Cloud Computing, Part 1

Distributed and Pervasive Systems, MSc

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Outline

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What is cloud computing?

The cloud

- A metaphor for the Internet. Something that is remote.

Cloud computing

- The delivery of online computing services
- Most often, these include servers, storage, databases software and analytics
- Management is done by third-party
- Services are often at an enterprise-level

Benefits

- Lower costs
- Accessibility
- Productivity
- Scalability
- Updates

Cloud computing: Background

Origin

- Around 1970, the concept of virtual machine's (VMs) was invented
- In 1999, Salesforce.com delivered applications to users using a simple website
- In 2002, Amazon provided the first cloud service
- In 2009, Google Apps saw the light of day
- In 2009, Microsoft launched Azure

Most known providers

- Google Cloud (Search, Gmail)
- Amazon's AWS (Online marketplace)
- Microsoft Azure (OneDrive)

Deployment models

- Private cloud
- Public cloud (e.g. Amazon AWS, Google Cloud)

Outline

Monolithic vs. microservices

Monolithic

- Everything in one place
- Tightly coupled, runs as a single service
- Developed and scaled as one
- Hard to maintain

SoA-architecture

- Service-oriented architecture (SOA)
- Splits software application in smaller units
- Units communicate over network, but functions separately

What microservices are

- Modern version of the SoA-style
- Small, independent services that do one thing
- Highly maintainable, testable, loosely coupled
- "Instead of having one machine build a whole car, get multiple factories to work at the same time.

Monolitic vs. microservices

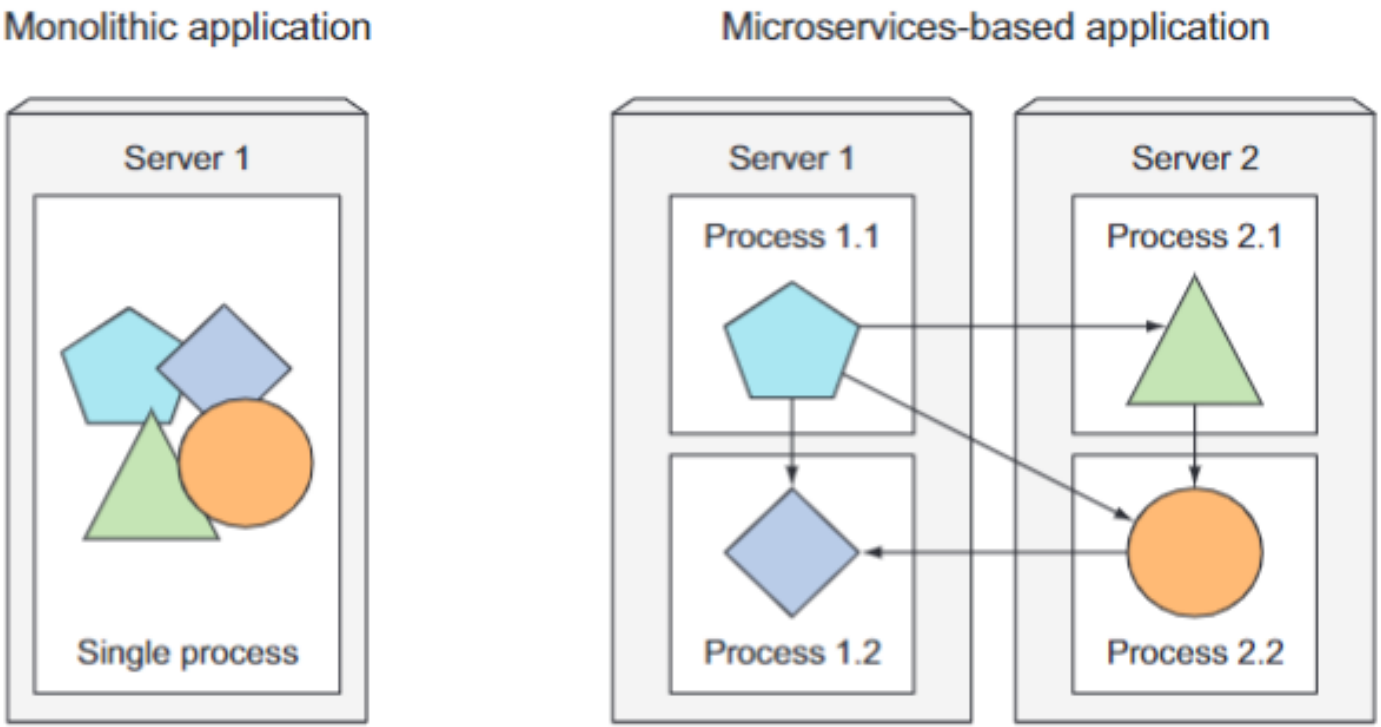
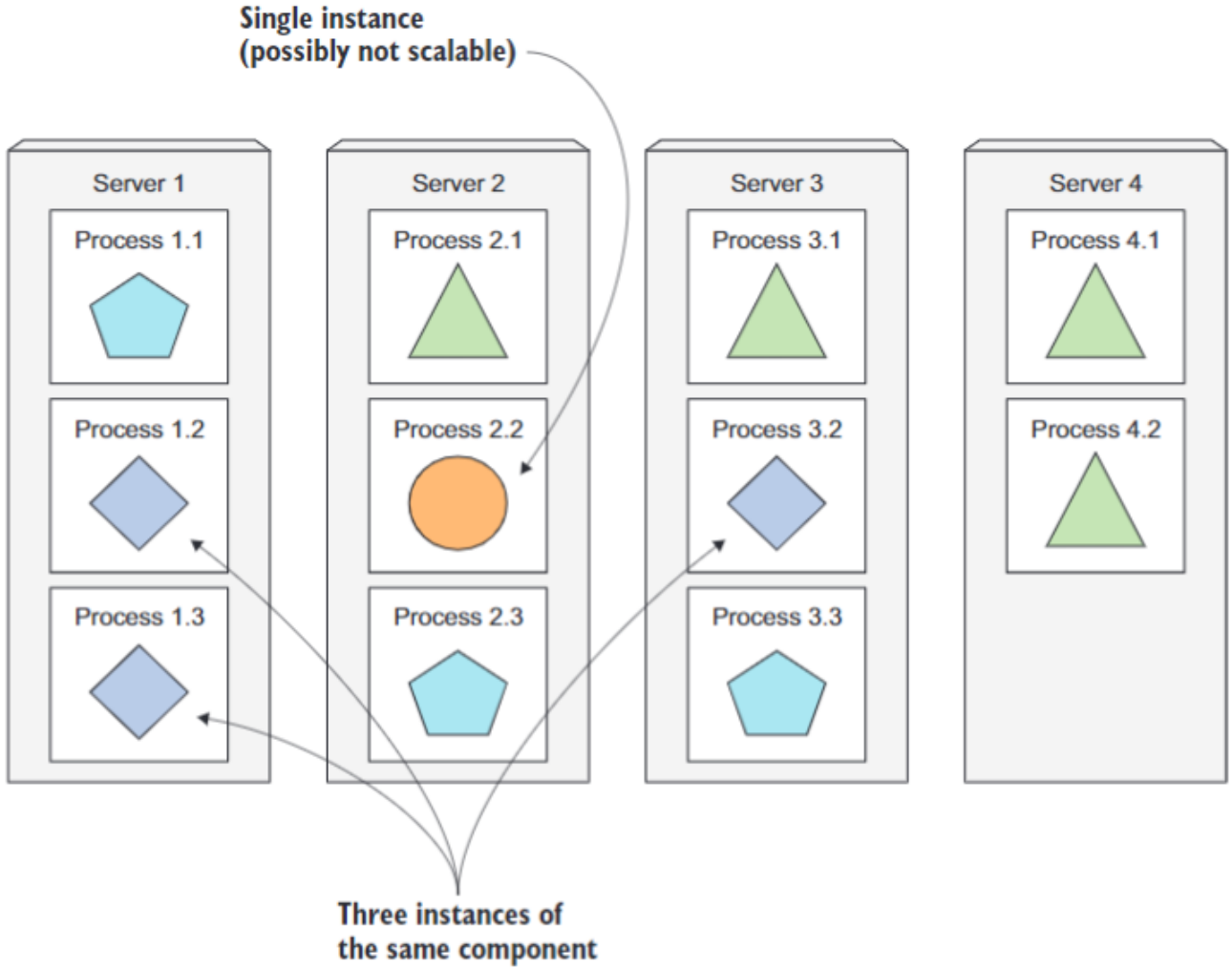


