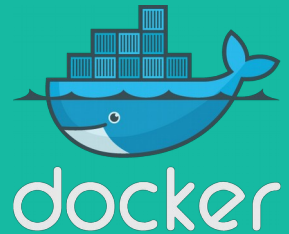


Introduction to Docker



Agenda

- Motivation: Shift from Monolithic to Microservices Architectures
- The problem solved by Docker
- How Docker is different from Virtual Machines
- Docker workflow: Build, Ship and Run
- Docker commands
- Hands-on exercise

Applications have changed dramatically

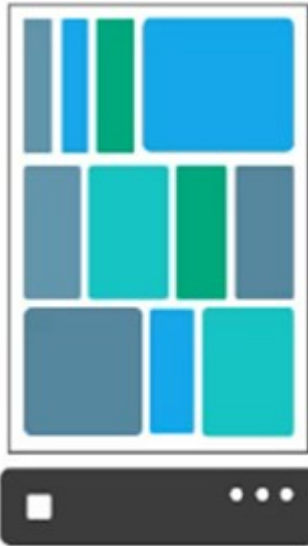
~2000

Today

Monolithic

Slowly-changing

Big (bare metal)
server



A Decade ago (and still valid)

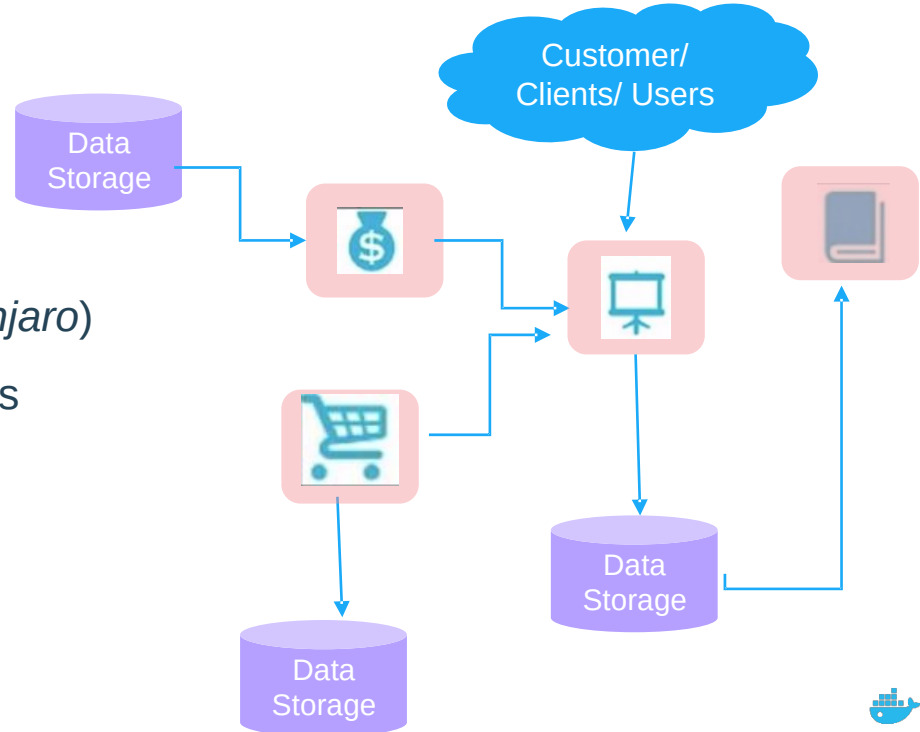
- Apps were monolithic
- Built on a single stack such as .NET or Java
- Long Lived
- Deployed to a single server

Applications have changed dramatically



Today

- Apps are constantly developed
- Newer version are deployed often (*Manjaro*)
- Built from **loosely coupled** components
- Deployed to a multitude of servers



Once upon a time... *A software stack*

(Linux, Apache, MySQL, PHP)

LAMP

.....



Now....much more distributed, complex...

Static website

nginx 1.5 + modsecurity + openssl +
bootstrap 2

User DB

postgresql + pgv8 + v8

Analytics DB

hadoop + hive + thrift + OpenJDK

Queue

Redis + redis-sentinel

Background workers

python 3.0 + celery + pyredis + libcurl + ffmpeg
+ libopencv + nodejs + phantomjs

