Kasperry π

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Abstract (max 250 words):

The project Kasperry PI consists of deploying a Kubernetes cluster, which has four Raspberry PI 4 (4Gb) and a development Raspberry PI to build the Docker images, also it will be accessible world-wide.

Kasperry PI required research and development to be able to build the cluster and make it work with public internet. The cluster contains monitoring, security and routing using ingress route. In order to achieve this, DataDog was implemented for monitoring and Traefik for doing the DNS routing. Security was a major concern and it has been implemented in every part of the cluster.

Furthermore, Kasperry PI project covers how to implement a CI/CD environment using Github and Github Actions, which is the new schema to work with distributed applications in microservices.

Finally, as a working proof, a web page was developed with Gatsby containing homemade "how to build a home production-ready Kubernetes cluster" tutorials.

All of these tutorials are available at https://kasperry.io/.

Keywords (between 4 and 8):

Kubernetes, Raspberry, Cluster, Kasperry, PI, Home Cluster

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1. Introduction

1.1 Context and Justification of the Project

The idea of this project is to provide knowledge on building a home cluster. Once built, the home cluster can be used to establish web pages or IoT projects. It is an important topic because in this way, one can get a production-ready small cluster with a low budget, which can be used to host services.

This is possible with low cost hardware thanks to the last revision of Raspberry PI increasing memory RAM to 4Gb.

Previous models of the Raspberry PI did not have enough resources to build a production-ready cluster. The solution to this is either to have a proper server and spend a significant amount of money, or to just run a server without any kind of deployment or scaling system.

With the new technologies, it seems feasible to build a home cluster with Raspberry PI, and this project is going to prove it.

1.2 Work objectives

- Build a production-ready home cluster using Raspberry PI
- Enable monitoring using DataDog.
- Enable reverse routing and domain resolver for Kubernetes using Traefik.
- Deploy a web page using CI / CD solution provided by Github Actions.
- Publish the tutorials under the domain kasperry.io for the purpose of knowledge sharing.

1.3 Approach and method followed

For the purpose of the research, content on the internet has been referred to in order to obtain all the relevant information and knowledge regarding the project, and therefore, to apply and execute accordingly. In particular, third party software and popular opinions are referred to herein.

The important consideration is how to choose between various Open Source Software and demonstrate how to build a cluster at home. This project aims to ensure that everyone can build an affordable cluster without having to use the costly cloud services provided by the big companies.

1.4 Work Planning

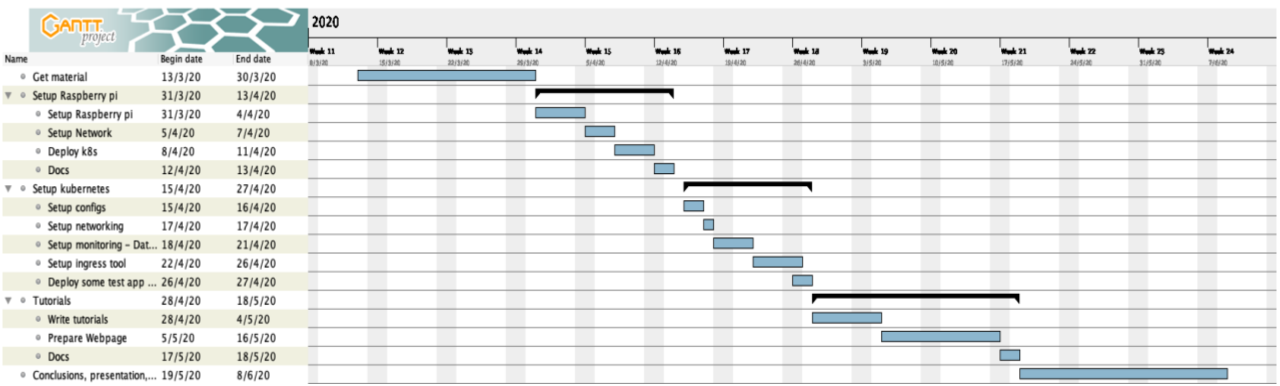


Figure 1. Gantt timeline. It defines deadlines to ensure a time-quality work.

1.5 Brief summary of products obtained

The project will be divided into 4 sections.

- **Big Picture**
  All of the software used to build Kasperry PI will be explained. In addition, other possible alternatives will be considered and set out briefly.

- **Architecture**
  The architecture of Kasperry PI will be explained. As well as the reason for choosing this approach.

- **Building process**
  How Kasperry PI is built step by step, including the details and problems encountered during the process, will be set out.

- **Results**
  Validations, “why’s” of Kasperry PI.

2. Kasperry π

2.1 Big Picture

Before starting, it would be helpful to be aware of what is available on the market in the year of 2020. Every year, or even every month, there is new software / tool / methodology ready to use. As a result, this big puzzle has to be described piece by piece.

2.1.1 Raspberry PI

Raspberry PI 4 (4Gb) is the selected board to be used. With the latest release of this board, the minimum requirements to deploy a cluster of Kubernetes have been met. More importantly, this board is the most accepted and commonly used on the market. The popularity and probable continuous development of the board makes the project more meaningful in the long term. Last but not the least, it is very affordable.

Despite the aforesaid, Kasperry PI is not limited to this board. In fact, in order to build a home cluster, one can apply the knowledge shared in the tutorials to whichever ARM board he deems appropriate, as long as the board chosen meets the minimum requirements to deploy a cluster of Kubernetes.

2.1.2 Docker

“Docker is a set of platform as a service (PaaS) products that uses OS-level virtualization to deliver software in packages called containers. Containers are isolated from one another and bundle their own software, libraries and configuration files; they can communicate with each other through well-defined channels. All containers are run by a single operating system kernel and therefore use fewer resources than virtual machines.” [11].

Figure 2 illustrates how Docker makes use of the architecture of the OS to deploy containers by reusing it, shown as App A, App B… It is like creating OS layers.

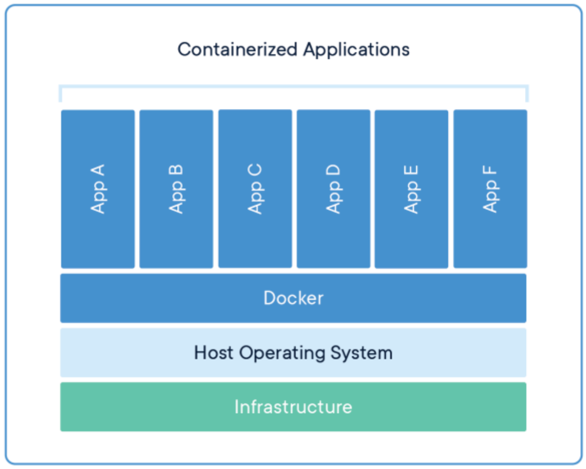


Figure 2. Docker Containers [4]

Docker is compatible with ARM infrastructure.

- Containerd

"Containerd was designed to be used by Docker and Kubernetes as well as any other container platform that wants to abstract away syscalls or OS specific functionality to run containers on linux, windows, solaris, or other OSes." [17].

Figure 3 illustrates the tasks of Containerd. It shows how the engine can run syscalls to containers and vice versa.

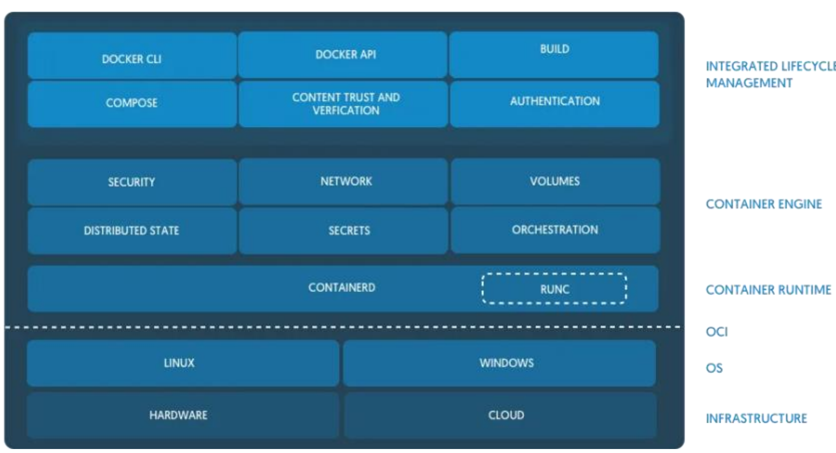


Figure 3. Containerd [17]

2.1.3 Mesosphere

2.1.3.1 Apache Mesos

“Apache Mesos abstracts CPU, memory, storage, and other compute resources away from machines (physical or virtual), enabling fault-tolerant and elastic distributed systems to easily be built and run effectively. Built using the same principles as the Linux kernel, only at a different level of abstraction. The Mesos kernel runs on every machine and provides applications (e.g., Hadoop, Spark, Kafka, Elasticsearch) with API’s for resource management and scheduling across the entire datacenter and cloud environments.” [13]

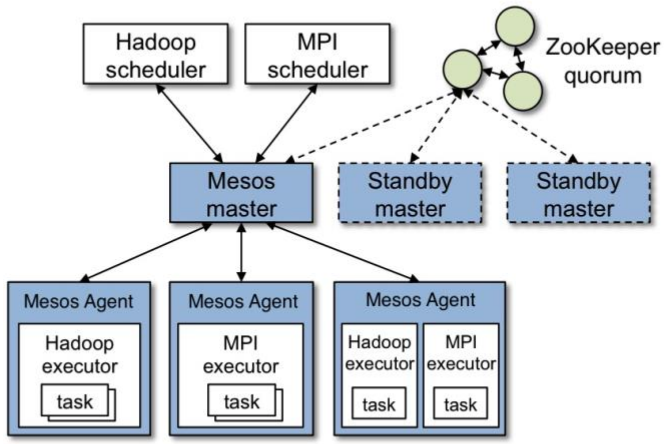


Figure 4. Mesos Architecture [14]

“ZooKeeper is a centralized service for maintaining configuration information, naming, providing distributed synchronization, and providing group services. All of these kinds of services are used in some form or another by distributed applications.” [16]

Apache Mesos is a powerful tool backed up by Apache, a massive company experienced in servers and providing them as an open source.

Unfortunately, this platform is not fully compatible with Raspberry PI. There are developments trying to work on its compatibility issue, but at this stage Apache Mesos just provides partial ARM coverage.

2.1.3.2 Marathon

“Marathon is a framework (or meta framework) that can launch applications and other frameworks. Marathon can also serve as a container orchestration platform which can provide scaling and self-healing for containerized workloads. The figure below shows the architecture of Mesos + Marathon.” [12]

“A container orchestration platform for Mesos and DC/OS” [15]

In other words, the combination of Apache Mesos + Marathon can be compared with Kubernetes.

Unfortunately, Marathon is dependent on Apache Mesos which does not fully support ARM.

2.1.4 Kubernetes

“Kubernetes is a portable, extensible, open-source platform for managing containerized workloads and services, that facilitates both declarative configuration and automation. It has a large, rapidly growing ecosystem. Kubernetes services, support, and tools are widely available.

The name Kubernetes originates from Greek, meaning helmsman or pilot. Google open-sourced the Kubernetes project in 2014. Kubernetes combines over 15 years of Google’s experience running production workloads at scale with best-of-breed ideas and practices from the community.” [5]

Figure 5 shows the diagram of a Kubernetes cluster with some of the components and their relation. Important concepts and components of Kubernetes are as follows:

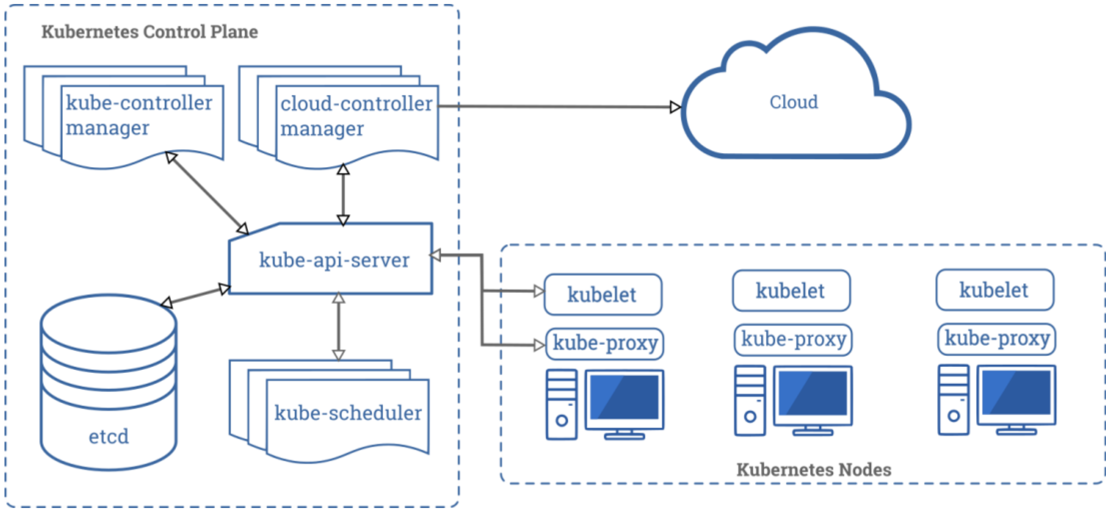


Figure 5. Kubernetes Diagram [5]

- **Api Server**
  This component is the management hub for the Kubernetes master node. It facilitates communication between the various components, thereby maintaining cluster health.

