**What problem does docker solve?**

This is the fundamental question of everyone who wants to start out with Docker. Let’s answer the question in the clearest and simplest way possible, with everyday words, not Docker terminology.

**What problem does Docker solve?** Docker solves the problem of having identical environments across various stages of development and having isolated environments for your individual applications.

The problem itself is as old as software development. Environment setup and management is a tedious task in every project.

In the old days we used custom scripts for that. We used to host various different applications on the same physical machine without any virtualization. It was usually a configuration nightmare to juggle with environment variables, trying to keep applications independently configurable or using two different versions of the same technology (like Java) on the same machine.

It used to be common practice to run your production applications on dedicated machines, while development or test environments were clattered with a lot of different applications to save hardware cost. In these cases your development and test servers were configured much differently than your production server.

Our infrastructure teams used to create different environment scripts for different stages, like development, test, staging and production. These environments were not identical, just mostly similar.

On top of all this, we used to do our local development and unit testing on Windows machines, while all other stages were run on Unix systems.

Working like this was not impossible, but it was a costly, time consuming effort to manage these environments with a lot of inherent risk that caused a lot of quality issues in all stages.

Docker provides a solution to this problem with containerization.

## **What is containerization?**

Containerization means, that your application runs in an isolated container, that is an explicitly defined, reproducable and portable environment. The analogy is taken from freight transport where you ship your goods in containers.

A container of an app is the app’s operating environment in our computing scenario. With Docker you ship the operating environment along with your application.

Containerization is not a new phenomenon, Linux Containers have been around for a while already, added to the Linux kernel in 2008. You can google LXC to learn more about the topic.

Linux containers aim to solve the same problem. They are self contained execution environments that act like they were standalone Linux machines, they have their own dedicated hardware resources. In reality they are not separate machines, because containers run on top of the same Linux kernel.

In other words you can install one Linux system and create several containers on top of it, that you can use as isolated machines, while they are actually running on the same Linux machine and share most of the core resources.

The key here is resource sharing. Docker started out creating specialized Linux containers. The idea is the same. You don’t need a separate, full blown physical or virtual machine to give isolated environments to your applications.

You can put your applications into containers that share most resources amongst each other. Containers are only different in the necessary minimum that is required to behave like an isolated environment.

**Running Docker on your machine**

**In order to use Docker on your local machine or on your server, you need Docker Engine.** [You can download and install Docker Engine for Mac, Windows and Linux from the Docker site, follow this link.](https://docs.docker.com/engine/installation/)

Please note that the way we run Docker on Mac and Windows used to be much different not too long ago. I’m writing this on October 13th, 2016. If you see tutorials that say that you need Docker Toolbox, Docker Machine or boot2docker to run docker containers on Mac and Windows, then be aware that those are outdated.

Those tools were required because Docker did not have native support on Mac and Windows, so you had to run a virtual machine and Docker Machine and boot2docker gave you the tools to do that.

Today Docker for Mac and Windows give you native tools to run docker on your machine. They run Linux under the hood, but it’s incorporated into an official native app. You may still find yourself in situations when you need Docker Toolbox or boot2docker, one such scenario is when you use a Mac produced before 2010.

Installation of Docker for Mac and Windows is done with a wizard, please follow the steps and come back when you are done. Linux installation requires a few more manual steps, you’ll find distro specific instructions on the Docker link above.

When the installation is complete you should have Docker Engine up and running on your machine.

If you are on Mac, you can check the little whale icon in the top bar near the clock. You should be having the necessary command line tools to run containers. Let’s check if this is the case. Let’s run these commands in the Terminal app.

➜ ~ docker --version

Docker version 1.12.1, build 6f9534c

➜ ~ docker-compose --version

docker-compose version 1.8.0, build f3628c7

**docker --version** and **docker-compose --version** show the version information of two essential Docker tools. If the above works, you are ready to move on to the next step.

## **What are the building blocks of Docker?**

We have seen the containers I’m running on my machine. Let’s see where they come from.

The three containers I had up were nginx proxy, mariadb and Wordpress. I created them from Docker Images. Let’s look at this terminology.

A Docker image is the definition of a container. To make it really clear, an image is like a snapshot a software component. It contains the required executables, environment settings, so that it gives you a turn key solution. You just type **docker run** and a preconfigured image will be used to start a container.

In other words a container is a running instance of an image.

You can use the same image to start multiple containers. You can add runtime parameters to adjust some settings like port mappings, shared volumes and such.

The first thing you need for your development is the image that servers your goals

## **Docker images**

Images may come from two sources:

* image repository, I use the [Docker Hub](https://hub.docker.com/explore/), I’m not aware of any other significant repository, the hub serves me well.
* you can create your own images. We will talk about this in more details, because this part is awesome. Docker images are layered, so you can build them layer by layer, and you can build your images starting from other images.

Let’s just visit [Docker Hub](https://hub.docker.com/explore/) and lay your hands on your first image. You can sign up if you want to, you don’t need a registration to browse and use images though.

