

# Docker with Kubernetes + Swarm

# Table of Contents

1. Creating and Using Containers	3
2. Docker Commands	3
3. Starting a Nginx Web Server	6
3.1. Image vs Container	6
3.2. Run/Stop/Remove Container	6
4. What happens when we run a Container?	13
5. Containers vs VM	14
Assignment 1	15
6. What's Going On In Containers	17
7. Getting a Shell Inside Containers	19
8. Docker Networks: Concepts for Private and Public Comms in Containers	25

## 1. Creating and Using Containers

- Check versions of our docker cli and engine
- Create a Nginx (web server) container
- Common container management commands
- Docker Networking Basics

## 2. Docker Commands

- ***docker version***

This command simply returns the version of our client and the server (also called the engine) which runs in the background on our machine - called a daemon on macOS. Our docker command line is actually talking to the server on the machine and returning its values as well as the client's values.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker version
Client: Docker Engine - Community
 Version:          19.03.8
 API version:     1.40
 Go version:      go1.12.17
 Git commit:      afacb8b
 Built:            Wed Mar 11 01:21:11 2020
 OS/Arch:          darwin/amd64
 Experimental:    true

Server: Docker Engine - Community
 Engine:
  Version:          19.03.8
  API version:     1.40 (minimum version 1.12)
  Go version:      go1.12.17
  Git commit:      afacb8b
  Built:            Wed Mar 11 01:29:16 2020
  OS/Arch:          linux/amd64
  Experimental:    true
 containerd:
  Version:          v1.2.13
  GitCommit:        7ad184331fa3e55e52b890ea95e65ba581ae3429
 runc:
  Version:          1.0.0-rc10
  GitCommit:        dc9208a3303feef5b3839f4323d9beb36df0a9dd
 docker-init:
  Version:          0.18.0
  GitCommit:        fec3683
```

- ***docker info***

This command returns a lot more stuff than just the version. It'll actually give us a lot of details about our configuration and setup for our engine.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker info
Client:
  Debug Mode: false
  Plugins:
    app: Docker Application (Docker Inc., v0.8.0)
    buildx: Build with BuildKit (Docker Inc., v0.3.1-tp-docker)

Server:
  Containers: 0
    Running: 0
    Paused: 0
    Stopped: 0
  Images: 0
  Server Version: 19.03.8
  Storage Driver: overlay2
    Backing Filesystem: <unknown>
    Supports d_type: true
    Native Overlay Diff: true
  Logging Driver: json-file
  Cgroup Driver: cgroupfs
  Plugins:
    Volume: local
    Network: bridge host ipvlan macvlan null overlay
    Log: awslogs fluentd gcplogs gelf journald json-file local logentries splunk syslog
  Swarm: inactive
  Runtimes: runc
  Default Runtime: runc
  Init Binary: docker-init
  containerd version: 7ad184331fa3e55e52b890ea95e65ba581ae3429
  runc version: dc9208a3303feef5b3839f4323d9beb36df0a9dd
  init version: fec3683
  Security Options:
    seccomp
      Profile: default
  Kernel Version: 4.19.76-linuxkit
  Operating System: Docker Desktop
  OSType: linux
  Architecture: x86_64
  CPUs: 2
  Total Memory: 3.848GiB
  Name: docker-desktop
  ID: 6UPS:2KP3:FQBB:LDQI:4TYV:FLBN:G306:2V03:3KE6:AJBX:JKWM:DITI
  Docker Root Dir: /var/lib/docker
  Debug Mode: true
    File Descriptors: 37
    Goroutines: 43
    System Time: 2020-06-06T21:41:09.570812627Z
    EventsListeners: 3
  HTTP Proxy: gateway.docker.internal:3128
  HTTPS Proxy: gateway.docker.internal:3129
  Registry: https://index.docker.io/v1/
  Labels:
```

- **docker**

This returns a list of all the commands we can use in Docker.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker
Usage: docker [OPTIONS] COMMAND
      A self-sufficient runtime for containers

Options:
  --config string        Location of client config files (default "/Users/hetanshmehta/.docker")
  -c, --context string   Name of the context to use to connect to the daemon (overrides DOCKER_HOST env var and default context set with "docker context use")
  -D, --debug             Enable debug mode
  -H, --host list         Daemon socket(s) to connect to
  -l, --log-level string  Set the logging level ("debug"|"info"|"warn"|"error"|"fatal") (default "info")
  --tls                  Use TLS; implied by --tlsv1.2
  --tlscacert string     Trust certs signed only by this CA (default "/Users/hetanshmehta/.docker/ca.pem")
  --tlscert string        Path to TLS certificate file (default "/Users/hetanshmehta/.docker/cert.pem")
  --tlskey string         Path to TLS key file (default "/Users/hetanshmehta/.docker/key.pem")
  --tlsv1.2               Use TLS and verify the remote
  -v, --version            Print version information and quit

Management Commands:
  app*                 Docker Application (Docker Inc., v0.8.0)
  builder              Manage builds
  buildx*              Build with BuildKit (Docker Inc., v0.3.1-tp-docker)
  checkpoint           Manage checkpoints
  config               Manage Docker configs
  container            Manage containers
  context              Manage contexts
  image                Manage images
  manifest             Manage Docker image manifests and manifest lists
  network              Manage networks
  node                Manage Swarm nodes
  plugin               Manage plugins
  secret               Manage Docker secrets
  service              Manage services
  stack                Manage Docker stacks
  swarm                Manage Swarm
  system               Manage Docker
  trust                Manage trust on Docker images
  volume               Manage volumes