- **Scheduler**
  This component places the workload on the appropriate node – in this case all workload will be distributed accordingly to the feasible nodes.

- **Controller Manager**
  This component ensures that the cluster's desired state matches the current state by scaling workload up and down.

- **Proxy**
  The Kubernetes network proxy runs on each node. This reflects services as defined in the Kubernetes API on each node and it can do simple TCP, UDP, and SCTP stream forwarding or round robin TCP, UDP and SCTP forwarding across a set of backends.

- **Kubelet**
  This component receives pod specifications from the API Server and manages pods running in the host.

- **Etcd**
  This component stores configuration data which can be accessed by the Kubernetes master's API Server by simple HTTP or JSON API.

- **Container Network Interface (CNI)**
  Kubernetes has adopted the Container Network Interface(CNI) specification for managing network resources on a cluster.

- **Deployments**
  These building blocks can be used to create and manage a group of pods. Deployments can be used with a service tier for scaling horizontally or ensuring availability.

- **ReplicaSet**
  A ReplicaSet's purpose is to maintain a stable set of replica Pods running at any given time. As such, it is often used to guarantee the availability of a specified number of identical Pods.

- **DaemonSet**
  A DaemonSet ensures that all (or some) nodes run a copy of a Pod. As nodes are added to the cluster, Pods are added to them. As nodes are removed from the cluster, those Pods are garbage collected. Deleting a DaemonSet will clean up the Pods it created.

- **StatefulSet**
  Like a Deployment, a StatefulSet manages Pods that are based on an identical container spec. Unlike a Deployment, a StatefulSet maintains a sticky identity for each of their Pods. These pods are created from the same spec, but are not interchangeable: each has a persistent identifier that it maintains across any rescheduling.

- **Pods**
  Kubernetes deploys and schedules containers in groups called pods. Containers in a pod run on the same node and share resources such as filesystems, kernel namespaces, and an IP address.

- **Services**
  These are endpoints that can be addressed by name and can be connected to pods using label selectors. The service will automatically round-robin requests between pods. Kubernetes will set up a DNS server for the cluster that watches for new services and allows them to be addressed by name. Services are the "external face" of your container workload.

- **Ingress**
  An API object that manages external access to the services in a cluster, typically HTTP. Ingress may provide load balancing, SSL termination and name-based virtual hosting.

- **Namespaces**
  Namespaces are intended for use in environments with many users spreading across multiple teams, or projects. It is recommended to start using namespaces when the features they provide are needed.

- **Labels**
  These are key-value pairs attached to objects. They can be used to search and update multiple objects as a single set.

- **Persistent Volume**
  A PersistentVolume (PV) is a piece of storage in the cluster that has been provisioned by an administrator or dynamically provisioned using Storage Classes.

- **Storage Classes**
  A StorageClass provides a way for administrators to describe the "classes" of storage they offer. Different classes might map to quality-of-service levels, or to backup policies, or to arbitrary policies determined by the cluster administrators. Kubernetes itself is unopinionated about what classes represent. This concept is sometimes called "profiles" in other storage systems.

- **Secrets**
  Kubernetes Secrets allows storing and managing sensitive information, such as passwords, OAuth tokens, and ssh keys. Storing confidential information in a Secret is safer and more flexible than putting it verbatim in a Pod definition or in a container image.

- **ConfigMaps**
  A ConfigMap is an API object used to store non-confidential data in key-value pairs. Pods can consume ConfigMaps as environment variables, command-line arguments, or as configuration files in a volume.
  A ConfigMap allows decoupling environment-specific configuration from your container images so that your applications are easily portable.

Information obtained from sources [5 & 12 & 18]

2.1.4.1 Rancher K3s

"Certified Kubernetes distribution designed for production workloads in unattended, resource-constrained, remote locations or inside IoT appliances." [19]

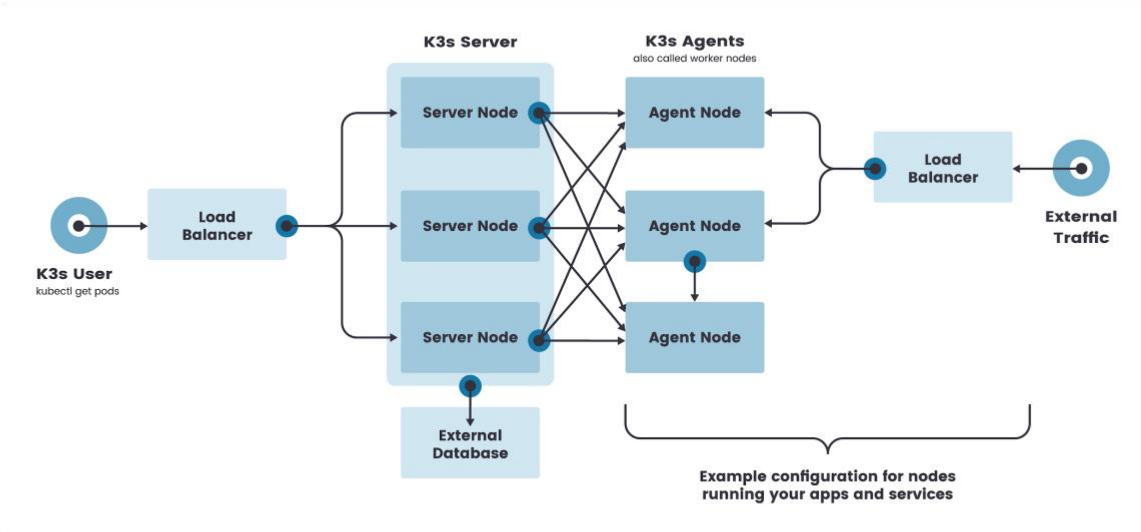


Figure 6. Rancher k3s Architecture Diagram [20]

Rancher k3s is probably the most common way to deploy a Kubernetes cluster using Raspberry PI. Previously it was the only way, given that Raspberry PI 1,2,3 do not have enough resources to run Kubernetes, nor does Raspberry PI 4 with 1Gb of RAM. Rancher k3s is a very good solution for a cluster with low capacity nodes.

Another important point to consider is if the project needs to use k3s HA, an external database is needed.

2.1.4.2 MicroK8s

"MicroK8s is a CNCF certified upstream Kubernetes deployment that runs entirely on your workstation or edge device. Being a snap it runs all Kubernetes services natively (i.e. no virtual machines) while packing the entire set of libraries and binaries needed. Installation is limited by how fast you can download a couple of hundred megabytes and the removal of MicroK8s leaves nothing behind." [25]

MicroK8s is similar to k3s. In this case, it is backed by canonical instead of Rancher, which means the community is who decides on the changes rather than a private company.

2.1.4.3 Minikube

“Minikube is a tool that makes it easy to run Kubernetes locally. Minikube runs a single-node Kubernetes cluster inside a Virtual Machine (VM) on your laptop for users looking to try out Kubernetes or develop with it day-to-day.” [5]

Minikube is mainly used for development purposes.

2.1.5 Helm

“Helm helps you manage Kubernetes applications — Helm Charts help you define, install, and upgrade even the most complex Kubernetes application.” [6]

In short, it can be said that Helm can be compared with apt, brew, snap, but it applies to Kubernetes.

Helm became a graduated project in CNCF in April 2020.

2.1.6 CNCF - Cloud Native Computing Foundation

“Sustaining and integrating open source technologies to orchestrate containers as part of a microservices architecture” [21]

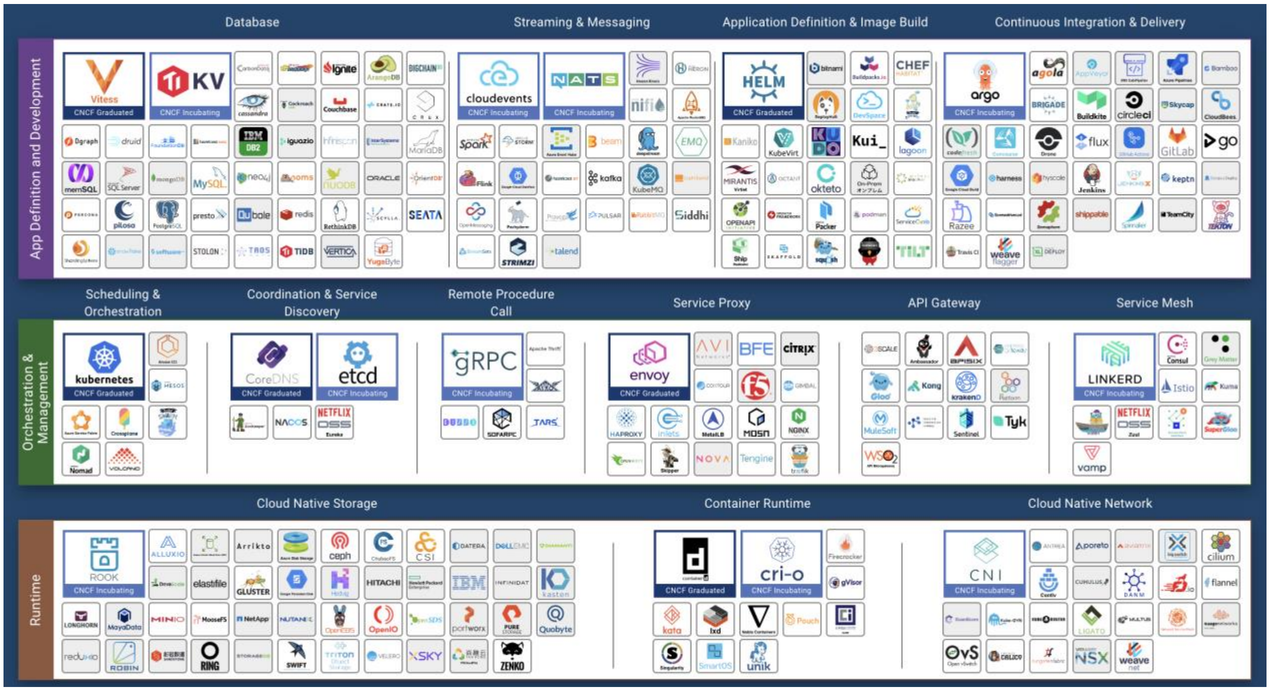


Figure 7. CNCF Software Landscape [10]

CNCF software is the preferred option when choosing a software to use in Kasperry PI, another criteria is the resources and compatibility with ARM.

2.2 Architecture

2.2.1 Planning & Schemas

Before starting to plan anything, the requisites to run a Kubernetes cluster are set out below.

- Ubuntu 16.04+
- Debian 9+
- CentOS 7
- Red Hat Enterprise Linux (RHEL) 7
- Fedora 25+
- HypriotOS v1.0.1+
- Container Linux (tested with 1800.6.0)
- 2 GB or more of RAM per machine (any less will leave little room for the apps)
- 2 CPUs or more
- Full network connectivity between all machines in the cluster (public or private network is fine)
- Unique hostname, MAC address, and product_uuid for every node.
- Certain ports are open on the machines.
- Swap disabled. Swap MUST be disabled in order to make the kubelet work properly.

This is everything one needs to know according to the official Kubernetes documents. Raspberry PI 4 has enough resources to run Kubernetes according to the above.

In addition, using a good router, firewall, etc. has to be considered. A breach in one of the apps, or a bad port opened unintentionally can expose the network to the world.

Having all of the information, the architecture of the cluster can be designed.

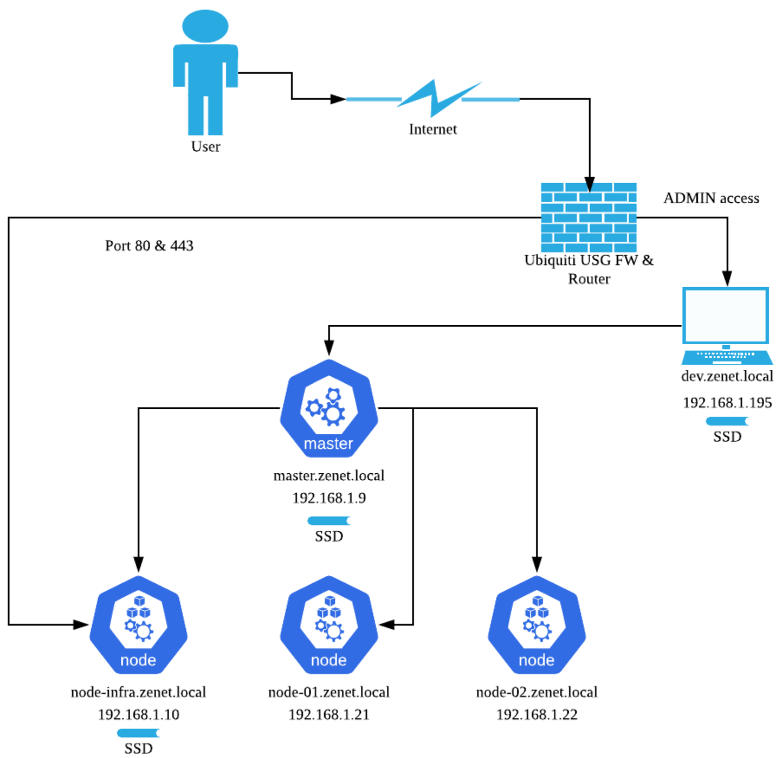


Figure 8. Kasperry PI cluster Architecture

As shown in Figure 8, a router with a firewall is used to filter the access to the local network.