Figure: Fig. by courtesy of Marko Luksa[1]

Monolitic vs. microservices



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Monolitic vs. microservices

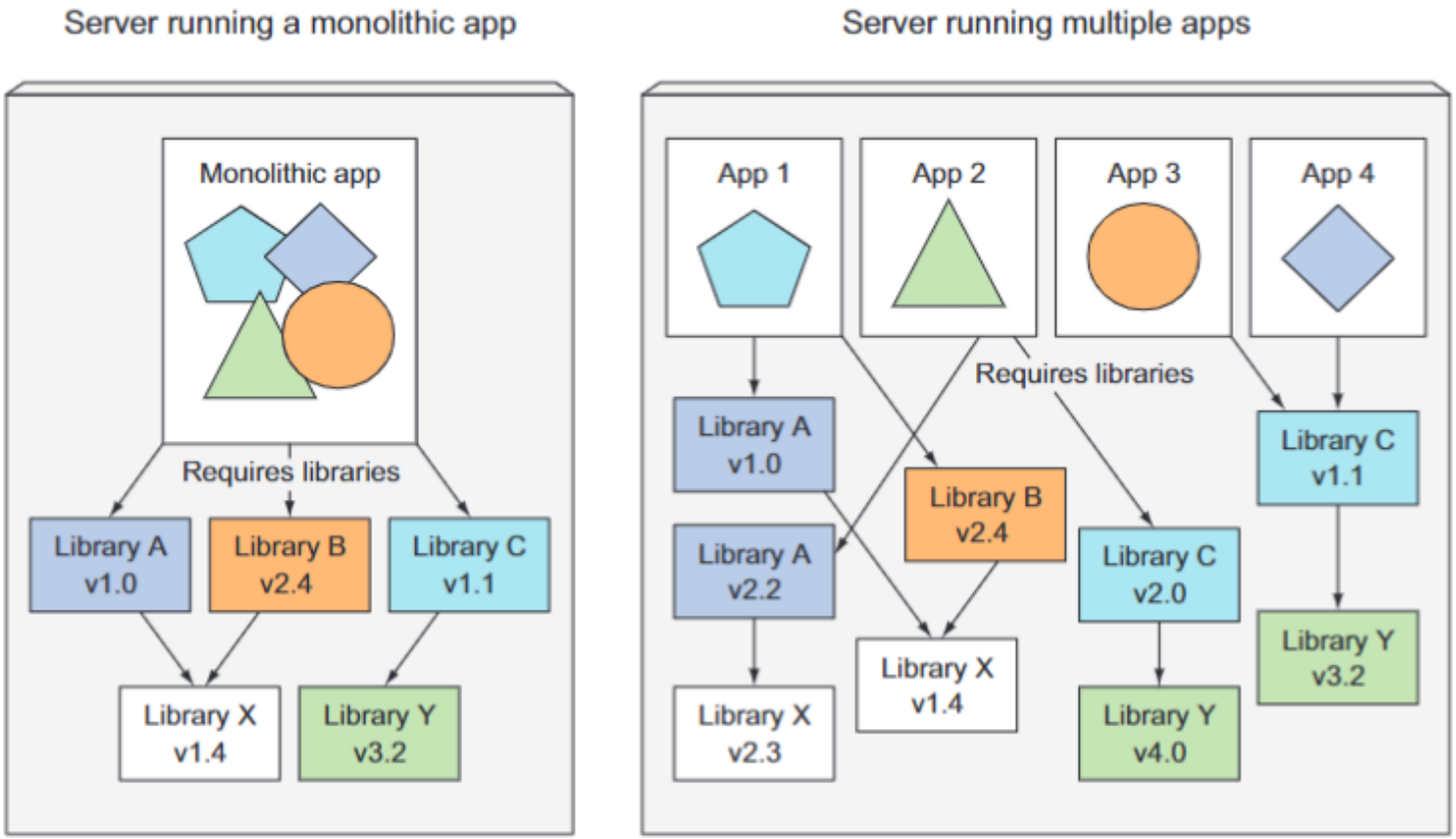

Figure: Fig. by courtesy of Marko Luksa[1]

Outline

Containers

Motivation

- We can't give every software component its own VM
- VM's are manual. We need automation
- Changes once place should not impact others

What containers are

- Containers are isolated software environments
- Application and dependencies bundled inside
- A lightweight version of VM's