Commands:
  attach               Attach local standard input, output, and error streams to a running container
  build                Build an image from a Dockerfile
  commit               Create a new image from a container's changes
  cp                  Copy files/folders between a container and the local filesystem
  create               Create a new container
  deploy               Deploy a new stack or update an existing stack
  diff                Inspect changes to files or directories on a container's filesystem
  events              Get real time events from the server
  exec                Run a command in a running container
  export              Export a container's filesystem as a tar archive
```

Syntax for docker management commands:

**NEW:** *docker <management-command> <sub-command> (options)*

**OLD:** *docker <command> (options)*

## 3. Starting a Nginx Web Server

- Image vs. Container
- Run/Stop/Remove Containers
- Check container logs and processes

### 3.1. Image vs Container

- An **image** is the binaries and libraries and source code that make up our application, i.e., image is the application we want to run.
- A **container** is the running instance of the image. We can have many containers based off the same image.

We're going to use the Open Source Nginx web server. So we'll be starting our containers based off that Nginx image. We get all our images from registries.

Docker's default image registry is called **Docker Hub** ([hub.docker.com](https://hub.docker.com))

### 3.2. Run/Stop/Remove Container

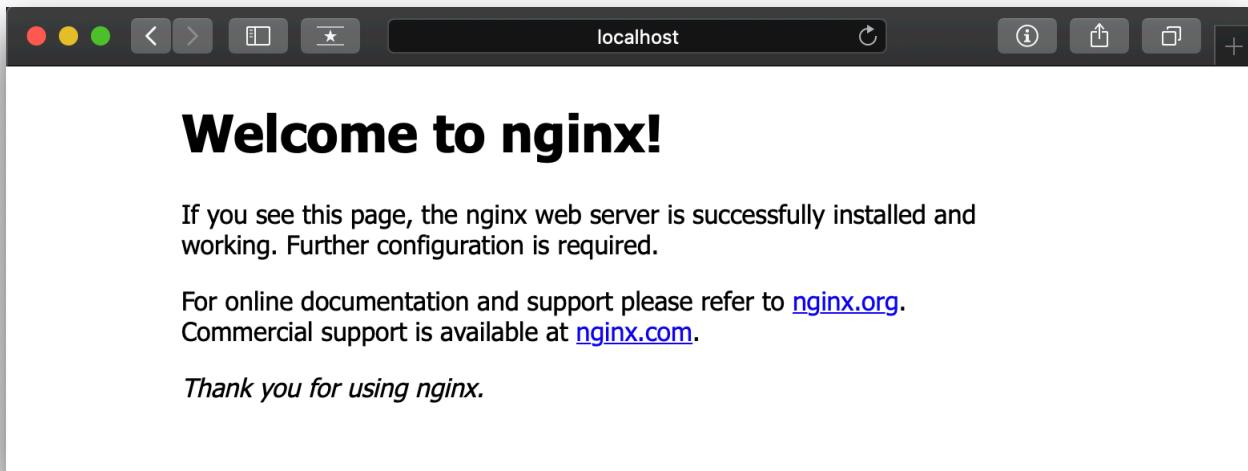
• **`docker container run -publish 80:80 nginx`**

- Downloads image 'nginx' from Docker Hub
- Starts a new container from the image
- Opens port 80 on the host IP (local machine) and sends all traffic from it to the executable running inside that container on the container (container IP) on port 80.
- Since Nginx is a web server, the traffic just forwards automatically through the web browser to the localhost and into that container

Note that we'll get a "bind" error if the left number (host port) is being used by anything else, even another container. We can use any port we want on the left, like **8080:80** or **8888:80**, then use **localhost:8888** when testing.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container run --publish 80:80 nginx
Unable to find image 'nginx:latest' locally
latest: Pulling from library/nginx
afb6ec6fdc1c: Pull complete
dd3ac8106a0b: Pull complete
8de28bdda69b: Pull complete
a2c431ac2669: Pull complete
e070d03fd1b5: Pull complete
Digest: sha256:c870bf53de0357813af37b9500cb1c2ff9fb4c00120d5fe1d75c21591293c34d
Status: Downloaded newer image for nginx:latest
/docker-entrypoint.sh: /docker-entrypoint.d/ is not empty, will attempt to perform configuration
/docker-entrypoint.sh: Looking for shell scripts in /docker-entrypoint.d/
/docker-entrypoint.sh: Launching /docker-entrypoint.d/10-listen-on-ipv6-by-default.sh
10-listen-on-ipv6-by-default.sh: Getting the checksum of /etc/nginx/conf.d/default.conf
10-listen-on-ipv6-by-default.sh: Enabled listen on IPv6 in /etc/nginx/conf.d/default.conf
/docker-entrypoint.sh: Launching /docker-entrypoint.d/20-envsubst-on-templates.sh
/docker-entrypoint.sh: Configuration complete; ready for start up
```

Switch over to a web browser, and type **localhost**.



Our Nginx server is listening.

