Lab 8: Docker Swarm

In this lab, you will work with Docker Swarm from the command line to manage running nodes, deploy services, and perform rolling updates on your services when needed. You will learn how to troubleshoot your Swarm nodes and deploy entire stacks using your existing Docker Compose files, as well as learning how you can use Swarm to manage your service configuration and secrets. The final part of this lab will provide you with the knowledge you need to get started using Swarmpit, which is a web-based interface for running and managing your Docker Swarm services and clusters.

Exercise 8.01: Running Services with Docker Swarm

This exercise is designed to help you become familiar with using the Docker Swarm commands to manage your services and containers. In the exercise, you will activate a cluster, set up a new service, test scaling up the service, and then remove the service from the cluster using Docker Swarm:

1. Although Swarm is included by default with your Docker installation, you still need to activate it on your system. Use the `docker swarm init` command to put your local system into Docker Swarm mode:

   ```
   docker swarm init
   ```

   Your output might be a little different from what you see here, but as you can see, once the swarm is created, the output provides details on how you can add extra nodes to your cluster with the `docker swarm join` command:

   ```
   Swarm initialized: current node (j2qxrpf0a1yhvcax6n2ajux69) is
   now a manager.
   To add a worker to this swarm, run the following command:
       docker swarm join --token SWMTKN-1-
   2w0fk5g2e18118zygvmvdxartd43n0ky6cmywy0ucxj8j7net1-5v1xvrt7
   1ag6ss7trl480e1k7 192.168.65.3:2377
   To add a manager to this swarm, run 'docker swarm join-token
   manager' and follow the instructions.
   ```

2. Now list the nodes you have in your cluster, using the `node ls` command:

   ```
   docker node ls
   ```

   You should have one node you are currently working on and its status should be `Ready`:

   ```
   ID         HOSTNAME          STATUS    AVAILABILITY
     MANAGER STATUS
   j2qx.. *   docker-desktop    Ready     Active
     Leader
   ```

   For clarity here, we have removed the `Engine Version` column from our output.

3. From your node, check the status of your swarm using the `docker info` command, providing further details of your Swarm cluster and how the node is interacting with it. It will also give you extra information if you need to troubleshoot issues later:

   ```
   docker info
   ```

As you can see from the output, you get all the specific details of your Docker Swarm cluster, including `NodeID` and `ClusterID`. If you don't have Swarm set up correctly on your system, all you will see is an output of `Swarm: inactive`:

```
…
Swarm: active
  NodeID: j2qxrpf0a1yhvcax6n2ajux69
  Is Manager: true
  ClusterID: pyejfsj9avjn595voauu9pqjv
  Managers: 1
  Nodes: 1
  Default Address Pool: 10.0.0.0/8
  SubnetSize: 24
  Data Path Port: 4789
  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
```

4. Start your first service on your newly created swarm. Create a service named `web` using the `docker service create` command and the `--replicas` option to set two instances of the container running:

```
docker service create --replicas 2 -p 80:80 --name web nginx
```

You will see that the two instances are successfully created:

```
uws28u6yny7ltvutq38166a1f
overall progress: 2 out of 2 tasks
1/2: running   [==========================================>]
2/2: running   [==========================================>]
verify: Service converged
```

5. Similar to the `docker ps` command, you can see a listing of the services running on your cluster with the `docker service ls` command. Execute the `docker service ls` command to view the details of the `web` service created in the *step 4*:

```
docker service ls
```

The command will return the details of the `web` service:

```
ID              NAME  MODE          REPLICAS   IMAGE
  PORTS
uws28u6yny7l    web   replicated    2/2        nginx:latest
  *:80->80/tcp
```

6. To view the containers currently running on your swarm, use the `docker service ps` command with the name of your service, `web`:

```
docker service ps web
```

As you can see, you now have a list of the containers running our service:

```
ID      NAME    IMAGE    NODE               DESIRED
  CURRENT STATE
viyz    web.1   nginx    docker-desktop     Running
  Running about a minute ago
mr4u    web.2   nginx    docker-desktop     Running
  Running about a minute ago
```

7. The service will only run the default `Welcome to nginx!` page. Use the node IP address to view the page. In this instance, it will be your localhost IP, `0.0.0.0`:

8. Scaling the number of containers running your service is easy with Docker Swarm. Simply provide the `scale` option with the number of total containers you want to have running, and the swarm will do the work for you. Perform the command shown here to scale your running web containers to `3`:

```
docker service scale web=3
```

The following output shows that the `web` service is now scaled to `3` containers:

```
web scaled to 3
overall progress: 3 out of 3 tasks
1/3: running   [==================================================>]
2/3: running   [==================================================>]
3/3: running   [==================================================>]
verify: Service converged
```

9. As in *step 5* of this exercise, run the `service ls` command:

```
docker service ls
```

You should now see three `web` services running on your cluster:

```
ID              NAME    MODE          REPLICAS    IMAGE
    PORTS
uws28u6yny7l    web     replicated    3/3         nginx:latest
    *:80->80/tcp
```

10. The following change is more suited to a cluster with more than one node, but you can run it anyway to see what happens. Run the following `node update` command to set the availability to `drain` and use your node ID number or name. This will remove all the containers running on this node as it is no longer available on your cluster. You will be provided with the node ID as an output:

```
docker node update --availability drain j2qxrpf0a1yhvcax6n2ajux69
```

11. If you were to run the `docker service ps web` command, you would see each of your `web` services shut down while trying to start up new `web` services. As you only have one node running, the services would be sitting in a pending state with `no suitable node` error. Run the `docker service ps web` command:

```
docker service ps web
```

    The output has been reduced to only show the second, third, fifth, and sixth columns, but you can see that the service is unable to start. The `CURRENT STATE` column has both `Pending` and `Shutdown` states:

```
NAME          IMAGE             CURRENT STATE
  ERROR
web.1         nginx:latest      Pending 2 minutes ago
  "no suitable node (1 node…"
\_ web.1      nginx:latest      Shutdown 2 minutes ago
web.2         nginx:latest      Pending 2 minutes ago
  "no suitable node (1 node…"
\_ web.2      nginx:latest      Shutdown 2 minutes ago
web.3         nginx:latest      Pending 2 minutes ago
  "no suitable node (1 node…"
\_ web.3      nginx:latest      Shutdown 2 minutes ago
```

12. Run the `docker node ls` command:

```
docker node ls
```

    This shows that your node is ready but in an `AVAILABILITY` state of `Drain`:

```
ID          HOSTNAME           STATUS    AVAILABILITY
  MANAGER STATUS
j2qx.. *    docker-desktop     Ready     Drain
  Leader
```

13. Stop the service from running. Use the `service rm` command, followed by the service name (in this instance, `web`) to stop the service from running:

```
docker service rm web
```

    The only output shown will be the name of the service you are removing:

```
web
```

14. You don't want to leave your node in a `Drain` state as you want to keep using it through the rest of the exercises. To get the node out of a `Drain` state and prepare to start managing swarm, set the availability to `active` with the following command using your node ID:

    ```
    docker node update --availability active j2qxrpf0a1yhvcax6n2ajux69
    ```

    The command will return the hash value of the node, which will be different for every user.

