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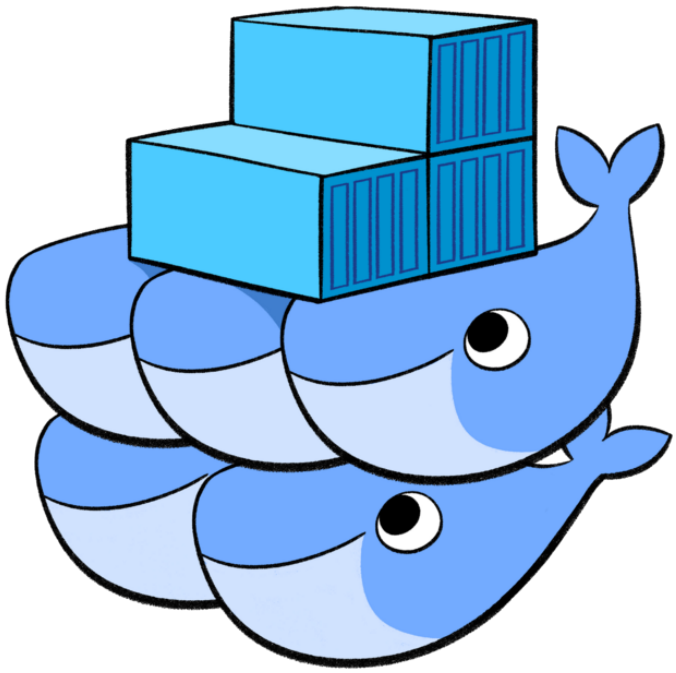
Docker Swarm Tutorial

Container Orchestration systems is where the next action is likely to be in the movement towards Building →Shipping → Running containers at scale. The list of software that currently provides a solution for this are Kubernetes, Docker Swarm, Apache Mesos and other.



This tutorial is going to be about exploring the new Docker Swarm mode, where the Container Orchestration support got baked into the Docker toolset itself.

While I do understand Kubernetes and have tried it out, this blog post represents my own learnings and exploring out Docker Swarm mode.

> *Update: Once you are done with this tutorial, you might to check up a follow up tutorial on how to run Docker Swarm on Google Compute Engine.*

> *Download a mini book (about 50 pages) that contains both the Docker Swarm Tutorial and Docker Swarm on Google Compute Engine. Click here to download the PDF.*

Why do we want a Container Orchestration System?

To keep this simple, imagine that you had to run hundreds of containers. You can easily see that if they are running in a distributed mode, there are multiple features that you will need from a management angle to make sure that the cluster is up and running, is healthy and more.

Some of these necessary features include:

- Health Checks on the Containers
- Launching a fixed set of Containers for a particular Docker image
- Scaling the number of Containers up and down depending on the load
- Performing rolling update of software across containers
- and more…

Let us look at how we can do some of that using Docker Swarm. The Docker Documentation and tutorial for trying out Swarm mode has been excellent.

Pre-requisites

- You are familiar with basic Docker commands
- You have Docker Toolbox installed on your system
- You have the Docker version 1.12 atleast

Create Docker Machines

The first step is to create a set of Docker machines that will act as nodes in our Docker Swarm. I am going to create 6 Docker Machines, where one of them will act as the Manager (Leader) and the other will be worker nodes. You can create less number of machines as needed.

I use the standard command to create a Docker Machine named **manager1** as shown below:

```
docker-machine create --driver hyperv manager1
```

Keep in mind that I am doing this on Windows 10, which uses the native Hyper-V manager so that's why I am using that driver. If you are using the Docker Toolbox with Virtual Box, it would be something like this:

```
docker-machine create --driver virtualbox manager1
```

Similarly, create the other worder nodes. In my case, as mentioned, I have created 5 other worker nodes.

After creating, it is advised that you fire the **docker-machine ls** command to check on the status of all the Docker machines (I have omitted the DRIVER .

```
NAME     DRIVER URL                       STATE
manager1 hyperv tcp://192.168.1.8:2376  Running
worker1  hyperv tcp://192.168.1.9:2376  Running
worker2  hyperv tcp://192.168.1.10:2376 Running
worker3  hyperv tcp://192.168.1.11:2376 Running
worker4  hyperv tcp://192.168.1.12:2376 Running
worker5  hyperv tcp://192.168.1.13:2376 Running
```

Note down the IP Address of the manager1, since you will be needing that. I will call that **MANAGER_IP** in the text later.