We can hit refresh several times and we'll see the log entries in our command line.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container run --publish 80:80 nginx
Unable to find image 'nginx:latest' locally
latest: Pulling from library/nginx
afbf6ec6fd1c: Pull complete
dd3ac8106a0b: Pull complete
8de28bdda69b: Pull complete
a2c431ac2669: Pull complete
e970d03fd1b5: Pull complete
Digest: sha256:c870bf53de0357813af37b9500cb1c2ff9fb4c00120d5fe1d75c21591293c34d
Status: Downloaded newer image for nginx:latest
/docker-entrypoint.sh: /docker-entrypoint.d/ is not empty, will attempt to perform configuration
/docker-entrypoint.sh: Looking for shell scripts in /docker-entrypoint.d/
/docker-entrypoint.sh: Launching /docker-entrypoint.d/10-listen-on-ipv6-by-default.sh
10-listen-on-ipv6-by-default.sh: Getting the checksum of /etc/nginx/conf.d/default.conf
10-listen-on-ipv6-by-default.sh: Enabled listen on IPv6 in /etc/nginx/conf.d/default.conf
/docker-entrypoint.sh: Launching /docker-entrypoint.d/20-envsubst-on-templates.sh
/docker-entrypoint.sh: Configuration complete; ready for start up
172.17.0.1 - - [06/Jun/2020:22:51:01 +0000] "GET / HTTP/1.1" 200 612 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_4) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/13.1 Safari/605.1.15"
2020/06/06 22:51:01 [error] 30#30: *2 open() "/usr/share/nginx/html/favicon.ico" failed (2: No such file or directory), client: 172.17.0.1, server: localhost, request: "GET /favicon.ico HTTP/1.1", host: "localhost", referer: "http://localhost/"
172.17.0.1 - - [06/Jun/2020:22:51:01 +0000] "GET /favicon.ico HTTP/1.1" 404 153 "http://localhost/" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_4) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/13.1 Safari/605.1.15"
172.17.0.1 - - [06/Jun/2020:22:51:26 +0000] "GET / HTTP/1.1" 200 612 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_4) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/13.1 Safari/605.1.15"
172.17.0.1 - - [06/Jun/2020:22:53:15 +0000] "GET / HTTP/1.1" 200 612 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_4) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/13.1 Safari/605.1.15"
172.17.0.1 - - [06/Jun/2020:22:53:16 +0000] "GET / HTTP/1.1" 200 612 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_4) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/13.1 Safari/605.1.15"
```

But we don't always want this running in the foreground inside of our command line.

- **`docker container run --publish 80:80 --detach nginx`**

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container run --publish 80:80 --detach nginx
dab0d9a7e0b5f38f3c6a2c644a2ad193e4c3fc52296f828c3a87bcd1dde572a0
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

The **detach** tells Docker to run it in the background. And we get back the unique **container ID** of our container. Every time we run a new container, we get a new container ID.

- ***docker container ls***

Command to list all our containers. And we'll see the one that's still running here.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container --help

Usage: docker container COMMAND

Manage containers

Commands:
  attach      Attach local standard input, output, and error streams to a running container
  commit      Create a new image from a container's changes
  cp          Copy files/folders between a container and the local filesystem
  create      Create a new container
  diff        Inspect changes to files or directories on a container's filesystem
  exec        Run a command in a running container
  export      Export a container's filesystem as a tar archive
  inspect    Display detailed information on one or more containers
  kill        Kill one or more running containers
  logs       Fetch the logs of a container
  ls          List containers
  pause       Pause all processes within one or more containers
  port        List port mappings or a specific mapping for the container
  prune      Remove all stopped containers
  rename     Rename a container
  restart    Restart one or more containers
  rm          Remove one or more containers
  run         Run a command in a new container
  start      Start one or more stopped containers
  stats      Display a live stream of container(s) resource usage statistics
  stop       Stop one or more running containers
  top         Display the running processes of a container
  unpause   Unpause all processes within one or more containers
  update     Update configuration of one or more containers
  wait       Block until one or more containers stop, then print their exit codes

Run 'docker container COMMAND --help' for more information on a command.
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

Only shows the running containers.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container ls
CONTAINER ID        IMAGE               COMMAND             CREATED            STATUS              PORTS               NAMES
dab0d9a7e0b5        nginx              "/docker-entrypoint..."   About an hour ago   Up About an hour   0.0.0.0:80->80/tcp   confident_robinson
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

- ***docker container stop <container\_ID>***

Stops the container matching the container id.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container stop dab0d
dab0d
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

Now when we list our containers, nothing shows up as no containers are running.

- ***docker container ls -a***

- When we ran each time the docker container run command, it started a new container from that Nginx image. One the right we notice that there's these random names which we didn't use.
- The container IDs and the names are required to be **unique** and if we don't specify it, then it will be created for us. We can always name something ourselves, or let it pick one on its own.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container ls -a
CONTAINER ID        IMAGE               COMMAND                  CREATED             STATUS              PORTS                 NAMES
dab0d9a7e0b5        nginx              "/docker-entrypoint..."   About an hour ago   Exited (0) 2 minutes ago
4bd9cf156353        nginx              "/docker-entrypoint..."   2 hours ago        Exited (0) About an hour ago
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

- Start a new container under **detach** mode. Open the web browser and type **localhost**. Refresh it a few times.
- By running in detached mode, we are able to have access to our command line when the container spins up and runs. Without it, we would have logs constantly fed onto the screen.

- ***docker container run --publish 80:80 --detach --name webhost nginx***

Creates a new container with name **webhost**.

- ***docker container logs <container\_name>***

It spits out the latest logs in the web host.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container run --publish 80:80 --detach --name webhost nginx
d42da8ec7b15        nginx              "/docker-entrypoint..."   6 seconds ago      Up 5 seconds          0.0.0.0:80->80/tcp    webhost
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container ls -a
CONTAINER ID        IMAGE               COMMAND                  CREATED             STATUS              PORTS                 NAMES
d42da8ec7b15        nginx              "/docker-entrypoint..."   6 seconds ago      Up 5 seconds          0.0.0.0:80->80/tcp    webhost
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container logs webhost
/docker-entrypoint.sh: /docker-entrypoint.d/ is not empty, will attempt to perform configuration
/docker-entrypoint.sh: Looking for shell scripts in /docker-entrypoint.d/
/docker-entrypoint.sh: Launching /docker-entrypoint.d/10-listen-on-ipv6-by-default.sh
10-listen-on-ipv6-by-default.sh: Getting the checksum of /etc/nginx/conf.d/default.conf
10-listen-on-ipv6-by-default.sh: Enabled listen on IPv6 in /etc/nginx/conf.d/default.conf
/docker-entrypoint.sh: Launching /docker-entrypoint.d/20-envsubst-on-templates.sh
/docker-entrypoint.sh: Configuration complete; ready for start up
172.17.0.1 - - [07/Jun/2020:01:27:59 +0000] "GET / HTTP/1.1" 200 612 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_4) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/13.1 Safari/605.1.15"
172.17.0.1 - - [07/Jun/2020:01:28:00 +0000] "GET / HTTP/1.1" 200 612 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_4) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/13.1 Safari/605.1.15"
172.17.0.1 - - [07/Jun/2020:01:28:00 +0000] "GET / HTTP/1.1" 200 612 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_4) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/13.1 Safari/605.1.15"
172.17.0.1 - - [07/Jun/2020:01:28:01 +0000] "GET / HTTP/1.1" 200 612 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_4) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/13.1 Safari/605.1.15"
172.17.0.1 - - [07/Jun/2020:01:28:01 +0000] "GET / HTTP/1.1" 200 612 "-" "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_4) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/13.1 Safari/605.1.15"
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

- **`docker container top <container_name>`**

Helps to identify the processes running inside the container. In case of Nginx, there's actually a master process and then it spawns worker processes based on the configuration.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container top webhost
PID          USER          TIME          COMMAND
2109         root          0:00          nginx: master process nginx -g daemon off;
2164         101           0:00          nginx: worker process
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

- **`docker container -help`**

Get a list of commands we could try on that container

We will now try to remove our containers. To list the containers, we can type in **`docker container ls -a`**

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container ls -a
CONTAINER ID        IMAGE               COMMAND             CREATED            STATUS              PORTS               NAMES
d42da8ec7b15        nginx              "/docker-entrypoint..."   58 minutes ago    Up 58 minutes          0.0.0.0:80->80/tcp   webhost
dab0d9a7e0b5        nginx              "/docker-entrypoint..."   3 hours ago       Exited (0) 2 hours ago   confident_robinson
4bd9cf156353        nginx              "/docker-entrypoint..."   3 hours ago       Exited (0) 3 hours ago   crazy_antonelli
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

- **`docker container rm <container_ID_1> <container_ID_2> ... <container_ID_n>`**

Remove all the 3 containers at the same time.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container rm d42da dab0d 4bd9c
dab0d
4bd9c
Error response from daemon: You cannot remove a running container d42da8ec7b15bc1b6f4bafe1ec54590b0f2e3a399f79ce2b46a0cf4493ca5d66a. Stop the container before attempting removal or force remove
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

We got an error. The first two were safely deleted. We cannot remove a running container because it's a safety measure. It makes sure that we don't accidentally remove the actual process that's still running.

We can simply stop the container first and then remove it.

Alternatively,

- **Docker container rm -f <container\_ID>**

-f is for force. We will forcefully remove our active container.

