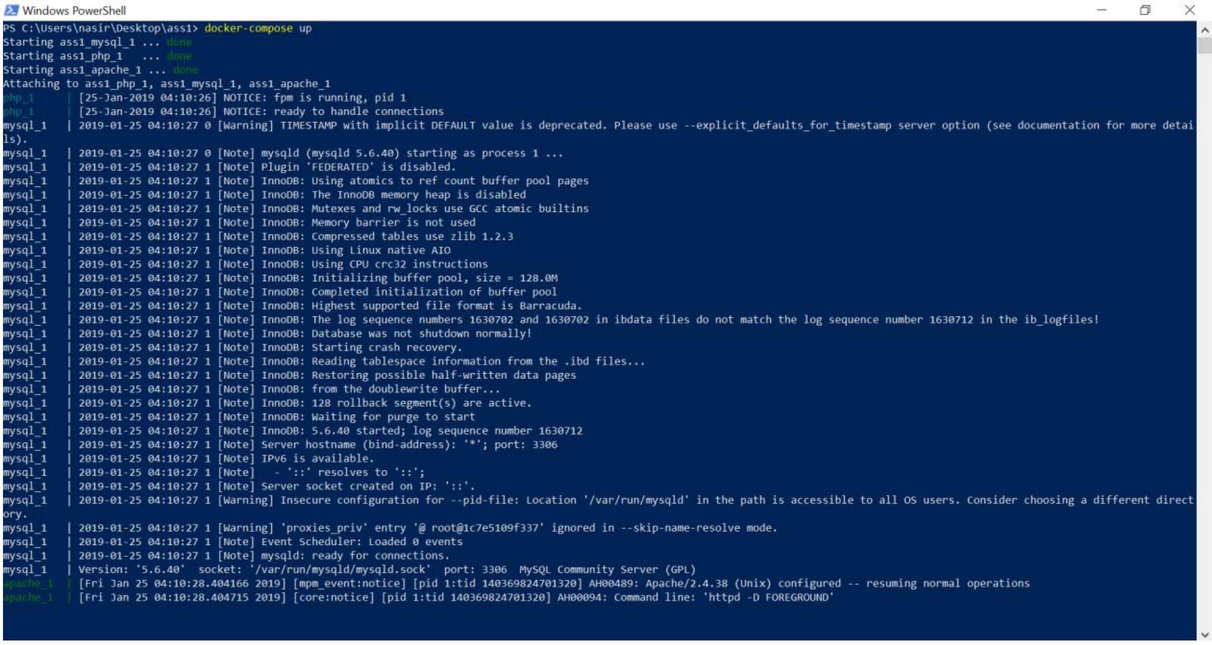


Figure 9: Execution of docker-compose up

Now, the image is built and run resulting in three containers running. The below figure describes the containers running. By using the command

- docker container ps

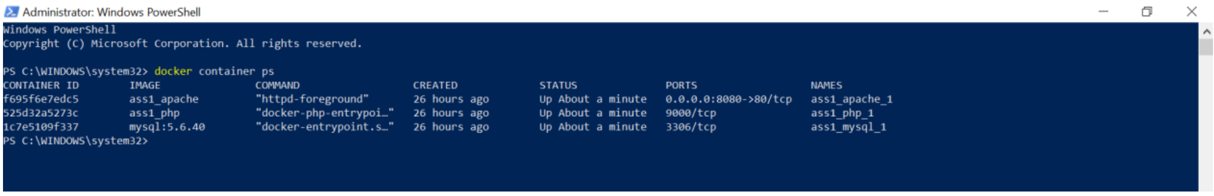


Figure 10: Containers running

The application is running on the 8080 port. The application can be accessed in localhost i.e. 127.0.0.1:8080 port. The below explains the application running on 127.0.0.1:8080 port

