

AN OPENSOURCE EBOOK

INTRODUCTION TO



docker[®]

Bobby Iliev

Table of Contents

About the book	10
About the author	11
Sponsors	12
Ebook PDF Generation Tool	14
Book Cover	15
License	16
Chapter 1: Introduction to Docker	17
What is Docker?	18
Why Use Docker?	19
Docker Architecture	20
Containers vs. Virtual Machines	21
Basic Docker Workflow	22
Docker Components	23
Use Cases for Docker	24
Conclusion	25
Chapter 2: Installing Docker	26
Docker Editions	27
Installing Docker on Linux	28
Installing Docker on macOS	32
Installing Docker on Windows	33
Post-Installation Steps	34
Docker Desktop vs Docker Engine	35
Troubleshooting Common Installation Issues	36
Updating Docker	37

Uninstalling Docker	38
Conclusion	39
Chapter 3: Working with Docker Containers	40
Running Your First Container	41
Basic Docker Commands	42
Running Containers in Different Modes	44
Port Mapping	45
Working with Container Logs	46
Executing Commands in Running Containers	47
Practical Example: Running an Apache Container	48
Container Resource Management	49
Container Networking	50
Data Persistence with Volumes	51
Container Health Checks	52
Cleaning Up	53
Conclusion	54
Chapter 4: What are Docker Images	55
Key Concepts	56
Working with Docker Images	57
Building Custom Images	59
Image Tagging	60
Pushing Images to Docker Hub	61
Image Layers and Caching	62
Multi-stage Builds	63
Image Scanning and Security	64
Best Practices for Working with Images	65
Image Management and Cleanup	66
Conclusion	67

Chapter 5: What is a Dockerfile	68
Anatomy of a Dockerfile	69
Dockerfile Instructions	70
Best Practices for Writing Dockerfiles	74
Advanced Dockerfile Concepts	76
Conclusion	77
Chapter 6: Docker Networking	78
Docker Network Drivers	79
Working with Docker Networks	80
Deep Dive into Network Drivers	83
Network Troubleshooting	86
Best Practices	87
Advanced Topics	88
Conclusion	89
Chapter 7: Docker Volumes	90
Why Use Docker Volumes?	91
Types of Docker Volumes	92
Working with Docker Volumes	94
Volume Drivers	96
Best Practices for Using Docker Volumes	97
Advanced Volume Concepts	98
Troubleshooting Volume Issues	100
Conclusion	101
Chapter 8: Docker Compose	102
Key Benefits of Docker Compose	103
The docker-compose.yml File	104

Key Concepts in Docker Compose	105
Basic Docker Compose Commands	106
Advanced Docker Compose Features	107
Practical Examples	109
Best Practices for Docker Compose	115
Scaling Services	116
Networking in Docker Compose	117
Volumes in Docker Compose	118
Conclusion	119
 Chapter 9: Docker Security Best Practices	120
1. Keep Docker Updated	121
2. Use Official Images	122
3. Scan Images for Vulnerabilities	123
4. Limit Container Resources	124
5. Use Non-Root Users	125
6. Use Secret Management	126
7. Enable Content Trust	127
8. Use Read-Only Containers	128
9. Implement Network Segmentation	129
10. Regular Security Audits	130
11. Use Security-Enhanced Linux (SELinux) or AppArmor	131
12. Implement Logging and Monitoring	132
Conclusion	133
 Chapter 10: Docker in Production: Orchestration with	
Kubernetes	134
Key Kubernetes Concepts	135
Setting Up a Kubernetes Cluster	136
Deploying a Docker Container to Kubernetes	137

Scaling in Kubernetes	139
Rolling Updates	140
Monitoring and Logging	141
Kubernetes Dashboard	142
Persistent Storage in Kubernetes	143
Kubernetes Networking	144
Kubernetes Secrets	145
Helm: The Kubernetes Package Manager	146
Best Practices for Kubernetes in Production	147
Conclusion	148
 Chapter 11: Docker Performance Optimization	149
1. Optimizing Docker Images	150
2. Container Resource Management	152
3. Networking Optimization	153
4. Storage Optimization	154
5. Logging and Monitoring	155
6. Docker Daemon Optimization	156
7. Application-Level Optimization	157
8. Benchmarking and Profiling	158
9. Orchestration-Level Optimization	159
Conclusion	160
 Chapter 12: Docker Troubleshooting and Debugging	161
1. Container Lifecycle Issues	162
2. Networking Issues	163
3. Storage and Volume Issues	164
4. Resource Constraints	165
5. Image-related Issues	166
6. Docker Daemon Issues	167