```
[(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container rm -f d42da  
d42da  
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % ]
```

All our containers have been cleaned.

## 4. What happens when we run a Container?

When we type **`docker container run`**, in the background it's actually going to look for the image that we specified at the end of the command.

When we typed nginx at the very end, that was the name of the image we wanted to run as a new container.

1. Looks for that image locally in image cache, doesn't find anything
2. Then looks in remote image repository (defaults to Docker Hub)
3. Downloads the latest version (nginx: latest version by default) and stores it in the image cache.
4. Creates new container based on that image. It's not going to make a copy of the image. It's actually going to just start a new layer of changes, right on top of where that image left off.
5. It's going to customize the networking - give it a specific virtual IP address that's inside a Docker virtual network. Gives it a virtual IP on a private network inside docker engine.
6. Opens up port we specified on host and forwards to port 80 in container. If we didn't specify the **Publish** command, i.e., **--publish**, it's not going to open up any ports at all. Since we did the **80:80**, that's telling it to take the port 80 on the host and forward all that traffic to the port 80 in the container.
7. The container finally starts by using the command (CMD) specified in the Dockerfile.



## 5. Containers vs VM

Often people compare containers to VMs. True, there are some similarities, but there's so many things that aren't the same.

***But actually, containers are really just a process running on your host operating system and are nothing like a virtual machine.***

A few useful links:

- 1) [https://github.com/mikegcoleman/docker101/blob/master/  
Docker eBook Jan 2017.pdf](https://github.com/mikegcoleman/docker101/blob/master/Docker%20eBook%20Jan%202017.pdf)
- 2) [https://www.youtube.com/watch?v=sK5i-  
N34im8&feature=youtu.be&list=PLBmVKD7o3L8v7KI\\_XXh3KaJl9Qw2lyuFl](https://www.youtube.com/watch?v=sK5i-N34im8&feature=youtu.be&list=PLBmVKD7o3L8v7KI_XXh3KaJl9Qw2lyuFl)

## Assignment 1

### Assignment: Manage Multiple Containers

- docs.docker.com and --help are your friend
- Run a nginx, a mysql, and a httpd (apache) server
- Run all of them --detach (or -d), name them with --name
- nginx should listen on 80:80, httpd on 8080:80, mysql on 3306:3306
- When running mysql, use the --env option (or -e) to pass in MYSQL\_RANDOM\_ROOT\_PASSWORD=yes
- Use docker container logs on mysql to find the random password it created on startup
- Clean it all up with docker container stop and docker container rm (both can accept multiple names or ID's)
- Use docker container ls to ensure everything is correct before and after cleanup

#### Solution:

##### Initializing containers

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container run -d -p 80:80 --name nginxServer nginx
d4f7cb3401c4403c19a3ee9e9239671d944c5bdb39e49cf58b8295b90c95a3b601
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container run -d -p 8080:80 --name apacheServer httpd
72794e168334ca8f367ce9140184ef015cbe099721e48aecbfbd9056691c1d86
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container run -d -p 3306:3306 --name sqlServer --env MYSQL_RANDOM_ROOT_PASSWORD=yes mysql
771db4b77aa21e727f9135d24aceb146a8c186a873d11dec916d05d7c150a8a
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker ps
CONTAINER ID        IMAGE               COMMAND             CREATED            STATUS              PORTS                         NAMES
771db4b77aa2        mysql              "docker-entrypoint.s..."   3 seconds ago      Up 3 seconds       0.0.0.0:3306->3306/tcp, 33060/tcp   sqlServer
72794e168334        httpd              "httpd-foreground"     About a minute ago   Up About a minute  0.0.0.0:8080->80/tcp   apacheServer
d4f7cb3401c4        nginx              "/docker-entrypoint..."   About a minute ago   Up About a minute  0.0.0.0:80->80/tcp   nginxServer
```