The access to the internal network will be using a VPN, the only 2 ports exposed to the public will be port 80 and 443 the http(s) standard ports.

Moreover, a cluster of 4 Raspberry PI will be built, deployed with Ubuntu 18.04, since 20.04 is still in beta and a lot of software is not yet available. Another Raspberry PI will be used for development purposes and to run pipelines CI / CD.

Then, one Raspberry PI will be running the master node and the other three minions. One minion, the one called node-infra, will be used for running a database, cache or an application needing a persistent volume.

The nodes master and node-infra will be deployed with an SSD and the operating system will boot in an external SSD disk. This is done because it is more R/W efficient, and also, the SD cards are not designed for storing intensive R/W Data and doing so can increase the probability of failure. [26]

Finally, the cluster has to be strongly secured by using TLS certificates.

2.2.2 Material and economic valuation

The material I will be using to build the cluster

Product	Qty	Price (S$)
Ubiquiti USG	1	206
Switch 8 Ports	1	189
Raspberry PI 4 (4Gb) with SD & power supply & heat sink	5	116
Ethernet Cable	6	6.90
Raspberry PI case with fan	5	12.50
External SSD Disk (500Gb)	2	159
Prices based in Singapore.		
Total		1,396.90

** Price in euros it will be around ~900 EUR.*

This is the price to have a basic production-ready Kubernetes cluster at home. Kasperry PI hardware can be upgraded in the future, but it is a good starting point.

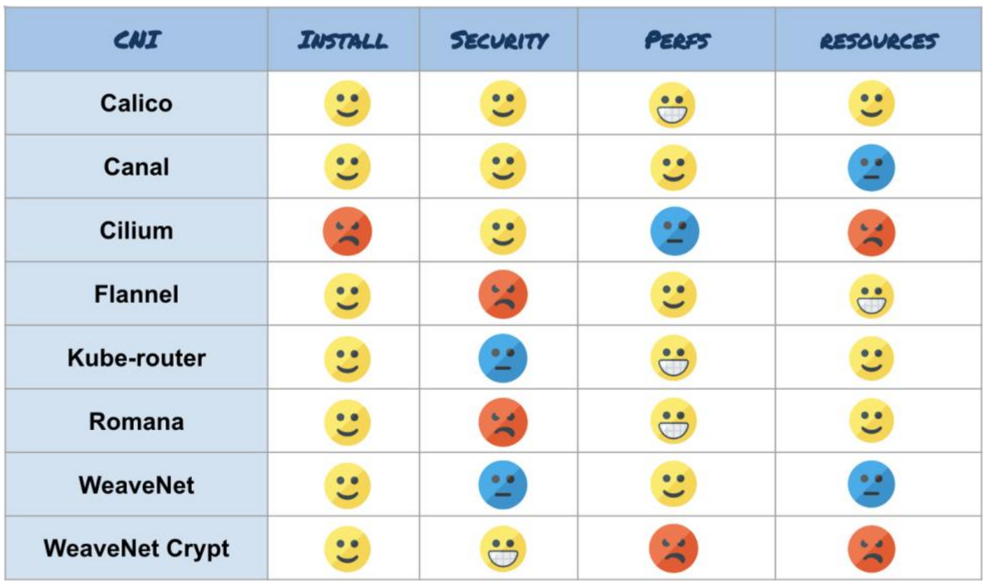
In the schema a SSD disk is also added to the dev Raspberry PI, which is supposed to increase the CI / CD speed.

Another key factor is to have a good internet connection and asking your ISP for a public IP address.

2.2.3 Network

For networking Calico has been chosen since judging from the reviews, it provides a lot of good functionalities and security.

There are more options to consider for building the cluster network. Figure 9 shows the information that was analyzed and explains the reason for discarding certain options.



CNI	INSTALL	SECURITY	PERFS	RESOURCES
Calico	🙂	🙂	😁	🙂
Canal	🙂	🙂	🙂	😕
Cilium	😠	🙂	😕	😠
Flannel	🙂	😠	🙂	😁
Kube-router	🙂	😕	😁	🙂
Romana	🙂	😠	😁	🙂
WeaveNet	🙂	😕	🙂	😕
WeaveNet Crypt	🙂	😁	😠	😠

Figure 9. CNI table comparison [1]

As shown in the comparison chart, the best options are Calico or WeaveNet Crypt if security is a concern.

Calico: The selected one. According to all comparisons, it is the most balanced option which gives support to all Kubernetes functionalities.

WeaveNet Crypt: Using Raspberry PI, it cannot afford to encrypt all connections. This part can be managed on the app side when necessary.

Canal: Similar to WeaveNet Crypt, it consumes too much resources. It also has less community support.

Cilium: It consumes too much resources, it would not be a good fit for Raspberry PI.

Flannel: Kubernetes recently stopped to support this CNI.

Kube-router & Romana: Discarded as there are better options to choose from.

2.2.4 Deployments

2.2.4.1 Tracing & Monitoring

Once the important aspect of the resource limitations running locally has been discussed, a full monitoring and tracing solution does not seem to be possible as there is a lot of data in the network. For example: deploying elasticsearch is known to be really expensive in terms of resource consumption, so EFK (elastic, fluentd and kibana) and ELK (elastic, logstash and kibana) which also does not give support to ARM have to be discarded. Loki with grafana and prometheus was evaluated as well. At first sight, it looked like a good fit for the Raspberry PI 4 since it is more lightweight, but it does not provide tracing, so Jaeger will be an option.

As at the moment of this project, considering the resources available, the best option is to use DataDog. DataDog offers monitoring, logging and tracing all in one place. It does not need to run a heavy search engine like elasticsearch. Only an agent has to be running giving a resources release for the cluster. Also, it is easier to set up.

However, there are some disadvantages of DataDog: Code is partially public and property of a private company. DataDog is really expensive. The logs are in a third party database, which can be considered insecure.

2.2.4.2 Load Balancing & Routing

After evaluating envoy, istio and nginx, ARM support is not in the roadmap.

For this reason, Traefik has been chosen as a load balancing and routing app, a CNCF project.

Furthermore, it provides support for ARM and has full Kubernetes compatibility.

Finally, an interesting feature of Traefik is auto SSL (https) using Let's Encrypt.

2.2.4.3 App

Gatsby has been selected to develop the app. In this case, the decision is a matter of personal preference. It is a ReactJS based framework which transpiles in html and makes the web really efficient.

The code will be published with the Dockerfile, Kubernetes yaml and the information to build the CI / CD.

2.2.4.4 Database

For this project, a database is not required although a deployment of PostgreSQL, MariaDB & MongoDB was successful.

If these databases are to be deployed, official Docker images have to be used instead of Bitnami images who are the ones supporting Helm installation. The deployment has to be created manually.

2.3 Building process

2.3.1 Setup Raspberry PI

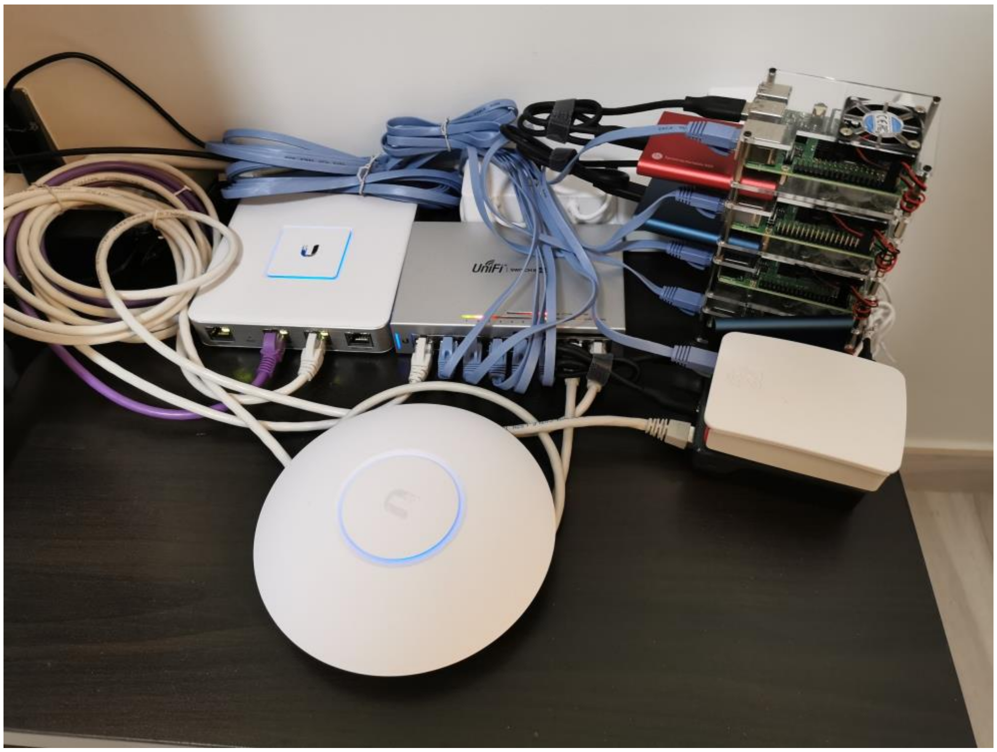


Figure 10. My production-ready home cluster!

Figure 10 is a presentation of how the project was built initially, including four Raspberry PI for the cluster and the dev Raspberry PI. Kindly note there is one extra Raspberry PI to manage the control panel of Ubiquiti and the WiFi AP which is used for home environment. Thanks to Ubiquiti, creating a safe environment is possible even if WiFi is shared with guests.

Also, three external SSD Disks (Samsung T5) are attached to the master node, being the top Raspberry PI in the rack (red SSD), below of which is the node-infra (blue SSD), and there is another blue SSD attached to the dev node.

Moreover, all the connections are over ethernet so as to provide the cluster with more stability.

An important detail during the process was to add a heat sink to all the Raspberry PI and a fan to the ones in the rack. It is a fairly cheap action yet an essential detail.

The CPU performance without adding these elements is considerably lower. The small step makes the difference.

Finally tidying up the cables and the set-up is completed! (Just hardware).

2.3.2 Setup Network and local domains

Now it is time to set up networking, which is an interesting point. A DHCP server provided by Ubiquiti will be used. For better support, a hostname resolver and static IP addresses will be set to the Raspberry PI.

At first sight this part seems straightforward and simple, but linking everything with the IP you want and making the hostname resolve the local domains properly without any conflict has been fun time!

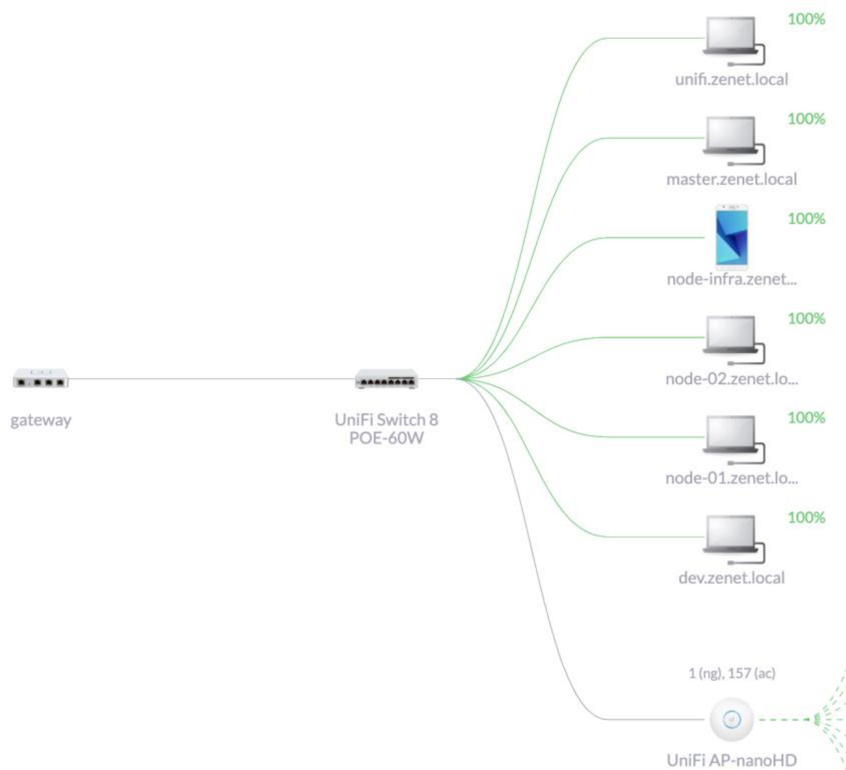


Figure 11. Devices Map Ubiquiti Control Panel

NAME ↑	MANUFACTURER	MAC	FIXED IP
dev.zenet.local	Raspberr		192.168.1.195
master.zenet.local	Raspberr		192.168.1.9
node-01.zenet.local	Raspberr		192.168.1.21
node-02.zenet.local	Raspberr		192.168.1.22
node-infra.zenet.local	Raspberr		192.168.1.10
unifi.zenet.local	Raspberr		192.168.1.8

Figure 12. Devices List Ubiquiti Control Panel

Thankfully at the end it works well as shown in figures 11 and 12 above.