Web frontend

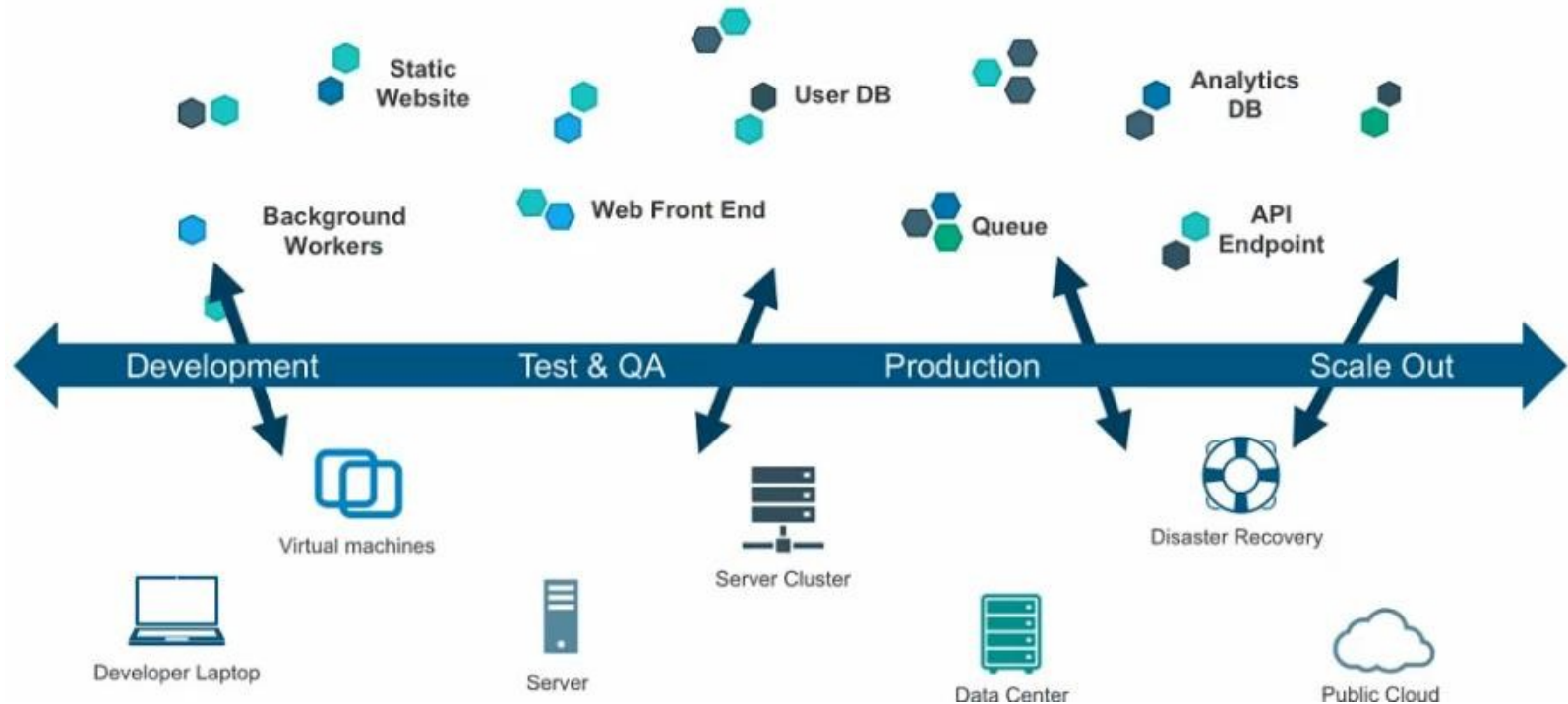
Ruby + Rails + sass + Unicorn

API endpoint

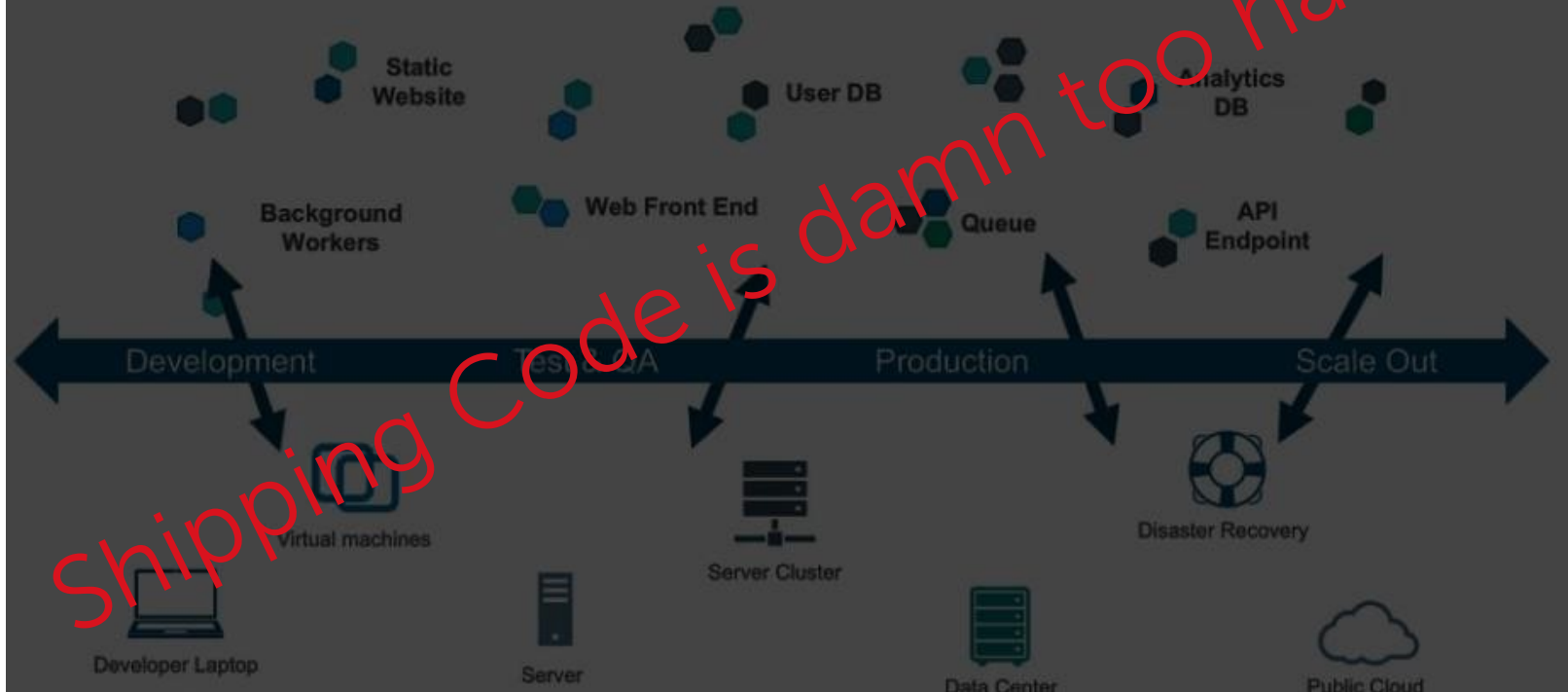
Python 2.7 + Flask + pyredis + celery + pycop
+ postgresql-client



The New Challenge of Distributed Apps















The New Challenge of Distributed Apps



An Effort to “host” different “stacks”...



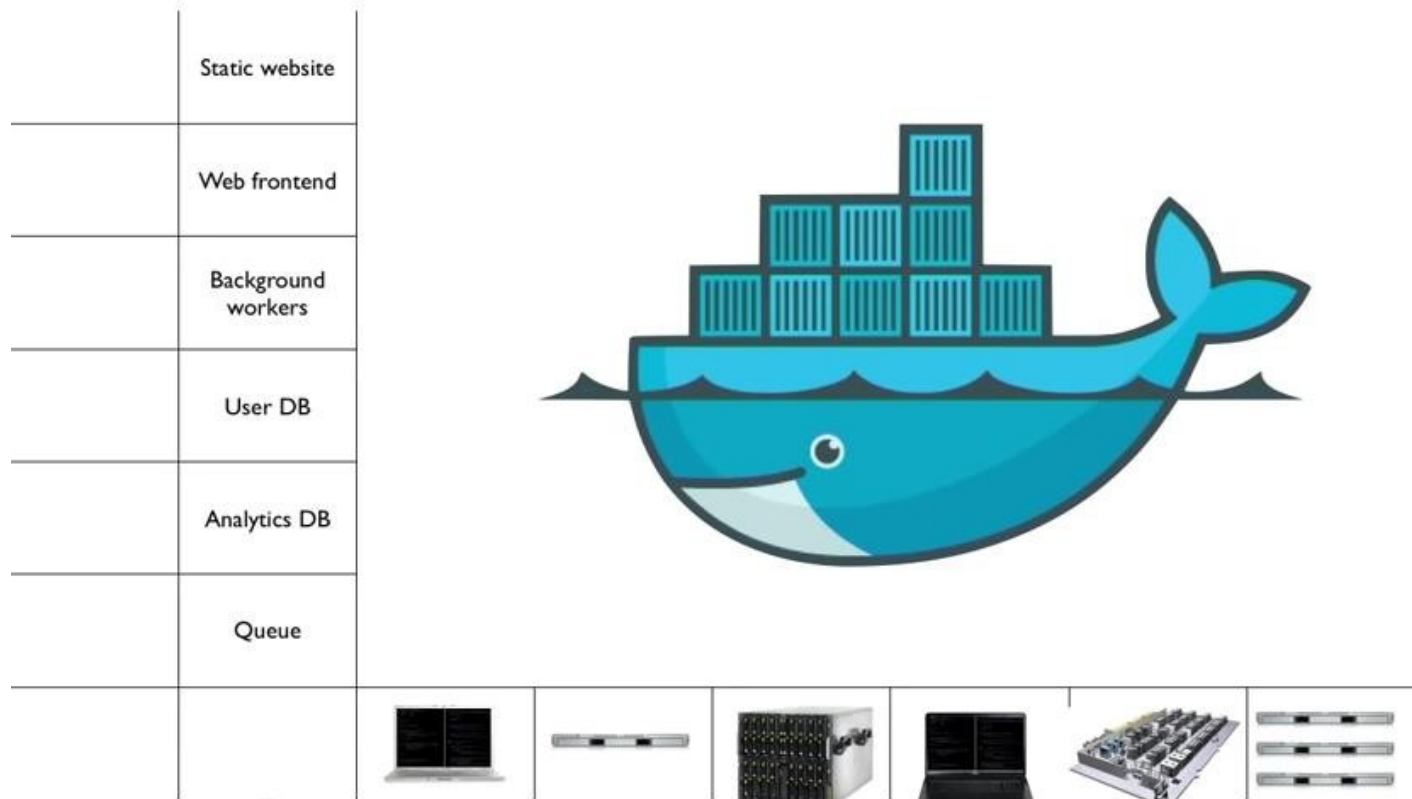
(Every possible goods) x (Every possible way to ship)

	?	?	?	?	?	?
	?	?	?	?	?	?
	?	?	?	?	?	?
	?	?	?	?	?	?
	?	?	?	?	?	?
	?	?	?	?	?	?
						

A Solution...



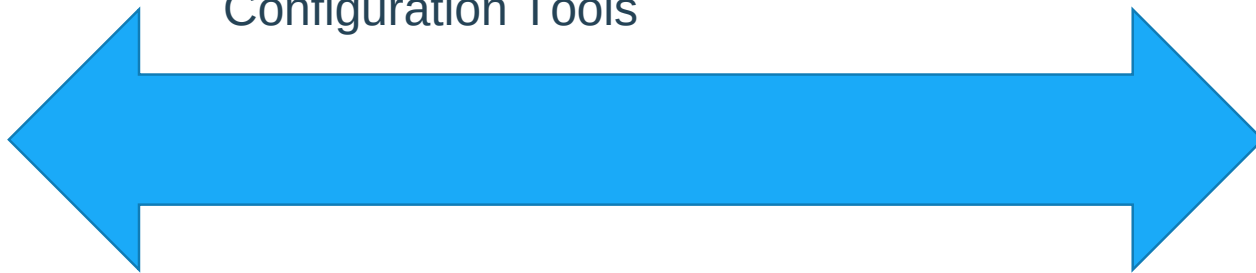
Docker ~ Brings standardization on packaging stacks