## SQL Password from logs:

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container logs sqlServer
2020-06-07 05:44:58+00:00 [Note] [Entrypoint]: Entrypoint script for MySQL Server 8.0.20-1debian10 started.
2020-06-07 05:44:58+00:00 [Note] [Entrypoint]: Switching to dedicated user 'mysql'
2020-06-07 05:44:58+00:00 [Note] [Entrypoint]: Entrypoint script for MySQL Server 8.0.20-1debian10 started.
2020-06-07 05:44:58+00:00 [Note] [Entrypoint]: Initializing database files
2020-06-07T05:44:58.536493Z 0 [Warning] [MY-011070] [Server] 'Disabling symbolic links using --skip-symbolic-links (or equivalent) is the default. Consider not using this option as it' is deprecated and will be removed in a future release.
2020-06-07T05:44:58.536536Z 0 [System] [MY-013169] [Server] /usr/sbin/mysqld (mysqld 8.0.20) initializing of server in progress as process 42
2020-06-07T05:44:58.542956Z 1 [System] [MY-013576] [InnoDB] InnoDB initialization has started.
2020-06-07T05:44:59.193183Z 1 [System] [MY-013577] [InnoDB] InnoDB initialization has ended.
2020-06-07T05:45:04:522044Z 6 [Warning] [MY-011070] [Server] root@localhost is created with an empty password ! Please consider switching off the --initialize-insecure option.
2020-06-07 05:45:04+00:00 [Note] [Entrypoint]: Database files initialized
2020-06-07 05:45:04+00:00 [Note] [Entrypoint]: Starting temporary server
2020-06-07T05:45:04:58.958677Z 0 [Warning] [MY-011070] [Server] 'Disabling symbolic links using --skip-symbolic-links (or equivalent) is the default. Consider not using this option as it' is deprecated and will be removed in a future release.
2020-06-07T05:45:04:58.958692Z 0 [System] [MY-010116] [Server] /usr/sbin/mysqld (mysqld 8.0.20) starting as process 89
2020-06-07T05:45:04:58.958752Z 1 [System] [MY-013576] [InnoDB] InnoDB initialization has started.
2020-06-07T05:45:05.524627Z 1 [System] [MY-013577] [InnoDB] InnoDB initialization has ended.
2020-06-07T05:45:05.542768Z 1 [System] [MY-01123] [Server] X Plugin ready for connections. Socket: '/var/run/mysqld/mysql.sock'
2020-06-07T05:45:05.796932Z 0 [Warning] [MY-010068] [Server] CA certificate ca.pem is self signed.
2020-06-07T05:45:05.801049Z 0 [Warning] [MY-011810] [Server] Insecure configuration for --pid-file: Location '/var/run/mysqld' in the path is accessible to all OS users. Consider choosing a different directory.
2020-06-07T05:45:05.804914Z 0 [System] [MY-010931] [Server] /usr/sbin/mysqld: ready for connections. Version: '8.0.20' socket: '/var/run/mysqld/mysqld.sock' port: 0 MySQL Community Server - GPL
2020-06-07 05:45:05+00:00 [Note] [Entrypoint]: Temporary server started.
Warning: Unable to load '/usr/share/zoneinfo/iso3166.tab' as time zone. Skipping it.
Warning: Unable to load '/usr/share/zoneinfo/leap-seconds.list' as time zone. Skipping it.
Warning: Unable to load '/usr/share/zoneinfo/zone.tab' as time zone. Skipping it.
Warning: Unable to load '/usr/share/zoneinfo/zone1970.tab' as time zone. Skipping it.
2020-06-07 05:45:11+00:00 [Note] [Entrypoint]: GENERATED ROOT PASSWORD: oeL8shooxie4no2chathe9Ahoewohlee
2020-06-07 05:45:11+00:00 [Note] [Entrypoint]: Stopping temporary server
2020-06-07T05:45:11.712895Z 10 [System] [MY-013172] [Server] Received SHUTDOWN from user root. Shutting down mysqld (Version: 8.0.20).
2020-06-07T05:45:13.965371Z 0 [System] [MY-010910] [Server] /usr/sbin/mysqld: Shutdown complete (mysqld 8.0.20) MySQL Community Server - GPL.
2020-06-07 05:45:14+00:00 [Note] [Entrypoint]: Temporary server stopped
2020-06-07 05:45:14+00:00 [Note] [Entrypoint]: MySQL init process done. Ready for start up.
2020-06-07T05:45:14.981068Z 0 [Warning] [MY-011070] [Server] 'Disabling symbolic links using --skip-symbolic-links (or equivalent) is the default. Consider not using this option as it' is deprecated and will be removed in a future release.
2020-06-07T05:45:14.981230Z 0 [System] [MY-010116] [Server] /usr/sbin/mysqld (mysqld 8.0.20) starting as process 1
2020-06-07T05:45:14.990153Z 1 [System] [MY-013576] [InnoDB] InnoDB initialization has started.
2020-06-07T05:45:14.214212Z 1 [System] [MY-013577] [InnoDB] InnoDB initialization has ended.
2020-06-07T05:45:15.337699Z 0 [System] [MY-01123] [Server] X Plugin ready for connections. Socket: '/var/run/mysqld/mysql.sock' bind-address: '::' port: 33060
2020-06-07T05:45:15.429845Z 0 [Warning] [MY-010068] [Server] CA certificate ca.pem is self signed.
2020-06-07T05:45:15.433527Z 0 [Warning] [MY-011810] [Server] Insecure configuration for --pid-file: Location '/var/run/mysqld' in the path is accessible to all OS users. Consider
```

## Remove and Clean-Up

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container ls
CONTAINER ID        IMAGE               COMMAND             CREATED            STATUS              PORTS               NAMES
771db4b77aa2        mysql              "docker-entrypoint.s..."   5 minutes ago      Up 5 minutes          0.0.0.0:3306->3306/tcp, 33060/tcp   sqlServer
72794e168334        httpd              "httpd-foreground"    6 minutes ago      Up 6 minutes          0.0.0.0:8080->80/tcp   apacheServer
d4f7cb3401c4        nginx              "/docker-entrypoint..."  7 minutes ago      Up 7 minutes          0.0.0.0:80->80/tcp   nginxServer
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container stop 771 727 d4f
771
727
d4f
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container rm 771 727 d4f
771
727
d4f
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container ls
CONTAINER ID        IMAGE               COMMAND             CREATED            STATUS              PORTS               NAMES
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container ls -a
CONTAINER ID        IMAGE               COMMAND             CREATED            STATUS              PORTS               NAMES
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

## 6. What's Going On In Containers

- We will now run Docker commands to understand what's going on inside a container.

Start a few containers

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container run -d --name nginx nginx
d0bcc6e3a6b8bc753d9462b281e864a877e769bb94a83ae851e454122e8457be
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container run -d --name mysql -e MYSQL_RANDOM_ROOT_PASSWORD=true mysql
a238f804acaf82b53463bad1c98eba33beb61771841c41578043463e3a93f4
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container ls
CONTAINER ID        IMAGE               COMMAND                  CREATED             STATUS              PORTS                 NAMES
a238f804acaf        mysql              "docker-entrypoint.s..."   5 seconds ago       Up 4 seconds          3306/tcp, 33060/tcp   mysql
d0bcc6e3a6b8        nginx              "/docker-entrypoint..."   About a minute ago  Up About a minute    80/tcp                nginx
```