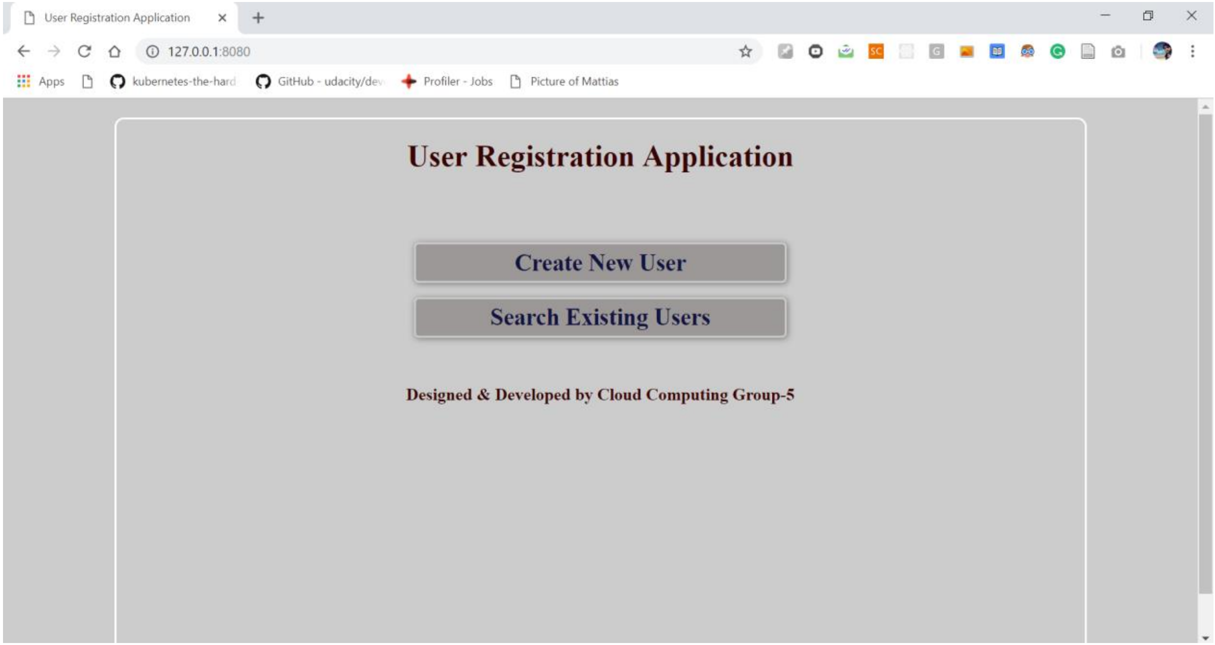


Figure 11: Application running on 127.0.0.1:8080 port

As explained above in the architecture, a user is registered, and containers are terminated. But the data is still persistent because of volumes. The below figures explain the container termination, volume created and running the containers by using volumes. All the commands must be executed as a root user.

Figure 12: containers stopped

In the above figure, it is known that all the containers are terminated. The volumes can be seen by using below command.

- docker volume ls

```
PS C:\WINDOWS\system32> docker volume ls
DRIVER              VOLUME NAME
local               5a081b7507c712c0aef5dcdaadb8454e8dc745bacb504b2706d9e39914bc11ee
local               harsha
PS C:\WINDOWS\system32>
```

Figure 12: Volumes created.

The containers can be restarted with the command.

- docker container start container name

```
PS C:\WINDOWS\system32> docker container start ass1_apache_1
ass1_apache_1
PS C:\WINDOWS\system32> docker container start ass1_php_1
ass1_php_1
PS C:\WINDOWS\system32> docker container start ass1_mysql_1
ass1_mysql_1
PS C:\WINDOWS\system32> docker container ls
CONTAINER ID        IMAGE               COMMAND                  CREATED             STATUS              PORTS                  NAMES
f695f6e7edc5        ass1_apache         "httpd-foreground"       27 hours ago        Up 37 seconds       0.0.0.0:8080->80/tcp   ass1_apache_1
525d32a5273c        ass1_php            "docker-php-entrypoi…"   27 hours ago        Up 23 seconds       9000/tcp               ass1_php_1
1c7e5109f337        mysql:5.6.40        "docker-entrypoint.s…"   27 hours ago        Up 11 seconds       3306/tcp               ass1_mysql_1
PS C:\WINDOWS\system32>
```

Figure 13: Restarting docker containers.