Less Portable,
Minimal Overhead

More Portable,
Lots of Overhead

Configuration Tools



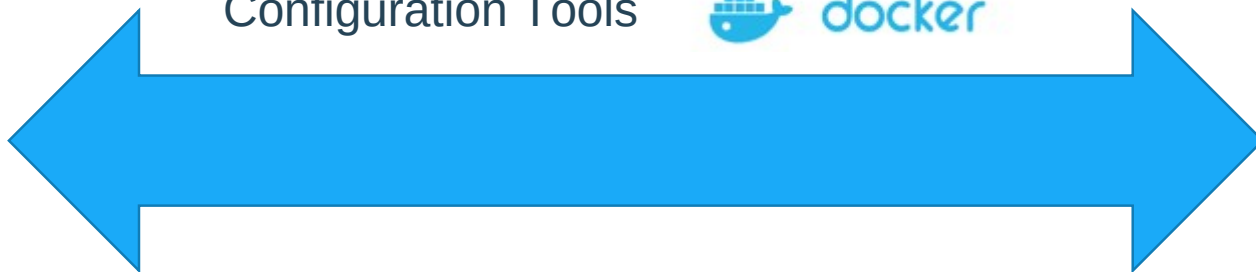
Manual Configuration

Traditional VMs

Less Portable,
Minimal Overhead

More Portable,
Lots of Overhead

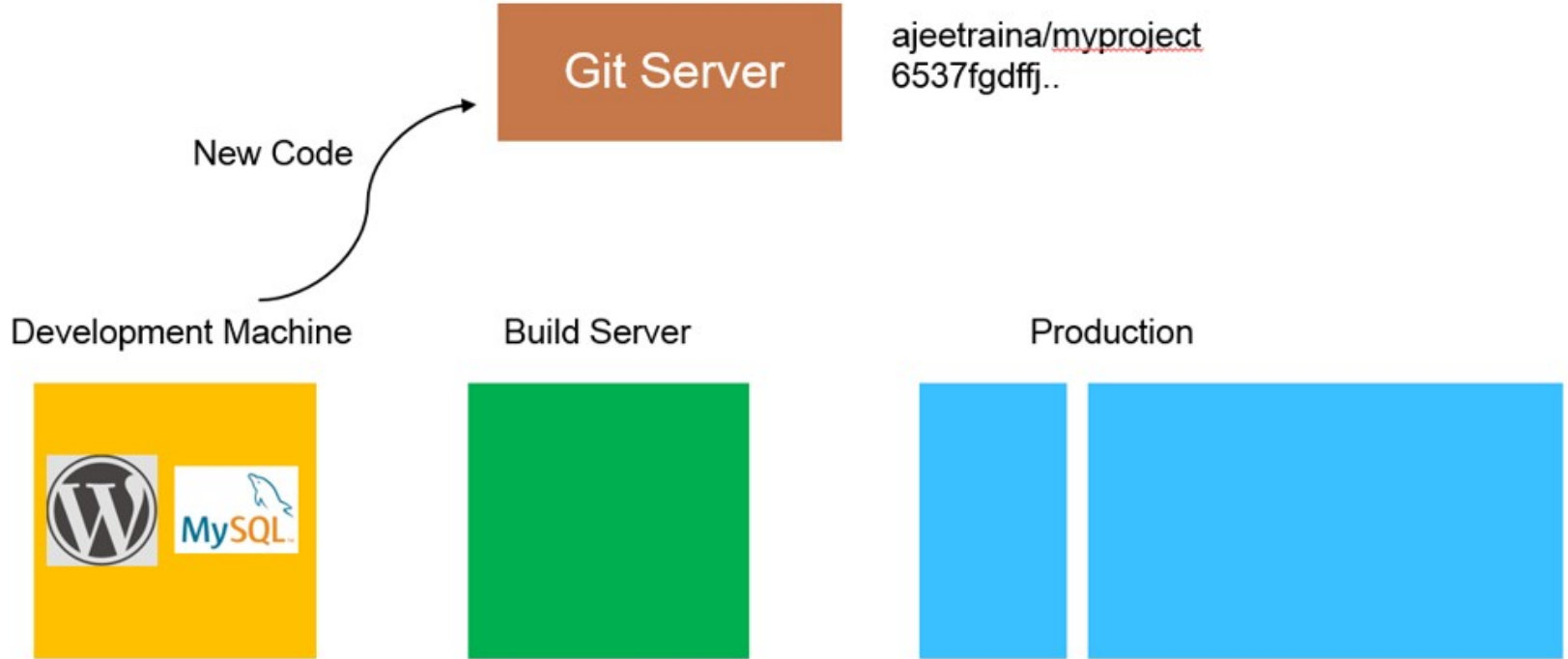
Configuration Tools