- **`docker container top <container_name>`**

Process list in one container

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container top mysql
PID      USER      TIME      COMMAND
1806     999      0:01      mysqld
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container top nginx
PID      USER      TIME      COMMAND
1716     root      0:00      nginx: master process nginx -g daemon off;
1772     101      0:00      nginx: worker process
```

- **`docker container inspect <container_name>`**

Details of how the container started and how it's configured and all of its metadata (startup, config, volumes, networking, etc). **Format:** JSON

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container inspect mysql
[{"Id": "a238f804acaf82b53463bad1c98eba33beb61771841c41578043463e3a93f4",
 "Created": "2020-06-08T22:06:16.4673558Z",
 "Path": "docker-entrypoint.sh",
 "Args": [
   "mysqld"
 ],
 "State": {
   "Status": "running",
   "Running": true,
   "Paused": false,
   "Restarting": false,
   "OOMKilled": false,
   "Dead": false,
   "Pid": 1806,
   "ExitCode": 0,
   "Error": "",
   "StartedAt": "2020-06-08T22:06:16.8948519Z",
   "FinishedAt": "0001-01-01T00:00:00Z"
 },
 "Image": "sha256:30f937e841c82981a9a6363f7f6f35ed6b9d5e3f16df50a72207e4a2a38983f",
 "ResolvConfPath": "/var/lib/docker/containers/a238f804acaf82b53463bad1c98eba33beb61771841c41578043463e3a93f4/resolv.conf",
 "HostnamePath": "/var/lib/docker/containers/a238f804acaf82b53463bad1c98eba33beb61771841c41578043463e3a93f4/hostname",
 "HostsPath": "/var/lib/docker/containers/a238f804acaf82b53463bad1c98eba33beb61771841c41578043463e3a93f4/hosts",
 "LogPath": "/var/lib/docker/containers/a238f804acaf82b53463bad1c98eba33beb61771841c41578043463e3a93f4/a238f804acaf82b53463bad1c98eba33beb61771841c41578043463e3a93f4-json.log",
 "Name": "mysql",
 "RestartCount": 0,
 "Driver": "overlay2",
 "Platform": "linux",
 "MountLabel": ""},
```

- **docker container stats**

Gives us a view of all our containers and the performance statistics for each in a real time stream.

CONTAINER ID	NAME	CPU %	MEM USAGE / LIMIT	MEM %	NET I/O	BLOCK I/O	PIDS
a238f804acaaf	mysql	1.57%	322.6MiB / 3.848GiB	8.19%	1.08kB / 0B	0B / 0B	38
d0bcc6e3a6b8	nginx	0.00%	2.523MiB / 3.848GiB	0.06%	1.87kB / 0B	0B / 0B	2

We get a streaming view of live performance data about our containers. Obviously in a production environment, we're going to have a more complicated monitoring and performance.