15. Run the `node ls` command:

    ```
    docker node ls
    ```

    It will now show the availability of our node as `Active` and ready your services to run again:

    ```
    ID          HOSTNAME           STATUS    AVAILABILITY
      MANAGER STATUS
    j2qx.. *    docker-desktop     Ready     Active
      Leader
    ```

16. Use the `docker node inspect` command with the `--format` option and search for the `ManagerStatus.Reachability` status to ensure that your node is reachable:

    ```
    docker node inspect j2qxrpf0a1yhvcax6n2ajux69 --format "{{
    .ManagerStatus.Reachability }}"
    ```

    If the node is available and can be contacted, you should see a result of `reachable`:

    ```
    reachable
    ```

17. Search for `Status.State` to ensure that the node is ready:

    ```
    docker node inspect j2qxrpf0a1yhvcax6n2ajux69 --format "{{ .Status.State }}"
    ```

    This should produce `ready`:

    ```
    ready
    ```

This exercise should have given you a good indication of how Docker Swarm is able to simplify your work, especially when you start to think about deploying your work into a production environment. We used the Docker Hub NGINX image, but we could easily use any service we have created as a Docker image that is available to our Swarm node.

Deploying Swarm Deployments from Docker Compose

In the following example, you will create a small test application using Django and PostgreSQL. The web application you will be setting up is very basic, so there is no real need to have a prior understanding of the Django web framework. Simply follow along and we will explain what is happening as we move through the exercise.

Exercise 8.02: Deploying Your Swarm from Docker Compose

In the following exercise, you will use `docker-compose.yml` to create a basic web application using a PostgreSQL database and the Django web framework. You will then use this `compose` file to deploy your services into your swarm without the need to run your services manually:

1. First, create a directory to run your application in. Call the directory `swarm` and move into the directory using the `cd` command:

```
mkdir swarm; cd swarm
```

2. Create a `Dockerfile` for your Django application in the new directory and, using your text editor, enter the details in the following code block. The `Dockerfile` will use the default `Python3` image, set environment variables relevant for Django, install relevant applications, and copy the code into the current directory of the container image:

```
FROM python:3
ENV PYTHONUNBUFFERED 1
RUN mkdir /application
WORKDIR /application
COPY requirements.txt /application/
RUN pip install -r requirements.txt
COPY . /application/
```

3. Create the `requirements.txt` file that your `Dockerfile` uses in the previous step to install all the relevant applications needed for it to run. Add in the following two lines with your text editor to install the version of `Django` and `Psycopg2` required by the Django application to communicate with the PostgreSQL database:

```
1 Django>=2.0,<3.0
2 psycopg2>=2.7,<3.0
```

4. Create a `docker-compose.yml` file using your text editor. Add in the first service for your database, as shown in the following code. The `db` service will use the latest `postgres` image from Docker Hub, exposing port `5432`, and also set the environment variable for `POSTGRES_PASSWORD`:

```
1 version: '3.3'
2
3 services:
4   db:
5     image: postgres
6     ports:
7       - 5432:5432
8     environment:
9       - POSTGRES_PASSWORD=docker
```

5. The second half of the `docker-compose.yml` file builds and deploys your web application. Build your `Dockerfile` in *line 10*, expose port `8000` to access it from your web browser, and set the database password to match your `db` service. You will also notice a Python command in *line 13* that will start the development web server for the Django application:

```
10   web:
11     build: .
12     image: swarm_web:latest
```

```
13      command: python manage.py runserver 0.0.0.0:8000
14      volumes:
15        - .:/application
16      ports:
17        - 8000:8000
18      environment:
19        - PGPASSWORD=docker
20      depends_on:
21        - db
```

6. Run the following command to pull and build the `db` and `web` services in your `docker-compose.yml`. The command will then run `django-admin startproject`, which will create your basic Django project, named `lab_eight`:

```
docker-compose run web django-admin startproject lab_eight .
```

The command should return the following output, in which you see the containers being pulled and built:

```
…
Status: Downloaded newer image for postgres:latest
Creating swarm_db_1 ... done
Building web
…
Successfully built 41ff06e17fe2
Successfully tagged swarm_web:latest
```

7. The `startproject` command you ran in the previous step should have created some extra files and directories in your swarm directory. Run the `ls` command to list all the files and directories in the swarm directory:

```
ls -l
```

You previously created the `Dockerfile`, `docker-compose.yml` file, and `requirements.txt` file, but now the build of the container has added the `lab_eight` Django directory and the `manage.py` file:

```
-rw-r--r--  1 user  staff  175  3 Mar 13:45 Dockerfile
drwxr-xr-x  6 user  staff  192  3 Mar 13:48 lab_eight
-rw-r--r--  1 user  staff  304  3 Mar 13:46 docker-compose.yml
-rwxr-xr-x  1 user  staff  634  3 Mar 13:48 manage.py
-rw-r--r--  1 user  staff   36  3 Mar 13:46 requirements.txt
```

8. To get your basic application running, you need to make some minor changes to the Django project settings. Open the `lab_eight/settings.py` file with your text editor and locate the entry that starts with `DATABASES`. This controls how Django will connect to your database, and by default, Django is set up to work with an SQLite database. The `DATABASES` entry should look like the following:

```
76 DATABASES = {
77     'default': {
78         'ENGINE': 'django.db.backends.sqlite3',
79         'NAME': os.path.join(BASE_DIR, 'db.sqlite3'),
80     }
81 }
```

You have a PostgreSQL database to deploy to Swarm as a part of our installation, so edit the `DATABASES` settings with the following eight lines so that Django will access this PostgreSQL database instead:

settings.py

```
76 DATABASES = {
77     'default': {
78         'ENGINE': 'django.db.backends.postgresql',
79         'NAME': 'postgres',
80         'USER': 'postgres',
81         'PASSWORD': 'docker',
82         'HOST': 'db',
83         'PORT': 5432,
84     }
85 }
```

9. At *line 28* of our `settings.py` file, we also need to add the IP address we are going to use as the `ALLOWED_HOSTS` configuration. We will configure our application to be accessible from the IP address `0.0.0.0`. Make the relevant changes to the settings file at *line 28* so that it now looks like the code below:

```
 27
 28 ALLOWED_HOSTS = ["0.0.0.0"]
```

10. Now test to see whether your basic project is working as expected. From the command line, deploy your services to Swarm with the `stack deploy` command. In the following command, specify the `docker-compose.yml` file to use with the `--compose-file` option and name the stack `test_swarm`:

```
docker stack deploy --compose-file docker-compose.yml test_swarm
```