In the previous figures it can be seen the domain is zenet.local. The reason for choosing this domain is that my nickname is AlberTenez, inverting Tenez is Zenet.

2.3.3 Deploying Kubernetes with the CNI (Flannel)

Now the hard part is done. Next step is to run some group of commands which can be found in the tutorials:

1. https://www.kasperry.io/install-k8s-pkg
2. https://www.kasperry.io/setup-k8s-calico

Following the install and setup tutorials we get the following result.

```
albertenez@master:~$ kubectl get nodes
NAME                    STATUS   ROLES    AGE     VERSION
master.zenet.local      Ready    master   9m43s   v1.18.2
node-01.zenet.local     Ready    <none>   9m5s    v1.18.2
node-02.zenet.local     Ready    <none>   8m41s   v1.18.2
node-infra.zenet.local  Ready    <none>   8m18s   v1.18.2
```

Figure 13. Kubectl get nodes

Now services can be run in the cluster.

The cluster has node-infra. In this node only specific containers need to be deployed. Therefore, this node will be labeled and tainted.

> kubectl label nodes node-infra.zenet.local worker=infra-master
> kubectl taint node node-infra.zenet.local workers=infra-master:NoSchedule

Tainting a node is the way to have control of what is deploying and where. Once done, the containers are not going to be scheduled in the node-infra by default.

2.3.4 Deploy DataDog

To deploy DataDog, Helm will be used to simplify the deployment management.

So, the documentation of DataDog [24] will be referred to for the purpose of setting the "values.yaml" according to the cluster architecture, basically specifying IP, ports and API secrets.

> wget -O datadog-values.yaml https://raw.githubusercontent.com/helm/charts/master/stable/datadog/values.yaml
> # Edit the file adding the no_verify and api_key, also enabled kube metrics.
> helm install -f datadog-values.yaml datadog stable/datadog

There are still a lot of problems with the API certificates x.509, mainly SSL identification problems. That is because Kubernetes is using self-signed certificates and custom domains ".local". As a possible solution, Datadog team recommends setting the insecure flag to the api requests [23].

Following the recommendation, after setting this flag to "no_verify" the cluster shows healthy status:

```
albertenez@master:~$ kubectl -n default get po
NAME                                          READY   STATUS    RESTARTS   AGE
datadog-b85b2                                 3/3     Running   0          6d23h
datadog-g8bfh                                 3/3     Running   0          6d23h
datadog-j2rrz                                 3/3     Running   0          6d23h
datadog-kube-state-metrics-7f4458b75b-pg5bd   1/1     Running   0          6d23h
datadog-ssd8r                                 3/3     Running   0          6d23h
```

Figure 14. Kubectl -n default get po

Figures 15, 16 and 17 are images of the control panel of DataDog. The log management page, system status and Kubernetes information are shown.

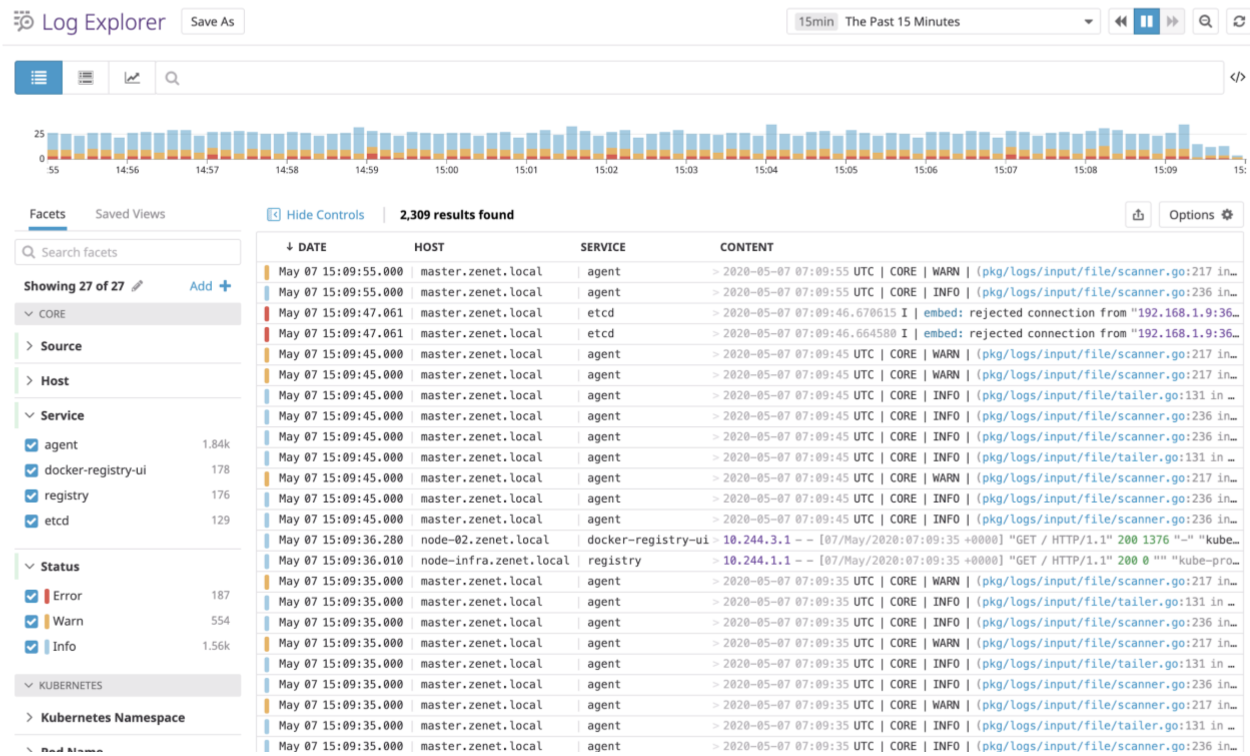
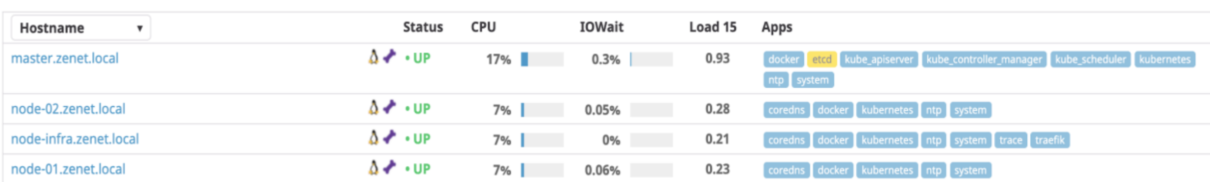


Figure 15. DataDog Logs Dashboard



Hostname	Status	CPU	IOWait	Load 15	Apps
master.zenet.local	UP	17%	0.3%	0.93	docker etcd kube_apiserver kube_controller_manager kube_scheduler kubernetes ntp system
node-02.zenet.local	UP	7%	0.05%	0.28	coredns docker kubernetes ntp system
node-infra.zenet.local	UP	7%	0%	0.21	coredns docker kubernetes ntp system trace traefik
node-01.zenet.local	UP	7%	0.06%	0.23	coredns docker kubernetes ntp system

Figure 16. DataDog Host metrics Dashboard

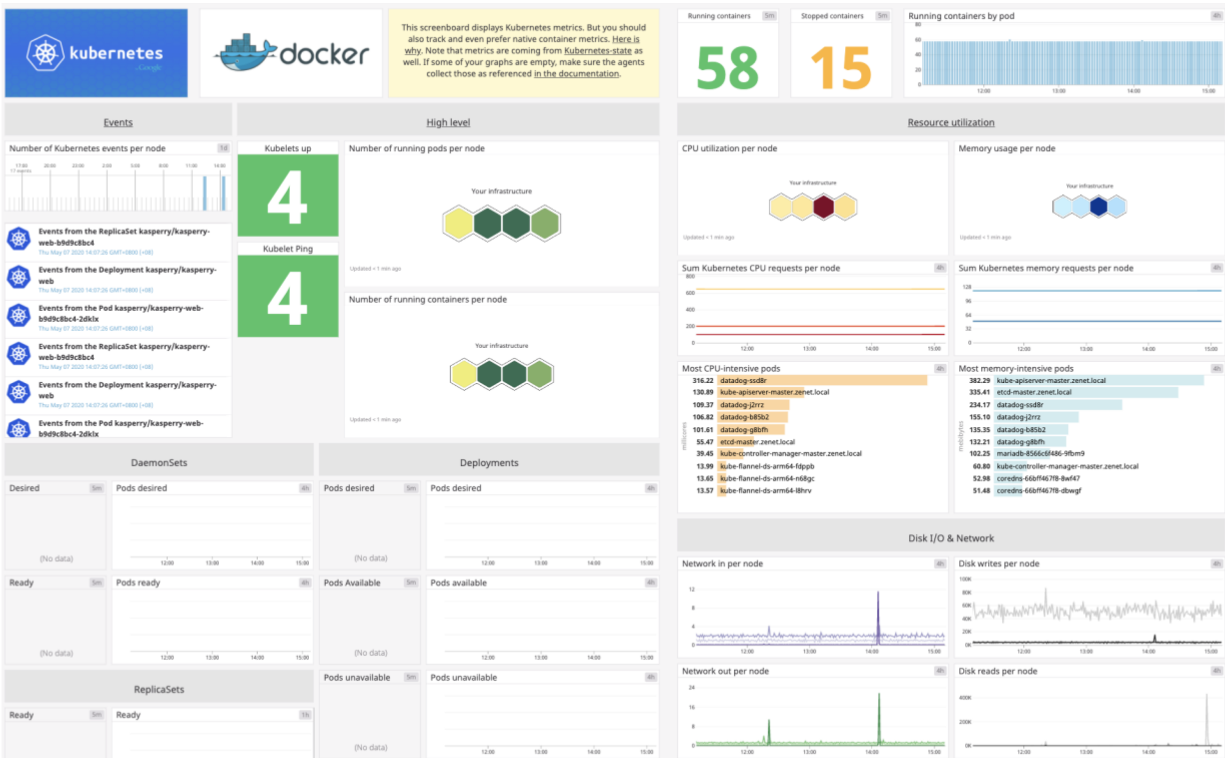


Figure 17. DataDog Kubernetes Dashboard

The above figures 15-17 provide a lot of information. However, there are still some blank pieces. That is because DataDog provides a lot of solutions which has to be checked one by one in order to make everything work smoothly.

Using DataDog relieves a lot of resources from the not-so-powerful Raspberry PI.

2.3.5 Deploy Traefik

To deploy Traefik, same as before, Helm will be used, since it is the recommended way and the easiest one. [22]

> wget -O traefik-values.yaml
https://raw.githubusercontent.com/containous/traefik-helm-chart/master/traefik/values.yaml
> helm repo add traefik https://containous.github.io/traefik-helm-chart
> helm repo update
> helm install --namespace=traefik -f traefik-values.yaml traefik traefik/traefik

In this case it is a bit different. Traefik does not use the official Helm repository. That is because the “helm stable/traefik” is the version 1.7 of Traefik using Helm v2 and the version that will be deployed has to be the newest one, v2.2 with Helm v3. The reason is that the cluster is using the v3 of Helm.

Once everything is deployed:

```
albertenez@master:~$ kubectl -n traefik get po
NAME                        READY   STATUS    RESTARTS   AGE
traefik-75f68bf744-ldwjs    1/1     Running   0          7d
```

Figure 18. Checking if traefik is running properly

The next step is to deploy Traefik to node-infra, which has a taint to disable Kubernetes scheduling pods to the node.

To get the pod scheduled to node-infra, the config tolerations has to be set as shown in Figure 19.

```
nodeSelector:
  worker: infra-master
tolerations:
  - key: "workers"
    value: "infra-master"
    effect: "NoSchedule"
```

Figure 19. nodeSelector and toleration example

Now, node-infra is running Traefik and the ports have been exposed to the host.

Figure 20 shows the control panel of Traefik, proving that the service is working.