## 7. Getting a Shell Inside Containers

This is all about getting into a container to mess around with the inside. No SSH needed, the docker cli is a great substitute for adding SSH to containers.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container ps
CONTAINER ID        IMAGE               COMMAND                  CREATED             STATUS              PORTS               NAMES
87f2b708fbe9        mysql              "docker-entrypoint.s..."   6 seconds ago      Up 5 seconds      3306/tcp, 33060/tcp   mysql
77f26a92c9f4        nginx             "/docker-entrypoint...."  14 seconds ago     Up 13 seconds     80/tcp              nginx
```

- **`docker container run -it <image> [COMMANDS] [ARG ...]`**

Start a new container interactively. The `-it` is actually two separate options. The '`t`' actually gives us a pseudo-tty which simulates a real terminal, like what SSH does. The '`i`' (interactive) allows us to keep that session open so that we can keep running more commands. When we're doing a docker container run, we have optional command and arguments that we can send in to the new container we're about to start to tell it what to run.

**Command:** bash

If the above command is run with `-it`, it will give us a terminal inside the running container. Notice when we run the command, we act as root on the container (and not the host). The number following it is actually the container ID. We can enter the standard bash commands: `ls -al`, `pwd`, `cd`, .... Type `exit` to stop the container.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container run -it --name proxy nginx bash
root@24f25dd60871:/# ls
bin boot dev docker-entrypoint.d docker-entrypoint.sh etc home lib lib64 media mnt opt proc root run sbin srv sys tmp usr var
root@24f25dd60871:/# pwd
/
root@24f25dd60871:/# ls -al
total 80
drwxr-xr-x  1 root root 4096 Jun  9 21:50 .
drwxr-xr-x  1 root root 4096 Jun  9 21:50 ..
-rw-rxr-x  1 root root    0 Jun  9 21:50 .dockercfg
drwxr-xr-x  2 root root 4096 May 14 14:50 bin
drwxr-xr-x  2 root root 4096 May  2 16:39 boot
drwxr-xr-x  5 root root 360 Jun  9 21:50 dev
drwxr-xr-x  1 root root 4096 Jun  2 16:23 docker-entrypoint.d
-rwxrwxr-x  1 root root 1087 Jun  2 00:35 docker-entrypoint.sh
drwxr-xr-x  1 root root 4096 Jun  9 21:50 etc
drwxr-xr-x  2 root root 4096 May  2 16:39 home
drwxr-xr-x  1 root root 4096 Jun  2 00:35 lib
drwxr-xr-x  2 root root 4096 May 14 14:50 lib64
drwxr-xr-x  2 root root 4096 May 14 14:50 media
drwxr-xr-x  2 root root 4096 May 14 14:50 mnt
drwxr-xr-x  2 root root 4096 May 14 14:50 opt
dr-xr-xr-x 151 root root    0 Jun  9 21:50 proc
drwx----- 2 root root 4096 May 14 14:50 root
drwxr-xr-x  3 root root 4096 May 14 14:50 run
drwxr-xr-x  2 root root 4096 May 14 14:50 sbin
drwxr-xr-x  2 root root 4096 May 14 14:50 srv
dr-xr-xr-x 12 root root    0 Jun  9 21:50 sys
drwxrwxrwt  1 root root 4096 Jun  2 00:35 tmp
drwxr-xr-x  1 root root 4096 May 14 14:50 usr
drwxr-xr-x  1 root root 4096 May 14 14:50 var
root@24f25dd60871:/# exit
exit
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

Let's see the command that it ran. The default command for an Nginx container is to run the Nginx program itself. But when we typed our last command, we changed that default program to actually be Bash, which gave us our shell. When we exited the shell, the container stopped. Because containers only run as long as the command that it ran on startup runs. Since we changed it to Bash, simply exiting Bash quit it.

CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS	NAMES
24f25da60871	nginx	"/docker-entrypoint..."	12 minutes ago	Exited (0) 6 minutes ago		proxy
87f2b708fbe9	mysql	"docker-entrypoint.s..."	27 minutes ago	Up 27 minutes	3306/tcp, 33060/tcp	mysql
77f26a92c9f4	nginx	"/docker-entrypoint..."	27 minutes ago	Up 27 minutes	80/tcp	nginx

The command is different from the first Nginx server.

- Let's set up a container with a full distribution of Linux instead of actually doing the Nginx.

**`docker container run -it --name ubuntu ubuntu`**

The above command is going to download the Ubuntu image and place us in the prompt of this new container. Its default CMD is bash, so we don't have to specify it. We can use the apt package manager just like how we would in a standard Ubuntu server. We can actually install something: **`apt-get install -y curl`**

The thing about Ubuntu and other distributions inside a container is that they're usually very minimal. A live CD or the ISO of Ubuntu which we would normally put on a Virtual Machine is going to have a lot more software installed by default than a Ubuntu container. We can always add more software to with the apt package manager.

Once we exit the shell again, it will actually stop the container. If we start it again, it would have curl installed in it. But if we create a new container from Ubuntu image, that different container wouldn't have curl command line installed.

```
[base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container run -it --name ubuntu ubuntu
Unable to find image 'ubuntu:latest' locally
latest: Pulling from library/ubuntu
d51af753c3d3: Pull complete
fc878cd0a91c: Pull complete
6154df8ff988: Pull complete
fee5db0ff82f: Pull complete
Digest: sha256:747d2dbbaaee995098c9792d99bd333c6783ce56150d1b11e333bbceed5c54d7
Status: Downloaded newer image for ubuntu:latest
```

```
[root@7288bcc1bd9e:/# apt-get update
Get:1 http://security.ubuntu.com/ubuntu focal-security InRelease [107 kB]
Get:2 http://archive.ubuntu.com/ubuntu focal InRelease [265 kB]
Get:3 http://security.ubuntu.com/ubuntu focal-security/main amd64 Packages [118 kB]
Get:4 http://security.ubuntu.com/ubuntu focal-security/universe amd64 Packages [40.7 kB]
Get:5 http://security.ubuntu.com/ubuntu focal-security/restricted amd64 Packages [10.6 kB]
Get:6 http://security.ubuntu.com/ubuntu focal-security/multiverse amd64 Packages [1077 B]
Get:7 http://archive.ubuntu.com/ubuntu focal-updates InRelease [107 kB]
Get:8 http://archive.ubuntu.com/ubuntu focal-backports InRelease [98.3 kB]
Get:9 http://archive.ubuntu.com/ubuntu focal/multiverse amd64 Packages [177 kB]
Get:10 http://archive.ubuntu.com/ubuntu focal/main amd64 Packages [1275 kB]
Get:11 http://archive.ubuntu.com/ubuntu focal/universe amd64 Packages [11.3 MB]
Get:12 http://archive.ubuntu.com/ubuntu focal/restricted amd64 Packages [33.4 kB]
Get:13 http://archive.ubuntu.com/ubuntu focal-updates/main amd64 Packages [237 kB]
Get:14 http://archive.ubuntu.com/ubuntu focal-updates/multiverse amd64 Packages [1077 B]
Get:15 http://archive.ubuntu.com/ubuntu focal-updates/restricted amd64 Packages [13.1 kB]
Get:16 http://archive.ubuntu.com/ubuntu focal-updates/universe amd64 Packages [129 kB]
Get:17 http://archive.ubuntu.com/ubuntu focal-backports/universe amd64 Packages [2903 B]
Fetched 14.0 MB in 3s (4816 kB/s)
Reading package lists... Done
```

