

# The Past, Present, and Future of Kubernetes on Raspberry Pi

KubeCon, North America

**Alex Ellis** - OpenFaaS Ltd - CNCF Ambassador

# Comparison

- Why do it?
- Where are we today?
- How did we get there?
- Bill of Materials

- Future of ARM
- Demo & tools
- Cheatsheet
- Wrapping up



# Why do it?

- "Real world"
  - High Performance Computing (HPC)
  - For edge compute
    - CDN
    - CCTV / Machine Learning
    - Point of sales
  - Managed cloud services
  - All day battery



750 node cluster - NMC



Why do it?



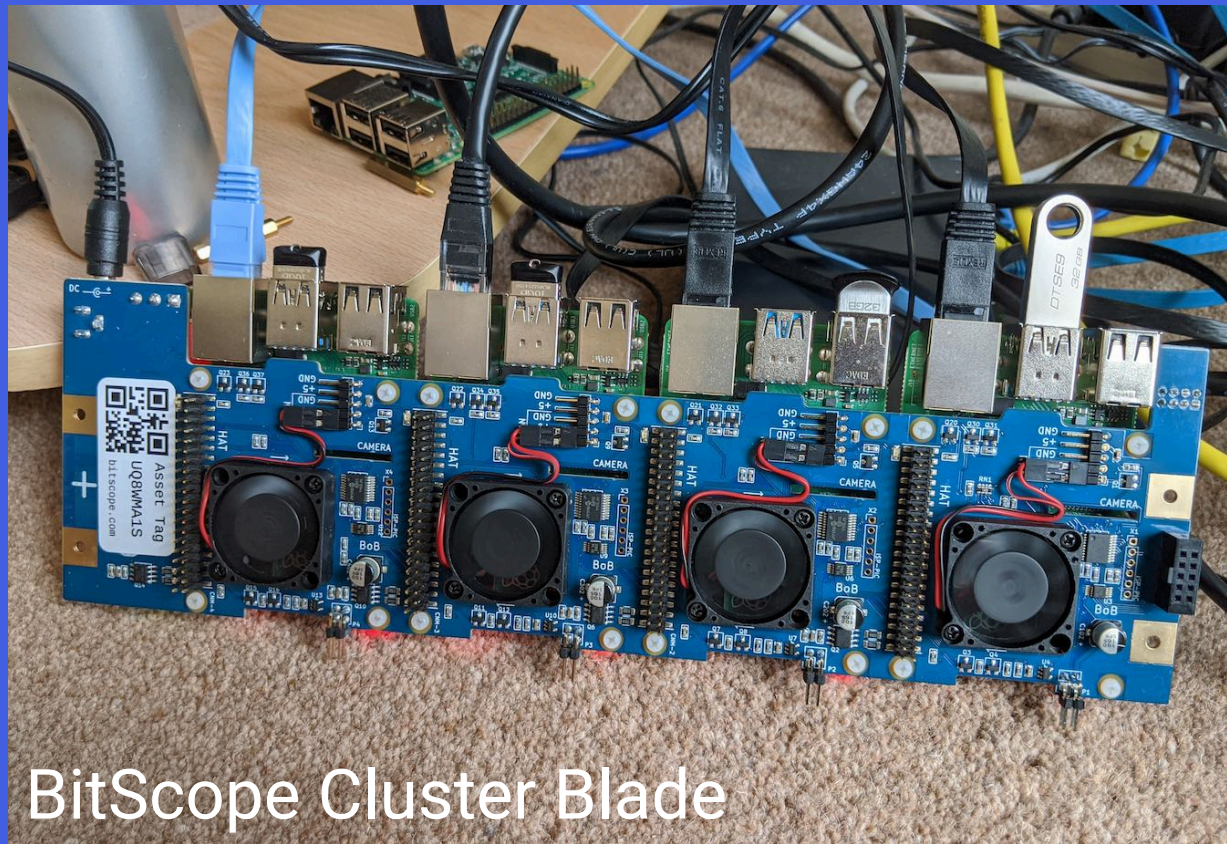
# Because **you** want to.

- Practice & learn on real hardware
- Private cloud
  - Cheap to run 24/7 (vs EKS etc)
  - Websites, APIs, blogs, bots, Alexa skills





# My demo rig



BitScope Cluster Blade



K3S



- 4x RPi4 2GB
- Netbooted
- HA etcd
- Public IP w/  
LoadBalancer



# The past - my first blog

- My Ghost blog from 2013
  - Node.js
  - Building SQLite
- Connectivity?
- Performance?
- Ingress?



# The past - my first cluster

29 MARCH 2016

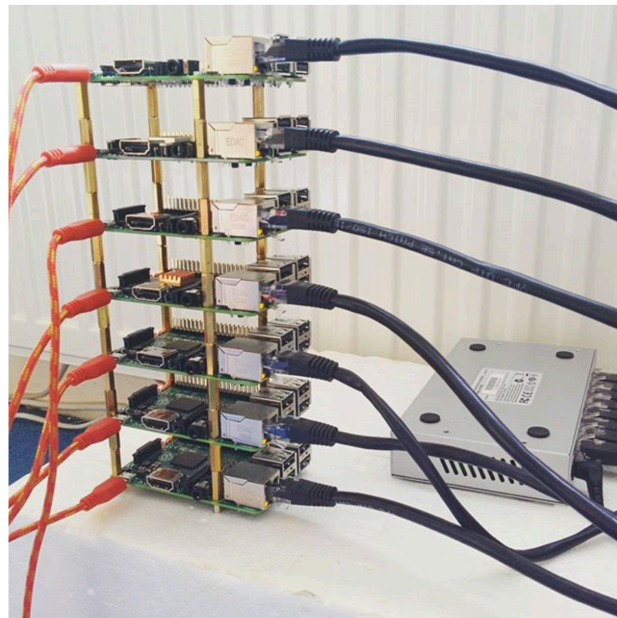
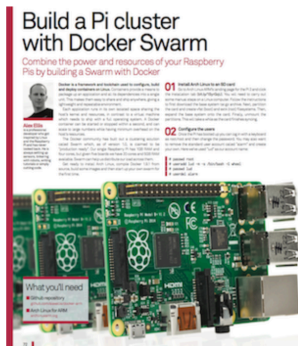
## Docker Article in Linux magazine