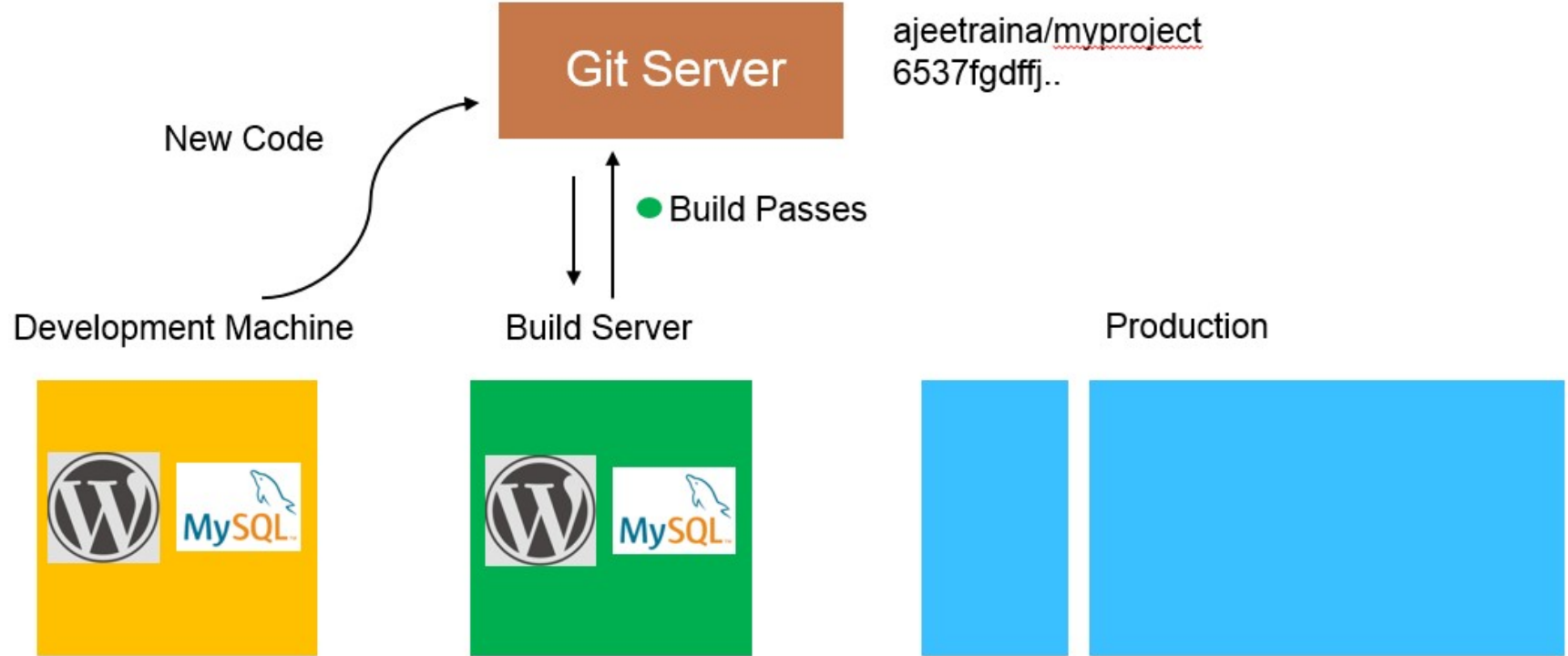
Manual Configuration

Traditional VMs

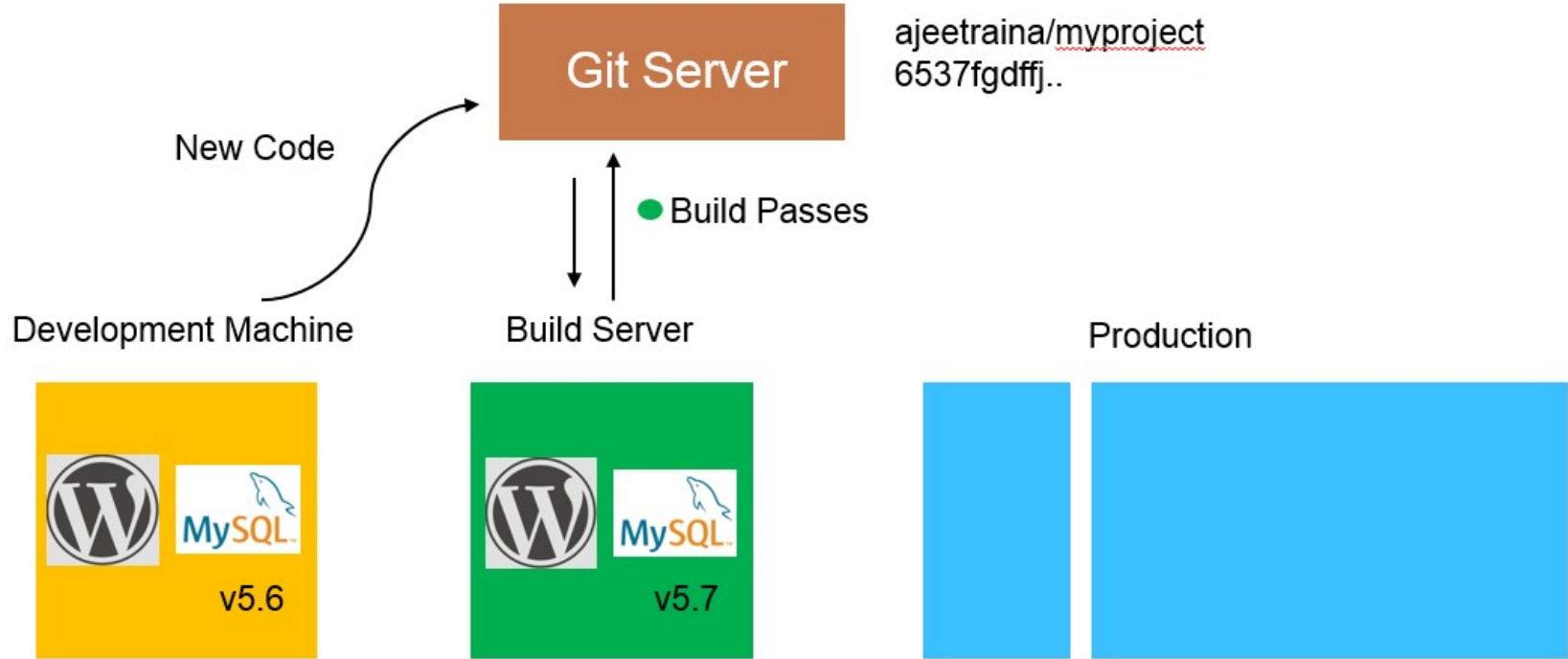
Development workflow (without Docker)



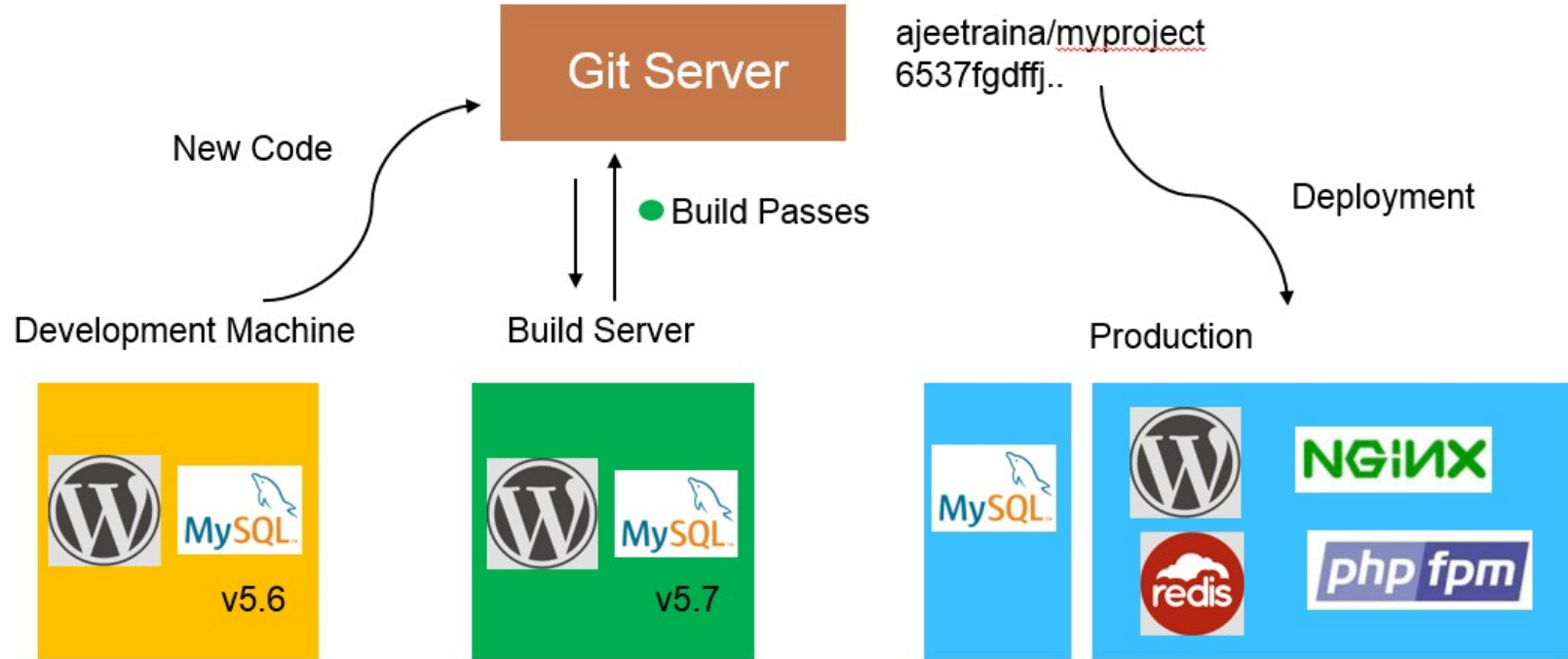
Development workflow (without Docker)



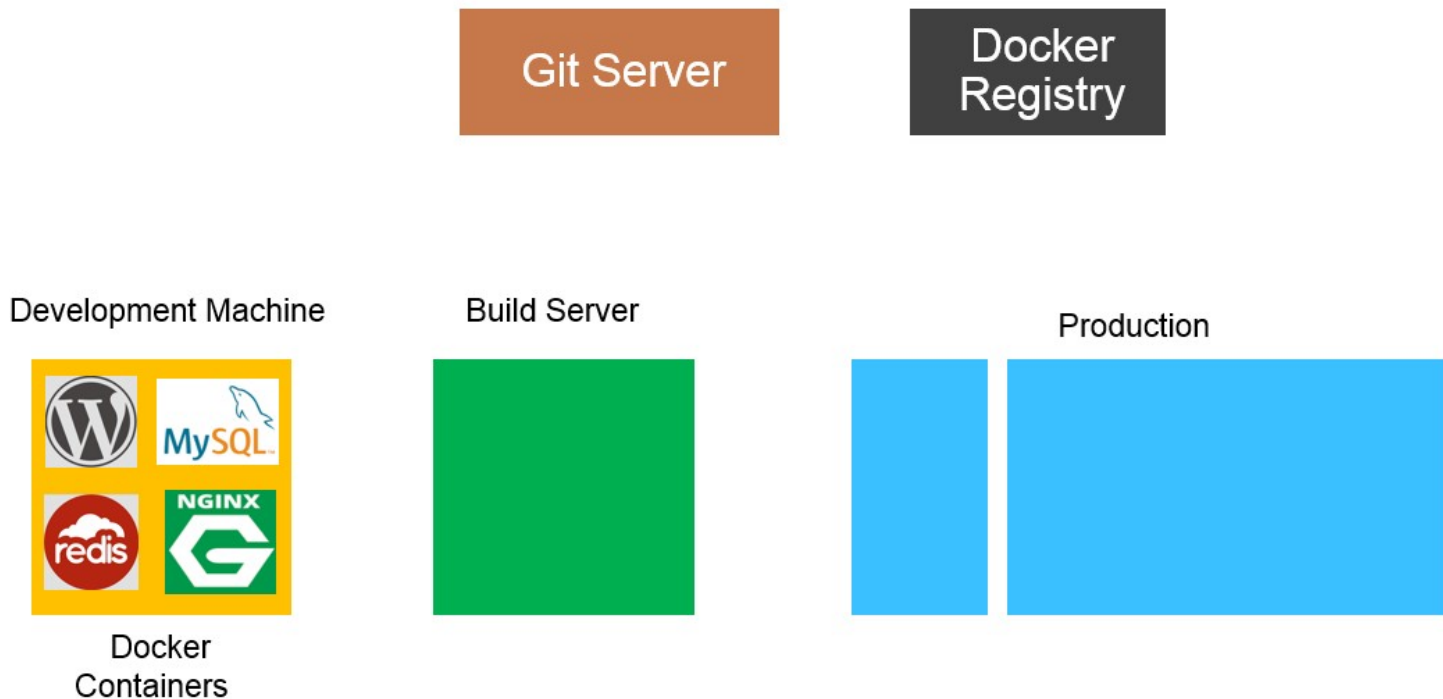
Development workflow (without Docker)