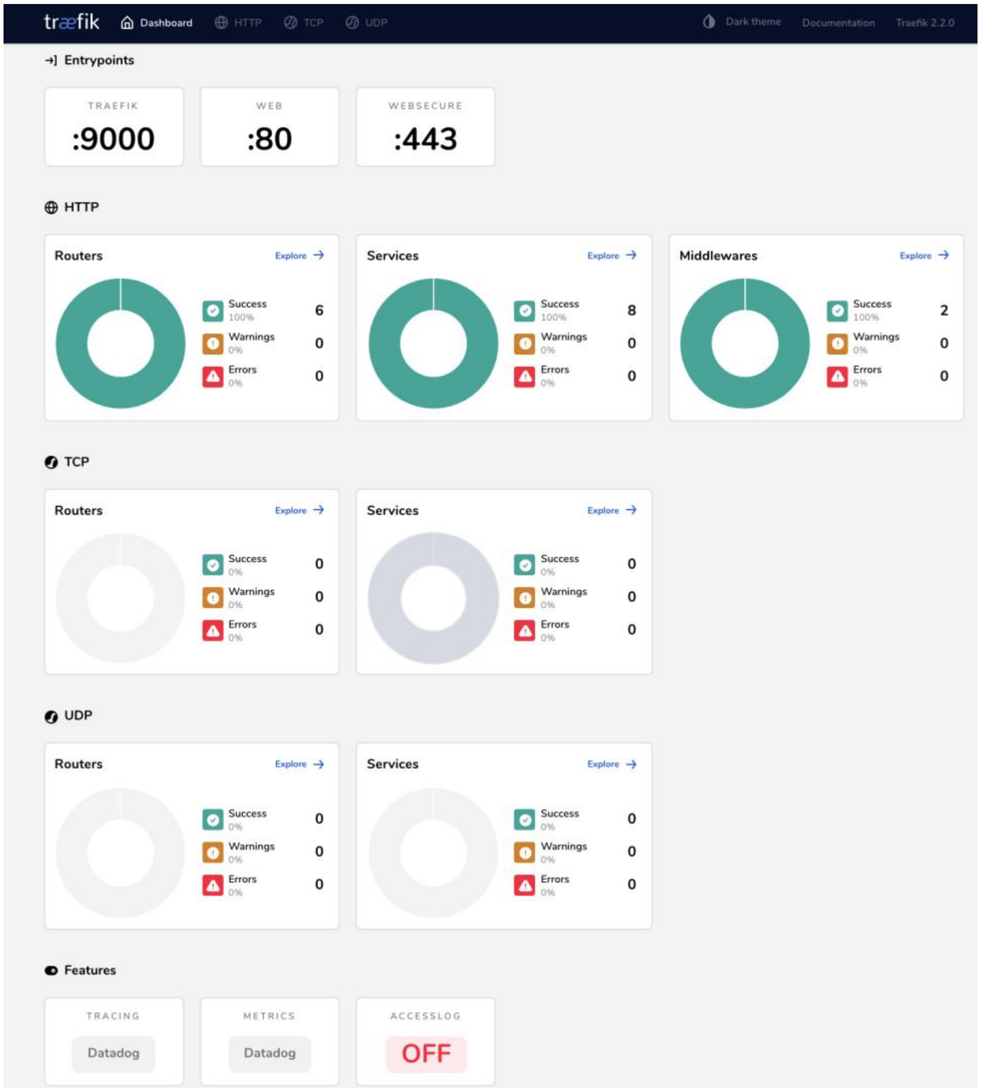


Figure 20. Traefik Dashboard

Access from outside the cluster is banned, since there is a firewall in the Ubiquiti which filters all new incoming traffic.

On the other hand, the public access to the pod, Traefik which will be managing the load balancer and routing, will be allowed.

NAME	FROM	PORT	DEST IP/PORT	ENABLED
http	Any	80	192.168.1.10:80	✓
https	Any	443	192.168.1.10:443	✓

Figure 21. Ubiquiti Port Forwarding manager

Figure 21 shows the ports of which the access has been granted to the public. For security reasons no other ports will be exposed to the public.

Now everything is ready to deploy an app!

2.3.6 Deploy Private Docker Registry

This is the most straight forward service to deploy.

Helm package: https://github.com/Joxit/docker-registry-ui
> git clone https://github.com/Joxit/docker-registry-ui.git
> cd docker-registry-ui/examples/helm/docker-registry-ui
> # Edit values accordingly our needs
> helm install --namespace=registry registry .

Traefik IngressRoute has to be created to make the Docker registry exposed.

Figure 22 shows the IngressRoute yaml with all configurations needed.

```yaml
---
apiVersion: traefik.containo.us/v1alpha1
kind: IngressRoute
metadata:
  name: registry-tls
  namespace: registry
spec:
  entryPoints:
    - websecure
  routes:
    - match: "Host(`registry.zenet.io`) && PathPrefix(`/v2`)"
      kind: Rule
      services:
        - name: registry-docker-registry
          port: 5000
      middlewares:
        - name: ipwhitelist
    - match: "Host(`registry.zenet.io`)"
      kind: Rule
      services:
        - name: registry-ui
          port: 80
      middlewares:
        - name: ipwhitelist
  tls:
    certResolver: namecheap
    domains:
      - main: zenet.io
        sans:
          - "*.zenet.io"
```

Figure 22. Docker Registry IngressRoute

Also, a middleware has been created to make sure nobody has access to the Docker registry without authorization. Figure 23 shows the yaml of this middleware used to whitelist the IPs of the cluster.

```yaml
---
apiVersion: traefik.containo.us/v1alpha1
kind: Middleware
metadata:
  name: ipwhitelist
  namespace: registry
spec:
  ipWhiteList:
    sourceRange:
      - 158.140.145.214
      - 192.168.1.1
```

Figure 23. Docker Registry Middleware IPWhiteList

Now the Docker registry is well protected.

Finally, to make the data more consistent the pod will be deployed to node-infra using persistent Volume as shown in Figure 24. Also, tolerations in Helm configuration is updated.

```yaml
---
apiVersion: v1
kind: PersistentVolume
metadata:
  name: pv-registry
spec:
  storageClassName: manual
  capacity:
    storage: 100Gi
  accessModes:
    - ReadWriteOnce
  hostPath:
    path: "/data/registry"

---
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: pvc-registry
  namespace: registry
spec:
  storageClassName: manual
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 100Gi
```

Figure 24. Persistent Volume & Persistent Volume Claim

And that's it! Now Docker registry is already running.

```
albertenez@master:~$ kubectl get -n registry po
NAME                                     READY   STATUS    RESTARTS   AGE
registry-docker-registry-c55d6d4c4-sqckj   1/1     Running   0          7d3h
registry-ui-5f5f996d86-mbrwg             1/1     Running   0          9d
```

Figure 25. Docker registry & registry UI running successfully

In addition, this repository provides a small UI which is shown in Figure 26.

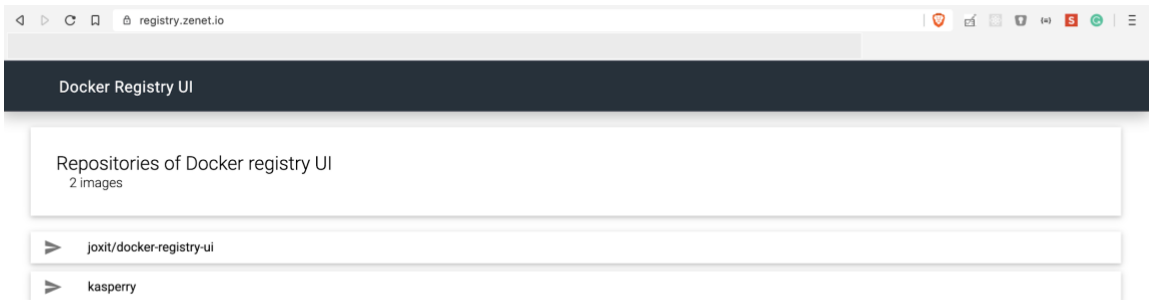


Figure 26. Screenshot of the UI made by Joxit

2.3.7 Deploy Kasperry PI app

Deploying Gatsby will require making a custom Kubernetes yaml.

The code of the webpage is completely public and accessible at: https://github.com/AlbertSabate/kasperry

To make it work using ARM, the Docker container needs to be built using the same architecture.

The dev Raspberry PI will be used for all building processes.

The following commands are for creating the Docker image using the dev Raspberry PI.

```
> git clone https://github.com/AlbertSabate/kasperry.git
> cd kasperry
> docker build -t registry.zenet.io/kasperry .
> docker push registry.zenet.io/kasperry
```

Now the new Docker image with the Gatsby website is available to the Docker registry.

Figure 27 shows the deployment yaml needed to deploy Kasperry PI.

```yaml
---
kind: Deployment
apiVersion: apps/v1
metadata:
  namespace: kasperry
  name: kasperry-web
  labels:
    app: kasperry-web
spec:
  replicas: 2
  selector:
    matchLabels:
      app: kasperry-web
  template:
    metadata:
      labels:
        app: kasperry-web
    spec:
      containers:
        - name: kasperry-web
          image: registry.zenet.io/kasperry
          ports:
            - name: web
              containerPort: 80
      imagePullSecrets:
        - name: zenet-registry
```

Figure 27. Kasperry PI Web Deployment

The deployment is responsible for deploying the new Docker image previously created to the kubernetes cluster.

```yaml
---
apiVersion: v1
kind: Service
metadata:
  name: kasperry-web
  namespace: kasperry
spec:
  ports:
    - protocol: TCP
      name: web
      port: 80
  selector:
    app: kasperry-web
```

Figure 28. Kasperry PI Web Service

Figure 28 shows the Kubernetes service. It is the responsible to expose the container to the cluster, and then Traefik will be the one exposing it to the public.

```yaml
---
# Redirect to https
apiVersion: traefik.containo.us/v1alpha1
kind: Middleware
metadata:
  name: https-redirect
  namespace: kasperry
spec:
  redirectScheme:
    scheme: https
    permanent: true
```

Figure 29. Middleware Traefik

This Middleware shown in figure 29 is an asset of Traefik. It is the way we have to create a 301 permanent redirect from http to https.

```yaml
---
apiVersion: traefik.containo.us/v1alpha1
kind: IngressRoute
metadata:
  name: kasperry-notls
  namespace: kasperry
spec:
  entryPoints:
    - web
  routes:
    - match: "Host(`kasperry.io`) || Host(`www.kasperry.io`)"
      kind: Rule
      services:
        - name: kasperry-web
          port: 80
      middlewares:
        - name: https-redirect
```

Figure 30. Traefik IngressRoute notls

Figure 30 shows another asset of Traefik, IngressRoute. It is the way to link the domain and the service and expose it to the public. This figure is the non-tls version.

It can be seen that the middleware shown in figure 29 linked in figure 30 is doing a force redirect to https.

```yaml
---
apiVersion: traefik.containo.us/v1alpha1
kind: IngressRoute
metadata:
  name: kasperry-tls
  namespace: kasperry
spec:
  entryPoints:
    - websecure
  routes:
    - match: "Host(`kasperry.io`) || Host(`www.kasperry.io`)"
      kind: Rule
      services:
        - name: kasperry-web
          port: 80
  tls:
    certResolver: namecheap
    domains:
      - main: kasperry.io
        sans:
          - "*.kasperry.io"
```

Figure 31. Traefik IngressRoute tls

Related with figure 30, figure 31 is the TLS version. The TLS version contains the data “certResolver”. certResolver is the credentials of the DNS provider, and then, Traefik will use let’s encrypt to create automatically a valid SSL Certificate.