29 MARCH 2016 on Raspberry PI, docker, tutorial, swarm, cluster, Linux User and Developer, networking

I've just had an updated version of my *Docker Swarm on the Raspberry PI* tutorial published in Linux User and Developer magazine issue 163. This was great timing as it co-incided with the official #DockerSwarm week. In the UK the magazine is sold on the shelf in WHSmith's, but if you've missed it you can get the 4-page tutorial in the digital PDF edition below:

Linux User and Developer: [Issue 163](#)

[@Docker re-tweets post!](#)



My stack of 7 Raspberry PI Model 2s running Docker Swarm







## Raspberry Pi Blog

[← All blog posts](#)[ARCHIVE](#) [RSS](#)

# Docker comes to Raspberry Pi



30th Aug 2016

Matt Richardson

31 comments

If you're not already familiar with [Docker](#), it's a method of packaging software to include not only your code, but also other components such as a full file system, system tools, services, and libraries. You can then run the software on multiple machines without a lot of setup. Docker calls these packages *containers*.



[Mayview Maersk](#) by Flickr user [Kees Torn](#)

Think of it like a shipping container and you've got some idea of how it works. Shipping containers are a standard size so that they can be moved around at ports, and shipped via sea or land. They can also contain almost anything. Docker containers can hold your software's code and its dependencies, so that it can easily run on many different machines. Developers often use them to create a web application server that runs on their own machine for development, and is then pushed to the cloud for the public to use.

### RELATED POSTS



**Programming your Pi Zero over USB**



**Serving the Raspberry Pi 3 launch from a Raspberry Pi 3**



**Vote for the top 20 Raspberry Pi projects in The MagPi!**

### NEXT POST



**Building Computer Labs in Western Africa**

### PREVIOUS POST



**Call me Ishmael**

Share this post [Twitter](#) [Facebook](#)

# cmd/compile, cmd/link: can't build large arm binaries with external linking, Kubernetes now too big #17028



Closed

luxas opened this issue on 8 Sep 2016 · 62 comments



luxas commented on 8 Sep 2016

Please answer these questions before submitting your issue. Thanks!

**What version of Go are you using ( `go version` )?**

go1.6.3

**What operating system and processor architecture are you using ( `go env` )?**

linux/arm

**What did you do?**

If possible, provide a recipe for reproducing the error.

A complete runnable program is good.

A link on play.golang.org is best.

Just run

```
docker run -it gcr.io/google_containers/kube-apiserver-arm:v1.4.0-alpha.3 /usr/local/bin/kube-apiserver
```

**What did you expect to see?**

kube-apiserver starting

## Assignees

No one assigned

## Labels

FrozenDueToAge

NeedsFix

## Projects

None yet

## Milestone

Go1.8

## Linked pull requests

Successfully merging a pull request may close this issue.

None yet

## Notifications

Customize

## Reader's clusters

- [Dino Fizzotti - Raspberry Pi Cluster Part 2: ToDo API running on Kubernetes with k3s](#)
- [Jim Angel's Kubernetes cluster for testing unreleased alpha / beta k8s versions](#)
- [roncrivera's 4-node home-lab running OpenFaaS in a gun-case](#)
- [Scott Hanselman's 6-node cluster running Kubernetes, OpenFaaS with the Pimoroni blinkt! Scott's cluster-selfie](#)
- [Ken Fukuyama's Kubernetes cluster running OpenFaaS from Japan](#)
- [Karol Stępniewski's Asus Tinkerboard cluster running OpenFaaS and K8s](#)
- [Bart Plasmeijer's K8s cluster](#)
- [Burton Rheutan's cluster stashed away in a closet](#)
- [Kevin Turcios' OpenFaaS cluster](#)
- [Estelle Auberix' OpenFaaS and K8s cluster for ServerlessConf Paris](#)
- [Davy's Kubernetes and OpenFaaS cluster](#)
- [Jaigouk Kim's OpenFaaS and K8s cluster with the Asus Tinkerboard](#)
- [Ram's 7-node homelab with OpenFaaS and Kubernetes](#)
- [David Muckle's OpenFaaS cluster](#)
- [Brian Moelk's battery-powered OpenFaaS cluster](#)
- [Marcus Smallman' DIY Raspberry Pi Kubernetes Cluster](#)
- [Mathias Deremer-Accettone's Serverless sur Raspberry PI avec Docker Swarm et OpenFaas](#)
- [Daniel Llewellyn's three node Raspberry Pi Swarm](#)
- [Gareth Bradley's 6 node Raspberry Pi Kubernetes Cluster](#)
- [Andreas Muttscheller's Raspberry Pi OpenFaaS k3s cluster provisioned with Ansible](#)
- [Ruan Bekker's K3s Setup with Golang and Traefik on a Raspberry Pi 4](#)

# k3s - "1.5GB less memory than kubeadm"\*



- Fast install with curl or k3sup
- Resources:
  - 500MB RAM - server
  - 50MB RAM - per agent
- Runs well on Raspberry Pi 4 and public cloud
- High Availability / multi-master:
  - SQL / embedded etcd

EDITORS' PICK | Aug 28, 2020, 10:53am EDT

## Why Is The Open Source Community Excited About K3s Project Joining CNCF?



**Janakiram MSV** Senior Contributor @

Cloud

*I cover Cloud Computing, Machine Learning, and Internet of Things*



Hot on the heels of KubeCon+CloudNativeCon, Rancher Labs [announced](#) the acceptance of [K3s](#) by the [Cloud Native Computing Foundation](#) (CNCF). It's joining the likes of OpenTelemetry, Network Service Mesh, Longhorn and 30 other projects in the Sandbox.