The command should set up the swarm network, the database, and the web services:

```
Creating network test_swarm_default
Creating service test_swarm_db
Creating service test_swarm_web
```

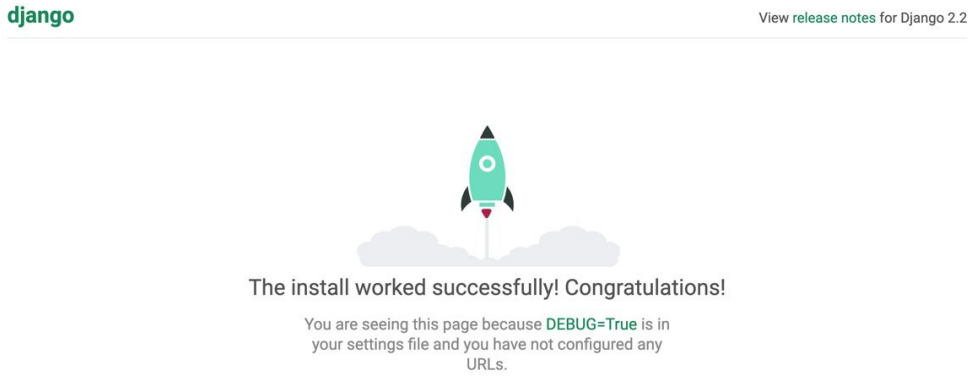
11. Run the `docker service ls` command, and you should be able to see the status for both the `test_swarm_db` and `test_swarm_web` services:

```
docker service ls
```

As you can see in the following output, they are both showing a `REPLICAS` value of `1/1`:

```
ID     NAME            MODE        REPLICAS  IMAGE
  PORTS
dsr.   test_swarm_db   replicated  1/1       postgres
kq3.   test_swarm_web  replicated  1/1       swarm_web:latest
  *:8000.
```

12. If your work has been successful, test it by opening a web browser and going to `http://0.0.0.0:8000`. If everything has worked, you should see the following Django test page displayed on your web browser:



13. To view the stacks currently running on your system, use the `stack ls` command:

```
docker stack ls
```

    You should see the following output, which shows two services running under the name of `test_swarm`:

```
NAME                SERVICES            ORCHESTRATOR
test_swarm          2                   Swarm
```

14. Use the `stack ps` command with the name of your swarm to view the services running and check whether there are any issues:

```
docker stack ps test_swarm
```

    The `ID`, `DESIRED STATE`, and `ERROR` columns are not included in the following reduced output. Also, it can be seen that the `test_swarm_web.1` and `test_swarm_db.1` services are running:

```
NAME                IMAGE               NODE
  CURRENT STATE
test_swarm_web.1    swarm_web:latest    docker-desktop
  Running
test_swarm_db.1     postgres:latest     docker-desktop
  Running
```

15. Just as you were able to start up all your services at once with the `deploy` command, you can stop the services all at once, as well. Use the `stack rm` command with the name of your swarm to stop all of your services from running and remove the stack:

```
docker stack rm test_swarm
```

    Note that all the services are stopped in the following output:

```
Removing service test_swarm_db
Removing service test_swarm_web
Removing network test_swarm_default
```

16. You still want to perform some extra work on your swarm as part of this exercise, but first, make a minor change to the `compose` file. Open the `docker-compose.yml` file with your text editor and add the

following lines to your web service to now have two replica web services created when deployed to the swarm:

```
22     deploy:
23       replicas: 2
```

The complete `docker-compose.yml` file should look like the following:

```
version: '3.3'
services:
  db:
    image: postgres
    ports:
      - 5432:5432
    environment:
      - POSTGRES_PASSWORD=docker
  web:
    build: .
    image: swarm_web:latest
    command: python manage.py runserver 0.0.0.0:8000
    volumes:
      - .:/application
    ports:
      - 8000:8000
    environment:
      - PGPASSWORD=docker
    deploy:
      replicas: 2
    depends_on:
      - db
```

17. Deploy the swarm again with the changes you have made using the same command, as you did earlier in *step 8*. Even if the `test_swarm` stack was still running, it would note and make the relevant changes to the services:

```
docker stack deploy --compose-file docker-compose.yml test_swarm
```

18. Run the `docker ps` command as follows:

```
docker ps | awk '{print $1 "\t" $2 }'
```

Only the first two columns are printed in the output shown here. You can now see that there are two `swarm_web` services running:

```
CONTAINER         ID
2f6eb92414e6      swarm_web:latest
e9241c352e12      swarm_web:latest
d5e6ece8a9bf      postgres:latest
```

19. To deploy a new version of the `swarm_web` service to your swarm without stopping the services, first, build a new Docker image of our web service. Don't make any changes to the image, but this time tag the image with the `patch1` tag to demonstrate a change while the service is running:

```
docker build . -t swarm_web:patch1
```

20. To perform a rolling update, use the `service update` command, providing details of the image you wish to update to and the service name. Run the following command, which uses the image you have just created with the `patch1` tag, on the `test_swarm_web` service:

    ```
    docker service update --image swarm_web:patch1 test_swarm_web
    ```

    Swarm will manage the update to make sure one of the services is always running before the update is applied to the rest of the images:

    ```
    image swarm_web:patch1 could not be accessed on a registry
    to record its digest. Each node will access
    swarm_web:patch1 independently, possibly leading to different
    nodes running different versions of the image.
    test_swarm_web
    overall progress: 2 out of 2 tasks
    1/2: running   [==========================================>]
    2/2: running   [==========================================>]
    verify: Service converged
    ```

    Note

    You'll notice the output shows the image was not available on a repository. As we only have one node running our swarm, the update will use the image built on the node. In a real-world scenario, we would need to push this image to a central repository that all our nodes have access to so they can pull it.

21. Run the `docker ps` command given here, which pipes its output to an `awk` command to only print the first two columns of `CONTAINER` and `ID`:

    ```
    docker ps | awk '{print $1 "\t" $2 }'
    ```

    The command will return the output such as the following:

    ```
    CONTAINER         ID
    ef4107b35e09      swarm_web:patch1
    d3b03d8219dd      swarm_web:patch1
    d5e6ece8a9bf      postgres:latest
    ```

22. What if you wanted to control the way the rolling updates occur? Run the following command to perform a new rolling update to your `test_swarm_web` services. Revert the changes you made to deploy the image with the `latest` tag, but this time, make sure there is a `30`-second delay in performing the update as this will give your web service extra time to start up before the second update is run:

    ```
    docker service update --update-delay 30s --image swarm_web:latest
    test_swarm_web
    ```

23. Run the `docker ps` command again:

    ```
    docker ps | awk '{print $1 "\t" $2 }'
    ```

    Note that the containers are now running the `swarm_web:latest` image again after you have performed the rolling update:

```
CONTAINER         ID
414e62f6eb92      swarm_web:latest
352e12e9241c      swarm_web:latest
d5e6ece8a9bf      postgres:latest
```

By now, you should see the benefit of using a swarm, especially when we start to scale out our applications using Docker Compose. In this exercise, we have demonstrated how to easily deploy and manage a group of services onto your swarm using Docker Compose and upgrade services with rolling updates.