One way to get the IP address of the manager1 machine is as follows:

```
$ docker-machine ip manager1
192.168.1.8
```

You should be comfortable with doing a SSH into any of the Docker Machines. You will need that since we will primarily be executing the

docker commands from within the SSH session to that machine.

Keep in mind that using docker-machine utility, you can SSH into any of the machines as follows:

```
docker-machine ssh <machine-name>
```

As an example, here is my SSH into **manager1** docker machine.

```
$ docker-machine ssh manager1
                        ##         .
                  ## ## ##        ==
               ## ## ## ## ##    ===
           /"""""""""""""""""\___/ ===
      ~~~ {~~ ~~~~ ~~~ ~~~~ ~~~ ~ /  ===- ~~~
           \_______ o           __/
             \     \         __/
              \____\_______/
 _                 _   ____     _            _
| |__   ___   ___ | |_|___ \ __| | ___   ___| | _____ _
__
| '_ \ / _ \ / _ \| __| __) / _` |/ _ \ / __| |/ / _ \
'__|
| |_) | (_) | (_) | |_ / __/ (_| | (_) | (__|   <  __/ |
|_.__/ \___/ \___/ \__|_____\__,_|\___/ \___|_|\_\___|_|
Boot2Docker version 1.12.1, build HEAD : ef7d0b4 - Thu
Aug 18 21:18:06 UTC 2016
Docker version 1.12.1, build 23cf638
docker@manager1:~$
```

Our Swarm Cluster

Now that our machines are setup, we can proceed with setting up the Swarm.

The first thing to do is initialize the Swarm. We will SSH into the manager1 machine and initialize the swarm in there.

```
$ docker-machine ssh manager1
```

This will initialize the SSH session and you should be at prompt as shown below:

```
$ docker-machine ssh manager1
                        ##         .
                  ## ## ##        ==
               ## ## ## ## ##    ===
           /"""""""""""""""""\___/ ===
      ~~~ {~~ ~~~~ ~~~ ~~~~ ~~~ ~ /  ===- ~~~
           \_______ o           __/
             \    \         __/
              \____\_______/
 _                 _   ____     _            _
| |__   ___   ___ | |_|___ \ __| | ___   ___| | _____ _
__
| '_ \ / _ \ / _ \| __| __) / _` |/ _ \ / __| |/ / _ \
'__|
| |_) | (_) | (_) | |_ / __/ (_| | (_) | (__|   <  __/ |
|_.__/ \___/ \___/ \__|_____\__,_|\___/ \___|_|\_\___|_|
Boot2Docker version 1.12.1, build HEAD : ef7d0b4 - Thu
Aug 18 21:18:06 UTC 2016
Docker version 1.12.1, build 23cf638
docker@manager1:~$
```

Perform the following steps:

```
$ docker swarm init --advertise-addr MANAGER_IP
```

On my machine, it looks like this:

```
docker@manager1:~$ docker swarm init — advertise-addr
192.168.1.8
Swarm initialized: current node
(5oof62fetd4gry7o09jd9e0kf) is now a manager.


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

```
docker swarm join \
 — token SWMTKN-1-
5mgyf6ehuc5pfbmar00njd3oxv8nmjhteejaald3yzbef7osl1-
ad7b1k8k3bl3aa3k3q13zivqd \
 192.168.1.8:2377
```

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

```
docker@manager1:~$
```

Great!

You will also notice that the output mentions the docker swarm join command to use in case you want another node to join as a worker. Keep in mind that you can have a node join as a worker or as a manager. At any point in time, there is only one LEADER and the other manager nodes will be as backup in case the current LEADER opts out.

At this point you can see your Swarm status by firing the following command as shown below:

```
docker@manager1:~$ docker node ls
ID              HOSTNAME STATUS AVAILABILITY MANAGER
STATUS
5oof62fetd..*   manager1 Ready  Active       Leader
```

This shows that there is a single node so far i.e. manager1 and it has the value of Leader for the MANAGER column.

Stay in the SSH session itself for **manager1**.

Joining as Worker Node

To find out what docker swarm command to use to join as a node, you will need to use the join-token <role> command.

To find out the join command for a **worker**, fire the following command:

```
docker@manager1:~$ docker swarm join-token worker
To add a worker to this swarm, run the following
command:

docker swarm join \
 — token SWMTKN-1-
5mgyf6ehuc5pfbmar00njd3oxv8nmjhteejaald3yzbef7osl1-
ad7b1k8k3bl3aa3k3q13zivqd \
 192.168.1.8:2377

docker@manager1:~$
```

Joining as Manager Node

To find out the the join command for a manager, fire the following command:

```
docker@manager1:~$ docker swarm join-token manager
To add a manager to this swarm, run the following
command:

docker swarm join \
 — token SWMTKN-1-
5mgyf6ehuc5pfbmar00njd3oxv8nmjhteejaald3yzbef7osl1-
8xo0cmd6bryjrsh6w7op4enos \
 192.168.1.8:2377

docker@manager1:~$
```

Notice in both the above cases, that you are provided a token and it is joining the Manager node (you will be able to identify that the IP address is the same the **MANAGER_IP** address).

Keep the SSH to manager1 open. And fire up other command terminals for working with other worker docker machines.

Adding Worker Nodes to our Swarm

Now that we know how to check the command to join as a worker, we can use that to do a SSH into each of the worker Docker machines and then fire the respective join command in them.

In my case, I have 5 worker machines (worker1/2/3/4/5). For the first worker1 Docker machine, I do the following:

- SSH into the worker1 machine i.e. docker-machine ssh worker1
- Then fire the respective command that I got for joining as a worker. In my case the output is shown below:

```
docker@worker1:~$ docker swarm join \
 — token SWMTKN-1-
5mgyf6ehuc5pfbmar00njd3oxv8nmjhteejaald3yzbef7osl1-
ad7b1k8k3bl3aa3k3q13zivqd \
 192.168.1.8:2377
This node joined a swarm as a worker.
docker@worker1:~$
```

I do the same thing by launching SSH sessions for worker2/3/4/5 and then pasting the same command since I want all of them to be worker nodes.

After making all my worker nodes join the Swarm, I go back to my manager1 SSH session and fire the following command to check on the status of my Swarm i.e. see the nodes participating in it:

```
docker@manager1:~$ docker node ls
ID                           HOSTNAME  STATUS
AVAILABILITY  MANAGER STATUS
1ndqsslh7fpquc7fi35leig54    worker4   Ready   Active
1qh4aat24nts5izo3cgsboy77    worker5   Ready   Active
25nwmw5eg7a5ms4ch93aw0k03    worker3   Ready   Active
5oof62fetd4gry7o09jd9e0kf *  manager1  Ready   Active
Leader
5pm9f2pzr8ndijqkkblkgqbsf    worker2   Ready   Active
9yq4lcmfg0382p39euk8lj9p4    worker1   Ready   Active
docker@manager1:~$
```

As expected, you can see that I have 6 nodes, one as the manager (manager1) and the other 5 as workers.

We can also do execute the standard docker info command here and zoom into the Swarm section to check out the details for our Swarm.

```
Swarm: active
 NodeID: 5oof62fetd4gry7o09jd9e0kf
 Is Manager: true
 ClusterID: 6z3sqr1aqank2uimyzijzapz3
 Managers: 1
 Nodes: 6
 Orchestration:
  Task History Retention Limit: 5
 Raft:
  Snapshot Interval: 10000
  Heartbeat Tick: 1
  Election Tick: 3
 Dispatcher:
  Heartbeat Period: 5 seconds
 CA Configuration:
  Expiry Duration: 3 months
 Node Address: 192.168.1.8
```

Notice a few of the properties:

- The Swarm is marked as active. It has 6 Nodes in total and 1 manager among them.
- Since I am running the **docker info** command on the manager1 itself, it shows the **Is Manager** as **true**.

- The Raft section is the Raft consensus algorithm that is used. Check out the details here.

Create a Service

Now that we have our swarm up and running, it is time to schedule our containers on it. This is the whole beauty of the orchestration layer. We are going to focus on the app and not worry about where the application is going to run.

All we are going to do is tell the manager to run the containers for us and it will take care of scheduling out the containers, sending the commands to the nodes and distributing it.

To start a service, you would need to have the following:

- What is the Docker image that you want to run. In our case, we will run the standard **nginx** image that is officially available from the Docker hub.
- We will expose our service on port 80.
- We can specify the number of containers (or instances) to launch. This is specified via the **replicas** parameter.
- We will decide on the name for our service. And keep that handy.

What I am going to do then is to launch 5 replicas of the nginx container. To do that, I am again in the SSH session for my manager1 node. And I give the following **docker service create** command:

```
docker service create --replicas 5 -p 80:80 --name web
nginx
```

```
ctolq1t4h2o859t69j9pptyye
```

What has happened is that the Orchestration layer has now got to work.

You can find out the status of the service, by giving the following command:

```
docker@manager1:~$ docker service ls
ID            NAME  REPLICAS  IMAGE  COMMAND
```

```
ctolq1t4h2o8  web   0/5       nginx
```

This shows that the replicas are not yet ready. You will need to give that command a few times.

In the meanwhile, you can also see the status of the service and how it is getting orchestrated to the different nodes by using the following command:

```
docker@manager1:~$ docker service ps web
ID  NAME   IMAGE  NODE      DESIRED STATE  CURRENT STATE
ERROR
7i*  web.1  nginx  worker3   Running        Preparing 2
minutes ago
17*  web.2  nginx  manager1  Running        Running 22
seconds ago
ey*  web.3  nginx  worker2   Running        Running 2
minutes ago
bd*  web.4  nginx  worker5   Running        Running 45
seconds ago
dw*  web.5  nginx  worker4   Running        Running 2
minutes ago
```

This shows that the nodes are getting setup. It could take a while.

But notice a few things. In the list of nodes above, you can see that the 5 containers are being scheduled by the orchestration layer on **manager1, worker2, worker3, worker4 and worker5**. There is no container scheduled for **worker1** node and that is fine.

A few executions of **docker service ls** shows the following responses:

```
docker@manager1:~$ docker service ls
ID            NAME  REPLICAS  IMAGE  COMMAND
ctolq1t4h2o8  web   3/5       nginx
docker@manager1:~$
```

and then finally:

```
docker@manager1:~$ docker service ls
ID              NAME REPLICAS IMAGE COMMAND
ctolq1t4h2o8    web  5/5      nginx
docker@manager1:~$
```

If we look at the service processes at this point, we can see the following:

```
docker@manager1:~$ docker service ps web
ID  NAME   IMAGE  NODE      DESIRED STATE  CURRENT STATE
ERROR
7i*  web.1  nginx  worker3   Running        Running 4
minutes ago
17*  web.2  nginx  manager1  Running        Running 7
minutes ago
ey*  web.3  nginx  worker2   Running        Running 9
minutes ago
bd*  web.4  nginx  worker5   Running        Running 8
minutes ago
dw*  web.5  nginx  worker4   Running        Running 9
minutes ago
```

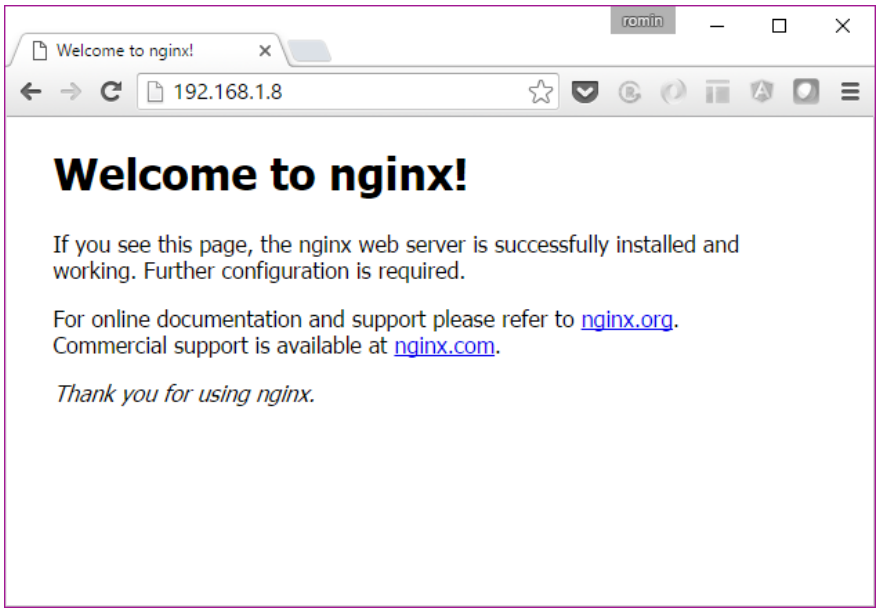
If you do a **docker ps** on the manager1 node right now, you will find that the nginx daemon has been launched.