# k3s - 3 is less than 8



- Full Kubernetes (GA)
- Built-in choices:
  - Flannel - network driver
  - SQLite - etcd replacement
  - containerd - runtime

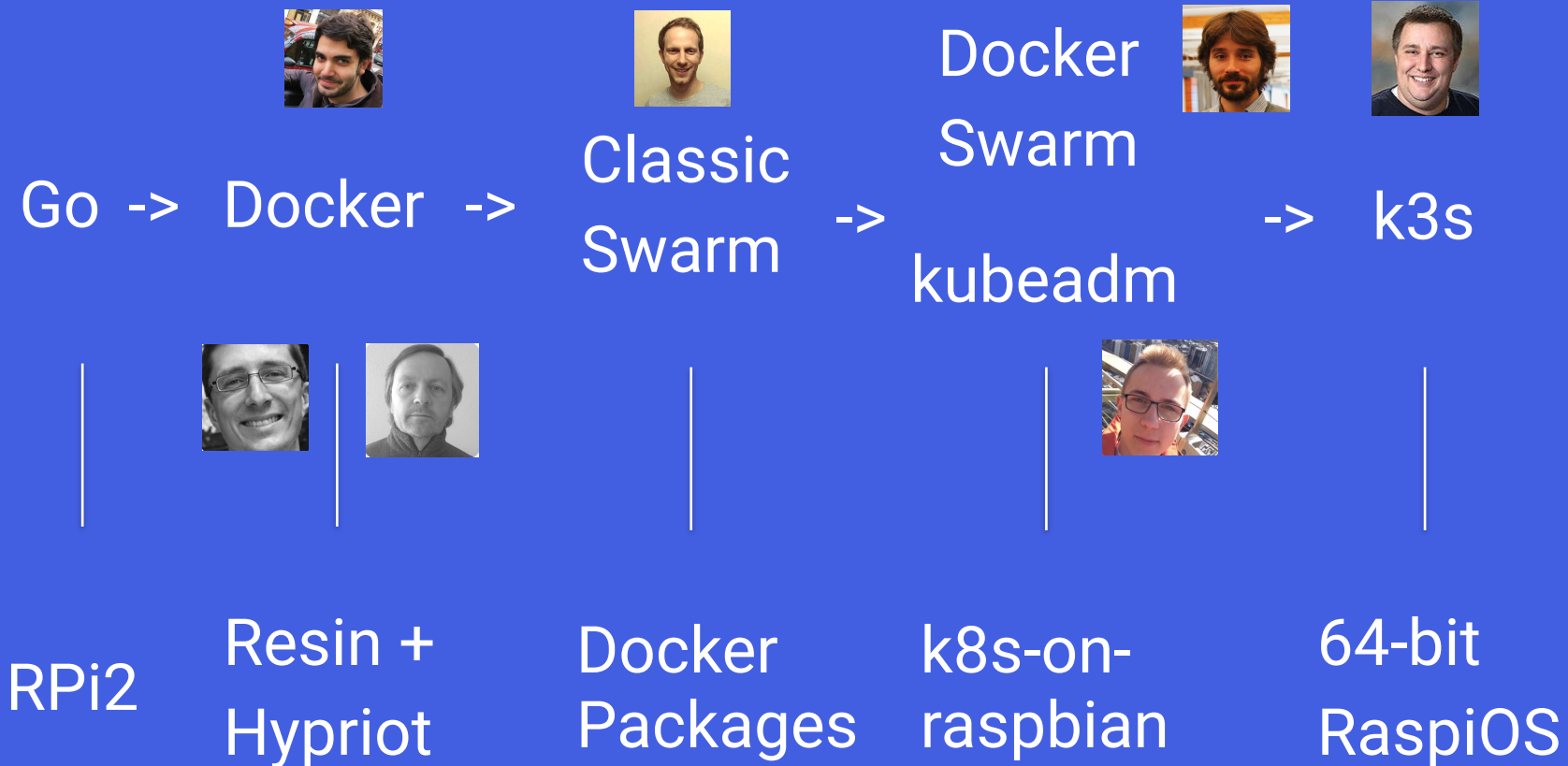
## Bonus:

- local-path-provisioner - volumes
- Traefik 1.x - IngressController
- metrics-server, helm CRD





# The past - journey of evolution



# Bill of Materials

What's your budget?

- Spare parts
- On a budget
- Space conscious
- Best in class - industrial

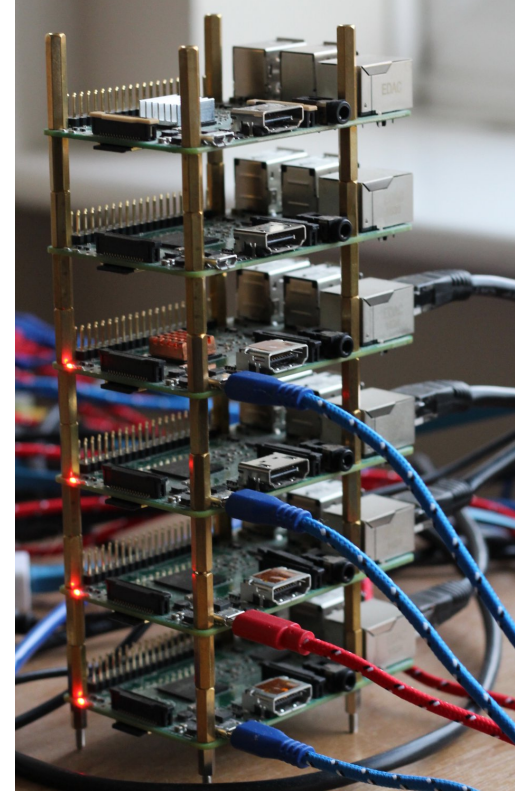


# Build your own: spare parts

## Raid your parts box

- Copper “stand-off” columns
- RPi 3 plus SD cards
- 8 port Gigabit switch
- 8-way USB-charger

