Function as a Service

General Principles, Container Virtualization and OpenFaaS – Summer Term 2018

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Function as a Service

Figure: Popular FaaS Offerings:
(a) AWS Lambda [1]
(b) Google Cloud Functions [2]
(c) IBM Cloud Functions [3]
(d) Apache OpenWhisk [4]

Function as a Service (FaaS)

- Event-driven
- Scalable
- Fast deployment of code
- Payment per invocation

Amazon Alexa

Alexa Skills are executed in AWS Lambda!

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FaaS General Architecture I

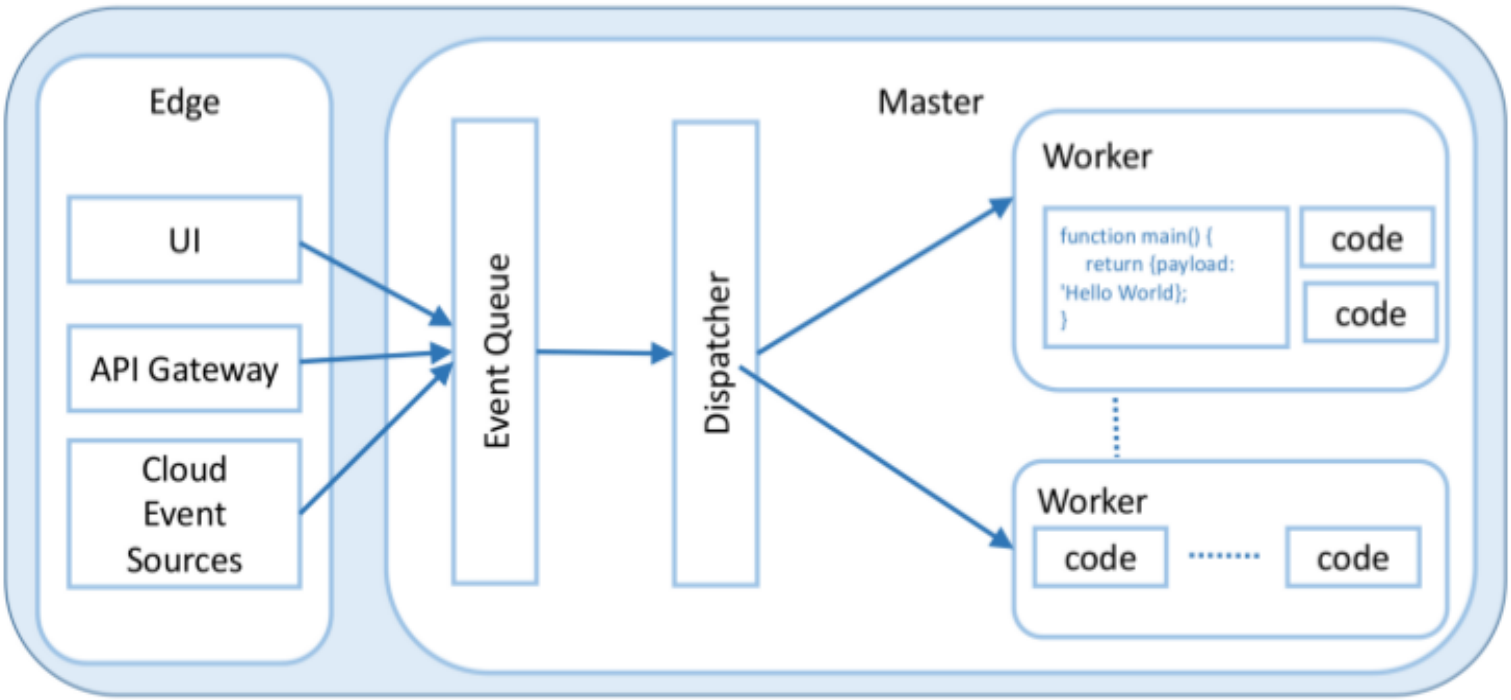

Figure: General FaaS Architecture [5]

FaaS General Architecture II

Edge

- **UI** – An UI for the management of functions
- **API Gateway** – The general API for the implemented functions

Event Queue/Dispatcher

- **Event Queue** – Manages the triggered Events
- **Dispatcher** – Manages the scaling of invocations

Worker

- **Worker Processes/Containers** – Execute the function invocations

Interesting Paper

Figure 2 and the explanation of the architecture are taken from the paper of Baldini et.al. [5]

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Function as a Service

The Service consists of:

- Scalability – Reaction to large number of Requests
- Environment – Running the code on a Platform
- Virtualization – Capsulation of running code

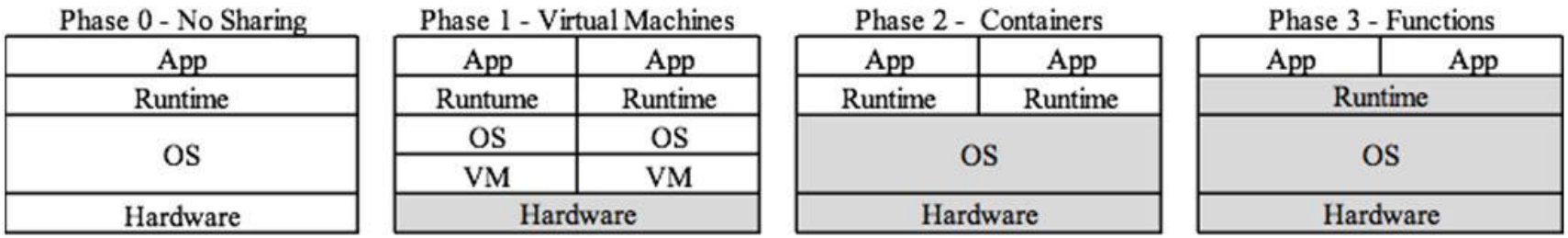

Figure: Evolution of Virtualization [6]

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Docker

Figure: Docker

Source:
`https://www.docker.com/brand-guidelines`

Docker

- Released by dotCloud 2013
- Enables Container Virtualization
- A more advanced form of Application Virtualization
- Available for:
  Linux, MacOS, Windows

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Docker Architecture

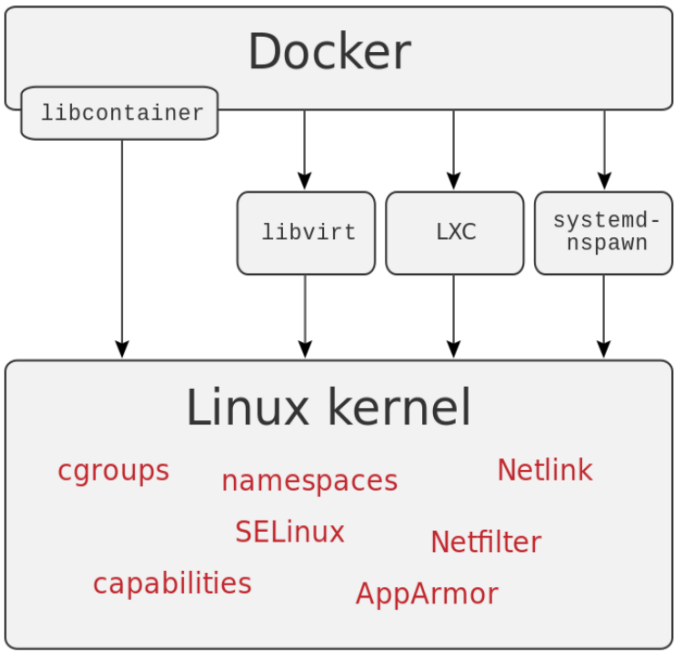

Figure: Docker Architecture

Docker Architecture

- Docker uses the Linux Kernel
- `libcontainer` creates containers
- `libvirt` manages Virtual Environments
- LXC will be replaced by `libcontainer`

Source: `https://de.wikipedia.org/wiki/Docker_(Software)`

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Docker Application Architecture I