By using volumes, the data is persistent. The below figure explains the persistent data ran by the container.

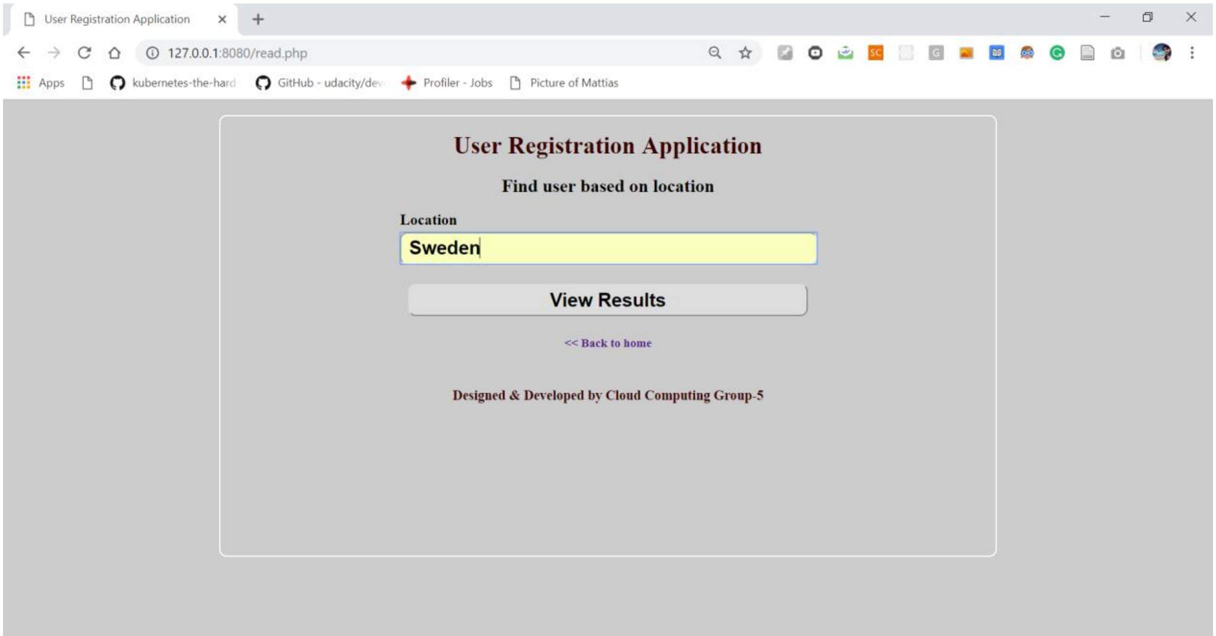


Figure 14: Search by location

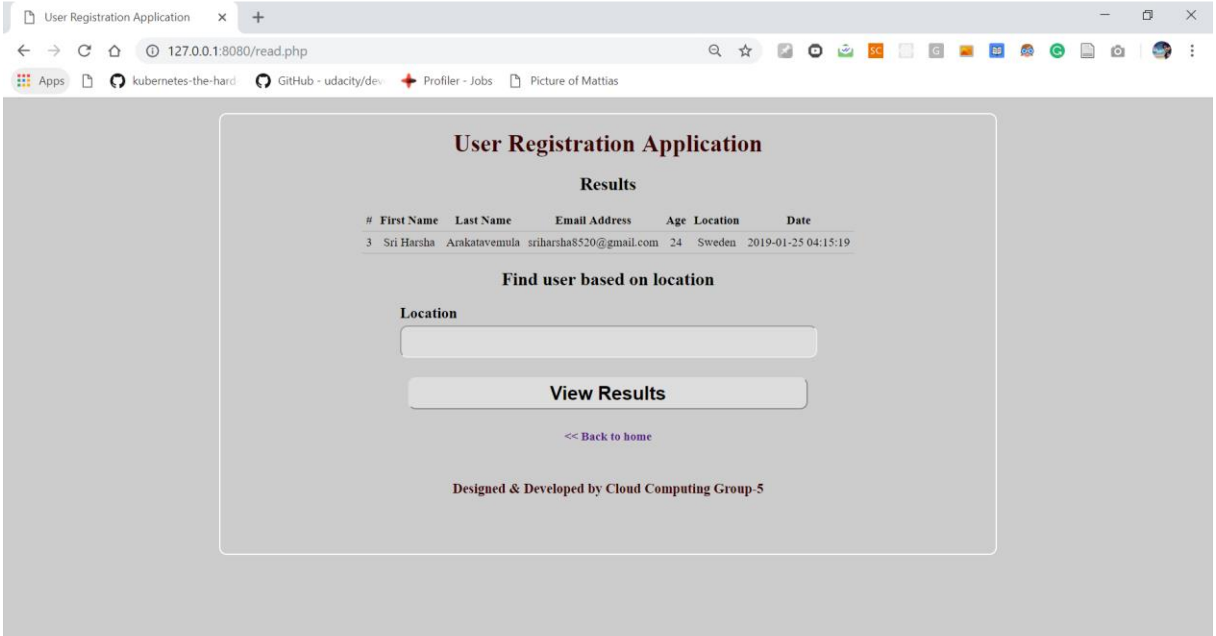


Figure 15: Persistent data by volumes.

Thus, the volumes are used to persistent data ran by a container. By using bind mount file or a directory is hosted from the host machine is mounted into a container. Two folders have been mounted on host machine to two different containers.

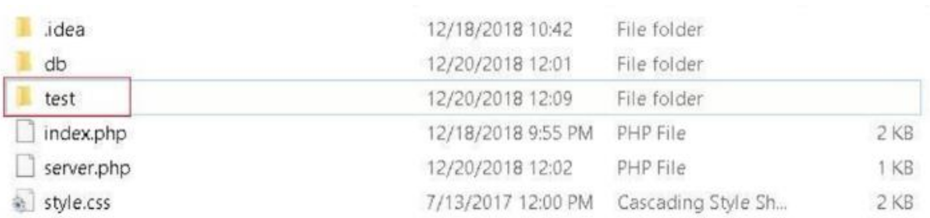


Figure 16: Folder with name test is on host.

Figure 17: Folder test on the container.

Windows PowerShell

```
PS D:\Program\XAMPP\xampp\htdocs\phpweb> docker exec -it htdocs_db_1 /bin/bash
root@fbe59e5be4fb:/# ls
bin  boot  dev  docker-entrypoint-initdb.d  entrypoint.sh  etc  home  lib  lib64  media  mnt  opt  proc  root  run  sbin  srv  sys  tmp  usr  var
root@fbe59e5be4fb:/# cd docker-entrypoint-initdb.d/
root@fbe59e5be4fb:/docker-entrypoint-initdb.d# ls
db.sql  db1.sql
root@fbe59e5be4fb:/docker-entrypoint-initdb.d#
```

Figure 18: Init.sql file on container.

Now, a docker service called swarm is used to create a cluster. This cluster contains three docker machines, one manager named as manager1 and two workers named as worker1 and worker2. Thus, there are three docker machines are running. To create a docker machine the following command is used. The same command is used to create three docker machines. The following figure explains the docker machines created.