A normal VM vs. containers

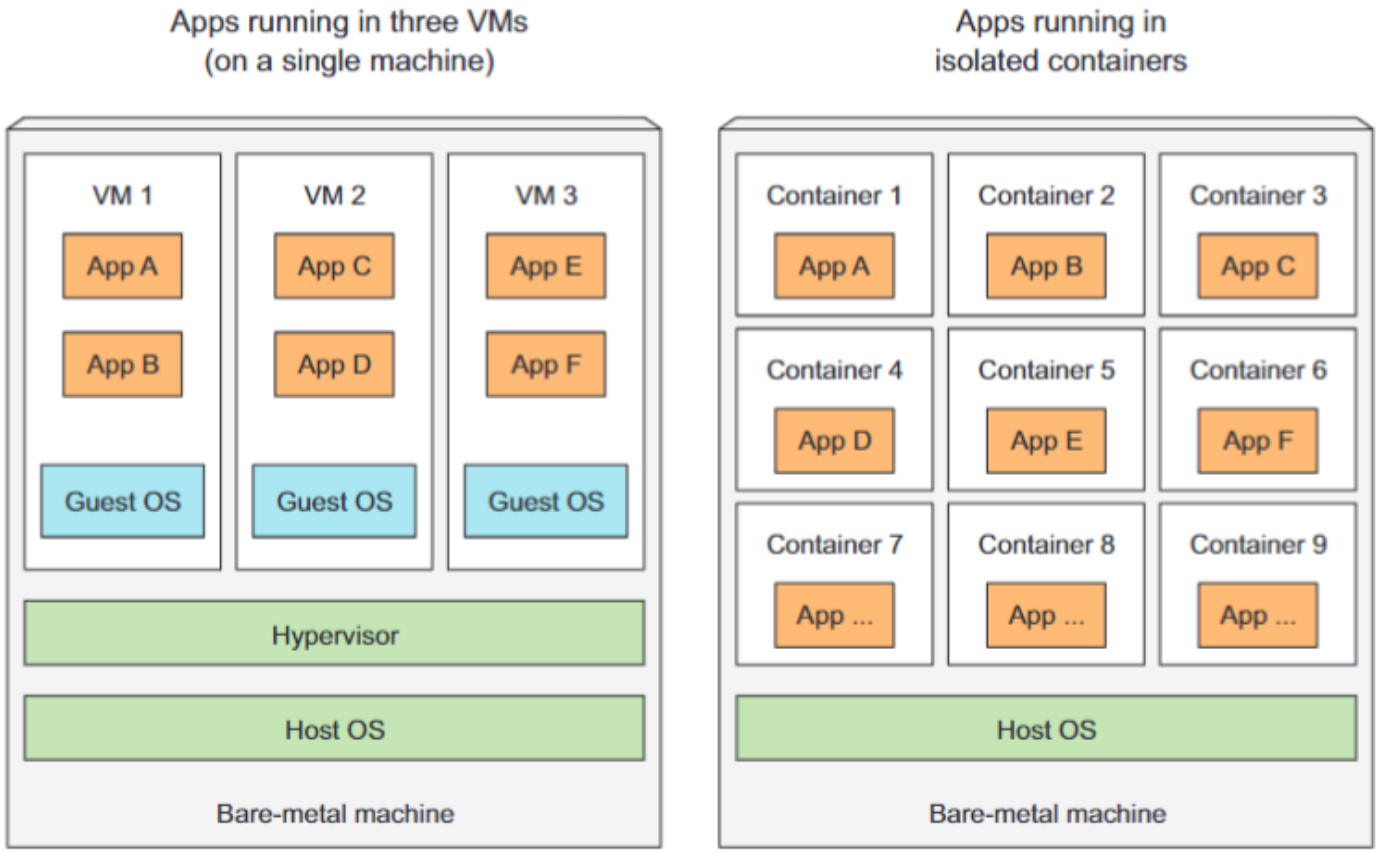

Figure: Fig. by courtesy of Marko Luksa[1]

Docker

Motivation

- We need suitable tooling to create containers
- It should be automated, predictable and fast
- It should run everywhere, be modular and scale well

What Docker is

- Docker is a container tool that can run and create containers
- Containers only see their exact file system
- Similar to VM's, but less overhead
- Consists of reusable layers
- Uses a Dockerfile

Important concepts

- Images. Something you package your application into
- Registries. A repository to store your image
- Containers. Like normal Linux container

The Docker build process

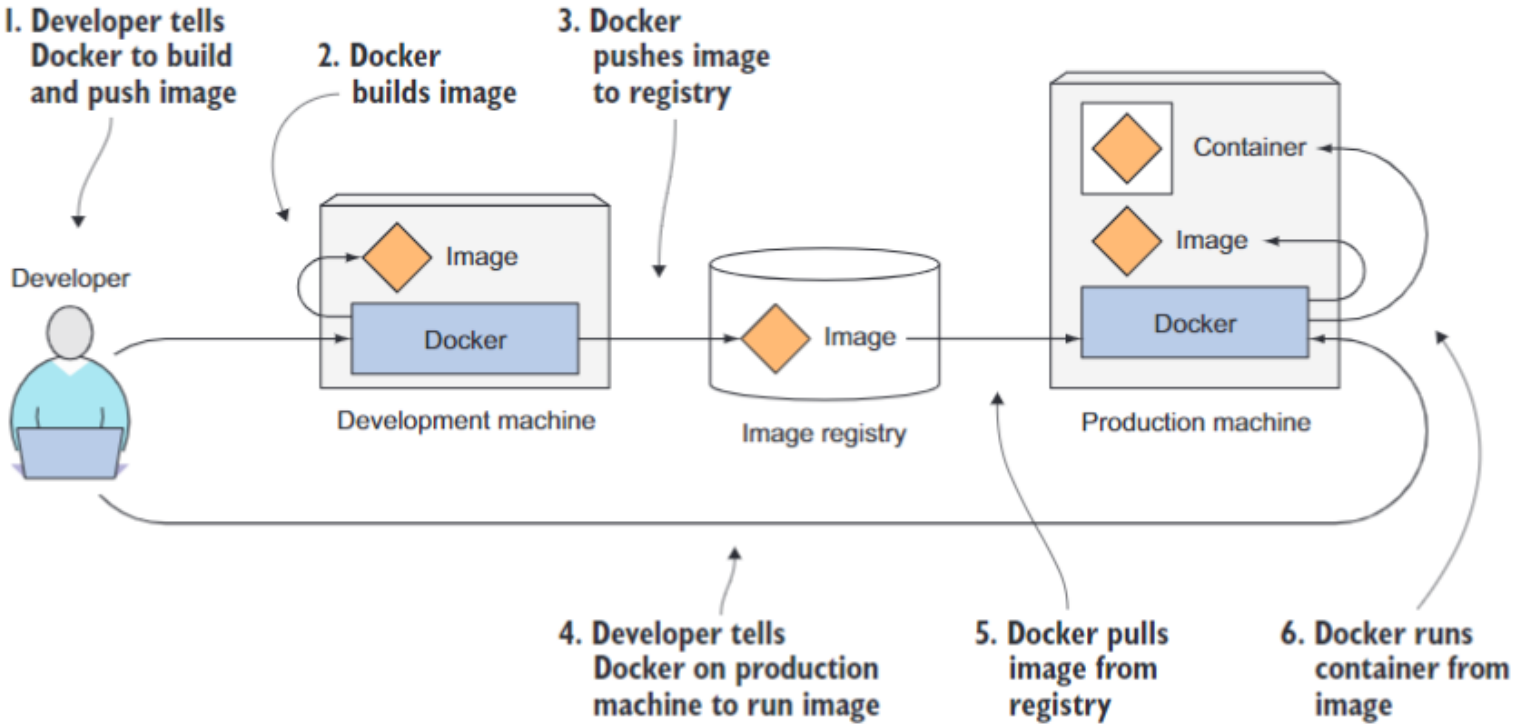

Figure: Fig. by courtesy of Marko Luksa[1]