Netbooting requires 3B+



# Build your own: on a budget (**recommended**)

Start with 1-4 RPi's

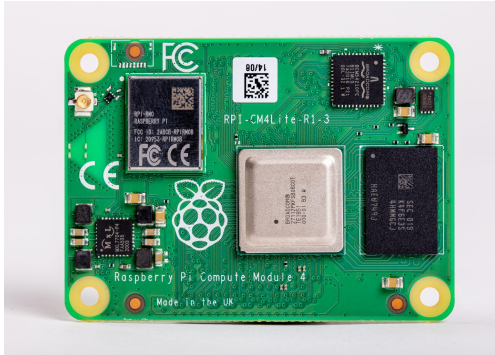
- RPi 4 - 2GB model plus SD cards
- 8 port Gigabit switch
- 3-4x Official PSUs
- Add fans!

Upgrade: netboot from a PC



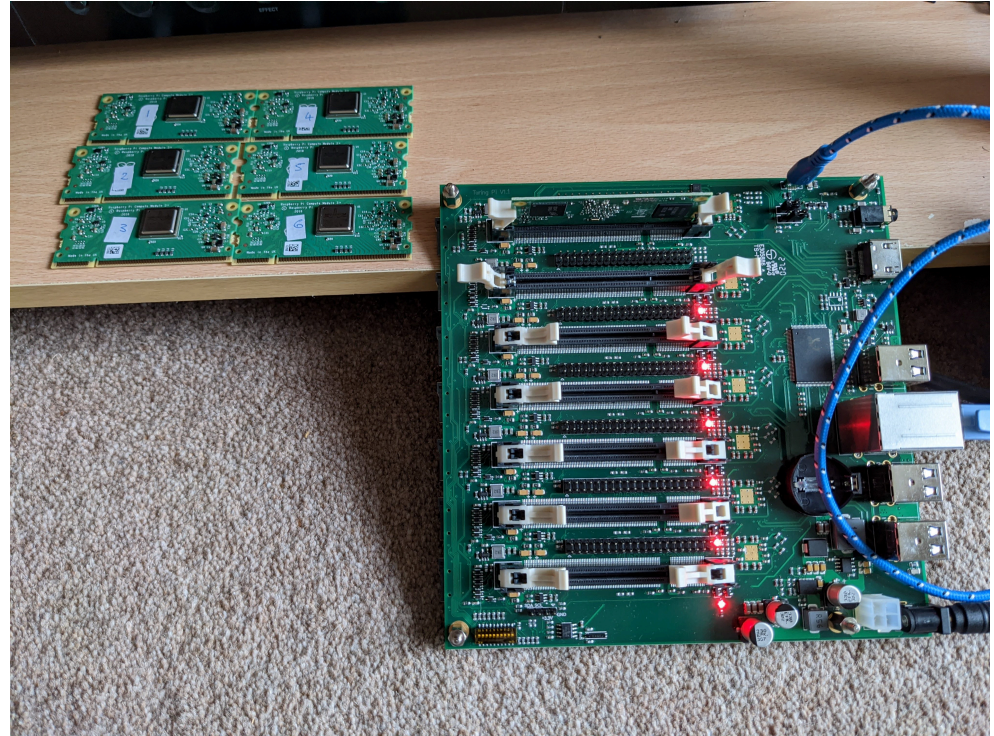
# Build your own: space conscious

- 1x Turing Pi
- 7x CM3+ modules
- mini-ITX case (optional)



*CM4 variant arriving soon*

Expensive, but very tidy



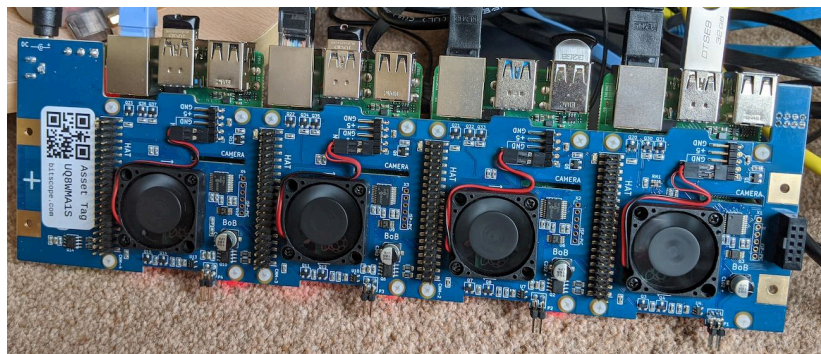


# Build your own: best in class

Pro-grade, rack-mountable

- 4-8 RPi4
- 12-24v PSU
- Stackable

Netboot for industrial  
reliability



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## Raspberry Pi Blog

[← All blog posts](#)[ARCHIVE](#) [RSS](#)

# Five years of Raspberry Pi clusters



7th Apr 2020

Ashley Whittaker

22 comments



*In this guest blog post, [OpenFaaS](#) founder and Raspberry Pi super-builder [Alex Ellis](#) walks us down a five-year-long memory lane explaining how things have changed for cluster users.*

I've been writing about running Docker on Raspberry Pi for five years now and things have got a lot easier than when I started back in the day. There's now no need to patch the kernel, use a bespoke OS, or even build Go and Docker from scratch.