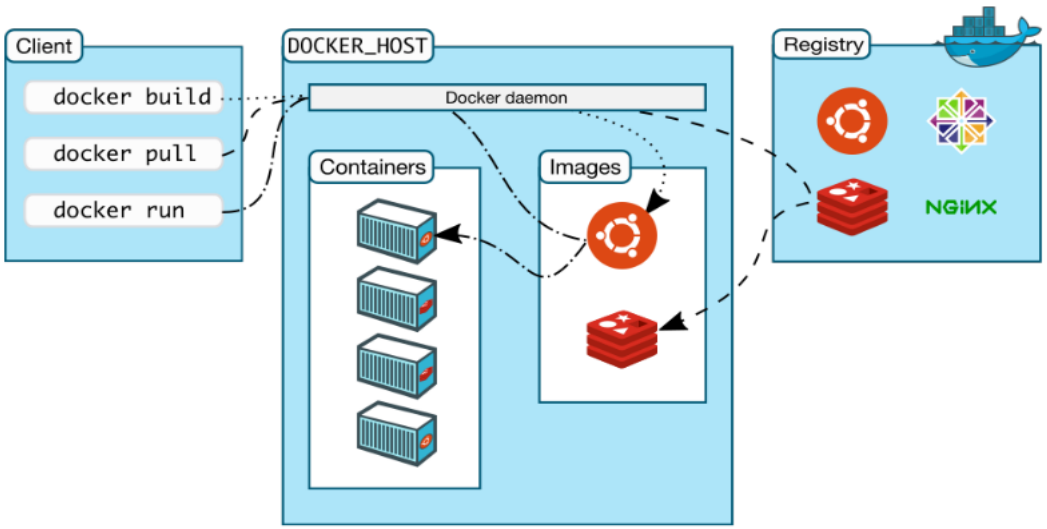

Figure: Docker Application Architecture

Source: `https://docs.docker.com/engine/docker-overview/#docker-architecture`

Applications in Docker [7]

- Client-Server Architecture
- Docker Client `docker`
- Docker Daemon `dockerd`

Docker Objects

- Images
- Containers

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Docker Application Architecture II

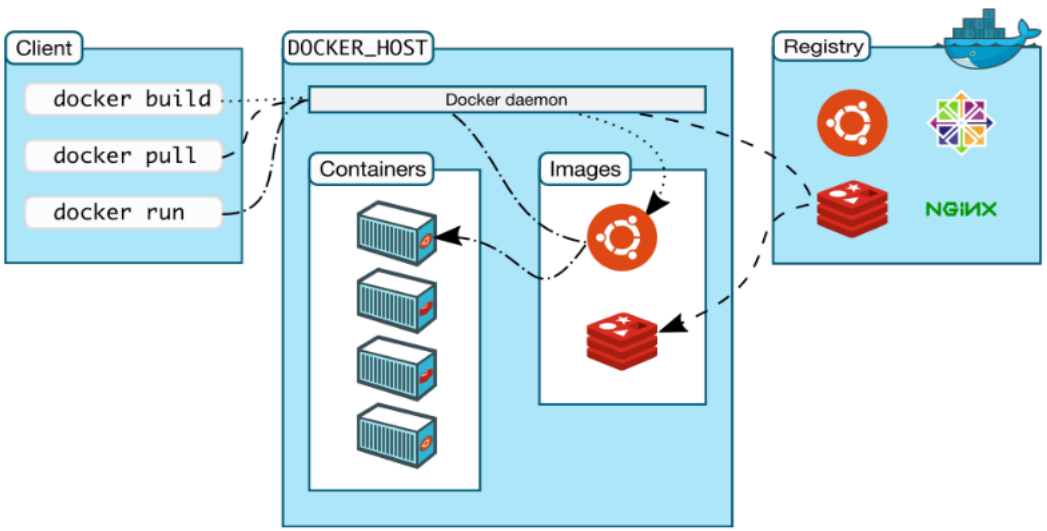

Figure: Docker Application Architecture

Source: `https://docs.docker.com/engine/docker-overview/#docker-architecture`

Docker Client `docker`

- Manages Docker Daemon/s

Docker Daemon `dockerd`

- Listens to Requests
- Manages Docker Objects (images, containers, etc.)

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Docker Application Architecture III