Running apps in VM's vs. containers

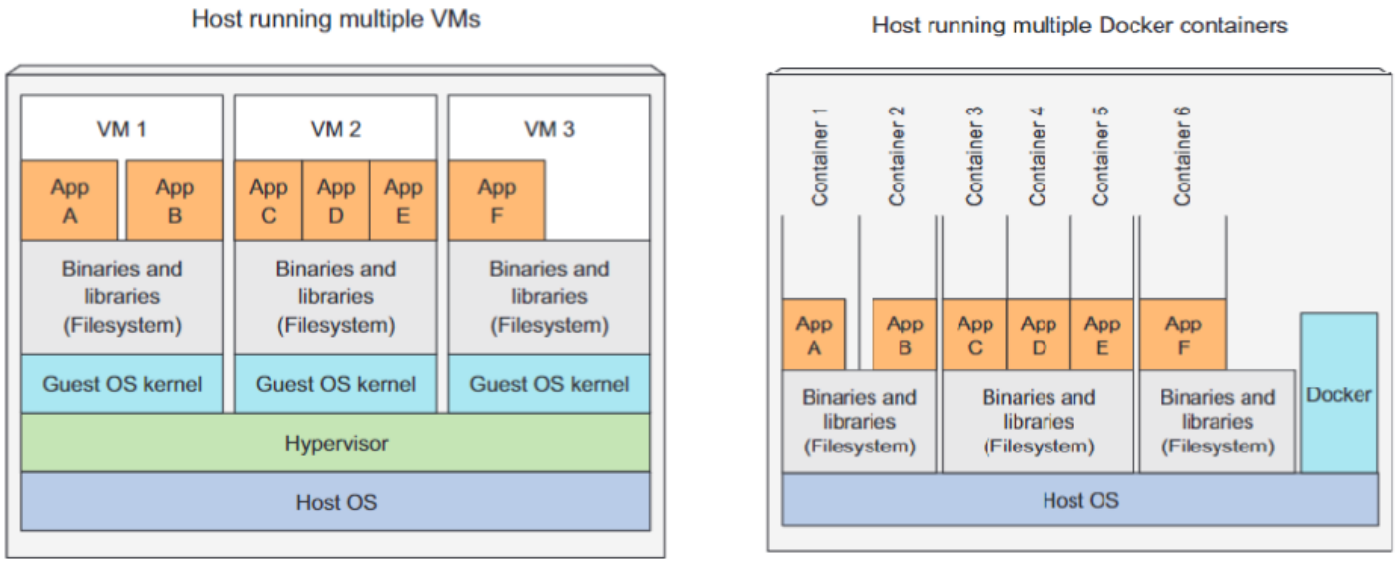

Figure: Fig. by courtesy of Marko Luksa[1]

Outline

Kubernetes

Motivation

- We need something to manage our containers
- Should be reliable, automated and scalable
- Should ease the process of deploying containers

What Kubernetes is

- Open-source container orchestration engine
- Made by Google, open-sourced in 2014
- Google needed to better utilize their resources
- Enables easy deployment, scaling and managing
- Exposes whole datacenter as a single platform.

Running apps in VM's vs. containers

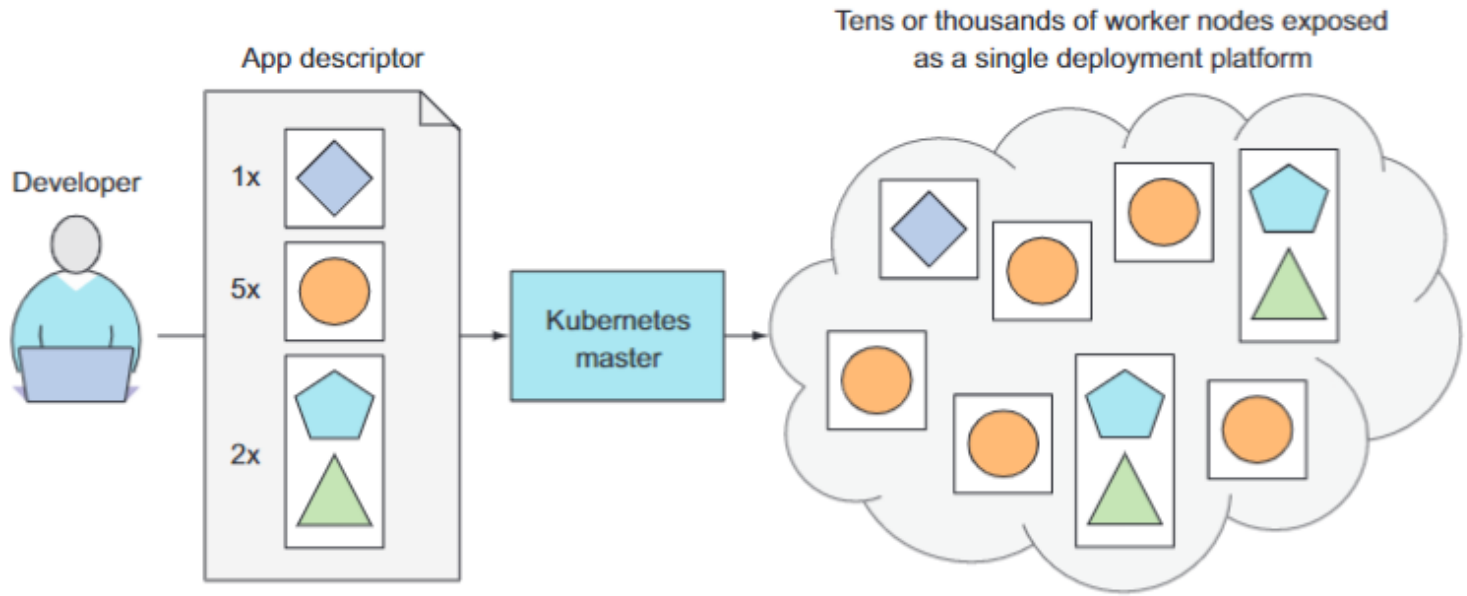

Figure: Fig. by courtesy of Marko Luksa[1]

Kubernetes cont.

Main features of Kubernetes

- Keep containers running.
- Scaling copies.
- Hitting a moving target.

Benefits of using Kubernetes

- Simplifying application deployment
- Achieve better utilization
- Health checking and self-healing
- Automatic scaling
- Access to services via API/DNS

Enterprise-use

- Often seen as a PaaS (OpenShift)

Kubernetes cont.

The master node hosts the Control Plane and worker nodes run deployments. The master contains

- API Server, which you and the Control Plane components communicate with
- The Scheduler, which schedules your apps
- The Controller Manager, keeps track of workers among others
- etcd, a distributed db that stores cluster configuration

The nodes contain

- Docker, rtk or another container runtime
- Kubelet, which talks to the API server and manages containers
- Kube-proxy, which load-balances network traffic