```
docker@manager1:~$ docker ps
CONTAINER ID        IMAGE               COMMAND
CREATED             STATUS              PORTS
NAMES
933309b04630        nginx:latest        "nginx -g
'daemon off"   2 minutes ago       Up 2 minutes
80/tcp, 443/tcp     web.2.17d502y6qjhd1wqjle13nmjvc
docker@manager1:~$
```

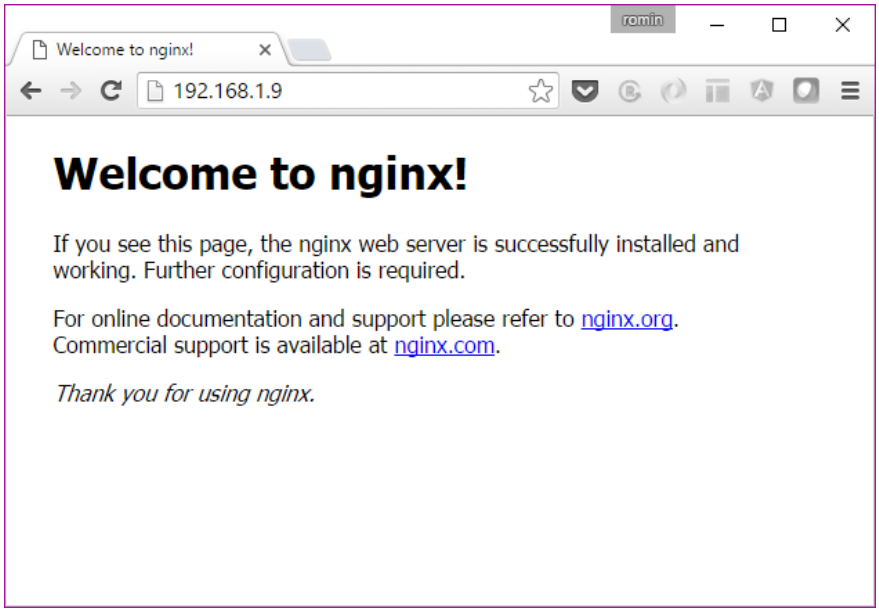
Accessing the Service

You can access the service by hitting any of the manager or worker nodes. It does not matter if the particular node does not have a container scheduled on it. That is the whole idea of the swarm.

Try out a curl to any of the Docker Machine IPs (manager1 or worker1/2/3/4/5) or hit the URL (http://<machine-ip>) in the browser. You should be able to get the standard NGINX Home page.



or if we hit the worker IP:



Nice, isn't it?

Ideally you would put the Docker Swarm service behind a Load Balancer.

Scaling up and Scaling down

This is done via the **docker service scale** command. We currently have 5 containers running. Let us bump it up to 8 as shown below by executing the command on the **manager1** node.

```
$ docker service scale web=8
```

```
web scaled to 8
```

Now, we can check the status of the service and the process tasks via the same commands as shown below:

```
docker@manager1:~$ docker service ls
ID            NAME REPLICAS IMAGE COMMAND
ctolq1t4h2o8 web  5/8      nginx
```

In the ps web command below, you will find that it has decided to schedule the new containers on worker1 (2 of them) and manager1 (one of them)

```
docker@manager1:~$ docker service ps web
ID   NAME   IMAGE  NODE      DESIRED STATE  CURRENT
STATE               ERROR
7i*  web.1  nginx  worker3   Running    Running 14
minutes ago
17*  web.2  nginx  manager1  Running    Running 17
minutes ago
ey*  web.3  nginx  worker2   Running    Running 19
minutes ago
bd*  web.4  nginx  worker5   Running    Running 17
minutes ago
dw*  web.5  nginx  worker4   Running    Running 19
minutes ago
8t*  web.6  nginx  worker1   Running    Starting about a
minute ago
b8*  web.7  nginx  manager1  Running    Ready less than
a second ago
0k*  web.8  nginx  worker1   Running    Starting about a
minute ago
```

We wait for a while and then everything looks good as shown below:

```
docker@manager1:~$ docker service ls
ID            NAME REPLICAS IMAGE COMMAND
ctolq1t4h2o8 web 8/8 nginx
```

```
docker@manager1:~$ docker service ps web
ID  NAME  IMAGE NODE     DESIRED STATE CURRENT STATE
ERROR
```

```
7i* web.1 nginx worker3  Running       Running 16
minutes ago
17* web.2 nginx manager1 Running       Running 19
minutes ago
ey* web.3 nginx worker2  Running       Running 21
minutes ago
bd* web.4 nginx worker5  Running       Running 20
minutes ago
dw* web.5 nginx worker4  Running       Running 21
minutes ago
8t* web.6 nginx worker1  Running       Running 4 minutes
ago
b8* web.7 nginx manager1 Running       Running 2 minutes
ago
0k* web.8 nginx worker1  Running       Running 3 minutes
ago
```

```
docker@manager1:~$
```

Inspecting nodes

You can inspect the nodes anytime via the docker node inspect command.

For example if you are already on the node (for example manager1) that you want to check, you can use the name self for the node.

```
$ docker node inspect self
```

Or if you want to check up on the other nodes, give the node name. For e.g.

```
$ docker node inspect worker1
```

Draining a node

If the node is ACTIVE, it is ready to accept tasks from the Master i.e. Manager. For e.g. we can see the list of nodes and their status by firing the following command on the **manager1** node.

```
docker@manager1:~$ docker node ls
ID                           HOSTNAME  STATUS
```

```
AVAILABILITY  MANAGER STATUS
1ndqsslh7fpquc7fi35leig54    worker4   Ready   Active
1qh4aat24nts5izo3cgsboy77    worker5   Ready   Active
25nwmw5eg7a5ms4ch93aw0k03    worker3   Ready   Active
5oof62fetd4gry7o09jd9e0kf *  manager1  Ready   Active
Leader
5pm9f2pzr8ndijqkkblkgqbsf    worker2   Ready   Active
9yq4lcmfg0382p39euk8lj9p4    worker1   Ready   Active
docker@manager1:~$
```

You can see that their **AVAILABILITY** is set to **READY**.

As per the documentation, When the node is active, it can receive new tasks:

- during a service update to scale up
- during a rolling update
- when you set another node to Drain availability
- when a task fails on another active node

But sometimes, we have to bring the Node down for some maintenance reason. This meant by setting the Availability to Drain mode. Let us try that with one of our nodes.

But first, let us check the status of our processes for the web services and on which nodes they are running:

```
docker@manager1:~$ docker service ps web
ID                         NAME   IMAGE  NODE
DESIRED STATE  CURRENT STATE           ERROR
7i*  web.1  nginx  worker3   Running        Running 54
minutes ago
17*  web.2  nginx  manager1  Running        Running 57
minutes ago
ey*  web.3  nginx  worker2   Running        Running 59
minutes ago
bd*  web.4  nginx  worker5   Running        Running 57
minutes ago
dw*  web.5  nginx  worker4   Running        Running 59
minutes ago
8t*  web.6  nginx  worker1   Running        Running 41
minutes ago
b8*  web.7  nginx  manager1  Running        Running 39
minutes ago
0k*  web.8  nginx  worker1   Running        Running 41
minutes ago
```

You find that we have 8 replicas of our service:

- 2 on manager1
- 2 on worker1
- 1 each on worker2, worker3, worker4 and worker5

Now, let us use another command to check what is going on in node **worker1.**

```
docker@manager1:~$ docker node ps worker1
ID   NAME   IMAGE  NODE     DESIRED STATE  CURRENT STATE
8t*  web.6  nginx  worker1  Running        Running 44
minutes ago
0k*  web.8  nginx  worker1  Running        Running 44
minutes ago

docker@manager1:~$
```

We can also use the docker node inspect command to check the availability of the node and as expected, you will find a section in the output as follows:

```
$ docker node inspect worker1
…..