Moving on, the page explains what Nginx is.

If we want to use this image, we can do two things:

* pull the image with **docker pull**. Docker pull will just download the image locally and you’ll see it in your image list.
* you can run the image with **docker run**, this will pull the image, if it’s not available locally and then run it. Run is just a one step solution to pull and run.

Whichever you use is a matter of personal preference.

Beginner tutorials will tell you to run the image straight away. I build solutions where several containers play together, so I usually pull the big picture first and then start tuning the execution parameters.

So, let’s just pull first. :) We will specify the version when we do so. Let’s pick the alpine variant. Issue this command in Terminal:

**docker pull nginx:1.10.1-alpine**

## **Running your first container**

I typed almost a whopping 2900 words so far. All of the above shall become a 5 second routine pretty quickly, so don’t worry, just practice. Take a deep breath, we’ll start our first container.

Please make sure that you’re not running a web server on your local machine on port 80, otherwise we’ll have a conflict. The Terminal command is:

**docker run --name my-nginx -p 80:80 nginx:1.10.1-alpine**

**docker run** is the command that starts up containers from images. If it cannot find the image locally it will pull it for you.

With **--name my-nginx** you can give your container a human readable name. When I run several wordpress containers, I usually use the site name to distinguish my apps. **--name** is optional, Docker will give your containers funny names if you don’t provide this parameter.

Without **-p 80:80** you can’t make the nginx server functional. This parameter maps the container’s port 80 to the host computer’s port 80.

what does this mean? This is needed because images, and thus running containers, expose pre-defined ports to the external world. Our Nginx container exposes ports 80 and 443 for http and https requests. (I found this information in the Dockerfile of the nginx image on the Docker hub). This means that you can send request to port 80 and 443 of your container. It does not mean that your local machine is listening on these ports.

In order to make a certain application available on your local machine, we have to map its port to the local machine’s port. This is done with **-p host-port:container-port**, in our case **-p 80:80**.

The computer that’s running the Docker Engine is called the host computer. In my case the host computer is my Mac, I run the Docker Engine with Docker for Mac. You installed yours at the beginning of the tutorial. So the machine that runs Docker engine is the host machine.

Your ultimate goal is to compose the services of your host with one or more Docker containers. Containers behave like standalone virtual machines. They have their own Linux file system, users, hardware resources, environment variables, executables and so on. Containers expose their services on pre-defined ports.

You may want to run more than one Nginx container on your host machine, when building multiple sites. In my case I run several wordpress containers and node containers on my Mac (and also in production). All your Nginx containers will expose port 80. You gotta find a way to send request to your container’s port 80 from your host machine. Therefore you have to map one of your host ports to the container port.

So what we did above was that we mapped **-p host:container**, i.e. **-p 80:80**, which means that **http://localhost:80** will be served by your container’s port 80. Since port 80 is the default http port, you don’t need to type that. (oh sorry, I’m going really basic here, but I think there are millions of young kids willing to code, and I wanna give them a chance to keep up). So **http://localhost** will go to your container’s port 80.

If you wanted to assign a different port on your host, let’s say 8080, you would use **-p 8080:80** in the above parameter. This would publish your nginx server on **http://localhost:8080**.

Let’s go back to our original scenario, open your browser now and check [**http://PublicIP**](http://publicip) **of Ec2**. You should see this:

## **Working with containers**

This container is running in the foreground. If you look at your terminal, you’ll see the requests appearing as you refresh the page. Let’s leave it like this for a while and focus on more substantial matters. Let’s open another terminal window, or terminal tab and use the command:

**docker ps**

➜ ~ docker ps

CONTAINER ID IMAGE COMMAND

CREATED STATUS PORTS NAMES

01041c82947c nginx:1.10.1-alpine "nginx -g 'daemon off"

41 minutes ago Up 41 minutes 0.0.0.0:80->80/tcp, 443/tcp my-nginx

3 weeks ago 54.03 MB

**docker ps** gives you the list of running containers. These containers are pre-configured running applications. This gives you a lot of flexibility in practice, you can stop a container with **docker stop**, start it again with **docker start** or restart it with **docker restart**.

What you cannot do though is, you cannot change a container. You cannot for example change the port mapping of an existing container. Containers are immutable. Once created, they retain the configuration they were created with. Makes sense if you don’t want to end up in a configuration spaghetti.

If you want to change the runtime parameters of a container, you’ll have to stop the container and remove it. Then you need to create a new container from the image with new runtime parameters. Let’s change our container so that it runs in the background.

Let’s issue the command **docker stop my-nginx** to stop the container.

Execute **docker ps** and note that the container has disappeared.

Run **docker ps -a**, this will list all containers, also the ones that are stopped. You’ll see your container here. If you used **docker start my-nginx** now, your container would start, but this is not what we want.

Run **docker rm my-nginx**

. This will remove the container. I usually remove my unused containers immediately.