### RELATED POSTS



**OctaPi: cluster computing and cryptography**



**Raspberry Pi clusters come of age**

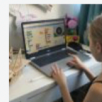


**Beowulf Clusters, node visualisation and more with Pi VizuWall**



**Docker comes to Raspberry Pi**

### NEXT POST



**Learn at home: a guide for parents #1**

# Open source tools for RPi clusters



Deploy APIs  
and functions

<https://openfaas.com/>



Provision k3s  
With SSH

<https://k3sup.dev/>



Get a public IP  
LoadBalancer

<https://inlets.dev/>



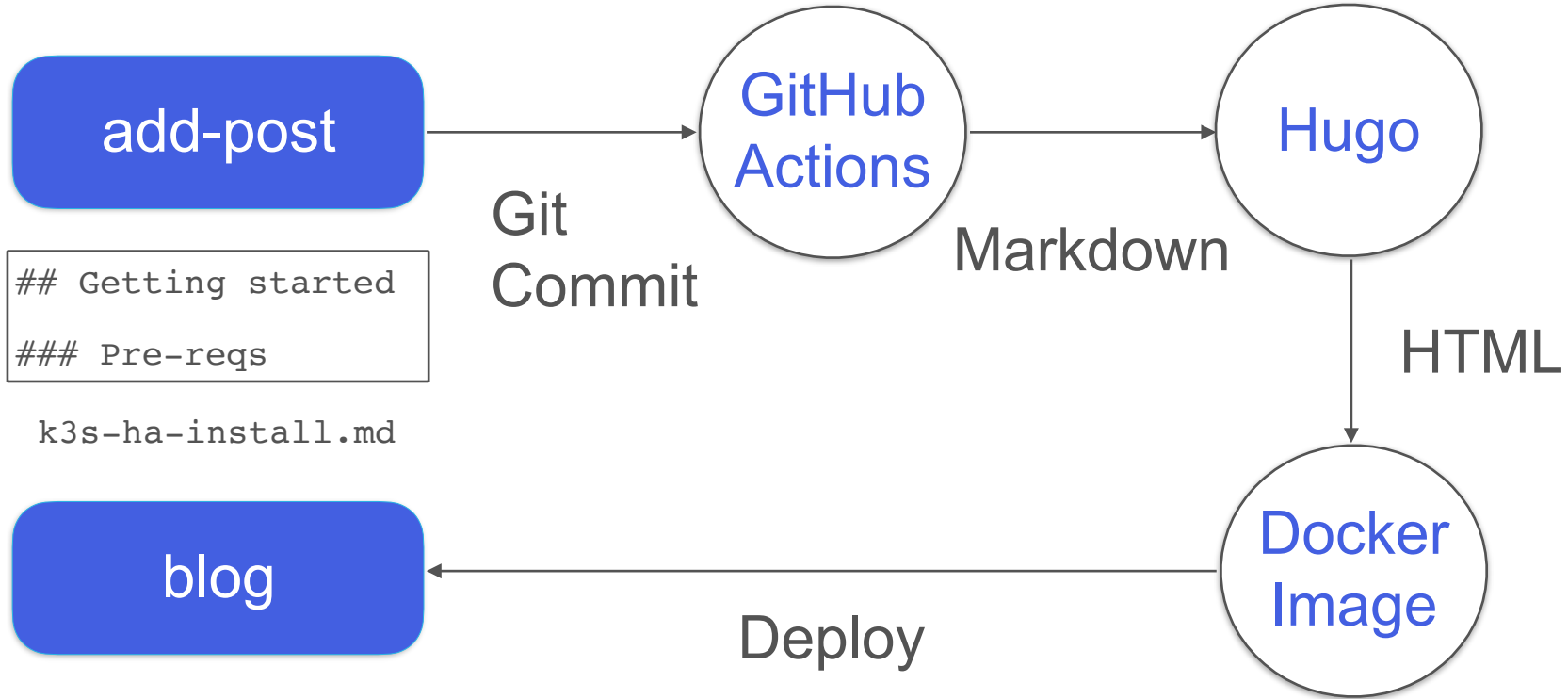
Install compatible  
Helm charts

<https://get-arkade.dev>

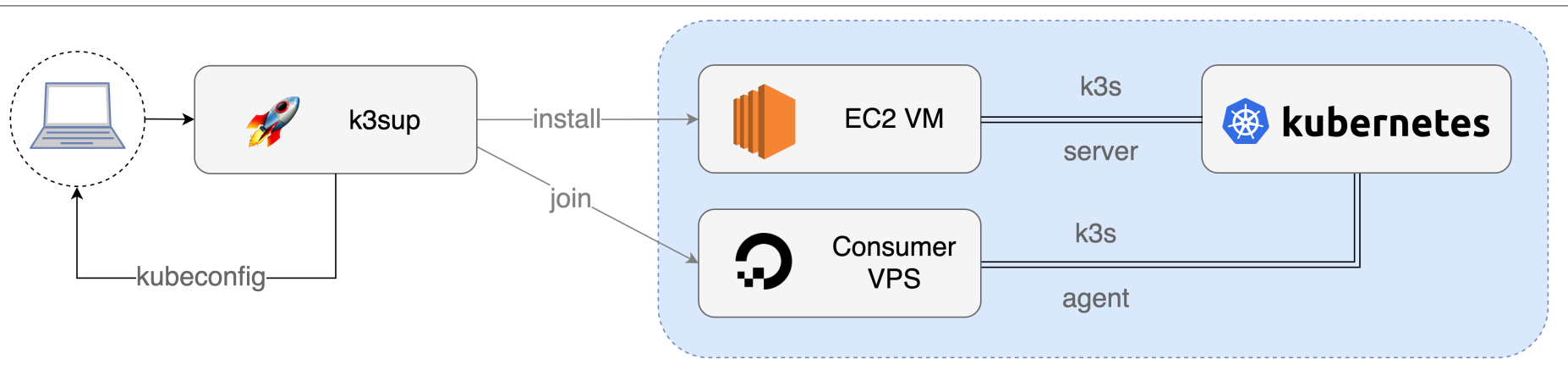




# Demo - blog/CMS with editor



# Install k3s over SSH



```
k3sup install --ip $SVR --user pi
```

```
k3sup join --ip $IP1 --user pi --server-ip $SVR
```