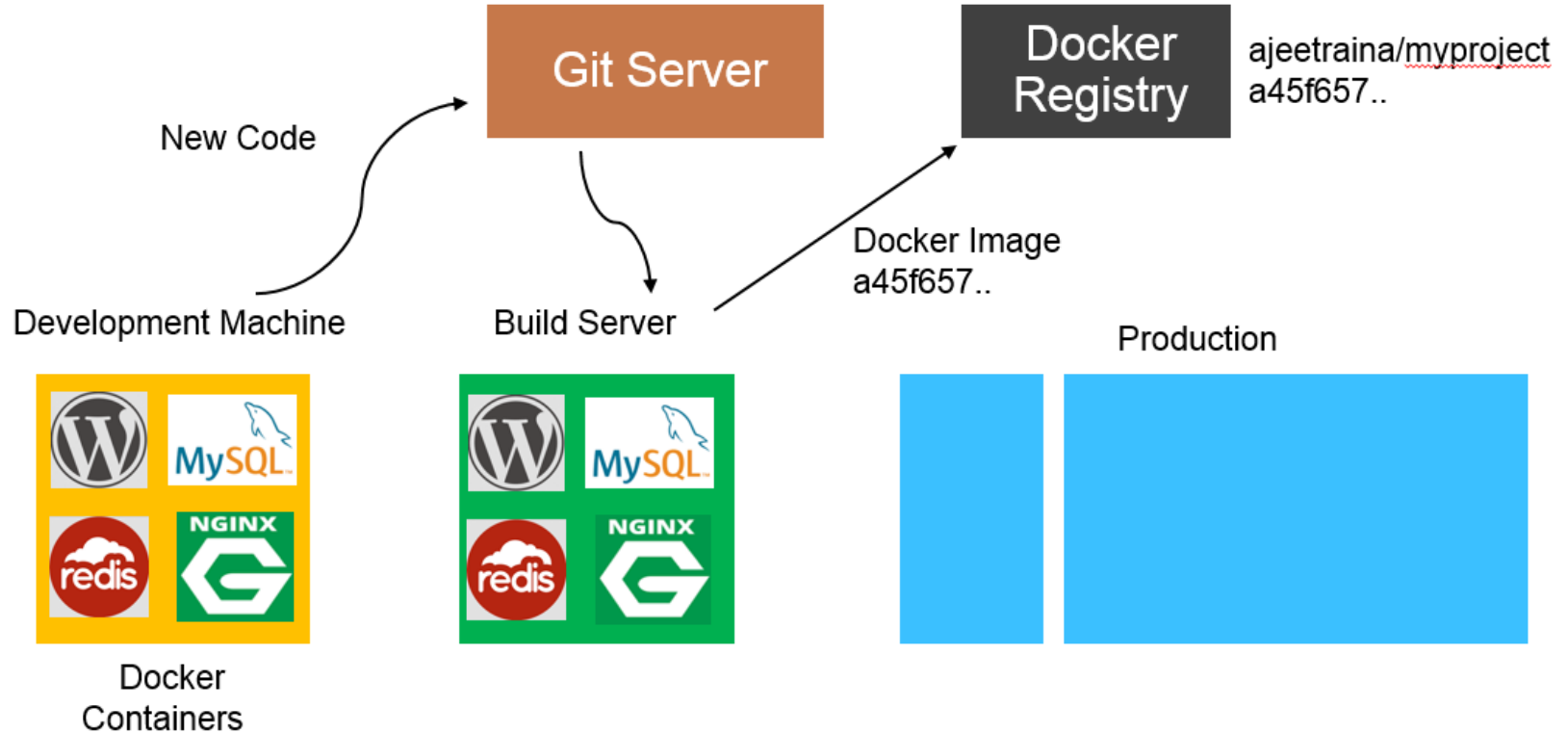
Development workflow (without Docker)



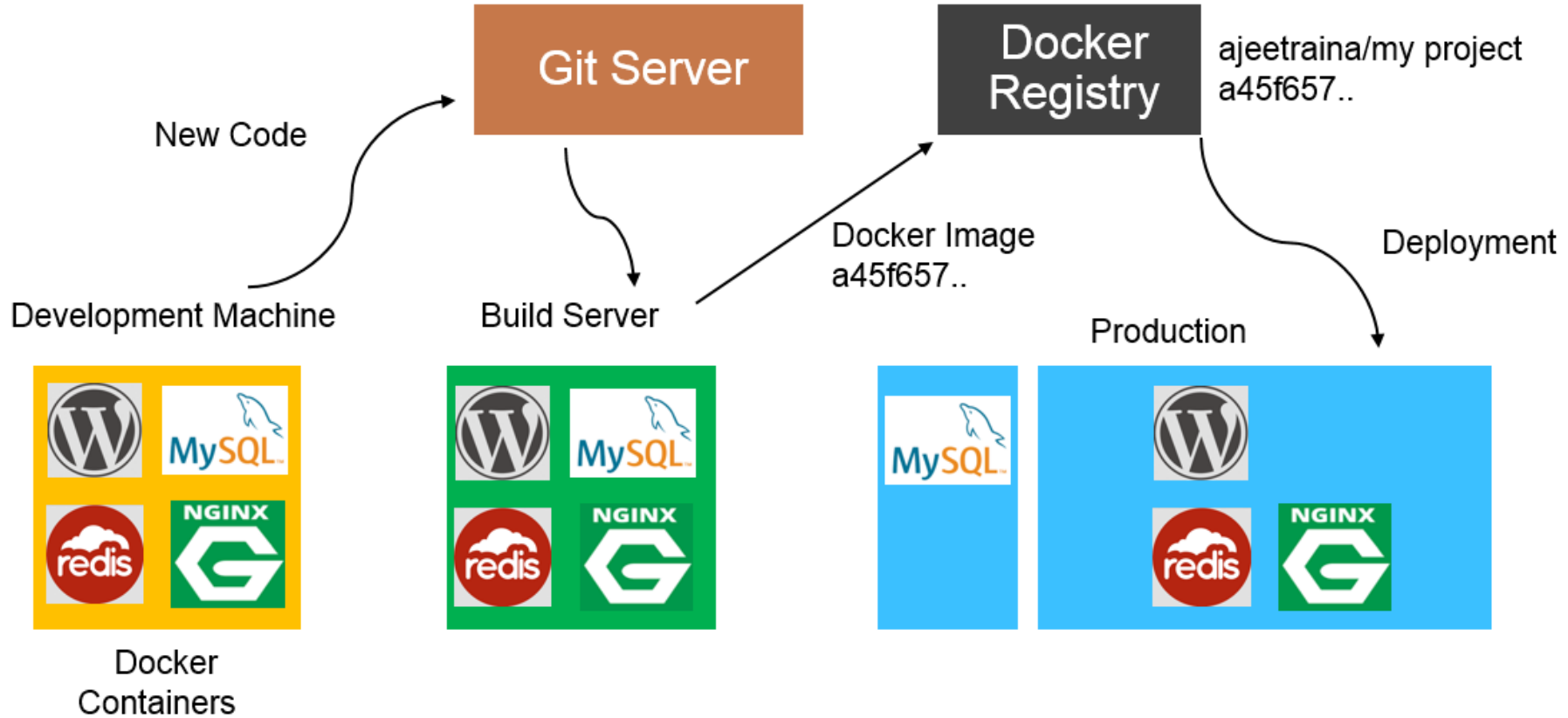
Development workflow (with Docker)



Development workflow (with Docker)



Development workflow (with Docker)