The components in Kubernetes

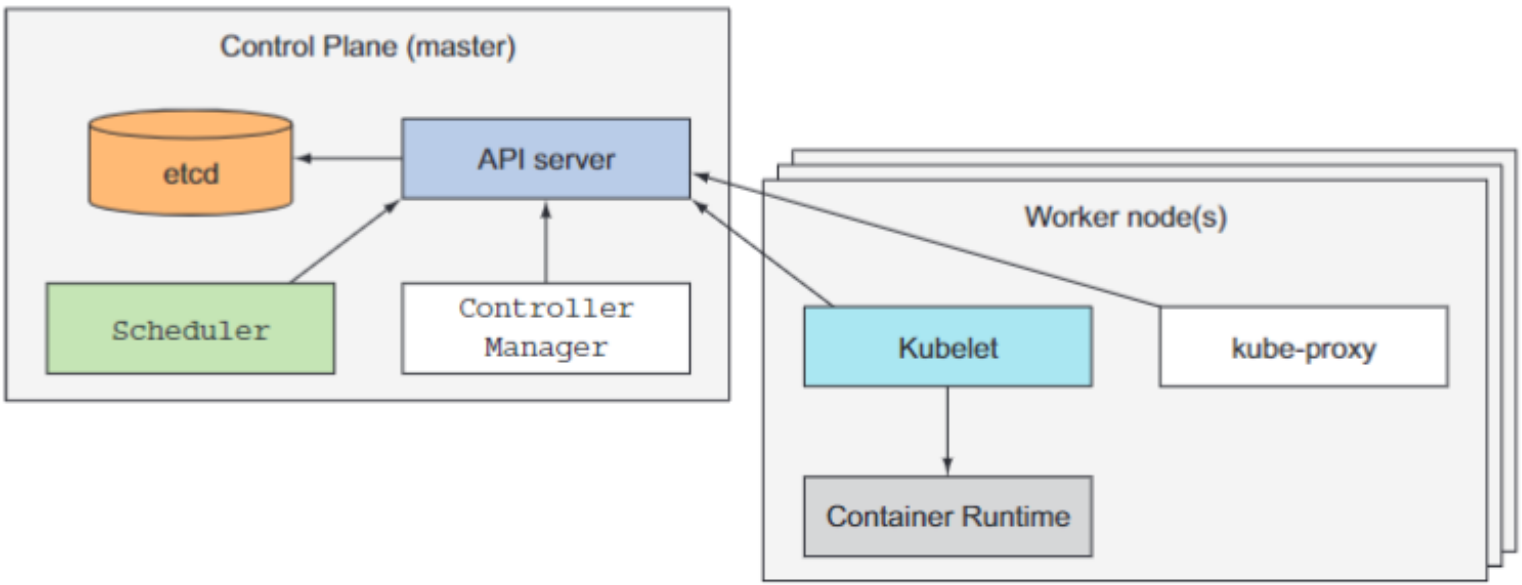

Figure: Fig. by courtesy of Marko Luksa[1]

An overview of Kubernetes's architecture

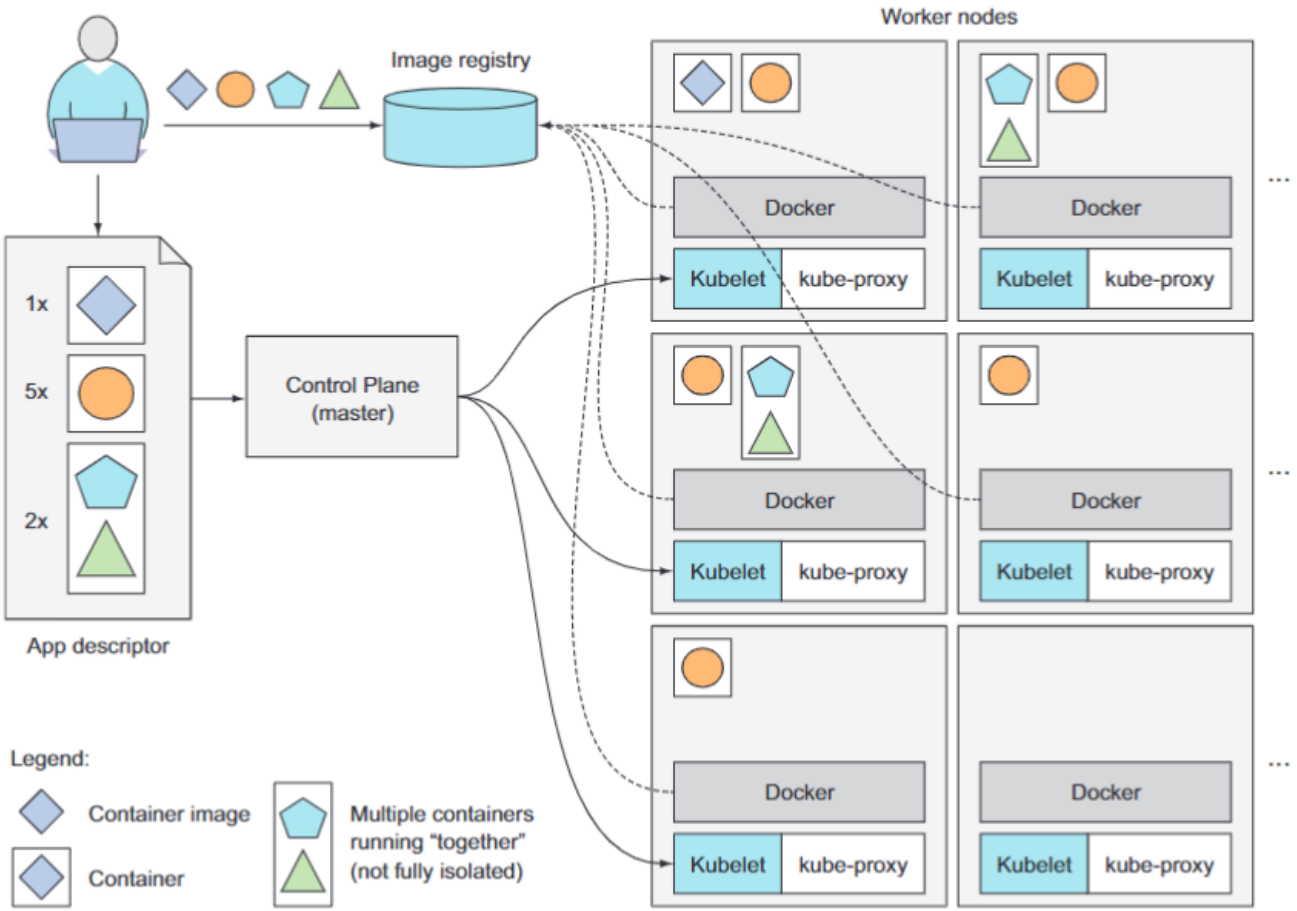

Figure: Fig. by courtesy of Marko Luksa[1]

Outline

Running the busybox image

Installing Docker and running a Hello World container

- Busybox is a single executable with many UNIX tools.

Listing 2.1 Running a Hello world container with Docker

```
$ docker run busybox echo "Hello world"
Unable to find image 'busybox:latest' locally
latest: Pulling from docker.io/busybox
9a163e0b8d13: Pull complete
fef924a0204a: Pull complete
Digest: sha256:97473e34e311e6c1b3f61f2a721d038d1e5eef17d98d1353a513007cf46ca6bd
Status: Downloaded newer image for docker.io/busybox:latest
Hello world
```

Figure: Listing. by courtesy of Marko Luksa[1]

```
$ docker run busybox echo "Hello world"
$ docker run <image>
$ docker run <image>:<tag>
```