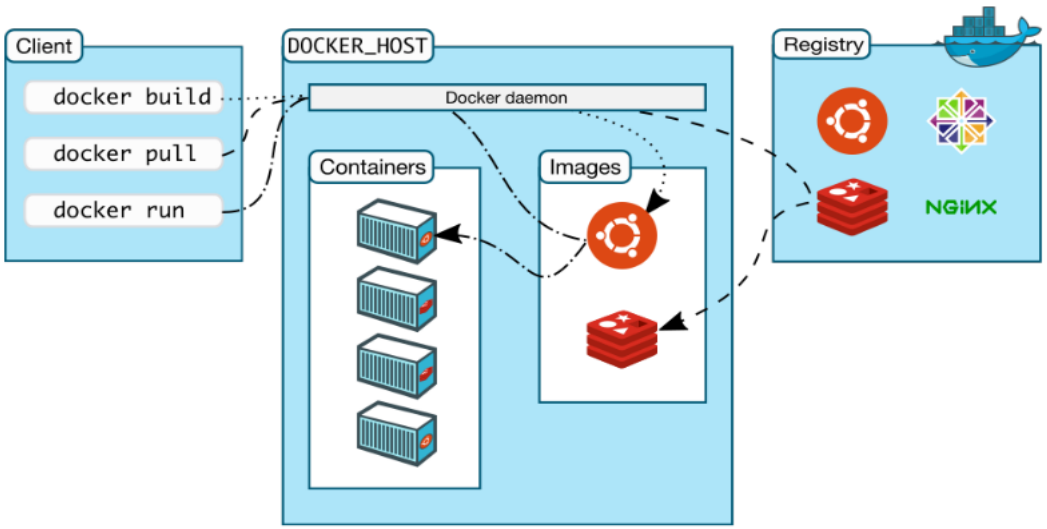

Figure: Docker Application Architecture

Source: `https://docs.docker.com/engine/docker-overview/#docker-architecture`

Docker Objects

- **Containers**
  - Runnable Instance
  - Isolated from other containers
- **Images**
  - Read-Only File
  - Defines an Application

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Docker Benefits

Docker has the following benefits:

- Less resource consumption than OS Virtualization
- Isolation of Applications
- Fast deployment
- Perfect for testing purposes
- Containers can be restarted

Docker Swarm and Kubernetes

The Docker Engine has a build in solution for Cluster deployment and management. The `swarm` mode enables the control over multiple Docker hosts and is crucial for the scalability of applications [8]. Kubernetes is a different system that enables deployment over multiple hosts.

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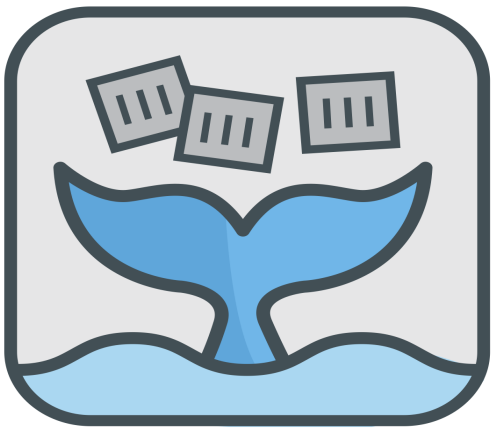
OpenFaaS



OPENFAAS

Figure: OpenFaaS

Source:
`https://github.com/openfaas`

OpenFaaS

- Open Source Platform
- Functions can be deployed and scaled
- Event-driven
- Lightweight
- Support for multiple languages: C#, Node.js, Python, Ruby

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OpenFaaS Architecture I

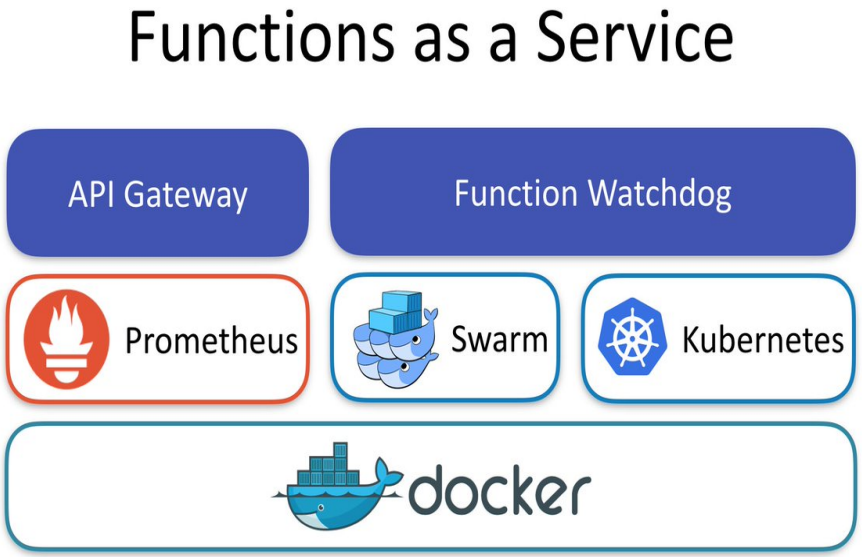

Figure: OpenFaaS Architecture [9]

OpenFaaS Architecture [9]

- **Gateway API**
  - Provides a Route to the functions
  - UI for the management of functions
  - Scales functions through Docker
- **Function Watchdog**
  - Functions are added as Docker Images
  - Entrypoint for HTTP Requests
  - In → `STDIN`
    Out → `STDOUT`