# Install CLIs and Helm charts



“get” CLIs:

```
arkade get kubectl --version v1.19.3
```

```
arkade get k3sup
```

```
arkade get faas-cli
```

“install”:

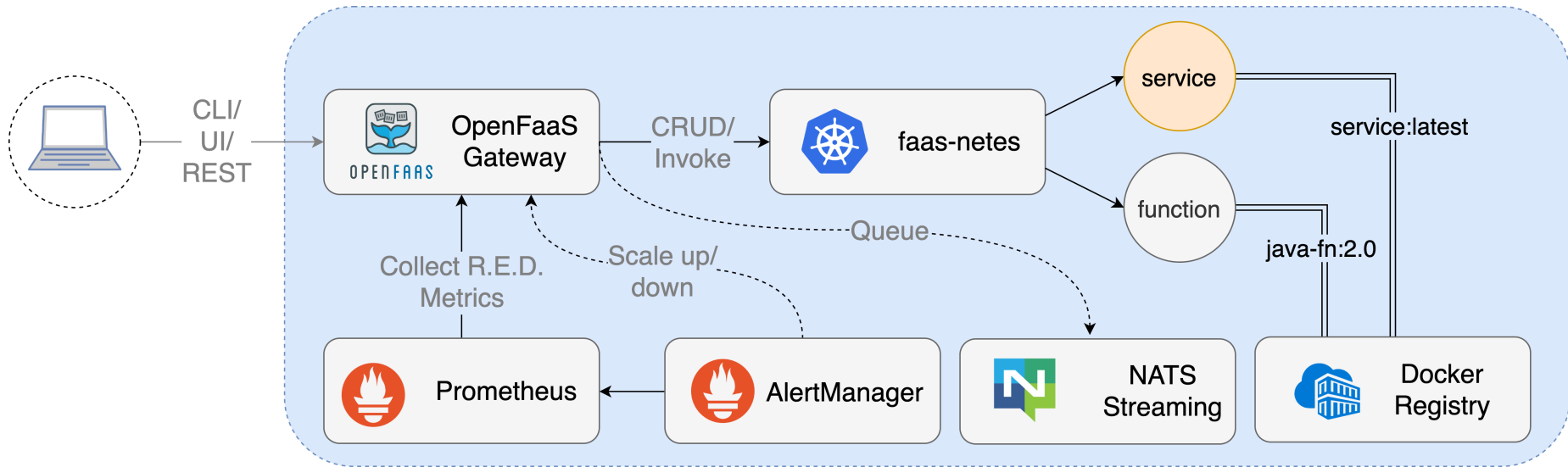
```
arkade install openfaas --load-balancer
```

```
arkade install ingress-nginx
```

```
arkade install cert-manager
```



# Deploy functions & microservices

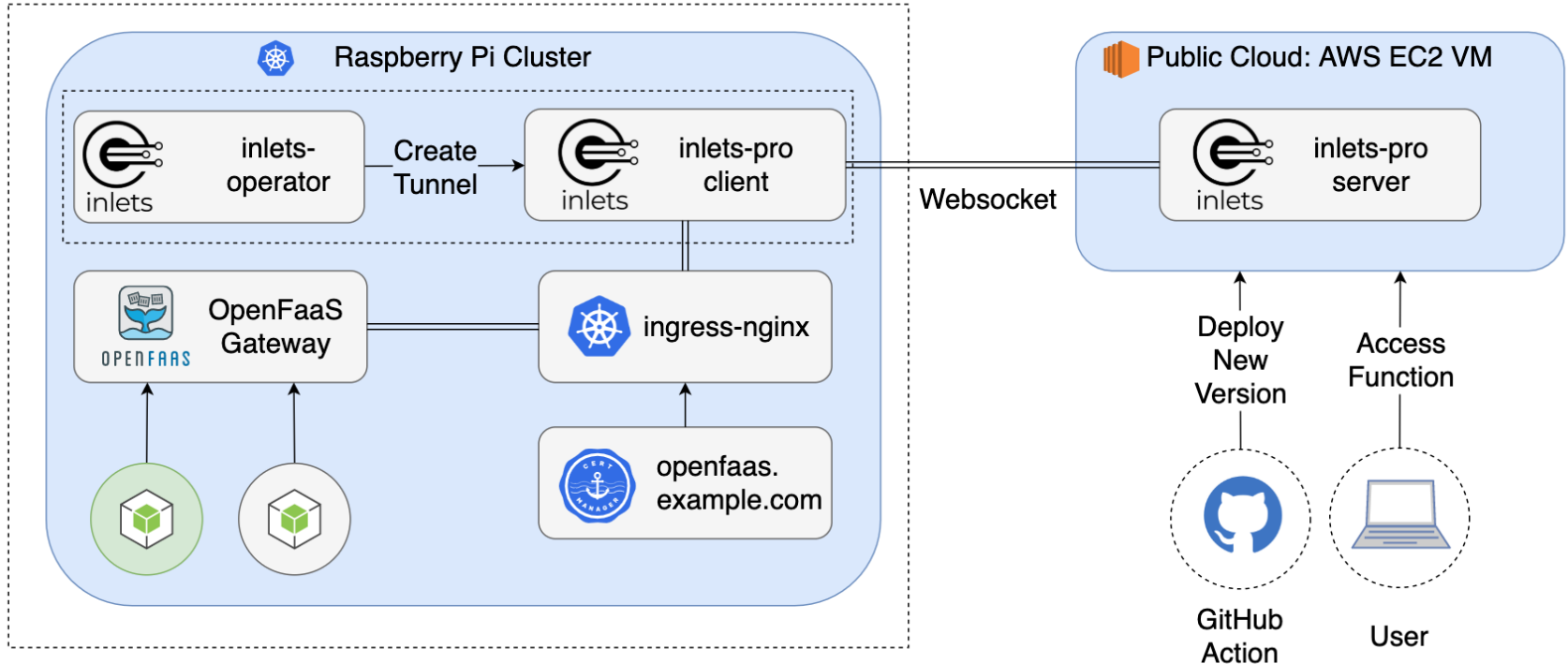


```
faas-cli new --lang python3 stripe-payment
faas-cli up -f stripe-payment.yml
```