The next section of this lab will expand your knowledge further to show how you can use Swarm to manage your configurations and secret values used within your environment.

Managing Secrets and Configurations with Docker Swarm

The following exercise will demonstrate how to use both configurations and secrets in your current Docker Swarm environment.

Exercise 8.03: Implementing Configurations and Secrets in Your Swarm

In this exercise, you will expand your Docker Swarm environment further. You will add a service to your environment that will help NGINX to route the requests through the proxy, before moving into your web service. You will set this up using traditional methods but then use the `config` and `secret` functions as part of your environment to observe their operations within Swarm and help users deploy and configure services more efficiently:

1. Currently, the web service is using the Django development web server via the `runserver` command to provide web requests. NGINX will not be able to route traffic requests through to this development server, and instead, you will need to install the `gunicorn` application onto our Django web service for traffic to be routed via NGINX. Start by opening your `requirements.txt` file with your text editor and add the application as in the highlighted third line:

   ```
   Django>=2.0,<3.0
   psycopg2>=2.7,<3.0
   gunicorn==19.9.0
   ```

   Note

   Gunicorn is short for **Green Unicorn** and is used as a **Web Service Gateway Interface** (**WSGI**) for Python applications. Gunicorn is widely used for production environments as it is seen to be one of the most stable WSGI applications available.

2. To run Gunicorn as part of your web application, adjust your `docker-compose.yml` file. Open the `docker-compose.yml` file with your text editor and change *line 13* to run the `gunicorn` application, instead of the Django `manage.py runserver` command. The following `gunicorn` command runs the `lab_eight` Django project via its WSGI service and binds to IP address and port `0.0.0.0:8000` :

   ```
   12     image: swarm_web:latest
   13     command: gunicorn lab_eight.wsgi:application          --bind
   0.0.0.0:8000
   14     volumes:
   ```

3. Rebuild your web service to make sure the Gunicorn application is installed on the container and available to run. Run the `docker-compose build` command:

```
docker-compose build
```

4. Gunicorn can also run without the need of the NGINX proxy, so test the changes you have made by running the `stack deploy` command again. If you already have your services deployed, don't worry, you can still run this command again. It will simply make the relevant changes to your swarm and match the changes in your `docker-compose.yml`:

```
docker stack deploy --compose-file docker-compose.yml test_swarm
```

   The command will return the following output:

```
Ignoring unsupported options: build
Creating network test_swarm_default
Creating service test_swarm_web
Creating service test_swarm_db
```

5. To ensure the changes have taken effect, make sure you open your web browser and verify that the Django test page is still being provided by your web service before moving on to the next step. As per your changes, the page should still be displayed at `http://0.0.0.0:8000`.

6. To start your implementation of NGINX, open the `docker-compose.yml` file again and change *lines 16 and 17* to expose port `8000` from the original `ports` command:

```
10   web:
11     build: .
12     image: swarm_web:latest
13     command: gunicorn lab_eight.wsgi:application          --bind
0.0.0.0:8000
14     volumes:
15       - .:/application
16     ports:
17       - 8000:8000
18     environment:
19       - PGPASSWORD=docker
20     deploy:
21       replicas: 2
22     depends_on:
23       - db
```

7. Keeping the `docker-compose.yml` file open, add your `nginx` service at the end of the `compose` file. All of the information here should be familiar to you by now. *Line 25* provides the location of a new NGINX directory, the `Dockerfile` you will create shortly, and the name of the image to be used when the service is deployed. *Lines 27* and *28* expose port `1337` to port `80` and *lines 29* and *30* show that NGINX needs to depend on the `web` service to run:

```
24   nginx:
25     build: ./nginx
26     image: swarm_nginx:latest
27     ports:
```

```
28       - 1337:80
29     depends_on:
30       - web
```

8. Now, set up the NGINX `Dockerfile` and configurations for the service. Start by creating a directory called `nginx`, as in the following command:

```
mkdir nginx
```

9. Create a new `Dockerfile` in the `nginx` directory, open the file with your text editor, and add in the details shown here. The `Dockerfile` is created from the latest `nginx` image available on Docker Hub. It removes the default configuration `nginx` file in *line 3* and then adds a new configuration that you need to set up shortly:

```
FROM nginx
RUN rm /etc/nginx/conf.d/default.conf
COPY nginx.conf /etc/nginx/conf.d
```

10. Create the `nginx.conf` file that the `Dockerfile` will use to create your new image. Create a new file called `nginx.conf` in the `nginx` directory and use your text editor to add the following configuration details:

```
upstream lab_eight {
    server web:8000;
}
server {
    listen 80;
    location / {
        proxy_pass http://lab_eight;
        proxy_set_header X-Forwarded-For
$proxy_add_x_forwarded_for;
        proxy_set_header Host $host;
        proxy_redirect off;
    }
}
```

    If you're unfamiliar with NGINX configurations, the preceding details are simply looking for requests to the web service and will route requests through to the `lab_eight` Django application.

11. With all the details now in place, build your new image for the NGINX service now set up in your `docker-compose.yml` file. Run the following command to build the image:

```
docker-compose build
```

12. Run the `stack deploy` command again:

```
docker stack deploy --compose-file docker-compose.yml test_swarm
```

    This time, you will notice that your output shows that the `test_swarm_nginx` service has been created and should be running:

```
Creating network test_swarm_default
Creating service test_swarm_db
Creating service test_swarm_web
Creating service test_swarm_nginx
```

13. Verify that all the services are running as part of your swarm with the `stack ps` command:

    ```
    docker stack ps test_swarm
    ```

    The resulting output has been reduced to show only four of the eight columns. You can see that the `test_swarm_nginx` service is now running:

    ```
    NAME                  IMAGE                NODE
      DESIRED STATE
    test_swarm_nginx.1    swarm_nginx:latest   docker-desktop
      Running
    test_swarm_web.1      swarm_web:latest     docker-desktop
      Running
    test_swarm_db.1       postgres:latest      docker-desktop
      Running
    test_swarm_web.2      swarm_web:latest     docker-desktop
      Running
    ```

14. To prove that requests are routing through the NGINX proxy, use port `1337` instead of port `8000`. Make sure that a web page is still being provided from your web browser by using the new URL of `http://0.0.0.0:1337`.