```
[root@7288bcc1bd9e:/# apt-get install -y curl
Reading package lists... Done
Building dependency tree
Reading state information... Done
```

```
[root@7288bcc1bd9e:/# curl google.com
<HTML><HEAD><meta http-equiv="content-type" content="text/html; charset=utf-8">
<TITLE>301 Moved</TITLE></HEAD><BODY>
<H1>301 Moved</H1>
The document has moved
<A HREF="http://www.google.com/">here</A>.
</BODY></HTML>
root@7288bcc1bd9e:/#
```

- We can start our container again using

```
docker container start -ai <container_name>
```

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container ls -a
CONTAINER ID        IMAGE               COMMAND             CREATED            STATUS              PORTS               NAMES
7288bcc1bd9e        ubuntu              "/bin/bash"        20 minutes ago   Exited (127) 3 minutes ago
24f25da60871        nginx              "/docker-entrypoint..."  About an hour ago   Exited (0) 55 minutes ago
87f2b708fbe9        mysql              "/docker-entrypoint..."  About an hour ago   Up About an hour
77f26a92c9f4        nginx              "/docker-entrypoint..."  About an hour ago   Up About an hour
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container start --help
Usage: docker container start [OPTIONS] CONTAINER [CONTAINER...]
Start one or more stopped containers
Options:
  -a, --attach           Attach STDOUT/STDERR and forward signals
  --checkpoint string    Restore from this checkpoint
  --checkpoint-dir string Use a custom checkpoint storage directory
  --detach-keys string   Override the key sequence for detaching a container
  -i, --interactive      Attach container's STDIN
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container start -ai ubuntu
[root@7288bcc1bd9e:/# ls -a
. . . .dockerenv bin boot dev etc home lib lib32 lib64 libx32 media mnt opt proc root run sbin srv sys tmp usr var
root@7288bcc1bd9e:/# ]
```

- **docker container exec [OPTIONS] CONTAINER COMMAND [ARG ...]**

Run additional command in existing container. This helps us run the shell inside a container that's already running something like Nginx or MySQL.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container exec --help
Usage: docker container exec [OPTIONS] CONTAINER COMMAND [ARG...]
Run a command in a running container
Options:
  -d, --detach           Detached mode: run command in the background
  --detach-keys string   Override the key sequence for detaching a container
  -e, --env list          Set environment variables
  -i, --interactive      Keep STDIN open even if not attached
  --privileged           Give extended privileges to the command
  -t, --tty               Allocate a pseudo-TTY
  -u, --user string       Username or UID (format: <nameluid>[:<groupgid>])
  -w, --workdir string    Working directory inside the container
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % ]
```

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container exec -it mysql bash
[root@87f2b708fbe9:/# ps aux
USER      PID %CPU %MEM    VSZ   RSS TTY      STAT START  TIME COMMAND
mysql        1  0.9  8.7 1724908 353268 ?      Ssl  21:35  0:47 mysqld
root       602  1.0  0.0  3868  3248 pts/0     Ss   22:57  0:00 bash
root       608  0.0  0.0  7640  2660 pts/0     R+   22:57  0:00 ps aux
[root@87f2b708fbe9:/# exit
exit
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

When we exit this bash shell, the mysql container is still running. Because the docker container ever actually runs an additional process on an existing running container, it's not going to affect the root process for the MySQL daemon.

This is very useful for jumping into containers when we need to troubleshoot or when we need to change something slightly on a running system, as well as using containers of different distributions to give us the environment we would have if we had a full machine like Ubuntu or an Alpine.

- Different Linux distros in containers

Alpine is a small security-focused distribution of Linux.

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker pull alpine
Using default tag: latest
dockelatest: Pulling from library/alpine
df20fa9351a1: Already exists
imageDigest: sha256:185518070891758909c9f839cf4ca393ee977ac378609f700f60a771a2dfe321
Status: Downloaded newer image for alpine:latest
docker.io/library/alpine:latest
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker image ls
REPOSITORY      TAG      IMAGE ID      CREATED      SIZE
nginx          latest    4392e5dad77d    7 days ago   132MB
bash           latest    0980cb958276    10 days ago  13.1MB
alpine          latest    a24bb4013296   11 days ago  5.57MB
mysql          latest    30f937e841c8    2 weeks ago  541MB
httpd          latest    d4e60c8eb27a    3 weeks ago  166MB
ubuntu          latest    1d622ef86b13   6 weeks ago  73.9MB
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

Let's do a Bash shell inside of Alpine. We get the following error:

```
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ % docker container run it alpine bash
unable to find image 'it:latest' locally
docker: Error response from daemon: pull access denied for it, repository does not exist or may require 'docker login': denied: requested access to the resource is denied.
See 'docker run --help'.
(base) hetanshmehta@Hetanshs-MacBook-Pro ~ %
```

This is because Bash isn't in the container. And this goes back to the concept that we can only run things in the container that already exists in its image when we start it or maybe something we've added through the exec or run commands.

Alpine does contain '**sh**' which we can make use of and install Bash by using its package manager '**apk**'.

### **Resources:**

Package Management:

<https://www.digitalocean.com/community/tutorials/package-management-basics-apt-yum-dnf-pkg>

## 8. Docker Networks: Concepts for Private and Public Comms in Containers