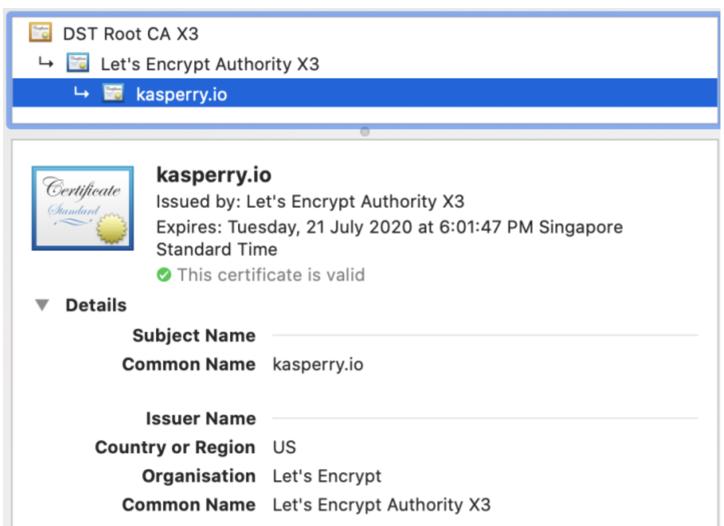


Figure 32. Valid Let’s Encrypt Certificate

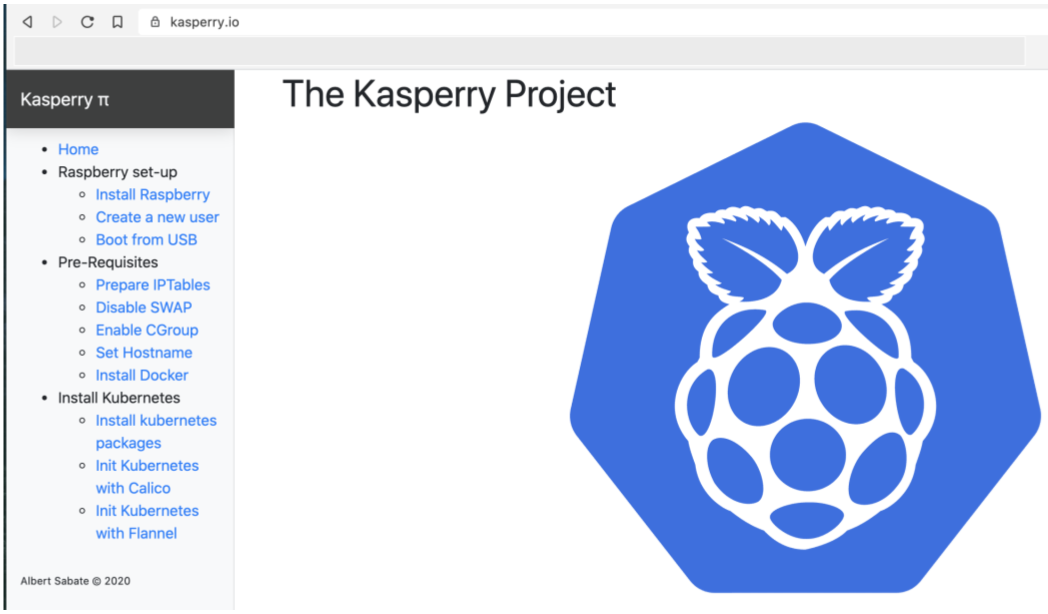


Figure 33. Kasperry PI (Under development) webpage

Figure 32 and 33 shows the webpage properly certificated and successfully running.

Finally, a Helm chart is created to be able to do automatic deployment easily.

> git clone https://github.com/AlbertSabate/kasperry.git
> # Configure helm/values.yaml
> helm install kasperry-web ./helm

2.3.8 CI / CD

The new Github Actions will be used to build the CI / CD. Since the webpage does not have tests the pipeline will be defined to build the Docker image, push it to the Docker registry and deploy Kubernetes using Helm.

Github Actions does not provide ARM compatibility, but it provides a self-hosting option which can be executed in the dev Raspberry PI.

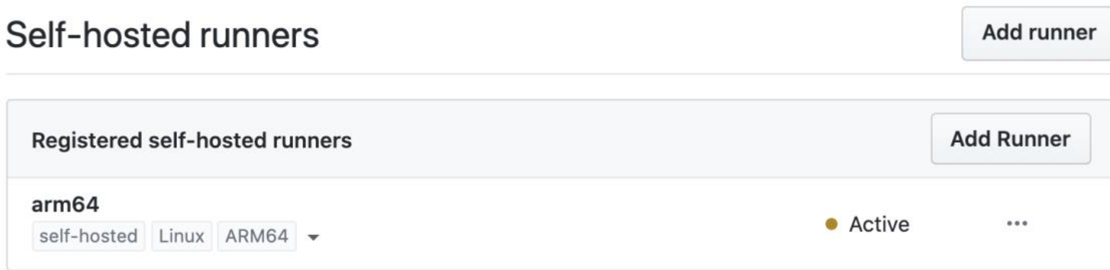


Figure 34. Github Actions Self-hosted runners

Figure 34 shows the self-host runner with ARM already active.

Figure 35 shows the missing part to make it work, the secrets with the keys to access to Kubernetes.

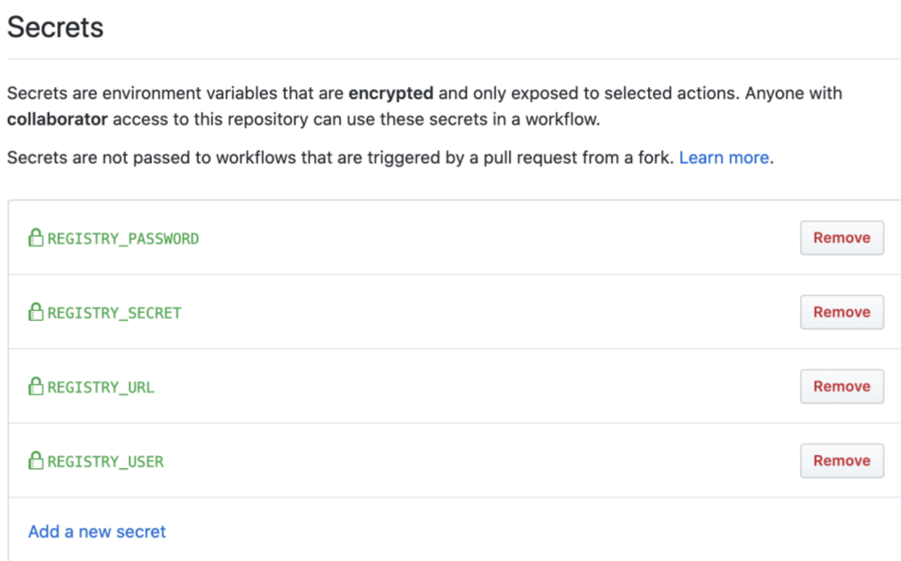


Figure 35. Github actions Secrets

Done, all prerequisites to make it work are green. So, it's time to start to code the pipelines.

Figure 36 shows the code used for the pipeline.

```yaml
name: Docker Image CI

on:
  push:
    branches: [ master ]
  pull_request:
    branches: [ master ]

jobs:

  build:

    runs-on: [ self-hosted, linux, ARM64 ]

    steps:
    - uses: actions/checkout@v2
    - name: Login into docker
      run: docker login registry.zenet.io -u ${{ secrets.REGISTRY_USER }} -p ${{ secrets.REGISTRY_PASSWORD }}
    - name: Build the Docker image
      run: docker build . --file Dockerfile --tag ${{ secrets.REGISTRY_URL }}/kasperry:$GITHUB_RUN_ID
    - name: Tagging master
      run: docker tag ${{ secrets.REGISTRY_URL }}/kasperry:$GITHUB_RUN_ID ${{ secrets.REGISTRY_URL }}/kasperry:latest
    - name: Push to docker registry
      run: docker push ${{ secrets.REGISTRY_URL }}/kasperry
    - name: Update kubernetes deployment
      run: helm upgrade --namespace=kasperry kasperry ./helm --set imagePullSecret=${{ secrets.REGISTRY_SECRET }} --set
image.repository=${{ secrets.REGISTRY_URL }}/kasperry --set image.tag=$GITHUB_RUN_ID
```

Figure 36. Github actions pipeline

It is a really simple approach, running everything inside of the Raspberry PI. What the pipeline is doing is checking out master, versioning, executing Docker build and Helm upgrade.

Figure 37 shows how the pipeline is successfully executed.

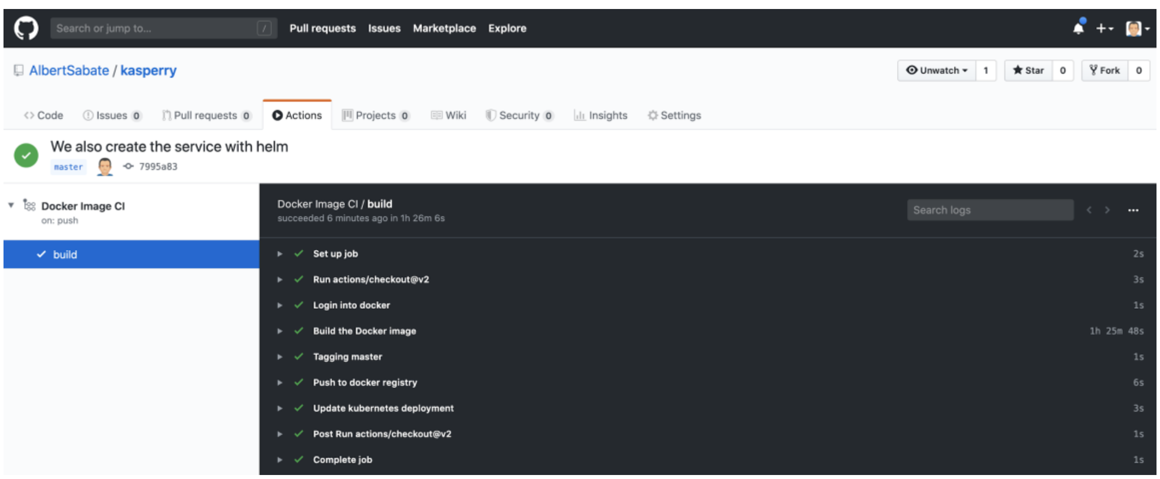


Figure 37. Github Action Passed Pipelines

This CI / CD is really simple, but it proves a working solution on how to build a pipeline with whatever resources we have.

2.4 Results

Figure 38. Final cluster result (Hardware)

Figure 38 presents the final result of Kasperry PI hardware as defined in figure 8. There is also an extra Raspberry PI, which was used to test Ubuntu 20.04 LTS.

On the other hand, the software successfully running is:

- **Kubernetes**
  Successfully deployed on v1.18.2.

- **Traefik**
  Successfully deployed on v2.2.0.

- **DataDog**
  Successfully deployed on v7.19.0-rc.7 of the agent. In this case, a development version has to be used to get ARM support.

- **Docker registry**
  Successfully deployed on v2 using the UI provided by Joxit.

- **Github Actions**

  Running the self-runner successfully in dev node. The workflow is:
  - git push to master
  - Triggers the Github Actions
  - Executes the workflow shown in figure 37 which is running in the dev node with access to Kubernetes cluster to apply the new deployment

Once hardware and software are settled, the CI / CD part has to be explained.

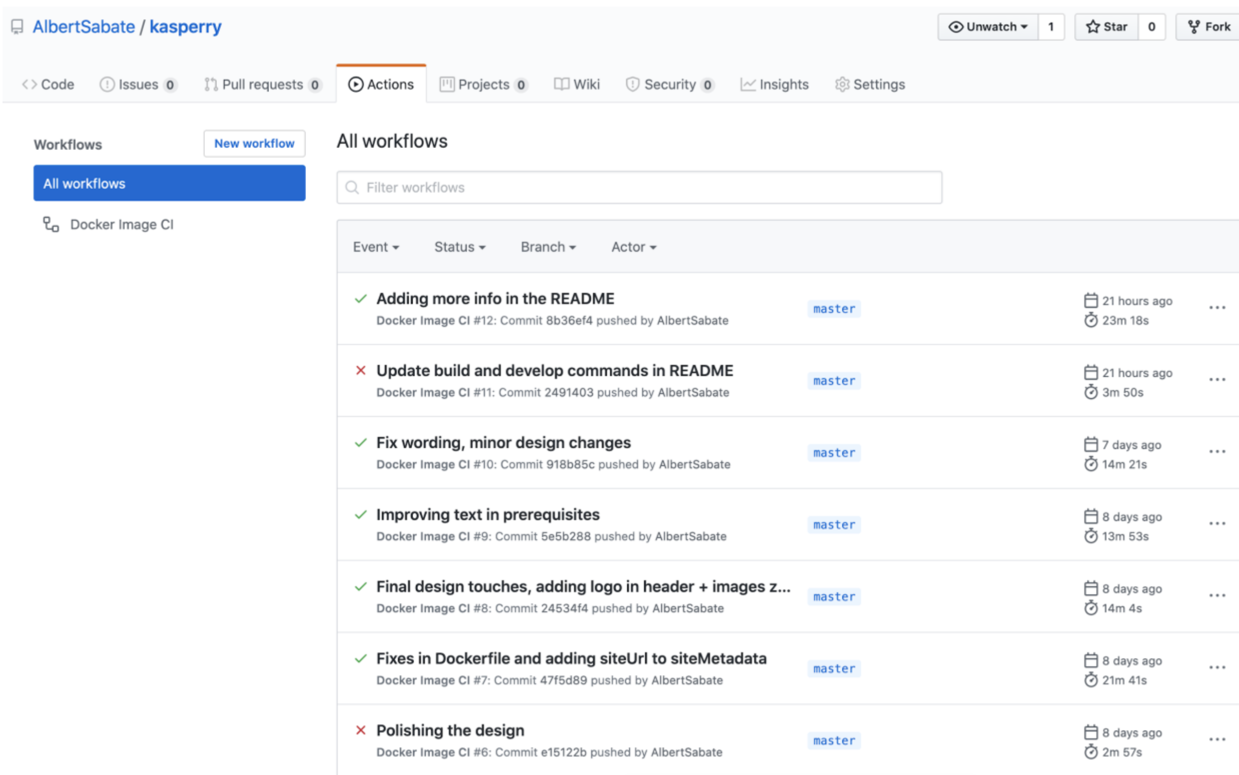


Figure 39. Github Actions workflows

Figure 39 shows how the pipeline runs successfully for each push to branch master. When the pipeline fails, the workflow is stopped and the webpage does not get deployed, in prevention of having an error on production.