15. This has been a great addition to the services running on Swarm but is not using the correct configuration management features. You already have an NGINX configuration created previously in this exercise. Create a Swarm configuration by using the `config create` command with the name of the new configuration and the file you are going to create the configuration from. Run the following command to create the new configuration from your `nginx/nginx.conf` file:

    ```
    docker config create nginx_config nginx/nginx.conf
    ```

    The output from the command will provide you with the created configuration ID:

    ```
    u125x6f6lhv1x6u0aemlt5w2i
    ```

16. Swarm also gives you a way to list all the configurations created as part of your Swarm, using the `config ls` command. Make sure the new `nginx_config` file has been created in the previous step and run the following command:

    ```
    docker config ls
    ```

    `nginx_config` has been created in the following output:

    ```
    ID            NAME           CREATED           UPDATED
    u125x6f6…     nginx_config   19 seconds ago    19 seconds ago
    ```

17. View the full details of the configuration you have created using the `docker config inspect` command. Run the following command with the `--pretty` option to make sure the configuration output

is in a readable form:

```
docker config inspect --pretty nginx_config
```

The output should look similar to what you see here, showing details of the NGINX configuration you have just created:

```
ID:             u125x6f6lhv1x6u0aemlt5w2i
Name:           nginx_config
Created at:          2020-03-04 19:55:52.168746807 +0000 utc
Updated at:          2020-03-04 19:55:52.168746807 +0000 utc
Data:
upstream lab_eight {
    server web:8000;
}
server {
    listen 80;
    location / {
        proxy_pass http://lab_eight;
        proxy_set_header X-Forwarded-For
$proxy_add_x_forwarded_for;
        proxy_set_header Host $host;
        proxy_redirect off;
    }
}
```

18. As you have now set up the configuration in Swarm, make sure the configuration is no longer built into the container image. Instead, it will be provided when the Swarm is deployed. Open the `Dockerfile` in the `nginx` directory and remove the fourth line of the `Dockerfile`. It should now look similar to the details given here:

    ```
    FROM nginx:1.17.4-alpine
    RUN rm /etc/nginx/conf.d/default.conf
    ```

    Note

    Remember that the change we are making here will make sure that we don't need to build a new NGINX image every time the configuration changes. This means we can use the same image and deploy it to a development swarm or a production swarm. All we would do is change the configuration to make the environment. We do need to create the image that can use the config we have created and stored in Swarm, though.

19. The previous step in this exercise made a change to the `nginx` `Dockerfile`, so now rebuild the image to make sure it is up to date:

    ```
    docker-compose build
    ```

20. Open the `docker-compose.yml` file with your text editor to update the `compose` file so that our `nginx` service will now use the newly created Swarm `config`. At the bottom of the `nginx` service, add in the configuration details with the source name of the `nginx_cof` configuration you created earlier. Be sure to add it to the running `nginx` service so it can be used by the container. Then, set up a separate configuration for the file. Even though you have created it manually in the previous steps, your swarm needs to know about it when it is deployed. Add the following into your `docker-compose.yml`:

```
25   nginx:
26     build: ./nginx
27     image: swarm_nginx:latest
28     ports:
29       - 1337:80
30     depends_on:
31       - web
32     configs:
33       - source: nginx_conf
34         target: /etc/nginx/conf.d/nginx.conf
35
36 configs:
37   nginx_conf:
38     file: nginx/nginx.conf
```

21. Deploy your swarm again:

    ```
    docker stack deploy --compose-file docker-compose.yml test_swarm
    ```

    In the following output, you should now see an extra line showing `Creating config test_swarm_nginx_conf`:

    ```
    Creating network test_swarm_default
    Creating config test_swarm_nginx_conf
    Creating service test_swarm_db
    Creating service test_swarm_web
    Creating service test_swarm_nginx
    ```

22. There is still more you can do to take advantage of Swarm, and one extra feature not used yet is the secrets function. Just as you created a configuration earlier in this exercise, you can create a `secret` with a similar command. The command shown here first uses `echo` to output the password you want as your secret value, and then, using the `secret create` command, it uses this output to create the secret named `pg_password`. Run the following command to name your new secret `pg_password`:

    ```
    echo "docker" | docker secret create pg_password -
    ```

    The command will output the ID of the secret created:

    ```
    4i1cwxst1j9qoh2e6uq5fjb8c
    ```

23. View the secrets in your swarm using the `secret ls` command. Run this command now:

    ```
    docker secret ls
    ```

    You can see that your secret has been created successfully with the name of `pg_password`:

    ```
    ID                          NAME           CREATED
      UPDATED
    4i1cwxst1j9qoh2e6uq5fjb8c   pg_password    51 seconds ago
      51 seconds ago
    ```

24. Now, make the relevant changes to your `docker-compose.yml` file. Previously, you simply entered the password you wanted for your `postgres` user. As you can see in the following code, here, you will point the environment variable to the secret you created earlier as `/run/secrets/pg_password`. This means it will search through the available secrets in your swarm and assign the secret stored in `pg_password`. You also need to refer to the secret in the `db` service to allow it access. Open the file with your text editor and make the following changes to the file:

```
4   db:
5     image: postgres
6     ports:
7       - 5432:5432
8     environment:
9       - POSTGRES_PASSWORD=/run/secrets/pg_password
10    secrets:
11      - pg_password
```

25. The `web` service uses the same secret to access the PostgreSQL database. Move into the `web` service section of the `docker-compose.yml` and change *line 21* to resemble the following, as it will now use the secret you have created:

```
20    environment:
21       - PGPASSWORD=/run/secrets/pg_password
22    deploy:
```

26. Finally, just as you have done with your configuration, define the secret at the end of `docker-compose.yml`. Add in the following lines at the end of your `compose` file:

```
41 secrets:
42  pg_password:
43    external: true
```

27. Before deploying your changes, you have made a lot of changes to the `compose` file, so your `docker-compose.yml` file should look similar to what is shown in the following code block. You have three services running with the `db`, `web`, and `nginx` services set up, and we now have one `config` instance and one `secret` instance:

    docker-compose.yml

```
version: '3.3'
services:
  db:
    image: postgres
    ports:
      - 5432:5432
    environment:
      - POSTGRES_PASSWORD=/run/secrets/pg_password
    secrets:
      - pg_password
  web:
    build: .
    image: swarm_web:latest
    command: gunicorn lab_eight.wsgi:application --bind  0.0.0.0:8000
```

```
    volumes:
      - .:/application
    ports:
      - 8000:8000
```

Note

There are a few changes to our service, and if there are any issues in deploying the changes to Swarm, it may be worth deleting the services and then re-deploying to make sure all the changes take effect correctly.

This is the final run of your Swarm deployment for this exercise:

```
docker stack deploy --compose-file docker-compose.yml test_swarm
```

28. Run the deployment and make sure the services are running and deployed successfully:

```
Creating network test_swarm_default
Creating config test_swarm_nginx_conf
Creating service test_swarm_db
Creating service test_swarm_web
Creating service test_swarm_nginx
```

In this exercise, you have practiced using Swarm to deploy a complete set of services using your `docker-compose.yml` file and have them running in a matter of minutes. This part of the lab has also demonstrated some extra functionality of Swarm using `config` and `secret` instances to help us reduce the amount of work needed to move services to different environments. Now that you know how to manage Swarm from the command line, you can further explore Swarm cluster management in the following section using a web interface with Swarmpit.