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OpenFaaS Architecture II

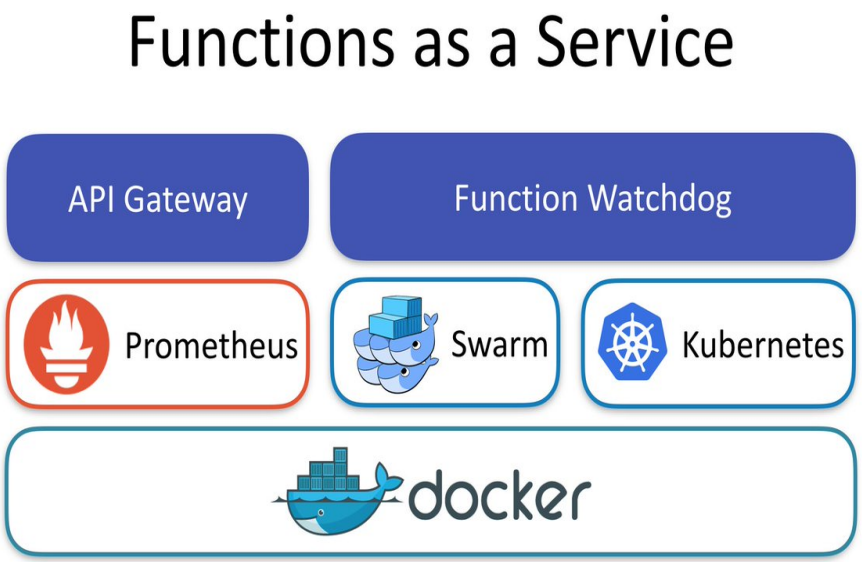

Figure: OpenFaaS Architecture [9]

OpenFaaS Architecture [9]

- **Prometheus**
  - Collects Metrics
  - Function Metrics can be inspected
  - Can be accessed through Web-UI
- **Docker**
  - Isolates Functions in Docker Images
  - Docker Swarm distributes functions
  - Kubernetes can be used to orchestrate Docker Instances

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OpenFaaS Benefits

OpenFaaS has the following benefits:

- Open Source
- Low resource consumption
- Deployment of functions
- Autoscaling
- Build in Monitoring and Metrics (Prometheus)

OpenFaaS on Raspberry Pi

OpenFaaS together with Docker Swarm have a low resource consumption. Therefore OpenFaaS has been installed on a cluster of 6 Raspberry Pis. Further evaluation of the service on Raspberry Pis has to be made. More information about installation on Raspberry Pi [10].

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Conclusion

Function as a Service characteristics:

- More fine grained buisiness model (payment per invocation)
- Functions have no side effects, stateless model
- Scaling of functions with Container Virtualization (Docker)
- Shorter developement and deployment cycles (DevOps)
- Suitable technology for microservices

Outlook

FaaS is a new technology in the field of Cloud Platform Services. With the developement of IoT, Smart Homes and other event-driven technologies the number of private FaaS Frameworks and public FaaS offerings will grow in the near future!

References I

[1] "AWS Lambda," https://aws.amazon.com/lambda/, accessed 27th May 2018.

[2] "Google Cloud Functions BETA," https://cloud.google.com/functions/, accessed 27th May 2018.

[3] "IBM Cloud Functions," https://www.ibm.com/cloud/functions, accessed 27th May 2018.

[4] "Apache OpenWhisk," https://openwhisk.apache.org/, accessed 27th May 2018.

[5] I. Baldini, P. C. Castro, K. S. Chang, P. Cheng, S. J. Fink, V. Ishakian, N. Mitchell, V. Muthusamy, R. M. Rabbah, A. Slominski, and P. Suter, "Serverless Computing: Current Trends and Open Problems," *CoRR*, vol. abs/1706.03178, 2017. [Online]. Available: http://arxiv.org/abs/1706.03178

References II

[6] T. Lynn, P. Rosati, A. Lejeune, and V. Emeakaroha, "A Preliminary Review of Enterprise Serverless Cloud Computing (Function-as-a-Service) Platforms," in *2017 IEEE International Conference on Cloud Computing Technology and Science (CloudCom)*, Dec 2017, pp. 162–169.

[7] "Docker Docs," https://docs.docker.com/, accessed 27th May 2018.

[8] "Docker Swarm," https://docs.docker.com/engine/swarm/, accessed 27th May 2018.

[9] "OpenFaaS - Serverless Functions Made Simple," https://docs.openfaas.com/, accessed 28th May 2018.

[10] "Your Serverless Raspberry Pi cluster with Docker," https://blog.alexellis.io/your-serverless-raspberry-pi-cluster/, accessed 28th May 2018.