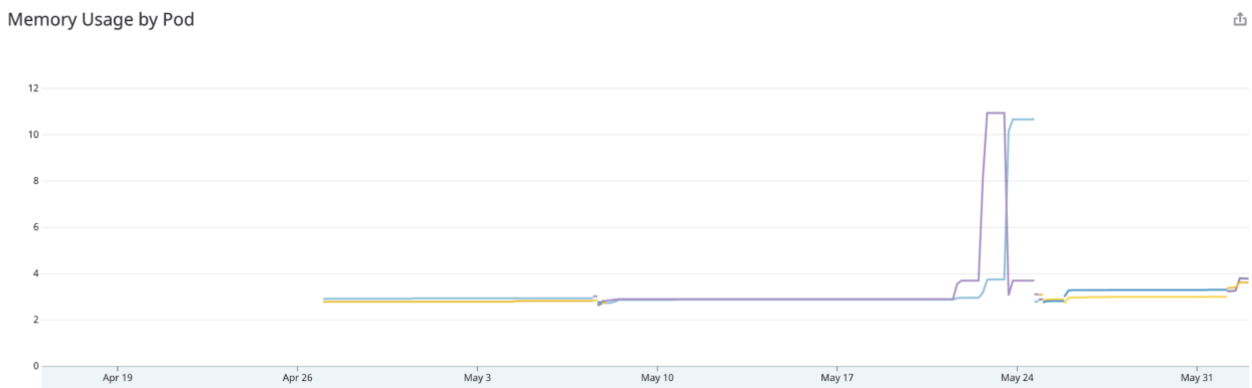


Figure 40. DataDog memory usage by Kasperry PI pods

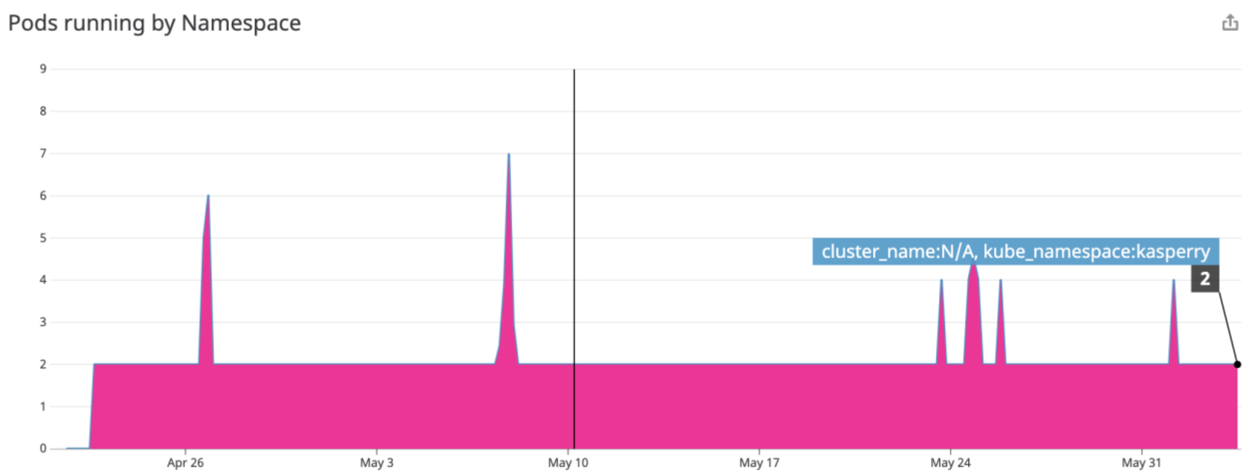


Figure 41. DataDog Kasperry PI running pods

Filter series

Value	Min	Avg	Max	Metric	Tags ↓
14	5	7.05	17	kubernetes.pods.running	cluster_name:N/A,kube_namespace:default
2	2	2.11	6.98	kubernetes.pods.running	cluster_name:N/A,kube_namespace:kasperry
14	14	14.14	17	kubernetes.pods.running	cluster_name:N/A,kube_namespace:kube-system
1	1	1.03	4	kubernetes.pods.running	cluster_name:N/A,kube_namespace:mariadb
2	1	2	5	kubernetes.pods.running	cluster_name:N/A,kube_namespace:registry
1	1	1.05	6	kubernetes.pods.running	cluster_name:N/A,kube_namespace:traefik

Figure 42. Index of figure 41

Figures 40-42 shows DataDog graphs, aiming to prove the deployments happen automatically and without downtime to the webpage. Figure 41 shows specifically there are never less than 2 containers deployed.

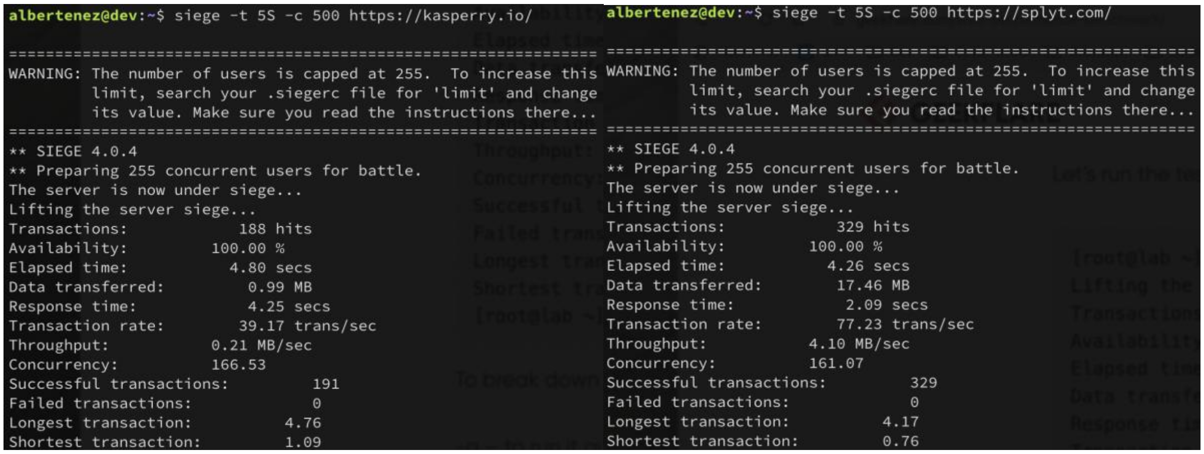


Figure 43 & 44. Kasperry PI vs Splyt benchmark comparison

Figure 43 and 44 show a benchmark comparing Kasperry PI website with another landing page deployed on GCloud. In both cases, the availability is 100%, and concurrency is even better on Kasperry PI website. Kasperry PI is a very optimized website where the data transferred is 0.99MB in comparison to the 17.46MB from Splyt.

The only downside is that home internet is not as stable as the corporate one. And most likely only one IP address will be assigned to the home internet.

Taking all into consideration, the final result I can give after building all of this project is that Kasperry PI is a really good server candidate, small but ready for production.

3. Conclusions

Building Kasperry PI needed a lot of knowledge on Kubernetes, networking and webpage design. To obtain the knowledge a lot of reading and analyzing of documents, articles, news, etc. are required. It develops into a deep learning process on the most recent DevOps technology.

Furthermore, Kasperry PI web page contains a lot of tutorials to reproduce the project and it is available worldwide. The webpage is publicly accessible, and it is hosted on the cluster built following these tutorials.

Finally, Kasperry PI was successfully built. It has been running for more than 30days as of now, which proves that the objectives of this project have been achieved.

Kasperry PI has been completed and it could demonstrate that building a production-ready cluster is possible even at home, which is a meaningful discovery.

4. Glossary

K8s or Kube: Short for Kubernetes.
DC/OS: Distributed Cloud Operating System, ie how mesos defines its OS.
CI/CD: In software engineering, CI/CD or CICD generally refers to the combined practices of continuous integration and either continuous delivery or continuous deployment.
ARM: A family of reduced instruction set computing architectures for computer processors.
PaaS: Platform as a service.
OS: Operating system, eg windows, linux, mac, etc.
Cloud: Storing and accessing data and programs over the Internet instead of the computer's hard drive.
Minion: Refers to a worker node.
Worker: Worker machines. It runs run containerized applications.
Master: A master node is a node which controls and manages a set of worker nodes.
ISP: Internet Service Provider
SSD: Solid-state drive
YAML: A recursive acronym for "YAML Ain't Markup Language". A human-readable data-serialization language. It is commonly used for configuration files and in applications where data is being stored or transmitted.
Cluster: It is a set of loosely or tightly connected computers that work together so that, in many respects, they can be viewed as a single system.
GCloud: It is referring Google Cloud.
IP address: An Internet Protocol address is a numerical label assigned to each device connected to a computer network that uses the Internet Protocol for communication.
TLS: Transport Layer Security, and its now-deprecated predecessor, Secure Sockets Layer (SSL), are cryptographic protocols designed to provide communications security over a computer network.
SSL: Secure Sockets Layer is a security technology that is commonly used to secure server to browser transactions.
x.509: In cryptography, X.509 is a standard defining the format of public key certificates.
DNS: The Domain Name System is a hierarchical and decentralized naming system for computers, services, or other resources connected to the Internet or a private network.
HTTP: The Hypertext Transfer Protocol is an application protocol for distributed, collaborative, hypermedia information systems.

HTTPS: Hypertext Transfer Protocol Secure is an extension of the Hypertext Transfer Protocol.

DevOps: DevOps is a set of practices that combines software development and IT operations. It aims to shorten the systems development life cycle and provide continuous delivery with high software quality.

RC: Release Candidate

Pipeline: In computing, a pipeline, also known as a data pipeline, is a set of data processing elements connected in series, where the output of one element is the input of the next one.

DHCP: The Dynamic Host Configuration Protocol is a network management protocol used on Internet Protocol networks whereby a DHCP server dynamically assigns an IP address and other network configuration parameters to each device on a network so they can communicate with other IP networks.

VPN: A virtual private network extends a private network across a public network and enables users to send and receive data across shared or public networks as if their computing devices were directly connected to the private network.

MAC address: A media access control address is a unique identifier assigned to a network interface controller for use as a network address in communications within a network segment.

CPU: A central processing unit, also called a central processor or main processor, is the electronic circuitry within a computer that executes instructions that make up a computer program.

SWAP: SWAP memory is basically parts/pages of memory from the RAM which is switching to use a file (or partition) dedicated on the hard-drive as memory space instead.

RAM: Random-access memory is a form of computer memory that can be read and changed in any order, typically used to store working data and machine code.

GB: The gigabyte is a multiple of the unit byte for digital information. The prefix giga means 10^9 in the International System of Units.

MB: The megabyte is a multiple of the unit byte for digital information. Its recommended unit symbol is MB. The unit prefix mega is a multiplier of 1000000 in the International System of Units.

UUID: A universally unique identifier is a 128-bit number used to identify information in computer systems.

Bit: The bit is a basic unit of information in information theory, computing, and digital communications.

Byte: It is a unit of digital information that most commonly consists of eight bits.

IT: Information technology is the use of computers to store, retrieve, transmit, and manipulate data or information.

5. Bibliography

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23. https://github.com/DataDog/integrations-core/issues/2582
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26. https://fstoppers.com/poll/how-often-do-sd-cards-really-fail-289251

6. Annexes

- https://kasperry.io
- https://github.com/AlbertSabate/kasperry

Kasperry PI Project README

Kasperry π

Build a production-ready home cluster with Raspberry PI.

All tutorial free of use :D

Develop

```
npm install
npx run develop
```

Build

```
npm install
npm run build
docker build -t kasperry .
docker run --rm -p 80:80 kasperry
```

Now, open your browser and check what's going on in your http://localhost!

Deploy with Helm

```
# Is recommended to review values.yaml to set accordingly.
# kubectl & helm must be installed and configured.
helm upgrade --install --namespace=default kasperry ./helm
```

Example how to expose the service using Traefik -> IngressRoute.