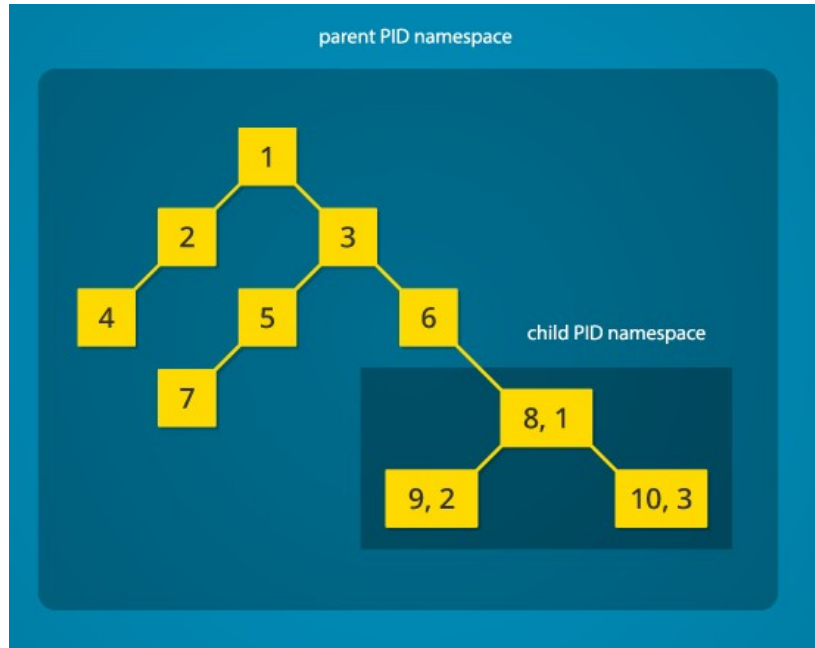
What is Docker?

- A tool that can package an application and its dependencies in a *virtual container*
- Implementation of a container which is portable using a concept of *image*
- Docker uses the host OS kernel, there is no custom or additional kernel inside running containers
- Docker uses resource isolation features of the Linux kernel such as cgroups and kernel namespaces to allow independent “containers” to run within a single Linux instance, avoiding the overhead of starting virtual machines



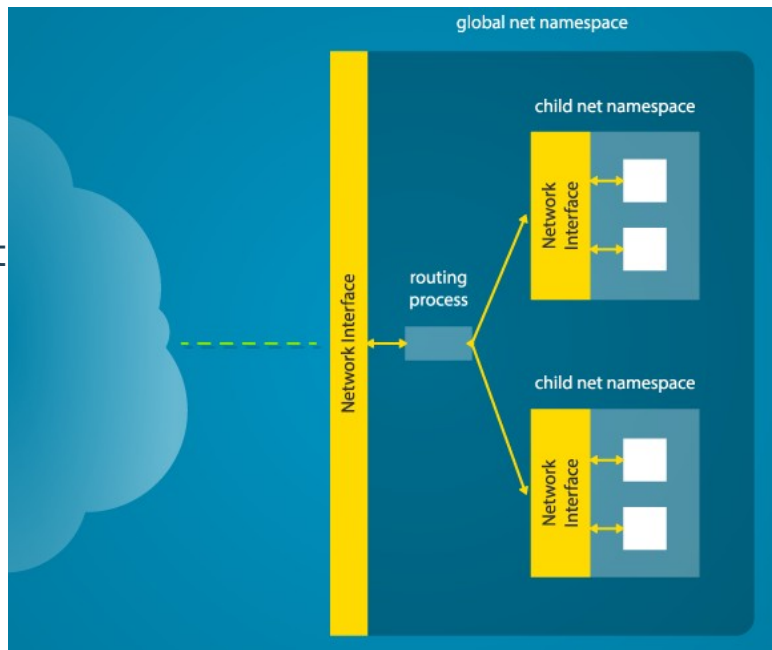
A note on Linux namespaces

- Isolation for several aspects of processes and resources
- See for example: Process ID isolation
Processes in the child namespace do not see the parent process's existence;
processes in the parent namespace have a complete view of processes in the child namespace
- Still, processes can compete for exclusive access to shared **real** resources (e.g. open a socket on port 80)

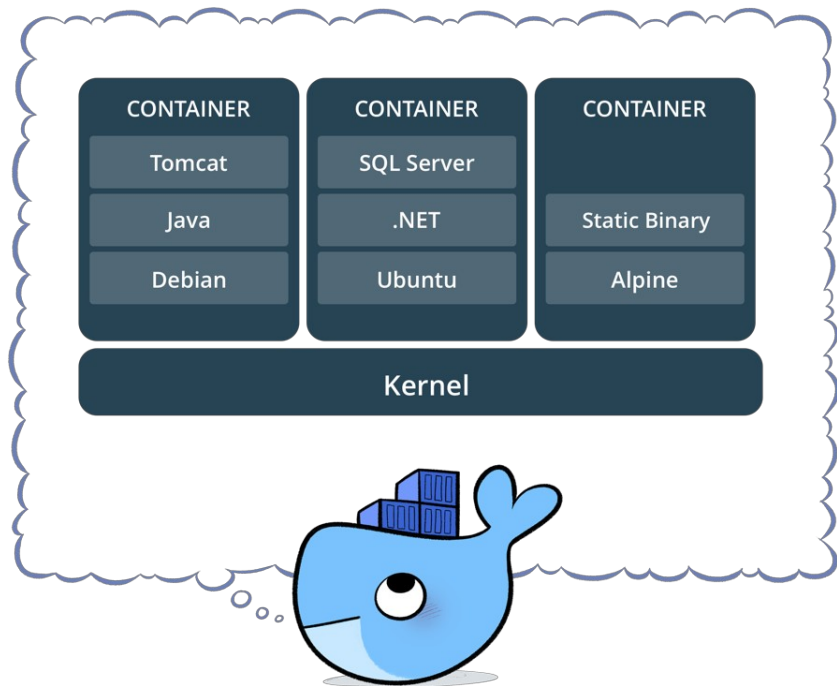


A note on Linux namespaces (cont.)

- Isolation for several aspects of processes and resources
- See for example: Process ID isolation
Processes in the child namespace do not see the parent process's existence;
processes in the parent namespace have a complete view of processes in the child namespace
- Still, processes can compete for exclusive access to shared **real** resources (e.g. open a socket on port 80)
 - A pair of virtual Ethernet connections (ends) must be created, between a parent and a child namespace
 - Both ends must be assigned a virtual IP address



What is Docker?

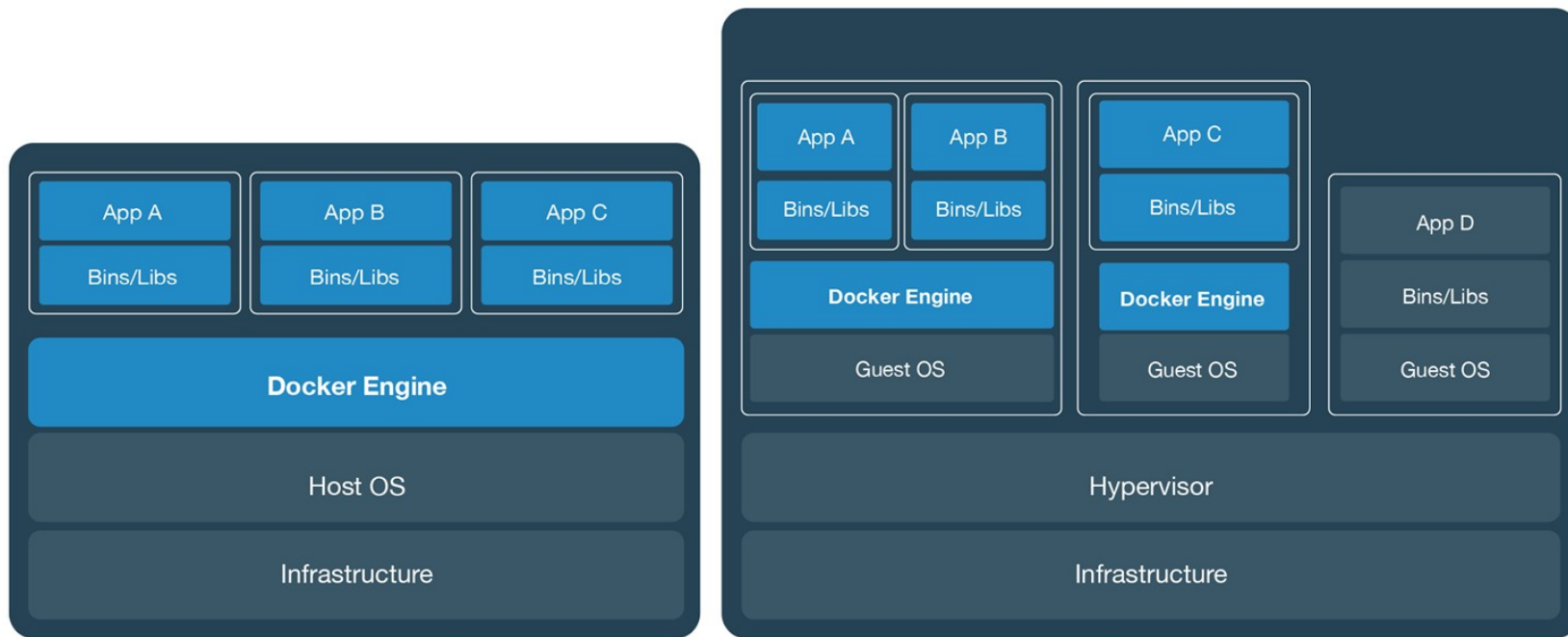


- Standardized packaging for software and dependencies
- Isolate apps from each other
- Share the same OS kernel
- Works for all major Linux distributions
- Available for Windows (Server, since 2016) and MacOS