7. Debugging Techniques	168
8. Performance Debugging	169
9. Docker Compose Troubleshooting	170
Conclusion	171
Chapter 13: Advanced Docker Concepts and Features	172
1. Multi-stage Builds	173
2. Docker BuildKit	174
3. Custom Bridge Networks	175
4. Docker Contexts	176
5. Docker Content Trust (DCT)	177
6. Docker Secrets	178
7. Docker Health Checks	179
8. Docker Plugins	180
9. Docker Experimental Features	181
10. Container Escape Protection	182
11. Custom Dockerfile Instructions	183
12. Docker Manifest	184
13. Docker Buildx	185
14. Docker Compose Profiles	186
Conclusion	187
Chapter 14: Docker in CI/CD Pipelines	188
1. Docker in Continuous Integration	189
2. Docker in Continuous Deployment	190
3. Docker Compose in CI/CD	192
4. Security Scanning	193
5. Performance Testing	194
6. Environment-Specific Configurations	195
7. Caching in CI/CD	196

8. Blue-Green Deployments with Docker	197
9. Monitoring and Logging in CI/CD	198
Conclusion	199

Chapter 15: Docker and Microservices Architecture 200

1. Principles of Microservices	201
2. Dockerizing Microservices	202
3. Inter-service Communication	203
4. Service Discovery	205
5. API Gateway	206
6. Data Management	207
7. Monitoring Microservices	208
8. Scaling Microservices	209
9. Testing Microservices	210
10. Deployment Strategies	211
Conclusion	212

Chapter 16: Docker for Data Science and Machine Learning .. 213

1. Setting Up a Data Science Environment	214
2. Managing Dependencies with Docker	215
3. GPU Support for Machine Learning	216
4. Distributed Training with Docker Swarm	217
5. MLOps with Docker	218
6. Data Pipeline with Apache Airflow	219
7. Reproducible Research with Docker	220
8. Big Data Processing with Docker	221
9. Automated Machine Learning (AutoML) with Docker	222
10. Hyperparameter Tuning at Scale	223
Conclusion	224

What is Docker Swarm mode	225
Docker Services	226
Building a Swarm	227
 Managing the cluster	 230
Promote a worker to manager	232
Using Services	233
Scaling a service	235
Deleting a service	237
Docker Swarm Knowledge Check	238
 Conclusion	 239
Other eBooks	240

About the book

- **This version was published on August 19 2024**

This is an introduction to Docker ebook that will help you learn the basics of Docker and how to start using containers for your SysOps, DevOps, and Dev projects. No matter if you are a DevOps/SysOps engineer, developer, or just a Linux enthusiast, you will most likely have to use Docker at some point in your career.

The guide is suitable for anyone working as a developer, system administrator, or a DevOps engineer and wants to learn the basics of Docker.

About the author

My name is Bobby Iliev, and I have been working as a Linux DevOps Engineer since 2014. I am an avid Linux lover and supporter of the open-source movement philosophy. I am always doing that which I cannot do in order that I may learn how to do it, and I believe in sharing knowledge.

I think it's essential always to keep professional and surround yourself with good people, work hard, and be nice to everyone. You have to perform at a consistently higher level than others. That's the mark of a true professional.

For more information, please visit my blog at <https://bobbyiliev.com>, follow me on Twitter [@bobbyiliev_](#) and [YouTube](#).

Sponsors

This book is made possible thanks to these fantastic companies!

Materialize

The Streaming Database for Real-time Analytics.

Materialize is a reactive database that delivers incremental view updates. Materialize helps developers easily build with streaming data using standard SQL.

DigitalOcean

DigitalOcean is a cloud services platform delivering the simplicity developers love and businesses trust to run production applications at scale.

It provides highly available, secure, and scalable compute, storage, and networking solutions that help developers build great software faster.

Founded in 2012 with offices in New York and Cambridge, MA, DigitalOcean offers transparent and affordable pricing, an elegant user interface, and one of the largest libraries of open source resources available.

For more information, please visit <https://www.digitalocean.com> or follow [@digitalocean](https://twitter.com/digitalocean) on Twitter.

If you are new to DigitalOcean, you can get a free \$100 credit and spin up your own servers via this referral link here:

[Free \\$200 Credit For DigitalOcean](#)

DevDojo

The DevDojo is a resource to learn all things web development and web design. Learn on your lunch break or wake up and enjoy a cup of coffee with us to learn something new.

Join this developer community, and we can all learn together, build together, and grow together.

[Join DevDojo](#)

For more information, please visit <https://www.devdojo.com> or follow [@thedeveloper](#) on Twitter.

Ebook PDF Generation Tool

This ebook was generated by [Ibis](#) developed by [Mohamed Said](#).

Ibis is a PHP tool that helps you write eBooks in markdown.

Book Cover

The cover for this ebook was created with [Canva.com](https://www.canva.com).