# Demo - public function with CI

## Exposing OpenFaaS to the Internet with inlets-operator



Copyright OpenFaaS Ltd, 2020



# Demo - public function with CI



# The future: managed cloud

## AWS Graviton2

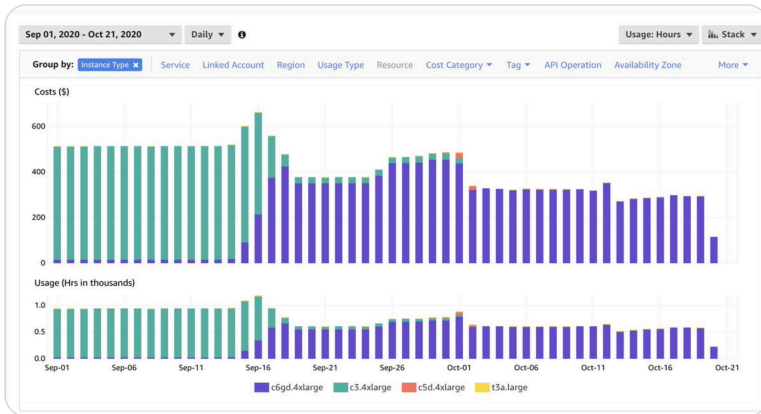
- Save on managed services
  - RDS
  - ElastiCache
- Up to 64 cores



Valentino Volonghi  
@dialtone\_



Yeah so this Graviton 2 switch ended up saving almost 50% of our costs, we were able to reduce the number of instances for the same performance, actually even a bit better.



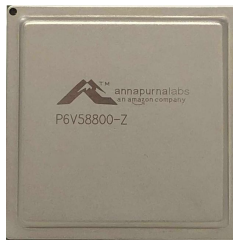
3:51 AM · Oct 21, 2020



106



21 people are Tweeting about this



# The future ARM in the datacentre



## Equinix Metal (Packet)

- Bare-metal
- Data-centre uplink
- 0.5-1.0 USD / hour
- Ecosystem support

c2.large.arm  
1x Ampere eMAG 8180 32-core @ 3.0GHz  
128GB RAM  
Coming soon:  
Altra Max 128 cores per proc!

1	[                     ]	7.0%	25	[                     ]	8.0%	49	[                     ]	7.5%	73	[                     ]	6.4%
2	[                     ]	7.5%	26	[                     ]	7.5%	50	[                     ]	5.2%	74	[                     ]	6.9%
3	[                     ]	11.4%	27	[                     ]	8.6%	51	[                     ]	8.0%	75	[                     ]	11.6%
4	[                     ]	10.9%	28	[                     ]	18.2%	52	[                     ]	5.7%	76	[                     ]	5.7%
5	[                     ]	8.0%	29	[                     ]	9.7%	53	[                     ]	6.9%	77	[                     ]	9.8%
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7	[                     ]	8.8%	31	[                     ]	11.5%	55	[                     ]	5.2%	79	[                     ]	8.0%
8	[                     ]	9.8%	32	[                     ]	8.0%	56	[                     ]	5.8%	80	[                     ]	9.8%
9	[                     ]	10.1%	33	[                     ]	9.7%	57	[                     ]	8.0%	81	[                     ]	9.8%
10	[                     ]	9.2%	34	[                     ]	9.2%	58	[                     ]	8.9%	82	[                     ]	10.3%
11	[                     ]	7.5%	35	[                     ]	10.5%	59	[                     ]	4.6%	83	[                     ]	8.5%
12	[                     ]	8.5%	36	[                     ]	8.7%	60	[                     ]	6.9%	84	[                     ]	6.4%
13	[                     ]	8.5%	37	[                     ]	10.8%	61	[                     ]	6.9%	85	[                     ]	19.5%
14	[                     ]	9.0%	38	[                     ]	9.1%	62	[                     ]	4.6%	86	[                     ]	9.8%
15	[                     ]	6.3%	39	[                     ]	10.3%	63	[                     ]	5.2%	87	[                     ]	9.2%
16	[                     ]	7.5%	40	[                     ]	11.4%	64	[                     ]	8.0%	88	[                     ]	8.5%
17	[                     ]	8.0%	41	[                     ]	12.6%	65	[                     ]	6.3%	89	[                     ]	11.0%
18	[                     ]	4.2%	42	[                     ]	11.4%	66	[                     ]	7.5%	90	[                     ]	7.5%
19	[                     ]	8.0%	43	[                     ]	8.1%	67	[                     ]	6.4%	91	[                     ]	7.5%
20	[                     ]	6.4%	44	[                     ]	9.2%	68	[                     ]	6.4%	92	[                     ]	9.8%
21	[                     ]	6.9%	45	[                     ]	10.3%	69	[                     ]	17.6%	93	[                     ]	9.8%
22	[                     ]	7.5%	46	[                     ]	8.7%	70	[                     ]	11.5%	94	[                     ]	9.1%
23	[                     ]	8.0%	47	[                     ]	10.3%	71	[                     ]	8.0%	95	[                     ]	6.4%
24	[                     ]	6.9%	48	[                     ]	11.4%	72	[                     ]	6.9%	96	[                     ]	6.2%
Mem	[                     ]				3.58G/126G						
Swp	[                     ]				0K/2.33G						
Tasks: 78, 1169 thr; 1 running											
Load average: 1.33 2.10 2.24											
Uptime: 513 days(!), 18:15:54											