VMs vs Docker - Differences

Virtual Machines	Docker
Each VM runs its own OS	All containers share the same kernel of the host
Boot up time is in minutes	Containers instantiate in seconds
VMs snapshots are used sparingly	Images are built incrementally on top of another like layers. Lots of images/snapshots
Not effective diffs. Not version controlled	Images can be diffed and can be version controlled. Dockerhub is like GITHUB
Cannot run more than couple of VMs on an average laptop	Can run many Docker containers in a laptop.
Only one VM can be started from one set of VMX and VMDK files	Multiple Docker containers can be started from one Docker image

Containers versus VMs



- When and when not? The GPU example...

Some Docker vocabulary

Containers

How you **run**
your application

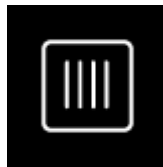
Images

How you **store**
your application



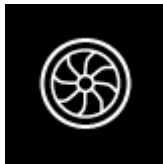
Docker Image

The basis of a Docker container. Represents a full application
Specified via *Dockerfiles*



Docker Container

The standard unit in which the application service resides and executes



Docker Engine

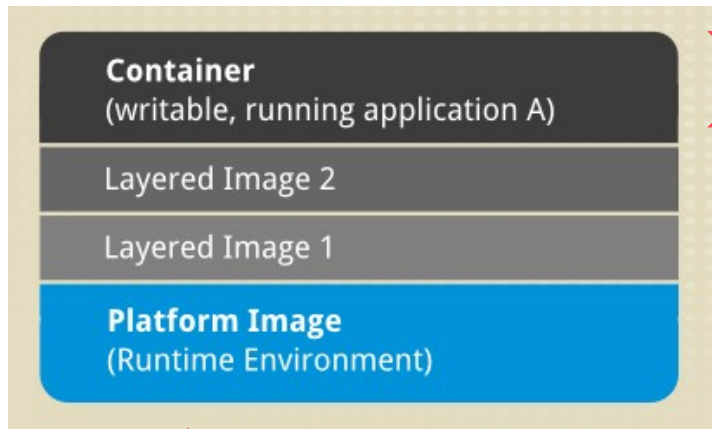
Creates, ships and runs Docker containers deployable on a physical or virtual, host locally, in a datacenter or cloud service provider



Registry Service (Docker Hub or Docker Trusted Registry)

Cloud or server based storage and distribution service for your images

Image Layering



- An application sandbox.
- Each container is based on an image that holds necessary config data.
- When you launch a container from an image, a writable layer is added on top of this image

- A static snapshot of the containers' configuration.
- Image is a read-only layer that is never modified, all changes are made in top-most writable layer, and can be saved only by creating a new image.
- Each image depends on one or more parent images

- An image that has no parent.
- Platform images define the runtime environment, packages and utilities necessary for containerized application to run.

Basic Docker Commands

Pulling Docker Image

```
$ docker pull fedora/httpd:version1.0
```

Listing out/removing Docker Images

```
$ docker image ls  
$ docker rmi fedora/httpd:version1.0
```

Running Docker Containers

```
$ docker container run -d -p 5000:5000 --name httpserver fedora/httpd:version1.0
```

Stopping the container

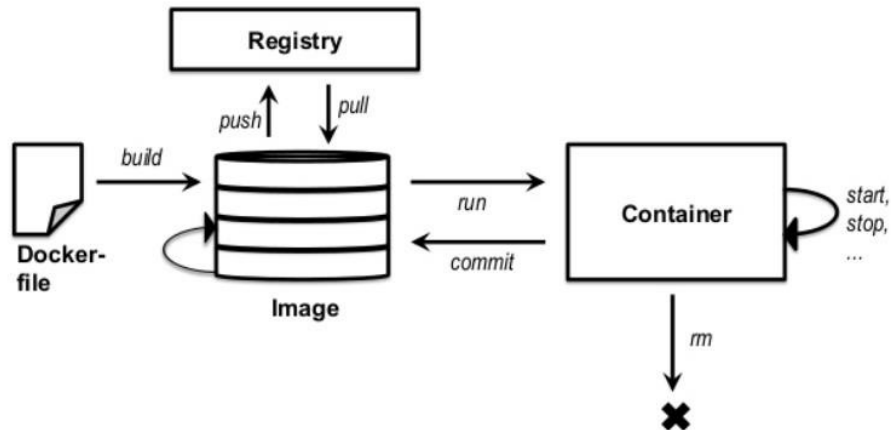
```
$ docker container stop httpserver (or <container id>)
```

Copying files from/to a container (volumes can also be used)

```
$ docker cp <container id>:<path> <host_path>
```

Execute commands in a running container

```
$ docker exec -it <container id> /bin/bash
```



Dockerfile Basics

Docker Images are built from a base image.

Base Images are built up using simple instructions such as

- Run a command.
- Add a file or directory.
- Create an environment variable.
- What process to run when this image.

```
FROM tomcat:7.0.62-jre8
MAINTAINER Jeff Ellin jeff.ellin@jeffellin.com
ENV CORE_SQL_URL "jdbc:postgresql://localhost:5432/core"
ENV CORE_SQL_USERNAME "tamr"
ENV CORE_SQL_PASSWORD "12345"
#Enable use of gui admin tool
add tomcat-users.xml $CATALINA_HOME/conf/tomcat-users.xml
#add the tamr war

add tamr.war /tamr/tamr.war
add catalina.sh $CATALINA_HOME/bin/catalina.sh
RUN mv /tamr/*.war $CATALINA_HOME/webapps/
```


FROM

The FROM instruction sets the Base Image for subsequent instructions. As such, a valid Dockerfile must have FROM as its first instruction. The image can be any valid image – it is especially easy to start by pulling an image from the Public Repositories.

```
FROM java:8-jre
```


ENV

The ENV instruction is also useful for providing required environment variables specific to services you wish to containerize, such as Postgres's PGDATA.

```
ENV TOMCAT_MAJOR 8  
ENV TOMCAT_VERSION 8.0.26
```

RUN

The instruction will execute any commands in a new layer on top of the current image and commit results. The resulting committed image is used for the next step in the Dockerfile.

```
RUN apt-get update && apt-get install -y \  
    bzip2 \  
    cvs \  
    git
```


ADD and Copy

These commands can be used to add files to the container

- For ADD if source is a tar file it is extracted
- ADD allows source file to be a URL
- Use a trailing slash to indicate a directory vs a file.

```
COPY hom* /mydir/      # adds files starting with "hom"  
COPY hom?.txt /mydir/  # ? replaced with any single char
```

EXPOSE

Notifies Docker that the container will listen on the specified network ports at runtime. This is used to interconnect containers using links (see the Docker User Guide) and to determine which ports to expose to the host when using the `-P` flag.

EXPOSE 8080

WORKDIR

The WORKDIR instruction sets the working directory for any RUN, CMD, COPY and ADD instructions that follow it in the Dockerfile.

It can be used multiple times in the Dockerfile. If a relative path is provided, it will be relative to the path of the previous WORKDIR instruction.

```
WORKDIR $CATALINA_HOME
```

CMD

The main purpose of a CMD is to provide defaults for an executing container.