If you ever need to create a graphic, poster, invitation, logo, presentation – or anything that looks good — give Canva a go.

License

MIT License

Copyright (c) 2020 Bobby Iliev

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

Chapter 1: Introduction to Docker

What is Docker?

Docker is an open-source platform that automates the deployment, scaling, and management of applications using containerization technology. It allows developers to package applications and their dependencies into standardized units called containers, which can run consistently across different environments.

Key Concepts:

1. **Containerization:** A lightweight form of virtualization that packages applications and their dependencies together.
2. **Docker Engine:** The runtime that allows you to build and run containers.
3. **Docker Image:** A read-only template used to create containers.
4. **Docker Container:** A runnable instance of a Docker image.
5. **Docker Hub:** A cloud-based registry for storing and sharing Docker images.

Why Use Docker?

Docker offers numerous advantages for developers and operations teams:

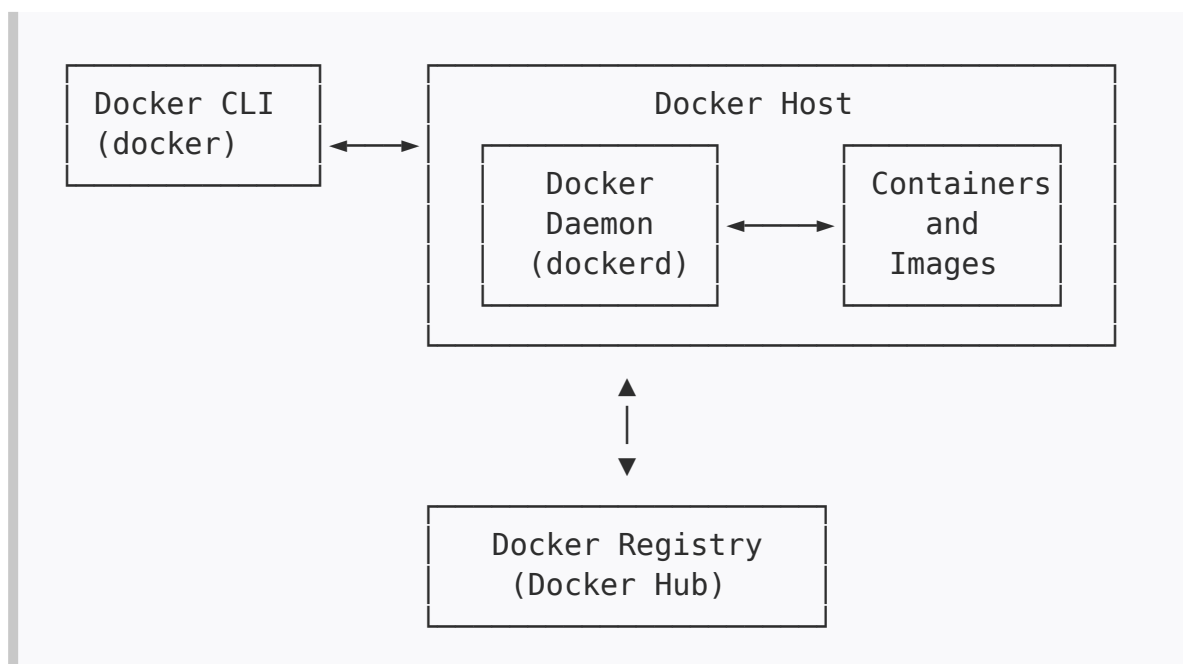
1. **Consistency:** Ensures applications run the same way in development, testing, and production environments.
2. **Isolation:** Containers are isolated from each other and the host system, improving security and reducing conflicts.
3. **Portability:** Containers can run on any system that supports Docker, regardless of the underlying infrastructure.
4. **Efficiency:** Containers share the host system's OS kernel, making them more lightweight than traditional virtual machines.
5. **Scalability:** Easy to scale applications horizontally by running multiple containers.
6. **Version Control:** Docker images can be versioned, allowing for easy rollbacks and updates.

Docker Architecture

Docker uses a client-server architecture:

1. **Docker Client:** The primary way users interact with Docker through the command line interface (CLI).
2. **Docker Host:** The machine running the Docker daemon (dockerd).
3. **Docker Daemon:** Manages Docker objects like images, containers, networks, and volumes.
4. **Docker Registry:** Stores Docker images (e.g., Docker Hub).