Running echo "Hello world" in a container

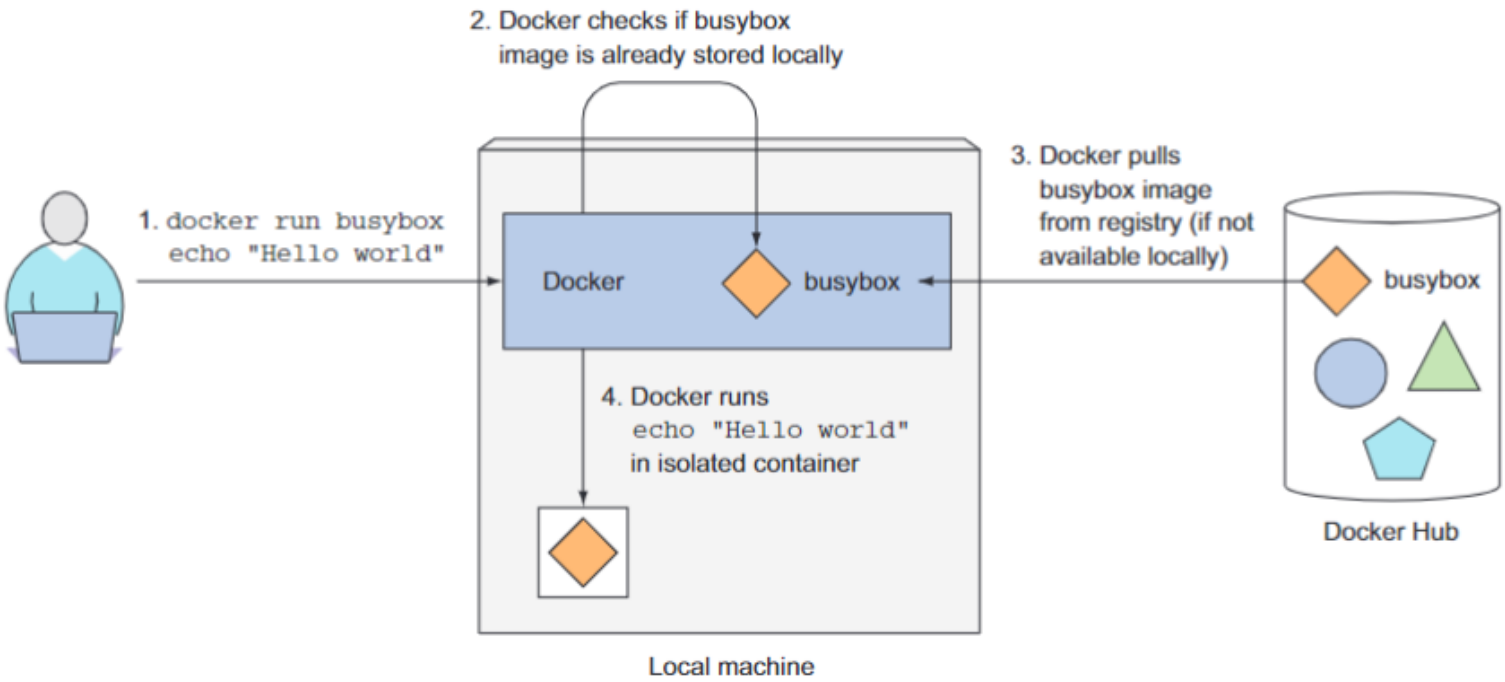

Figure: Fig. by courtesy of Marko Luksa[1]

Creating a Node.js app

- We make a simple HTTP app that can receive and reply to requests with its hostname
- Using Node.js and JavaScript

Listing 2.2 A simple Node.js app: app.js

```
const http = require('http');
const os = require('os');

console.log("Kubia server starting...");

var handler = function(request, response) {
  console.log("Received request from " + request.connection.remoteAddress);
  response.writeHead(200);
  response.end("You've hit " + os.hostname() + "\n");
};

var www = http.createServer(handler);
www.listen(8080);
```

Figure: Listing. by courtesy of Marko Luksa[1]

Creating a Dockerfile for the image

- We need a Dockerfile to create an image
- It describes the app and its dependencies

Listing 2.3 A Dockerfile for building a container image for your app

```
FROM node:7
ADD app.js /app.js
ENTRYPOINT ["node", "app.js"]
```

Figure: Listing. by courtesy of Marko Luksa[1]

Building the container image

The Docker daemon builds the image.

```
$ docker build -t kubia .
```

Listing 2.4 Listing locally stored images

```
$ docker images
REPOSITORY   TAG      IMAGE ID          CREATED             VIRTUAL SIZE
kubia        latest   d30ecc7419e7      1 minute ago        637.1 MB
...
```

Figure: Listing. by courtesy of Marko Luksa[1]

Listing 2.5 Listing running containers

```
$ docker ps
CONTAINER ID  IMAGE         COMMAND                CREATED        ...
44d76963e8e1  kubia:latest  "/bin/sh -c 'node ap   6 minutes ago  ...

...  STATUS              PORTS                    NAMES
...  Up 6 minutes        0.0.0.0:8080->8080/tcp   kubia-container
```

Figure: Listing. by courtesy of Marko Luksa[1]

Building a new container image from a Dockerfile

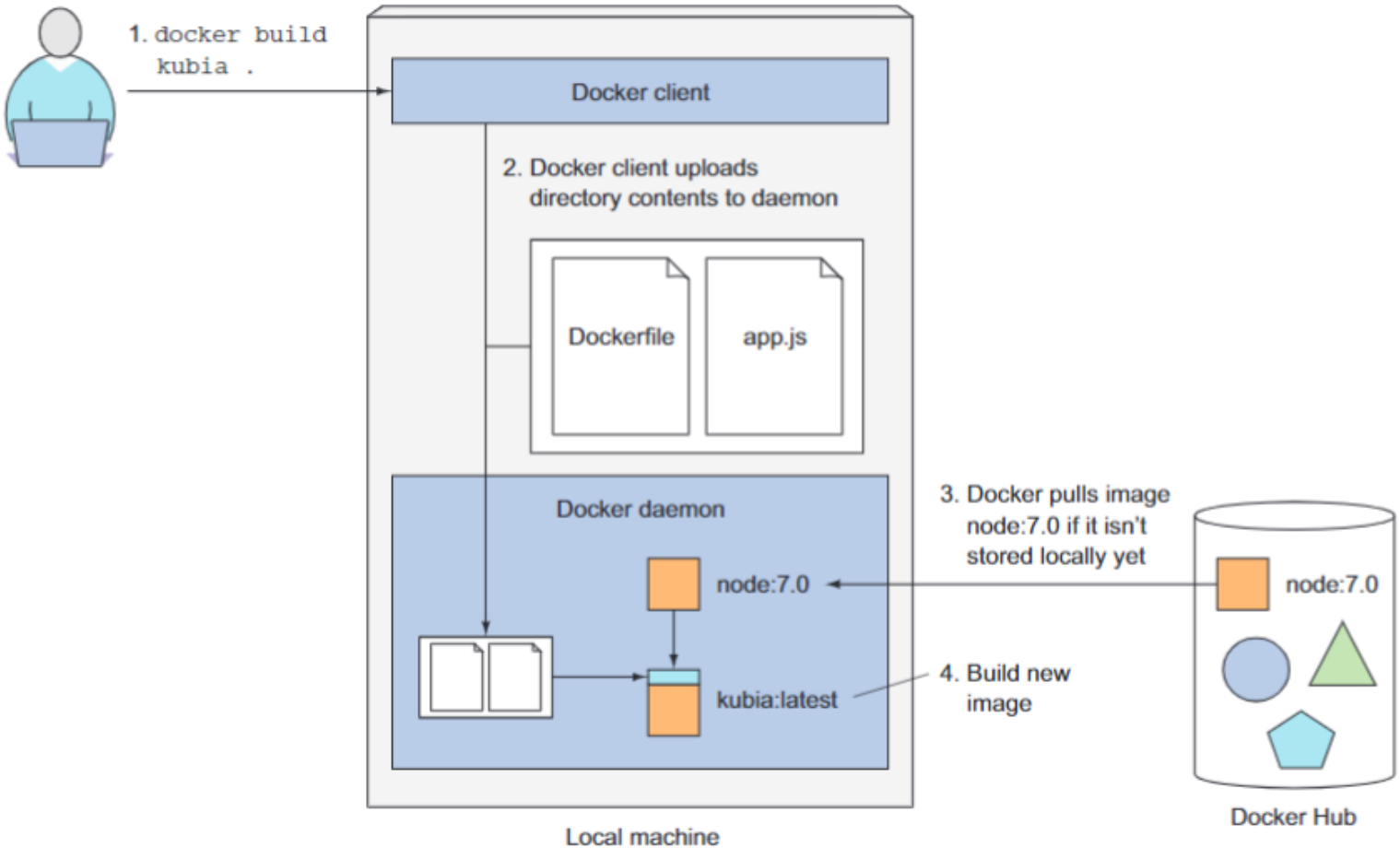

Figure: Fig. by courtesy of Marko Luksa[1]