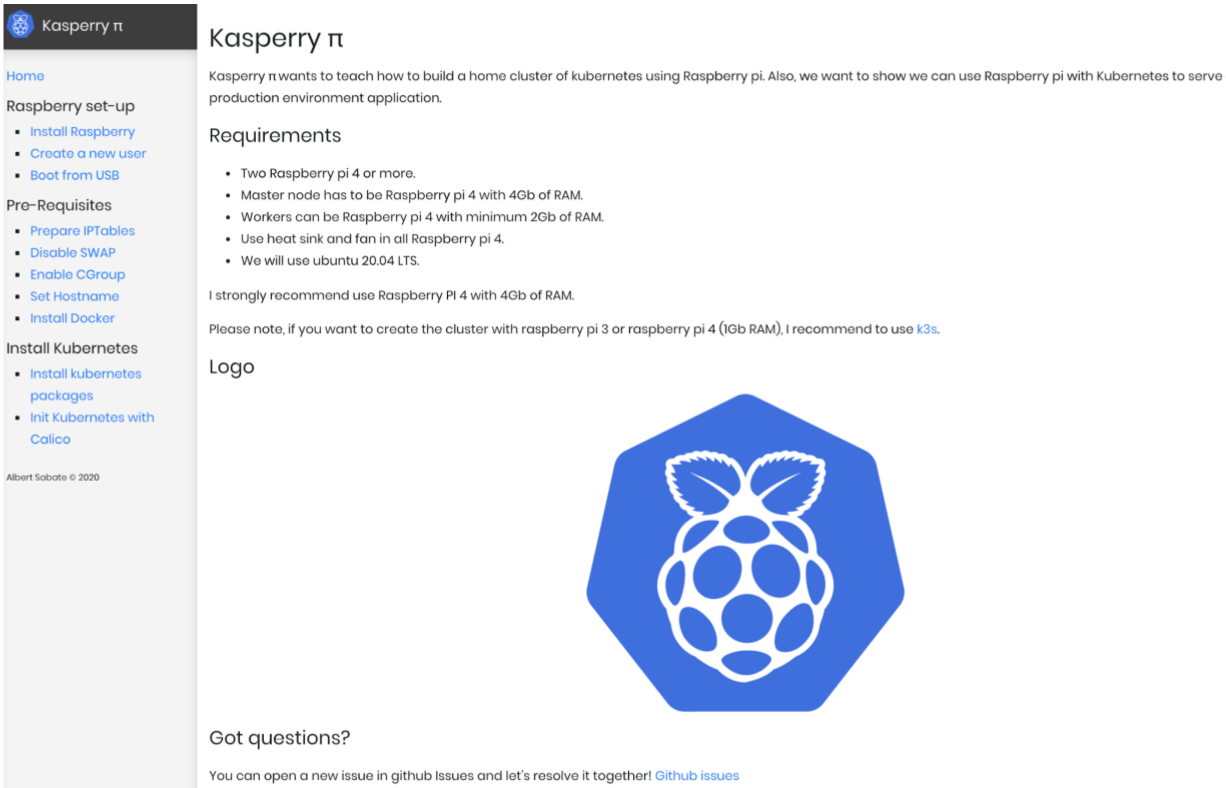
```
apiVersion: traefik.containo.us/v1alpha1
kind: IngressRoute
metadata:
  name: kasperry
  namespace: default
spec:
  entryPoints:
    - web # This should match with Traefik endpoint.
  routes:
    - match: "Host(`example.com`) || Host(`www.example.com`)" # DNS Server should be updated accorindgly
      kind: Rule
      services:
        - name: kasperry # use `kubectl get svc` to know the name of the service
          port: 80
```

Command to apply this yaml: `kubectl apply -f-`.

Third party software

This project is build using Gatsby.

Kasperry PI Web page



Kasperry π

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Kasperry π

Kasperry π wants to teach how to build a home cluster of kubernetes using Raspberry pi. Also, we want to show we can use Raspberry pi with Kubernetes to serve a production environment application.

Requirements

- Two Raspberry pi 4 or more.
- Master node has to be Raspberry pi 4 with 4Gb of RAM.
- Workers can be Raspberry pi 4 with minimum 2Gb of RAM.
- Use heat sink and fan in all Raspberry pi 4.
- We will use ubuntu 20.04 LTS.

I strongly recommend use Raspberry PI 4 with 4Gb of RAM.

Please note, if you want to create the cluster with raspberry pi 3 or raspberry pi 4 (1Gb RAM), I recommend to use k3s.

Logo

Got questions?

You can open a new issue in github Issues and let's resolve it together! Github issues

Installing Raspberry PI

Choosing Ubuntu 20.04 LTS 64bits to set-up the cluster.

You can download the following image for RPI: Install Ubuntu Server on a Raspberry Pi 2, 3 or 4 | Ubuntu

To install it in the SD Card we can execute the following commands: (Using MacOS)

```
[albert@kasperry.io] $ diskutil list
                       # Check the list to see what is your disk and partition number, in my case
[albert@kasperry.io] $ diskutil unmountDisk /dev/sda2
                       # Now we have to know where we download the ubuntu image and we have to pas
[albert@kasperry.io] $ sudo sh -c 'gunzip -c ~/Downloads/ubuntu20.04.img.xz | sudo dd of=/dev/sda2
```

This can take time, don't be scared if you don't see anything. If you get really impatient you can press `ctrl+t` to print the current status.

Once this is done we already can eject the SD Card: `diskutil eject /dev/sda2`.

Now, we are ready to insert the SD Card into the Raspberry PI, and let the magic happens! :D

Reminders

To access to the raspberry pi you can do `ssh ubuntu@<IP_ADDRESS>` with the password `ubuntu`.

If you are using another OS, you can refer to ubuntu download page and follow the official tutorial.

Creating user and remove default ubuntu

To create a new user, we can use the native command:

```
[albert@kasperry.io] $  sudo adduser <user_name>
                        # Follow steps
```

Adding the user to admin groups.

```
                        # Manually way to do it, since is a lot of groups.
[albert@kasperry.io] $  sudo vim /etc/group
                        # Add your new <user_name> to all groups which contains ubuntu.
                        # Separated by comma.
[albert@kasperry.io] $  exit
```

Now you can access again using your new created user.

Also, We recommend to login to ssh using certificate, It feels more safe than using password.

We start by creating the certificate in our machine.

```
[albert@localhost] $  ssh-keygen
                      # Follow steps
                      # It creates 2 files, copy all the content of your public cert.
                      # Usually id_rsa.pub
[albert@localhost] $  ssh <user_name>@kasperry.io
```

Time to configure our new certificate to the server.

```
[albert@kasperry.io] $  mkdir ~/.ssh
[albert@kasperry.io] $  vim ~/.ssh/authorized_keys
                        # Copy here the content of the newly created public key.
```

Check If the rights to do sudo are properly defined and then we can proceed to delete the ubuntu user, since is better not having it.

```
[albert@kasperry.io] $  deluser --remove-all-files ubuntu
                        # This will delete all files and folders of this user. Make sure you back-u
```

Finally, as an another recommended step. We can disable access ssh using password, since we have already configured our certificate.

```
[albert@localhost] $ | ssh -i ~/.ssh/id_rsa <user_name>@kasperry.io
```

Before to go to the next step try to access ssh using certificate.

```
[albert@kasperry.io] $ | sudo vim /etc/ssh/sshd_config
                       # We want to make sure the following lines are like this:
                       # ---
                       PermitRootLogin no

                       # To disable tunneled clear text passwords, change to no here!
                       PasswordAuthentication no
                       # ---
```

Everything is done here!

Booting Raspberry PI 4 from USB

Before to start we need to have some requirements

Requirements

- Ubuntu 20.04 freshly installed on the SD Card Install Ubuntu
- Ubuntu 20.04 freshly installed on the SSD Drive Install Ubuntu

Configuring Ubuntu to use the SSD as a root partition

We have to make the point clear. We are booting using the SD Card and mounting the SSD as a main partition.

What does that mean?

It means we cannot remove the SD Card, and the boot it happens using the SD Card.

Starting

Make sure we don't update anything before we change the boot to use the SSD.

- This is the boot partition: `/dev/mmcblk0p1` mounted at `/boot/firmware`. (This is the one we **always** use)
- This is the main partition: `/dev/mmcblk0p2` it will be no longer used.

First of all we execute:

```
[albert@kasperry.io] $ | sudo fdisk -l
                       # Check if we have available our external USB drive.
```

In my SSD:

- This is the boot partition: `/dev/sda1`. **NEVER USED**
- This is the main partition: `/dev/sda2`. This is the one we will use for our root partition.

We can edit the boot to use the SSD.

Edit the file:

```
[albert@kasperry.io] $ sudo vim /boot/firmware/cmdline.txt
                       # Replace the part `root=LABEL=writable` to `root=/dev/sda2`.
[albert@kasperry.io] $ sudo reboot
```

Now, it is gonna be using our SSD Partition.

Confirm it with:

```
[albert@kasperry.io] $ df
                       # Check if /dev/sda2 is mounted.
```

Easy right? 🙃

SUPER IMPORTANT NOTES

Now we have to understand how it works.

1. We see /dev/sda1 as boot partition.
2. **IS NOT TRUE**.
3. The real boot happens in `/dev/mmcblk0p1`.

So, when we update the kernel we have to make sure to mount `/dev/mmcblk0p1` as a boot partition and `/dev/sda2` as a root.

Is difficult, but we have to make sure we are doing it on this way. If not maybe you cannot boot again.

Friendly note

Raspberry pi team is working in provide a new firmware to real boot using USB without any of this "hack".

Not yet here.

IPTables

Another requisite of kubernetes is give iptables the ability to see bridge traffic. We can achieve that by executing:

```
                    # Note: We have to execute this as a root user
[root@kasperry.io] # modprobe br_netfilter

[root@kasperry.io] # cat <<EOF > /etc/sysctl.d/k8s.conf
                    net.bridge.bridge-nf-call-ip6tables = 1
                    net.bridge.bridge-nf-call-iptables = 1
                    EOF

[root@kasperry.io] # sysctl --system
[root@kasperry.io] # exit
```

Disable SWAP

As a requirement of kubernetes installation, we have to disable SWAP, since it can cause unexpected problems with kubelet.

Usually in ubuntu for raspberry is already off, but to make sure let's run:

```
[albert@kasperry.io] $ sudo swapoff -a

                       # Open fstab and if we have some line with swap, comment it out.
[albert@kasperry.io] $ sudo vim /etc/fstab
                       # Remember! To save and quit vim use: ctrl+c and :wq.
```

Enable CGroup

We have to add to our boot file `/boot/firmware/cmdline.txt` the following text at the end of the line `cgroup_enable=cpuset cgroup_memory=1 cgroup_enable=memory`.

Make sure you don't create a new line!

Reboot `sudo reboot`.

Setting up the Hostname

To set the hostname to the raspberry pi we can execute the following command:

```
[albert@kasperry.io] $ | sudo hostnamectl set-hostname new_host_name
[albert@kasperry.io] $ | sudo reboot
```

We can verify everything went right by executing `cat /etc/hostname`.

Install Essentials & Docker

```
                       | ### Allow apt-get to use a repository over HTTPS
[albert@kasperry.io] $ | sudo apt-get install \
                       |     apt-transport-https \
                       |     ca-certificates \
                       |     curl \
                       |     gnupg-agent \
                       |     software-properties-common \
                       |     build-essential
                       |
                       | ### Add Docker's official GPG key
[albert@kasperry.io] $ | curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo apt-key add
                       |
                       | ### Add Docker apt repository.
[albert@kasperry.io] $ | sudo add-apt-repository \
                       |    "deb [arch=arm64] https://download.docker.com/linux/ubuntu \
                       |    $(lsb_release -cs) \
                       |    stable"
                       |
                       | ### Installing Docker
[albert@kasperry.io] $ | sudo apt-get install docker-ce docker-ce-cli containerd.io
```

That's it!

Install Docker Engine on Ubuntu | Docker Documentation

Installing kubeadm & kubelet & kubectl

PreRequisites

- Set Hostname
- IPTables
- CGroup
- Disable SWAP
- Install Essentials and Docker

```
[albert@kasperry.io] $ | curl -s https://packages.cloud.google.com/apt/doc/apt-key.gpg | sudo apt-ke

[albert@kasperry.io] $ | cat <<EOF | sudo tee /etc/apt/sources.list.d/kubernetes.list
                       | deb https://apt.kubernetes.io/ kubernetes-xenial main
                       | EOF

[albert@kasperry.io] $ | sudo apt-get update
[albert@kasperry.io] $ | sudo apt-get install -y kubelet kubeadm kubectl
[albert@kasperry.io] $ | sudo apt-mark hold kubelet kubeadm kubectl
```

Installing kubeadm - Kubernetes

Setting up Kubernetes with Calico

To initialize the cluster is really easy, we are going to use kubeadm to do it.

```
[albert@kasperry.io] $ | sudo kubeadm init --pod-network-cidr=192.168.0.0/16
                       | # Really careful here to not conflict with your local network!!!!!!!!!!! Th
```

We already have created our cluster.

```
                       | # To have access to our cluster using kubectl, run the following commands.
[albert@kasperry.io] $ | mkdir -p $HOME/.kube
[albert@kasperry.io] $ | sudo cp -i /etc/kubernetes/admin.conf $HOME/.kube/config
[albert@kasperry.io] $ | sudo chown $(id -u):$(id -g) $HOME/.kube/config
```

Also, kubeadm provide us a join command. This command it should be executed in our worker nodes.

Finally, we should be able to execute the following command:

```
                       | # This apply Calico configurations
[albert@kasperry.io] $ | kubectl apply -f https://docs.projectcalico.org/manifests/calico.yaml
```

Information link

- Calico Webpage
- Compare other CNI