Let’s start a new container with new parameters:

**docker run --name my-nginx -d -p 80:80 nginx:1.10.1-alpine**

We added **-d** to start the container in detached mode, so it will run in the background. **http://localhost** should display the page we saw before.

Use **docker logs my-nginx** now to see the logs, or **docker logs -f my-nginx** to leave logs open in terminal and follow the requests.

Use **docker inspect my-nginx** to see the details of your container.

## **Executing commands in a running container**

This an interesting possibility. Let’s do the following:

**docker exec -ti my-nginx /bin/sh**

This command starts an interactive shell in our running container. You’ll get a shell with root access and will see all the Linux file system.

If you look around you’ll see that the container bears all the characteristics of a full blown Linux OS. If you type **env** you can review the environment variables, you can also look at the file system, if you wish.

You can use **docker exec** to execute a command in a running container. I haven’t used this in any serious business scenario, yet. I just use this option to look inside containers.

Let’s use **exit** to leave the shell and return to our terminal.

## **Data in Docker containers**

Now that we learnt so much about containers, let’s see another crucial aspect. Containers are meant to be stateless. This means that they are reproduced exactly as they were defined and they don’t carry any information with them from any runtime.

What do you need to do about this? If you change some data in a container during runtime, like data in a mariadb container for example, that data will be available only in that specific container instance. If you stop and restart your container your data will still be there. But if you stop and remove your container to start it with new parameters your data will be lost.

Code behaves in a similar way. You can copy your code when you build your image (I’ll show that later). When your code changes you have to re-build the image, destroy your containers and start new ones with the new image.

In order to manage data and code changes in a meaningful way, we can share volumes (meaning data volumes) between the host and the container. This is super important and I use this in all containers that I have.

Using volumes I can keep my mariadb data outside the container, or I can serve my local development directory with a Docker container.

We will use a config file on the host computer and mount it into our Nginx server.

### Mount a config file

Let’s create a directory for this step, and create a file called **nginx.conf** inside. The absolute path of my **nginx.conf** file on my local machine is this **/Users/marktakacs/Development/tutorials/docker/nginx.conf**.

For the sake of the tutorial let’s copy the default nginx configuration from the container into the **nginx.conf** file on the host. This doesn’t make much functional sense, it’s just a technical example. Let’s use this content:

Sample code of Nginx

user nginx;

worker\_processes 1;

error\_log /var/log/nginx/error.log warn;

pid /var/run/nginx.pid;

events {

worker\_connections 1024;

}

http {

include /etc/nginx/mime.types;

default\_type application/octet-stream;

log\_format main '$remote\_addr - $remote\_user [$time\_local] "$request" '

'$status $body\_bytes\_sent "$http\_referer" '

'"$http\_user\_agent" "$http\_x\_forwarded\_for"';

access\_log /var/log/nginx/access.log main;

sendfile on;

#tcp\_nopush on;

keepalive\_timeout 65;

#gzip on;

include /etc/nginx/conf.d/\*.conf;

}

We’ll map this file as a volume into our container. As a result our nginx.conf file on the host machine will be shared with the container. If you change the file on the host, the container will pick up the changes.

Let’s **docker stop my-nginx** and **docker rm my-nginx** and then recreate the continer with the following command:

**docker run --name my-nginx -d -p 80:80 -v /Users/marktakacs/Development/tutorials/docker/nginx.conf:/etc/nginx/nginx.conf:ro nginx:1.10.1-alpine**

I added the part that that starts with **-v**, this maps the local directory to the container. Make sure that you use your own local path as the first parameter after **-v**. **/etc/nginx/nginx.conf** is the path of the nginx.conf file in the container, you can find this information on the image’s page on the Docker Hub, too.

**:ro** means that we mount the volume in read only mode.

Now our container uses the config file on the local machine. How can you test this?

Open the **nginx.conf** file locally in a text editor like Vim, and remove the **#** from the line that says **#gzip on;**. You just uncommented the gzip feature of nginx, now nginx will send the responses compressed.

Restart the container so it will pick up the new configuration with **docker restart my-nginx**.

You can check compression in Chrome developer tools, under the Network tab and clicking the entry ‘localhost’. This is my response before and after the change.

Check with google help here

### Using source code from the host

Wow, how about source code? Let’s add a webpage to nginx with another volume mapping. Create a directory called **src** and create a file called **index.html** in that directory. Copy this inside:

<p>It’s time to update Docker server</p>

**docker stop my-nginx** and **docker rm my-nginx** before we recreate it. Use a command similar to mine:

**docker run --name my-nginx -d -p 80:80 -v /Users/marktakacs/Development/tutorials/docker/nginx.conf:/etc/nginx/nginx.conf:ro -v /Users/marktakacs/Development/tutorials/docker/src:/usr/share/nginx/html:ro nginx:1.10.1-alpine**

We added a new volume **-v** parameter to the command. It points to the **src** folder on the host (please use your own full path) and mounts it to **/usr/share/nginx/html** in the container. Again I got the container path of html files on Docker Hub. If you go to **http://localhost** now, you should see a familiar hello world page.