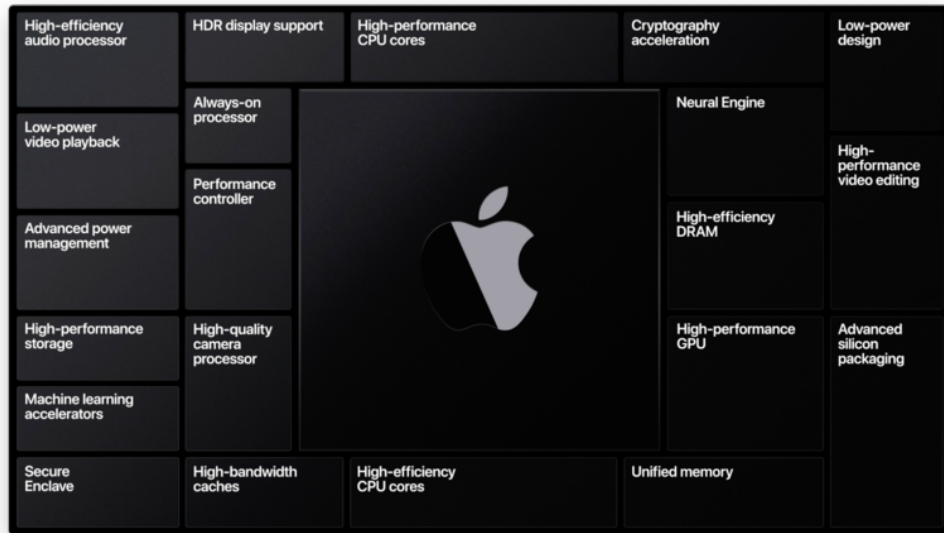




# The future - ARM on your workstation

## “Apple Silicon”

- ARM-64 instruction-set
- Multi-day battery
- Custom-designed chip
  - ML acceleration
  - Power management
  - Secure enclave



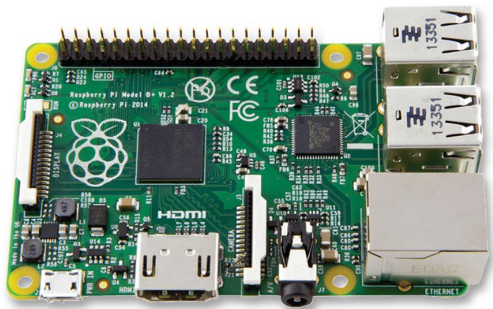
```
$ ./app
```

Illegal

instruction

# Past & present RPi versions

Raspberry Pi B - 32-bit **armv6**



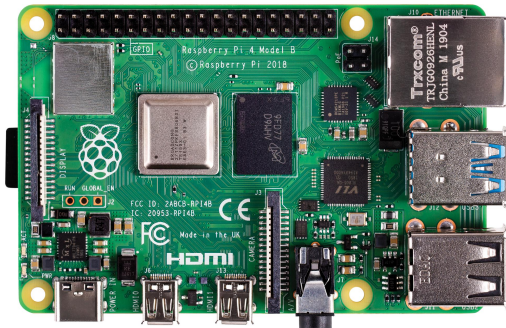
Raspberry Pi 3 - 64-bit **aarch64**



Raspberry Pi 2 - 32-bit **armv7**



Raspberry Pi 4 - 64-bit **aarch64**



# The future - Compiling Go for ARM

```
GOARCH=amd64 go build -o bin/faasd
```

```
GOARCH=arm GOARM=6 go build -o bin/faasd-armv6
```

```
GOARCH=arm GOARM=7 go build -o bin/faasd-armhf
```

```
GOARCH=arm64 go build -o bin/faasd-arm64
```

32-bit ARM aka armhf, armv7, armv7l

64-bit ARM aka arm64, aarch64



# The future - Docker and ARM

```
docker buildx build \  
    --platform linux/amd64,linux/arm/v7,linux/arm64
```

```
FROM --platform=${BUILDPLATFORM:-linux/amd64} golang:1.15 as builder  
  
ARG TARGETPLATFORM  
ARG BUILDPLATFORM  
ARG TARGETOS  
ARG TARGETARCH  
  
RUN CGO_ENABLED=${CGO_ENABLED} GOOS=${TARGETOS} GOARCH=${TARGETARCH} \  
    go build --ldflags "-s -w" -a -installsuffix cgo -o handler .  
  
FROM --platform=${TARGETPLATFORM:-linux/amd64} alpine:3.12  
COPY --from=builder /go/src/handler .  
CMD ["/handler"]
```

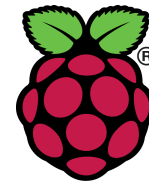


# Cheatsheet

- kubeadm got too hungry → k3s
- SD cards are unreliable → eMMC or netboot
- No LoadBalancer → inlets-operator
- Steep learning curve → k3sup install/join
- Discovering apps → arkade app install
- “Illegal instruction” → Docker buildx
- Storage/volumes → NFS, local path, Longhorn\*



# Wrapping up



- RPi & ARM widely used for “real work”
- Build your own private cloud
- Become an advocate
  - Find gaps
  - Raise Issues & PRs
  - Port software, packages, helm charts
- Look out for: Apple Silicon. Mainstream ARM laptops. CM4 w/NVMe.



Wrapping up

**Remember to have fun!**





# Thank You!

# Q&A

- <https://k3s.io> - k3s docs & website
- <https://twitter.com/alexellisuk> - follow for more content and samples
- <https://slack.openfaas.io/> - join our community & contribute to the tools