Here's a simplified diagram of the Docker architecture:



Containers vs. Virtual Machines

While both containers and virtual machines (VMs) are used for isolating applications, they differ in several key aspects:

Aspect	Containers	Virtual Machines
OS	Share host OS kernel	Run full OS and kernel
Resource Usage	Lightweight, minimal overhead	Higher resource usage
Boot Time	Seconds	Minutes
Isolation	Process-level isolation	Full isolation
Portability	Highly portable across different OSes	Less portable, OS-dependent
Performance	Near-native performance	Slight performance overhead
Storage	Typically smaller (MBs)	Larger (GBs)

Basic Docker Workflow

1. **Build:** Create a Dockerfile that defines your application and its dependencies.
2. **Ship:** Push your Docker image to a registry like Docker Hub.
3. **Run:** Pull the image and run it as a container on any Docker-enabled host.

Here's a simple example of this workflow:

```
# Build an image
docker build -t myapp:v1 .

# Ship the image to Docker Hub
docker push username/myapp:v1

# Run the container
docker run -d -p 8080:80 username/myapp:v1
```

Docker Components

1. **Dockerfile**: A text file containing instructions to build a Docker image.
2. **Docker Compose**: A tool for defining and running multi-container Docker applications.
3. **Docker Swarm**: Docker's native clustering and orchestration solution.
4. **Docker Network**: Facilitates communication between Docker containers.
5. **Docker Volume**: Provides persistent storage for container data.

Use Cases for Docker

1. **Microservices Architecture:** Deploy and scale individual services independently.
2. **Continuous Integration/Continuous Deployment (CI/CD):** Streamline development and deployment processes.
3. **Development Environments:** Create consistent development environments across teams.
4. **Application Isolation:** Run multiple versions of an application on the same host.
5. **Legacy Application Migration:** Containerize legacy applications for easier management and deployment.

Conclusion

Docker has revolutionized how applications are developed, shipped, and run. By providing a standardized way to package and deploy applications, Docker addresses many of the challenges faced in modern software development and operations. As we progress through this book, we'll dive deeper into each aspect of Docker, providing you with the knowledge and skills to leverage this powerful technology effectively.

Chapter 2: Installing Docker

Installing Docker is the first step in your journey with containerization. This chapter will guide you through the process of installing Docker on various operating systems, troubleshooting common issues, and verifying your installation.

Docker Editions

Before we begin, it's important to understand the different Docker editions available:

1. **Docker Engine - Community:** Free, open-source Docker platform suitable for developers and small teams.
2. **Docker Engine - Enterprise:** Designed for enterprise development and IT teams building, running, and operating business-critical applications at scale.
3. **Docker Desktop:** An easy-to-install application for Mac or Windows environments that includes Docker Engine, Docker CLI client, Docker Compose, Docker Content Trust, Kubernetes, and Credential Helper.

For most users, Docker Engine - Community or Docker Desktop will be sufficient.

Installing Docker on Linux

Docker runs natively on Linux, making it the ideal platform for Docker containers. There are two main methods to install Docker on Linux: using the convenience script or manual installation for specific distributions.

Method 1: Using the Docker Installation Script (Recommended for Quick Setup)

Docker provides a convenient script that automatically detects your Linux distribution and installs Docker for you. This method is quick and works across many Linux distributions:

1. Run the following command to download and execute the Docker installation script:

```
wget -q0- https://get.docker.com | sh
```

2. Once the installation is complete, start the Docker service:

```
sudo systemctl start docker
```

3. Enable Docker to start on boot:

```
sudo systemctl enable docker
```

This method is ideal for quick setups and testing environments. However, for production environments, you might want to consider the manual installation method for more control over the process.

Method 2: Manual Installation for Specific Distributions

For more control over the installation process or if you prefer to follow distribution-specific steps, you can manually install Docker. Here are instructions for popular Linux distributions:

Docker runs natively on Linux, making it the ideal platform for Docker containers. Here's how to install Docker on popular Linux distributions:

Ubuntu

1. Update your package index:

```
sudo apt-get update
```

2. Install prerequisites:

```
sudo apt-get install apt-transport-https ca-certificates  
curl software-properties-common
```

3. Add Docker's official GPG key:

```
curl -fsSL https://download.docker.com/linux/ubuntu/gpg |  
sudo apt-key add -
```

4. Set up the stable repository:

```
sudo add-apt-repository "deb [arch=amd64]  
https://download.docker.com/linux/ubuntu $(lsb_release -  
cs) stable"
```

5. Update the package index again:

```
sudo apt-get update
```

6. Install Docker:

```
sudo apt-get install docker-ce docker-ce-cli containerd.io
```

CentOS

1. Install required packages:

```
sudo yum install -y yum-utils device-mapper-persistent-  
data lvm2
```

2. Add Docker repository:

```
sudo yum-config-manager --add-repo  
https://download.docker.com/linux/centos/docker-ce.repo
```

This is a sample from "Introduction to Docker" by Bobby Iliev.

For more information, [Click here](#).