- docker-machine create -d hyperv –hyperv-virtual-switch ¨Primary Virtual Switch¨ manager1
- docker-machine create -d hyperv –hyperv-virtual-switch ¨Primary Virtual Switch¨ worker1
- docker-machine create -d hyperv –hyperv-virtual-switch ¨Primary Virtual Switch¨ worker 2

```
PS C:\WINDOWS\system32> docker-machine create -d hyperv --hyperv-virtual-switch "Primary Virtual Switch" manager1
Running pre-create checks...
Creating machine...
(manager1) Copying C:\Users\nasir\.docker\machine\cache\boot2docker.iso to C:\Users\nasir\.docker\machine\machines\manager1\boot2docker.iso...
(manager1) Creating SSH key...
(manager1) Creating VM...
(manager1) Using switch "Primary Virtual Switch"
(manager1) Creating VHD
(manager1) Starting VM...
(manager1) Waiting for host to start...
Waiting for machine to be running, this may take a few minutes...
Detecting operating system of created instance...
Waiting for SSH to be available...
Detecting the provisioner...
Provisioning with boot2docker...
Copying certs to the local machine directory...
Copying certs to the remote machine...
Setting Docker configuration on the remote daemon...
Checking connection to Docker...
Docker is up and running!
To see how to connect your Docker Client to the Docker Engine running on this virtual machine, run: C:\Program Files\Docker\Docker\Resources\bin\docker-machine.exe env manager1
```

Figure 19: Creating manager1

By using the below command, the docker machined which are created can be listed.

- docker-machine ls

The below figure shows the docker machines created.

```
PS C:\WINDOWS\system32> docker-machine ls
NAME       ACTIVE   DRIVER   STATE     URL                        SWARM   DOCKER     ERRORS
manager1   -        hyperv   Running   tcp://192.168.1.110:2376           v18.09.1
worker1    -        hyperv   Running   tcp://192.168.1.111:2376           v18.09.1
worker2    -        hyperv   Running   tcp://192.168.1.112:2376           v18.09.1
PS C:\WINDOWS\system32>
```

Figure 20: List of docker machines created.

There are totally three docker machines running one manager1 and two worker1 and worker2. Now, cluster is created by making manager1 as manager and worker1, worker2 as workers. By executing the below command, manager1 is made as manager.

- docker-machine manager1 ¨docker swarm init –advertise-addr 192.168.1.107¨

```
PS C:\WINDOWS\system32> docker-machine ssh manager1 "docker swarm init --advertise-addr 192.168.1.107"
Swarm initialized: current node (fwphhs5y5b2jfjvkmm75rrea9) is now a manager.

To add a worker to this swarm, run the following command:

    docker swarm join --token SWMTKN-1-22j469ac6nueq5w0j8or8u8eyn6u8qyd4y55pu51w62xlcu7b5-cbmbkli895nkt6cnxeachgchf 192.168.1.107:2377

To add a manager to this swarm, run 'docker swarm join-token manager' and follow the instructions.

PS C:\WINDOWS\system32>
```

Figure 21: making manager1 as manager.

In the above figure, it is shown that manager1 is manager. Now manager can join workers in his cluster by running the above-mentioned command in the figure in both worker1 and worker2. To enter into worker1 and worker2 the following command is used.

- docker-machine ssh worker1

```
PS C:\WINDOWS\system32> docker-machine ssh worker1
   ( '>')
  /) TC (\   Core is distributed with ABSOLUTELY NO WARRANTY.
 (/-_--_-\)           www.tinycorelinux.net

docker@worker1:~$
```

Figure 22: Entering into worker1

- docker-machine ssh worker2

```
PS C:\WINDOWS\system32> docker-machine ssh worker2
   ( '>')
  /) TC (\   Core is distributed with ABSOLUTELY NO WARRANTY.
 (/-_--_-\)           www.tinycorelinux.net

docker@worker2:~$
```