The layers of a container image

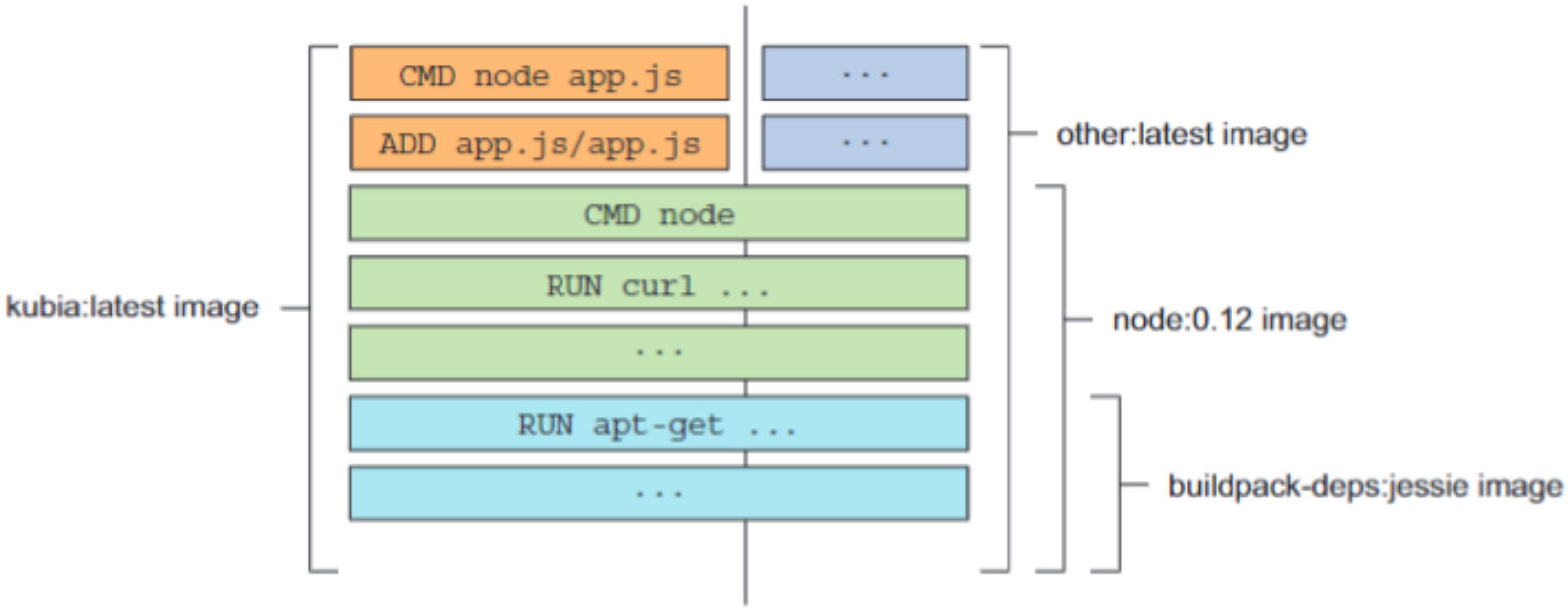

Figure: Fig. by courtesy of Marko Luksa[1]

More container commands

Running the container image

```
$ docker run --name kubia-container -p 8080:8080
$ curl localhost:8080
```

Exploring the inside of a running container

```
$ docker exec -it kubia-container bash
$ ps aux
```

Stopping and removing a container

```
$ docker stop kubia-container
$ docker rm kubia-container
```

Output of container commands

Listing 2.6 Listing processes from inside a container

```
root@44d76963e8e1:/# ps aux
USER  PID %CPU %MEM    VSZ   RSS TTY STAT START TIME COMMAND
root    1  0.0  0.1 676380 16504 ?   Sl   12:31 0:00 node app.js
root   10  0.0  0.0  20216  1924 ?   Ss   12:31 0:00 bash
root   19  0.0  0.0  17492  1136 ?   R+   12:38 0:00 ps aux
```

Figure: Listing. by courtesy of Marko Luksa[1]

Listing 2.8 A container has its own complete filesystem

```
root@44d76963e8e1:/# ls /
app.js  boot  etc   lib    media  opt   root  sbin  sys  usr
bin     dev   home  lib64  mnt    proc  run   srv   tmp  var
```

Figure: Listing. by courtesy of Marko Luksa[1]

Pushing the image to the registry

```
$ docker tag kubia <dockerid>/kubia
```

Listing 2.9 A container image can have multiple tags

```
$ docker images | head
REPOSITORY          TAG       IMAGE ID        CREATED              VIRTUAL SIZE
luksa/kubia         latest    d30ecc7419e7    About an hour ago    654.5 MB
kubia               latest    d30ecc7419e7    About an hour ago    654.5 MB
docker.io/node      7.0       04c0ca2a8dad    2 days ago           654.5 MB
...
```

Figure: Listing. by courtesy of Marko Luksa[1]

```
$ docker push <dockerid>/kubia
$ docker run -p 8080:8080 -d <dockerid>/kubia
```

Setting up a Kubernetes cluster with Minikube

What is minikube

- A tool that enables us to run Kubernetes locally
- Implements a local single node cluster
- Runs on macOS, Linux and Windows
- Used for Kubernetes development and prototyping
- Exercises and project make use of minikube

You can also order a hosted Kubernetes cluster at Google, Amazon, Microsoft Azure etc.

```
$ minikube start
$ kubectl get nodes
$ kubectl describe node <nodeid>
```

Introducing pods

Before we can deploy our app, we need to know what pod is

- A pod is a group of one or more tightly related containers that run together and share the same Linux namespace
- Each pod is like a separate logical machine.
- All containers in a pod will appear to be running on the same logical machine.

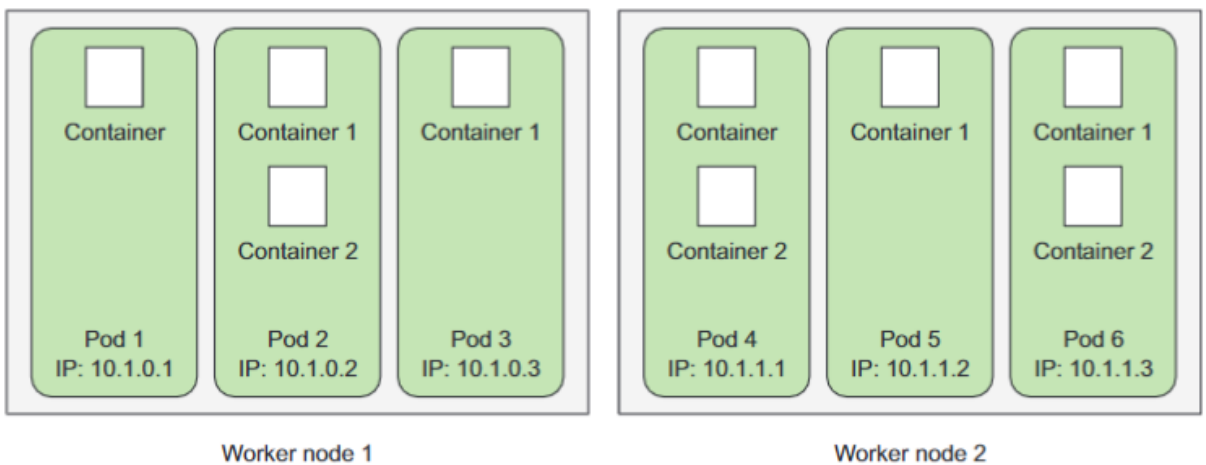

Figure: Fig. by courtesy of Marko Luksa[1]