Can be overridden with arguments to docker run

```
CMD ["catalina.sh", "run"]
```

Hands-on exercise

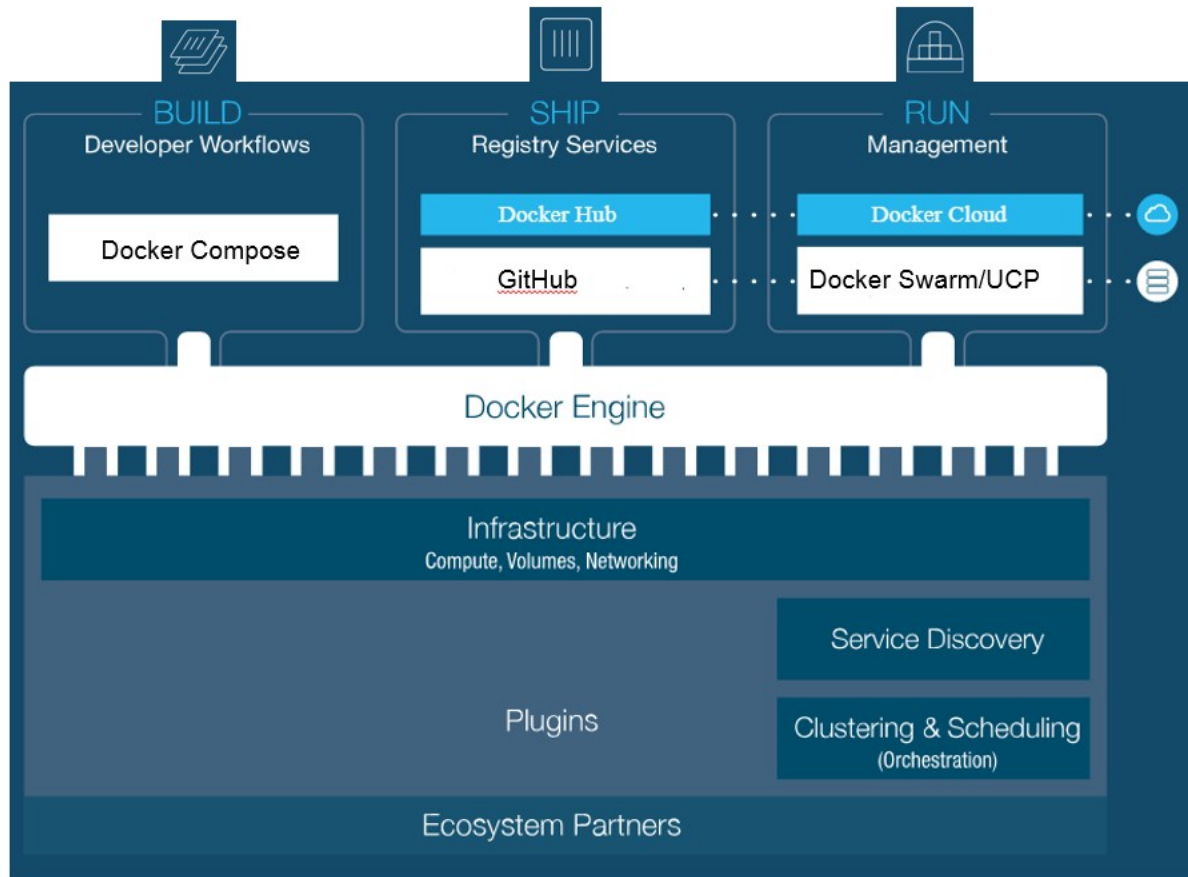
- a) Install Docker (sudo apt install docker.io)
- b) Create a folder, a bash script and a Dockerfile
- c) Instruct the Dockerfile to execute the script at container startup
- d) The script should list the contents of "/" and place the result in a file
- e) Build the image (docker build -t image_name .)
- f) Start a container based on the created image
- g) Let us use "docker exec" to log in the container and show the results
- h) Let us use "docker cp" to copy the output file into the host machine



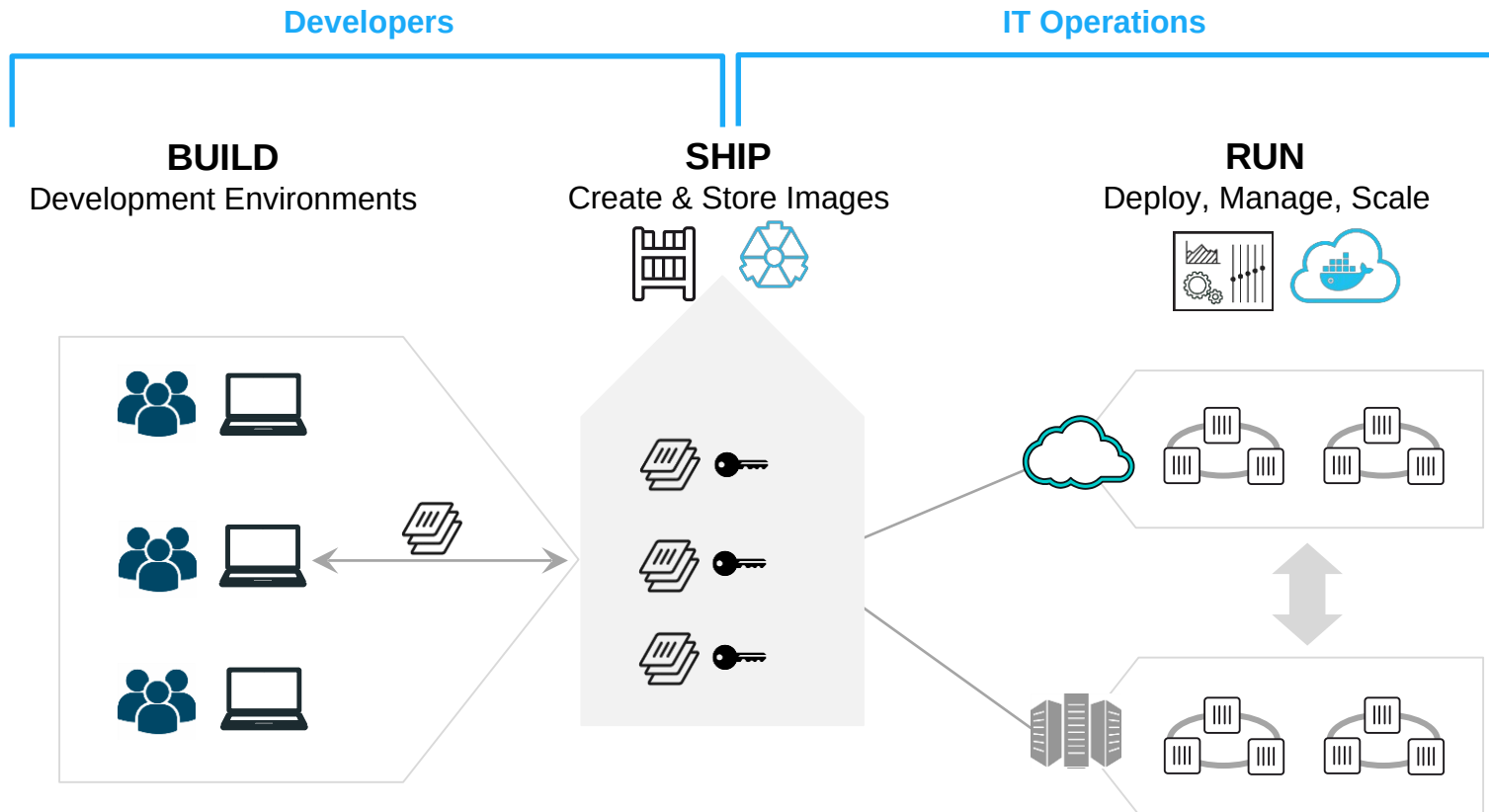
Build, Ship & Run



Docker Mission



Put it all together: Build, Ship, Run Workflow



Docker Compose – Building Microservices in easy way

```
version: '3'
services:
  db:
    image: mysql:5.7
    volumes:
      - db_data:/var/lib/mysql
    restart: always
    environment:
      MYSQL_ROOT_PASSWORD: somewordpress
      MYSQL_DATABASE: wordpress
      MYSQL_USER: wordpress
      MYSQL_PASSWORD: wordpress
  wordpress:
    depends_on:
      - db
    image: wordpress:latest
    ports:
      - "8000:80"
    restart: always
    environment:
      WORDPRESS_DB_HOST: db:3306
      WORDPRESS_DB_USER: wordpress
      WORDPRESS_DB_PASSWORD: wordpress
volumes:
  db_data:
```



Backend Service



Specify Volumes/Network



Environmental variables



Frontend Service



Specify Volumes/Network



Environmental variables