Managing Swarm with Swarmpit

The command line provides an efficient and useful way for users to control their Swarm. This can get a little confusing for some users if your services and nodes multiply as need increases. One way to help with managing and monitoring your Swarm is by using a web interface such as the one provided by Swarmpit to help you administer your different environments.

As you'll see shortly, Swarmpit provides an easy-to-use web interface that allows you to manage most aspects of your Docker Swarm instances, including the stacks, secrets, services, volumes networks, and configurations.

Swarmpit is a simple-to-use installation Docker image that, when run on your system, creates its swarm of services deployed in your environment to run the management and web interface. Once installed, the web interface is accessible from `http://0.0.0.0:888`.

To run the installer on your system to get Swarm running, execute the following `docker run` command. With this, you name the container `swampit-installer` and mount the container volume on `/var/run/docker.sock` so it can manage other containers on our system, using the `swarmpit/install:1.8` image:

```
docker run -it --rm   --name swarmpit-installer   --volume
/var/run/docker.sock:/var/run/docker.sock   swarmpit/install:1.8
```

The installer will set up a swarm with a database, an agent, a web application, and the network to link it all together. It will also guide you through setting up an administrative user to log on to the interface for the first time. Once you log in to the web application, the interface is intuitive and easy to navigate.

The following exercise will show you how to install and run Swarmpit on your running system and start to manage your installed services.

Exercise 8.04: Installing Swarmpit and Managing Your Stacks

In this exercise, you will install and run Swarmpit, briefly explore the web interface, and begin managing your services from your web browser:

1. It's not completely necessary to do so, but if you have stopped your `test_swarm` stack from running, start it up again. This will provide you with some extra services to monitor from Swarmpit:

   ```
   docker stack deploy --compose-file docker-compose.yml test_swarm
   ```

   Note

   If you are worried that there will be too many services running on your system at once, feel free to skip this `test_swarm` stack restart. The exercise can be performed as follows on the Swarmpit stack that is created as part of the installation process.

2. Run the following `docker run` command:

   ```
   docker run -it --rm   --name swarmpit-installer   --volume
   /var/run/docker.sock:/var/run/docker.sock   swarmpit/install:1.8
   ```

   It pulls the `install:1.8` image from the `swarmpit` repository and then runs through the process of setting up your environment details, allowing the user to make changes to the stack name, ports, administrator username, and password. It then creates the relevant services needed to run the applications:

   ```
   _____       ____ _ _ __ _ __ ___  _ __ (_) |_
   / __\ \ /\ / / _` | '__| '_ ` _ \| '_ \| | __|
   \__ \\ V  V / (_| | |  | | | | | | |_) | | |_
   |___/ \_/\_/ \__,_|_|  |_| |_| |_| .__/|_|\__|
                                     |_|
   Welcome to Swarmpit
   Version: 1.8
   Branch: 1.8
   …
   Application setup
   Enter stack name [swarmpit]:
   Enter application port [888]:
   Enter database volume driver [local]:
   Enter admin username [admin]:
   Enter admin password (min 8 characters long): ******
   DONE.
   Application deployment
   Creating network swarmpit_net
   Creating service swarmpit_influxdb
   Creating service swarmpit_agent
   Creating service swarmpit_app
   Creating service swarmpit_db
   DONE.
   ```

3. On the command line, run the `stack ls` command to ensure that you have the Swarmpit swarm deployed to your node:

   ```
   docker stack ls
   ```

   The following output confirms that Swarmpit is deployed to our node:

   ```
   NAME                SERVICES          ORCHESTRATOR
   swarmpit            4                 Swarm
   test_swarm          3                 Swarm
   ```

4. Use the `service ls` command to verify that the services needed by Swarmpit are running:

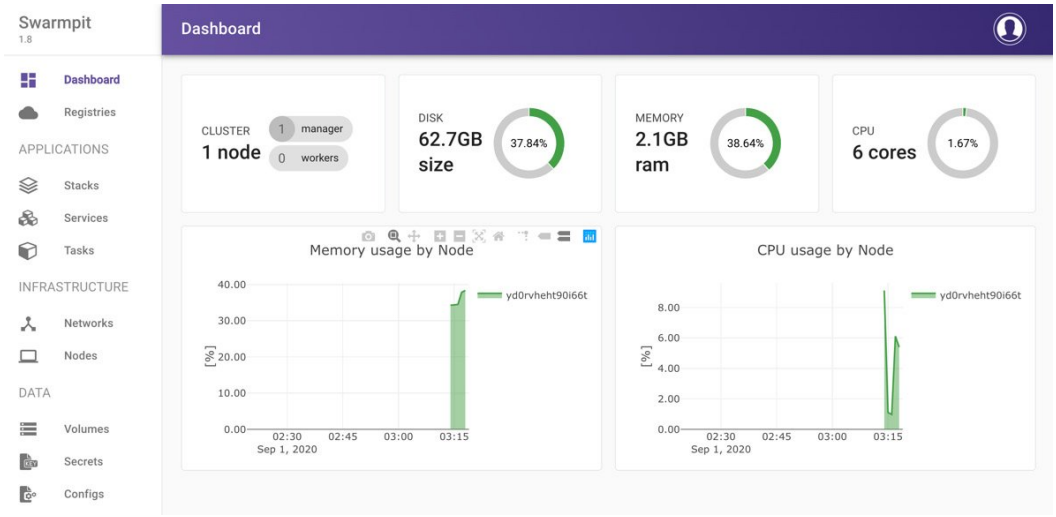
   ```
   docker service ls | grep swarmpit
   ```

   For clarity, the output shown here only displays the first four columns. The output also shows that the `REPLICAS` value for each service is `1/1`:

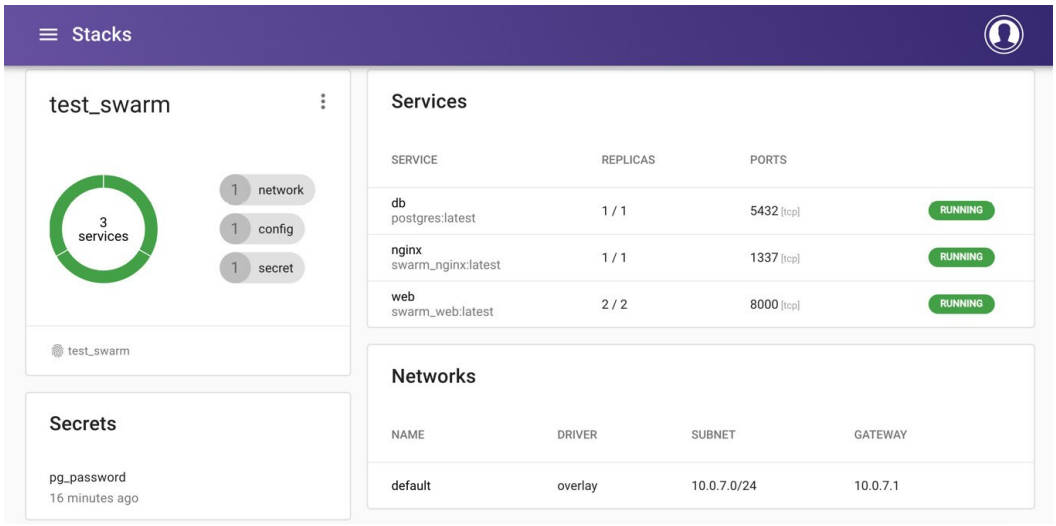
   ```
   ID              NAME                  MODE          REPLICAS
   vi2qbwq5y9c6    swarmpit_agent        global        1/1
   4tpomyfw93wy    swarmpit_app          replicated    1/1
   nuxi5egfa3my    swarmpit_db           replicated    1/1
   do77ey8wz49a    swarmpit_influxdb     replicated    1/1
   ```