Pod commands

Listing 2.14 Listing pods

```
$ kubectl get pods
NAME          READY     STATUS    RESTARTS   AGE
kubia-4jfyf   0/1       Pending   0          1m
```

Figure: Listing. by courtesy of Marko Luksa[1]

Listing 2.15 Listing pods again to see if the pod's status has changed

```
$ kubectl get pods
NAME          READY     STATUS    RESTARTS   AGE
kubia-4jfyf   1/1       Running   0          5m
```

Figure: Listing. by courtesy of Marko Luksa[1]

Running our first app on Kubernetes

```
$ kubectl run kubia --image=<dockerid>/kubia \\
 --port=8080 --generator=run-pod/v1
pod/kubia created
```

Accessing our application

We can create a service that exposes our pod to us

```
$ kubectl expose pod kubia --type=NodePort \\
  --name kubia-http
```

Listing 2.16 Listing Services

```
$ kubectl get services
NAME         CLUSTER-IP     EXTERNAL-IP   PORT(S)          AGE
kubernetes   10.3.240.1     <none>        443/TCP          34m
kubia-http   10.3.246.185   <pending>     8080:31348/TCP   4s
```

Figure: Listing. by courtesy of Marko Luksa[1]

Accessing our application cont.

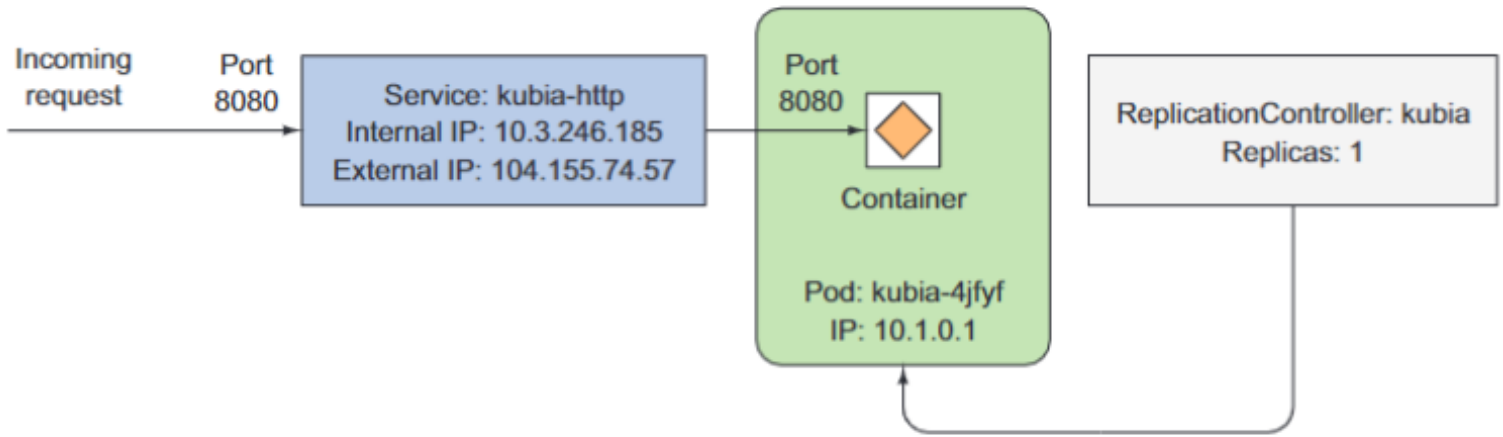

Figure: Fig. by courtesy of Marko Luksa[1]

Accessing our application cont.

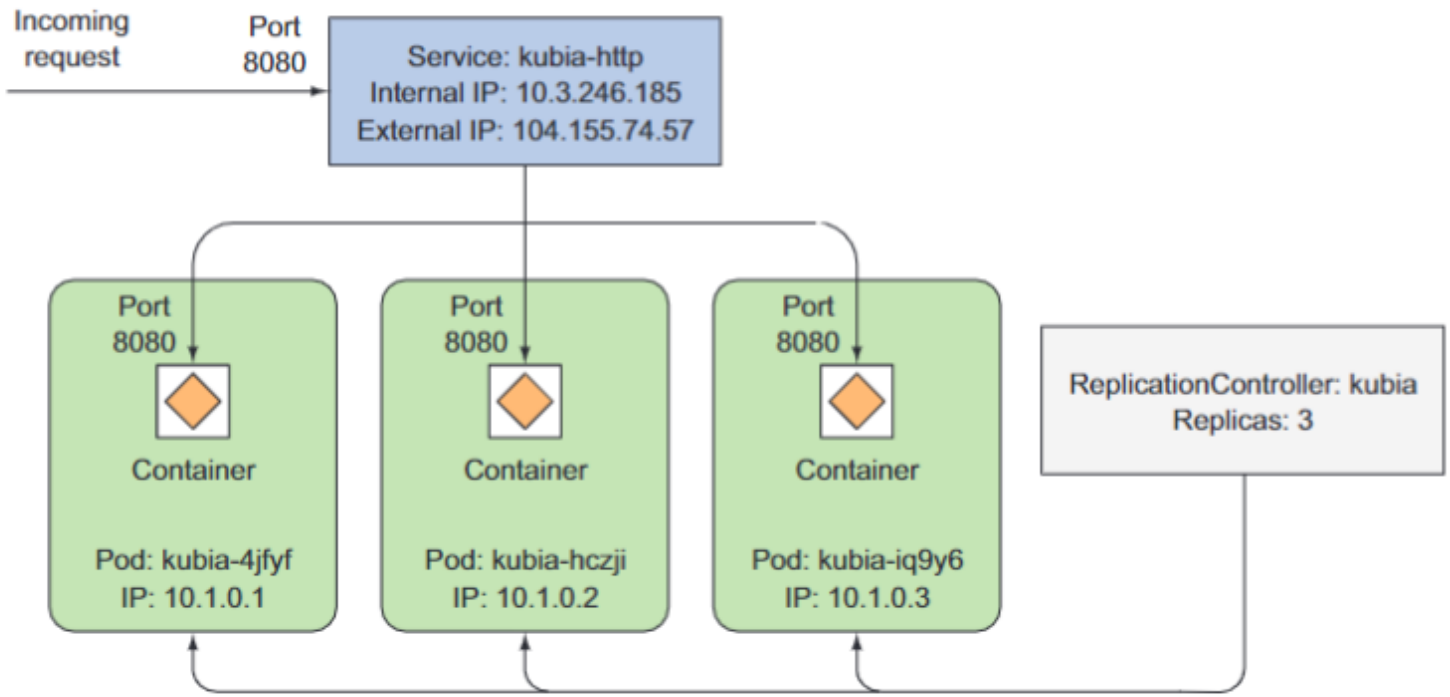

Figure: Fig. by courtesy of Marko Luksa[1]

References I

[1] Luksa, M. (2018). *Kubernetes in Action*. Manning Publications Co.