Figure 23: Entering into worker2

- docker-machine ssh manager1

```
PS C:\WINDOWS\system32> docker-machine ssh manager1
   ( '>')
  /) TC (\   Core is distributed with ABSOLUTELY NO WARRANTY.
 (/-_--_-\)           www.tinycorelinux.net

docker@manager1:~$
```

Figure 24: Entering into manager1

```
docker@worker1:~$ docker swarm join --token SWMTKN-1-2rejvo0h2uwbe7m5xbwyul17819f03fpx52btpd2h6ekzgkpfh-6543z1rnizu4kcz1k7ygvc1s1 192.168.1.113:2377
This node joined a swarm as a worker.
docker@worker1:~$
```

Figure 25: Worker1 joined swarm

```
docker@worker2:~$ docker swarm join --token SWMTKN-1-2rejvo0h2uwbe7m5xbwyul17819f03fpx52btpd2h6ekzgkpfh-6543z1rnizu4kcz1k7ygvc1s1 192.168.1.113:2377
This node joined a swarm as a worker.
docker@worker2:~$
```

Figure 26: Worker2 joined swarm

All the commands can be running in manager1 but not in worker1 and worker2 because only manager has the permissions. By executing the following command in manager1, information about the swarm cluster created can be known.

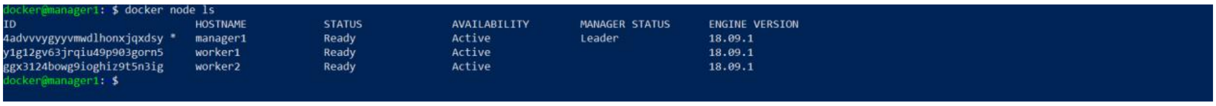
- docker swarm info

```
docker@manager1:~$ docker info
Containers: 0
 Running: 0
 Paused: 0
 Stopped: 0
Images: 0
Server Version: 18.09.1
Storage Driver: overlay2
 Backing Filesystem: extfs
 Supports d_type: true
 Native Overlay Diff: true
Logging Driver: json-file
Cgroup Driver: cgroupfs
Plugins:
 Volume: local
 Network: bridge host macvlan null overlay
 Log: awslogs fluentd gcplogs gelf journald json-file local logentries splunk syslog
Swarm: active
 NodeID: 4advvvygyyvmwdlhonxjqxdsy
 Is Manager: true
 ClusterID: s5055ccdefpcevfvucgfrmzij
 Managers: 1
 Nodes: 3
 Default Address Pool: 10.0.0.0/8
 SubnetSize: 24
 Orchestration:
  Task History Retention Limit: 5
 Raft:
  Snapshot Interval: 10000
  Number of Old Snapshots to Retain: 0
  Heartbeat Tick: 1
  Election Tick: 10
 Dispatcher:
  Heartbeat Period: 5 seconds
 CA Configuration:
  Expiry Duration: 3 months
  Force Rotate: 0
```

Figure 27: Information about swarm

By executing the following command in manager1, the status of the nodes in swarm can be known.