   It's time to log in to the Swarmpit web interface. Open your web browser and use `http://0.0.0.0:888` to open the Swarmpit login page and enter the admin username and password you set during the installation process:

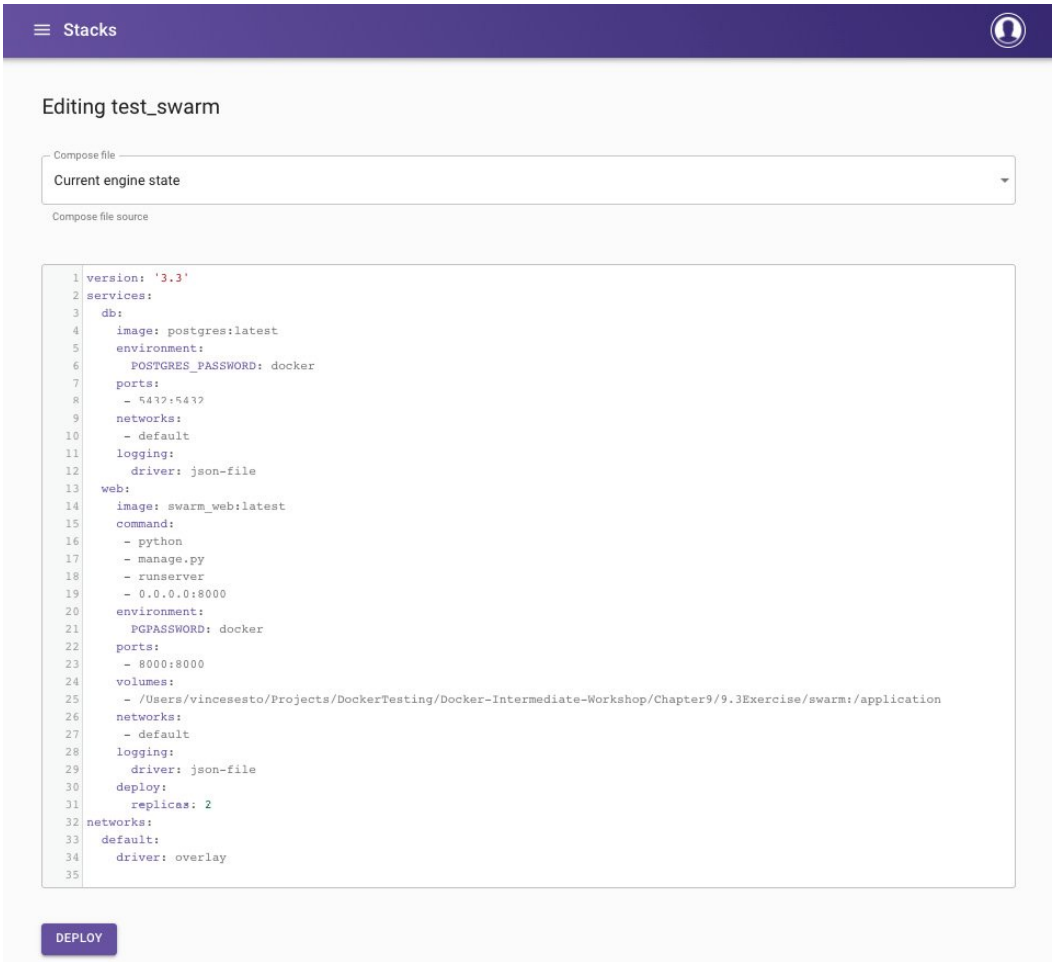
5. Once you log in, you're presented with the Swarmpit welcome screen, showing your dashboard of all your services running on the node, as well as details of the resources being used on the node. The left of the screen provides a menu of all the different aspects of the Swarm stack you can monitor and manage, including the stacks themselves, `Services`, `Tasks`, `Networks`, `Nodes`, `Volumes`, `Secrets`, `Configs`, and `Users`. Click on the `Stacks` option in the left-hand menu and select the `test_swarm` stack:



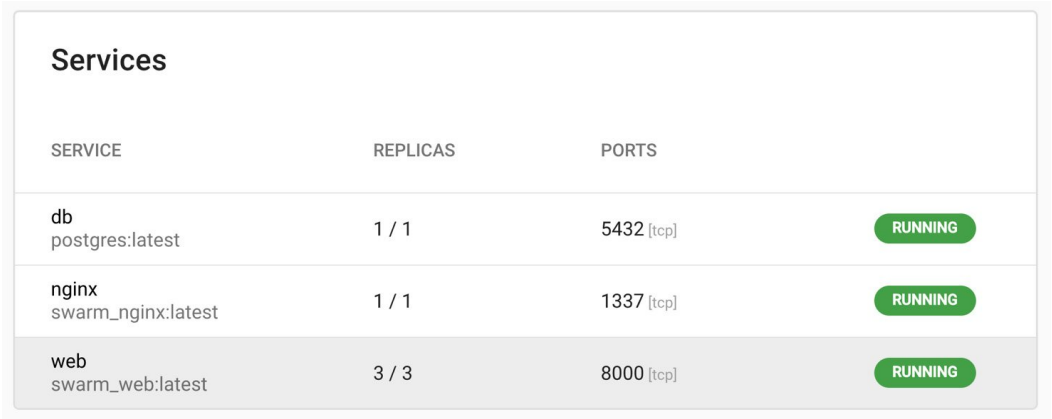
6. You should be presented with a screen similar to the following. The size of the screen has been reduced for clarity, but as you can see, it provides all the details of the interacting components of the stack---including the services available and the secrets and configs being used. If you click on the menu next to the stack name, as shown here, you can edit the stack. Click `Edit Stack` now:



7. Editing the stack brings up a page where you can make changes directly to the stack as if you were making changes to `docker-compose.yml`. Move down to the file, find the replicas entry for the web service, and change it to `3` from `2`:

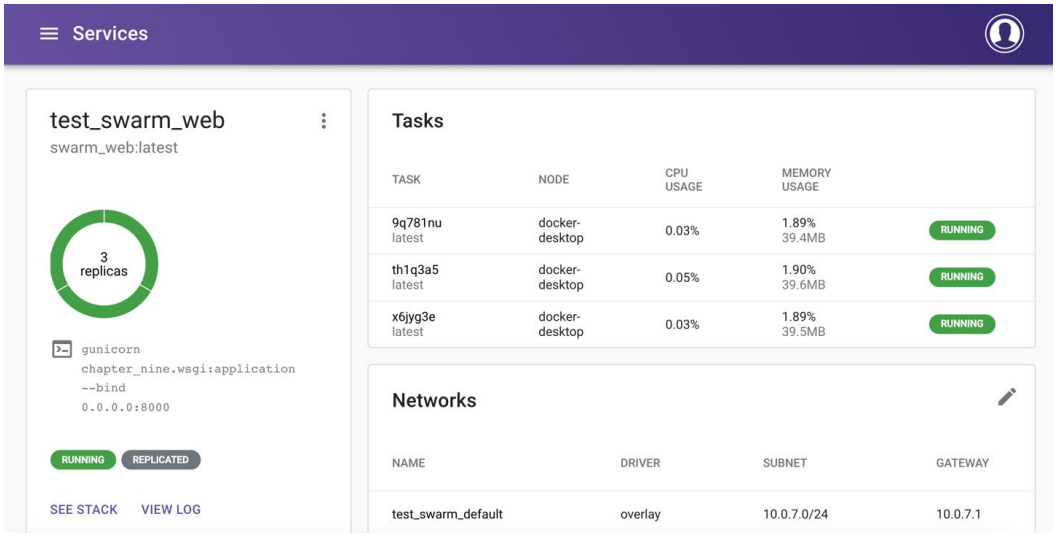


8. Click on the `Deploy` button at the bottom of the screen. This will deploy the changes to your `test_swarm` stack into the environment and return you to the `test_swarm` stack screen, where you should now see `3/3` replicas of the web service running:

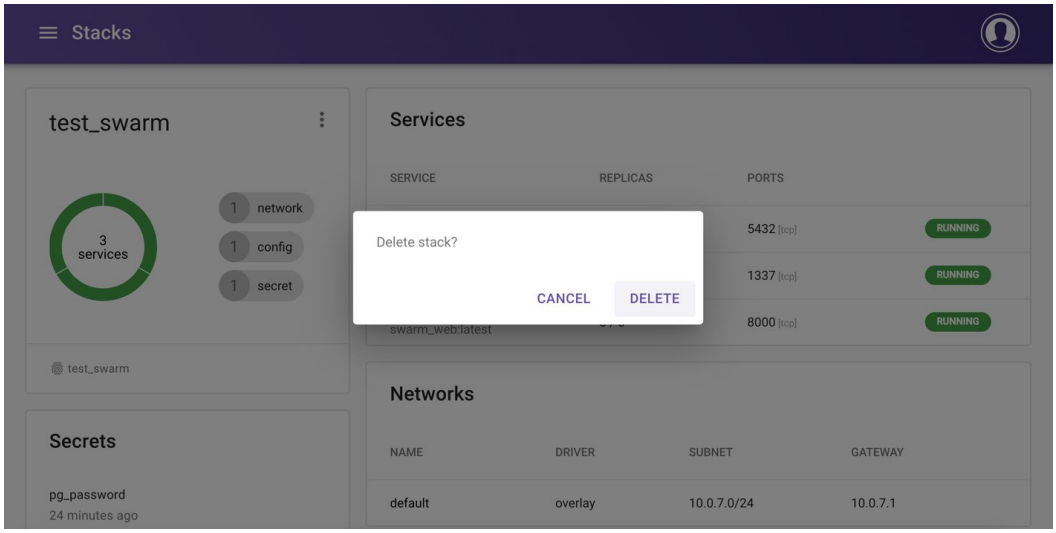


9. Notice that most of the options in Swarmpit are linked. On the `test_swarm` stack page, if you click on the web service from the `services` panel, you will open the `Service` page for the `test_swarm_web`

service. If you click the menu, you should see the following page:



10. Select `Rollback Service` from the menu, and you will see the number of replicas of the `test_swarm_web` service roll back to two replicas.
11. Finally, return to the `Stacks` menu and select the `test_swarm` again. With the `test_swarm` stack open, you have the option to delete the stack by clicking on the trash can icon toward the top of the screen. Confirm that you would like to delete the stack, and this will bring `test_swarm` down again and it will no longer be running on your node:



Note

Note that Swarmpit will allow you to delete the `swarmpit` stack. You will see an error, but when you try to reload the page, it will simply not come up again as all the services will have been stopped from running.

Although this has been only a quick introduction to Swarmpit, using your prior knowledge from this lab, the interface will allow you to intuitively deploy and make changes to your services and stacks. Almost anything that you can do

from the command line, you can also do from the Swarmpit web interface. This brings us to the end of this exercise and the end of the lab. The activities in the next section of this lab are designed to help expand your knowledge further.

Activity 8.01: Deploying the Panoramic Trekking App to a Single-Node Docker Swarm

You are required to use Docker Swarm to deploy web and database services in the Panoramic Trekking App. You will gather configurations to create a compose file for the application and deploy them to a single node Swarm using a `docker-compose.yml` file.

The steps you will need to take to complete this activity are as follows:

1. Gather all the applications and build the Docker images needed for the services of your swarm.
2. Create a `docker-compose.yml` file that will allow the services to be deployed to Docker Swarm.
3. Create any supporting images needed for the services to use once deployed.
4. Deploy your services onto Swarm and verify that all services are able to run successfully.

Your running services should look similar to the output shown here:

```
ID        NAME                MODE         REPLICAS
  IMAGE
k6kh…     activity_swarm_db   replicated   1/1
  postgres:latest
copa…     activity_swarm_web  replicated   1/1
  activity_web:latest
```

Summary

This lab has done a lot of work in moving our Docker environments from manually starting single-image services to a more production-ready and complete environment with Docker Swarm. We started this lab with an in-depth discussion of Docker Swarm and how you can manage your services and nodes from the command line, providing a list of commands and their use, and later implementing them as part of a new environment running a test Django web application.

We then expanded this application further with an NGINX proxy and utilized Swarm functionality to store configuration and secrets data so they no longer need to be included as part of our Docker image and can instead be included in the Swarm we are deploying. We then showed you how to manage your swarm using your web browser with Swarmpit, providing a rundown of the work we previously did on the command line and making a lot of these changes from a web browser. Swarm is not the only way you can orchestrate your environments when using Docker.

In the next lab, we will introduce Kubernetes, which is another orchestration tool used to manage Docker environments and applications. Here, you will see how you can use Kubernetes as part of your projects to help reduce the time you are managing services and improve the updating of your applications.