"Spec": {
 "Role": "worker",
 "Availability": "active"
 },
…
```

or

```
docker@manager1:~$ docker node inspect — pretty worker1
ID: 9yq4lcmfg0382p39euk8lj9p4
Hostname: worker1
Joined at: 2016-09-16 08:32:24.5448505 +0000 utc
Status:
 State: Ready
 Availability: Active
Platform:
 Operating System: linux
 Architecture: x86_64
Resources:
```

```
 CPUs: 1
 Memory: 987.2 MiB
Plugins:
 Network: bridge, host, null, overlay
 Volume: local
Engine Version: 1.12.1
Engine Labels:
 — provider = hypervdocker@manager1:~$
```

We can see that it is "**Active**" for its Availability attribute.

Now, let us set the **Availability** to **DRAIN**. When we give that command, the Manager will stop tasks running on that node and launches the replicas on other nodes with ACTIVE availability.

So what we are expecting is that the Manager will bring the 2 containers running on worker1 and schedule them on the other nodes (manager1 or worker2 or worker3 or worker4 or worker5).

This is done by updating the node by setting its availability to "drain".

```
docker@manager1:~$ docker node update --availability
drain worker1
worker1
```

Now, if we do a process status for the service, we see an interesting output (*I have trimmed the output for proper formatting*):

```
docker@manager1:~$ docker service ps web
ID   NAME       IMAGE  NODE      DESIRED STATE  CURRENT
STATE
7i*  web.1      nginx  worker3   Running   Running about
an hour ago
17*  web.2      nginx  manager1  Running   Running about
an hour ago
ey*  web.3      nginx  worker2   Running   Running about
an hour ago
bd*  web.4      nginx  worker5   Running   Running about
an hour ago
dw*  web.5      nginx  worker4   Running   Running about
an hour ago
2u*  web.6      nginx  worker4   Running   Preparing
about a min ago
8t*   \_ web.6  nginx  worker1   Shutdown  Shutdown
about a min ago
b8*  web.7      nginx  manager1  Running   Running 49
minutes ago
7a*  web.8      nginx  worker3   Running   Preparing
about a min ago
```

```
0k*   \_ web.8  nginx  worker1   Shutdown  Shutdown
about a min ago


docker@manager1:~$
```

You can see that the containers on worker1 (which we have asked to be drained) are being rescheduled on other workers. In our scenario above, they got scheduled to worker2 and worker3 respectively. This is required because we have asked for 8 replicas to be running in an earlier scaling exercise.

You can see that the two containers are still in "Preparing" state and after a while if you run the command, they are all running as shown below:

```
docker@manager1:~$ docker service ps web
ID  NAME       IMAGE  NODE      DESIRED STATE  CURRENT
STATE
7i*  web.1      nginx  worker3   Running   Running about
an hour ago
17*  web.2      nginx  manager1  Running   Running about
an hour ago
ey*  web.3      nginx  worker2   Running   Running about
an hour ago
bd*  web.4      nginx  worker5   Running   Running about
an hour ago
dw*  web.5      nginx  worker4   Running   Running about
an hour ago
2u*  web.6      nginx  worker4   Running   Running 8
minutes ago
8t*   \_ web.6  nginx  worker1   Shutdown  Shutdown 8
minutes ago
b8*  web.7      nginx  manager1  Running   Running 56
minutes ago
7a*  web.8      nginx  worker3   Running   Running 8
minutes ago
0k*   \_ web.8  nginx  worker1   Shutdown  Shutdown 8
minutes ago
```

This makes for cool demo, isn't it?

Remove the Service

You can simply use the service rm command as shown below:

```
docker@manager1:~$ docker service rm web
web
```

```
docker@manager1:~$ docker service ls
ID NAME REPLICAS IMAGE COMMAND
```

```
docker@manager1:~$ docker service inspect web
[]
Error: no such service: web
```

Applying Rolling Updates

This is straight forward. In case you have an updated Docker image to roll out to the nodes, all you need to do is fire an service update command.

For e.g.

```
$ docker service update --image <imagename>:<version>
web
```

Conclusion

I am definitely impressed with the simplicity of Docker Swarm. Just like the basic commands that come with the standard Docker toolset, it has been a good move to introduce the Swarm commands within the same toolset.

There is a lot more to Docker Swarm and I suggest that you dig further into the documentation.

I am not in a position to know whether Kubernetes or Swarm will emerge a winner but there is no doubt that we will have to understand both to see what their capabilities are and then take a decision.

> *Update: Once you are done with this tutorial, you might to check up a follow up tutorial on how to run Docker Swarm on Google Compute Engine.*

> *Download a mini book (about 50 pages) that contains both the Docker Swarm Tutorial and Docker Swarm on Google Compute Engine. Click here to download the PDF.*