- ➢ docker node ls

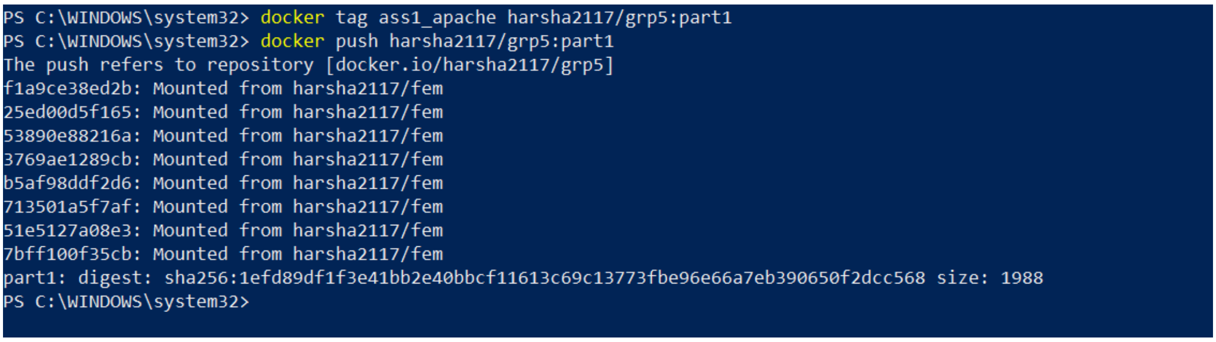


```
docker@manager1: $ docker node ls
ID                            HOSTNAME            STATUS              AVAILABILITY        MANAGER STATUS      ENGINE VERSION
4advvvygyyvmwdlhonxjqxdsy *   manager1            Ready               Active              Leader              18.09.1
y1g12gv63jrqiu49p903gorn5     worker1             Ready               Active                                  18.09.1
ggx3124bowg9ioghiz9t5n3ig     worker2             Ready               Active                                  18.09.1
docker@manager1: $
```

Figure 28: Status of the nodes.

The containers of the application running are pushed into the docker hub repository. The following command is used to tag the container and push into the repository.

- ➢ docker tag ass1_apache harsha2117/grp5:part1
- ➢ docker push harsha2117/grp5:part1



```
PS C:\WINDOWS\system32> docker tag ass1_apache harsha2117/grp5:part1
PS C:\WINDOWS\system32> docker push harsha2117/grp5:part1
The push refers to repository [docker.io/harsha2117/grp5]
f1a9ce38ed2b: Mounted from harsha2117/fem
25ed00d5f165: Mounted from harsha2117/fem
53890e88216a: Mounted from harsha2117/fem
3769ae1289cb: Mounted from harsha2117/fem
b5af98ddf2d6: Mounted from harsha2117/fem
713501a5f7af: Mounted from harsha2117/fem
51e5127a08e3: Mounted from harsha2117/fem
7bff100f35cb: Mounted from harsha2117/fem
part1: digest: sha256:1efd89df1f3e41bb2e40bbcf11613c69c13773fbe96e66a7eb390650f2dcc568 size: 1988
PS C:\WINDOWS\system32>
```

Figure 29: Pushing the container into repository

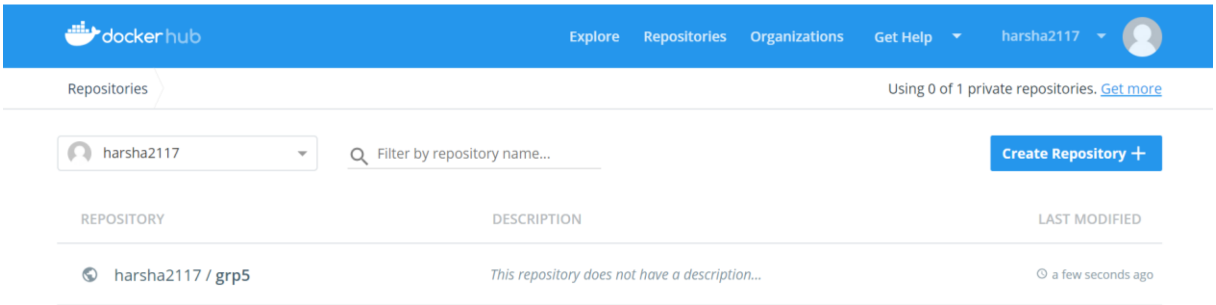


Figure 30: Repository created with name grp5

By using the below command, the contained from the repository is run on the swarm.

- ➢ docker service create --replicas 3 -p 8080:80 --aserver harsha2117/grp5:part1

By using the below command, the number of replicas running can be seen.

- ➢ docker service ls

```
docker@manager1: $ docker service ls
ID             NAME      MODE         REPLICAS   IMAGE                   PORTS
l5emotqcyqd0   aserver   replicated   3/3        harsha2117/grp5:part1   *:80->80/tcp
docker@manager1: $
```

Figure 31: Number of replicas created

By using the below command, the services running on the swarm are shown.

- ➢ docker service ps aserver

```
docker@manager1: $ docker service ps aserver
ID             NAME        IMAGE                   NODE       DESIRED STATE   CURRENT STATE           ERROR   PORTS
6hajfgnvnsu1   aserver.1   harsha2117/grp5:part1   worker2    Running         Running 3 minutes ago
wk4letjfhg2y   aserver.2   harsha2117/grp5:part1   manager1   Running         Running 3 minutes ago
yqnlqolh18n6   aserver.3   harsha2117/grp5:part1   worker1    Running         Running 3 minutes ago
docker@manager1: $
```

Figure 32: Services running

Now, scale service up and scale service down is performed. Scale service up is done by increasing the replicas from 3 to 5 by using the below command.

- ➢ docker service scale aserver=5

```
docker@manager1: $ docker service scale aserver=5
aserver scaled to 5
overall progress: 5 out of 5 tasks
1/5: running   [==================================================>]
2/5: running   [==================================================>]
3/5: running   [==================================================>]
4/5: running   [==================================================>]
5/5: running   [==================================================>]
verify: Service converged
docker@manager1: $
```

Figure 33: scaling up

The services running can be seen by using the below commands.

- ➢ docker service ls

```
docker@manager1: $ ddocker service ls
ID             NAME      MODE         REPLICAS   IMAGE                   PORTS
l5emotqcyqd0   aserver   replicated   5/5        harsha2117/grp5:part1   *:80->80/tcp
docker@manager1: $
```

Figure 34: Five replicas are running

- ➢ docker service ps aserver

```
docker@manager1: $ docker service ps aserver
ID             NAME        IMAGE                   NODE       DESIRED STATE   CURRENT STATE           ERROR   PORTS
6hajfgnvnsu1   aserver.1   harsha2117/grp5:part1   worker2    Running         Running 8 minutes ago
wk4letjfhg2y   aserver.2   harsha2117/grp5:part1   manager1   Running         Running 8 minutes ago
yqnlqolh18n6   aserver.3   harsha2117/grp5:part1   worker1    Running         Running 8 minutes ago
aaknnb4q8i3k   aserver.4   harsha2117/grp5:part1   worker1    Running         Running 2 minutes ago
53zxdfvughc6   aserver.5   harsha2117/grp5:part1   manager1   Running         Running 2 minutes ago
docker@manager1: $
```

Figure 35: Services running

Scale service down is done by decreasing the replicas from 5 to 2 by using the below command.

- ➢ docker service scale aserver=2

```
docker@manager1:~$ docker service scale aserver=2
aserver scaled to 2
overall progress: 2 out of 2 tasks
1/2: running   [==================================================>]
2/2: running   [==================================================>]
verify: Service converged
docker@manager1:~$
```

Figure 36: Scaling down

The service running can be seen by using the below commands.

- docker service ls

```
docker@manager1:~$ docker service ls
ID             NAME      MODE         REPLICAS   IMAGE                  PORTS
l5emotqcyqd0   aserver   replicated   2/2        harsha2117/grp5:part1  *:80->80/tcp
docker@manager1:~$
```

Figure 37: Two replicas are running.

- docker service ps aserver

```
docker@manager1:~$ docker service ps aserver
ID             NAME        IMAGE                   NODE       DESIRED STATE   CURRENT STATE            ERROR     PORTS
6hajfgnvnsu1   aserver.1   harsha2117/grp5:part1   worker2    Running         Running 11 minutes ago
wk4letjfhg2y   aserver.2   harsha2117/grp5:part1   manager1   Running         Running 11 minutes ago
docker@manager1:~$
```

Figure 38: Services running

Thus, scale service up and scale service down is done.