A K8-Based Mechanism for Remote Monitoring and Control of IoT Devices

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Motivation

Motivation

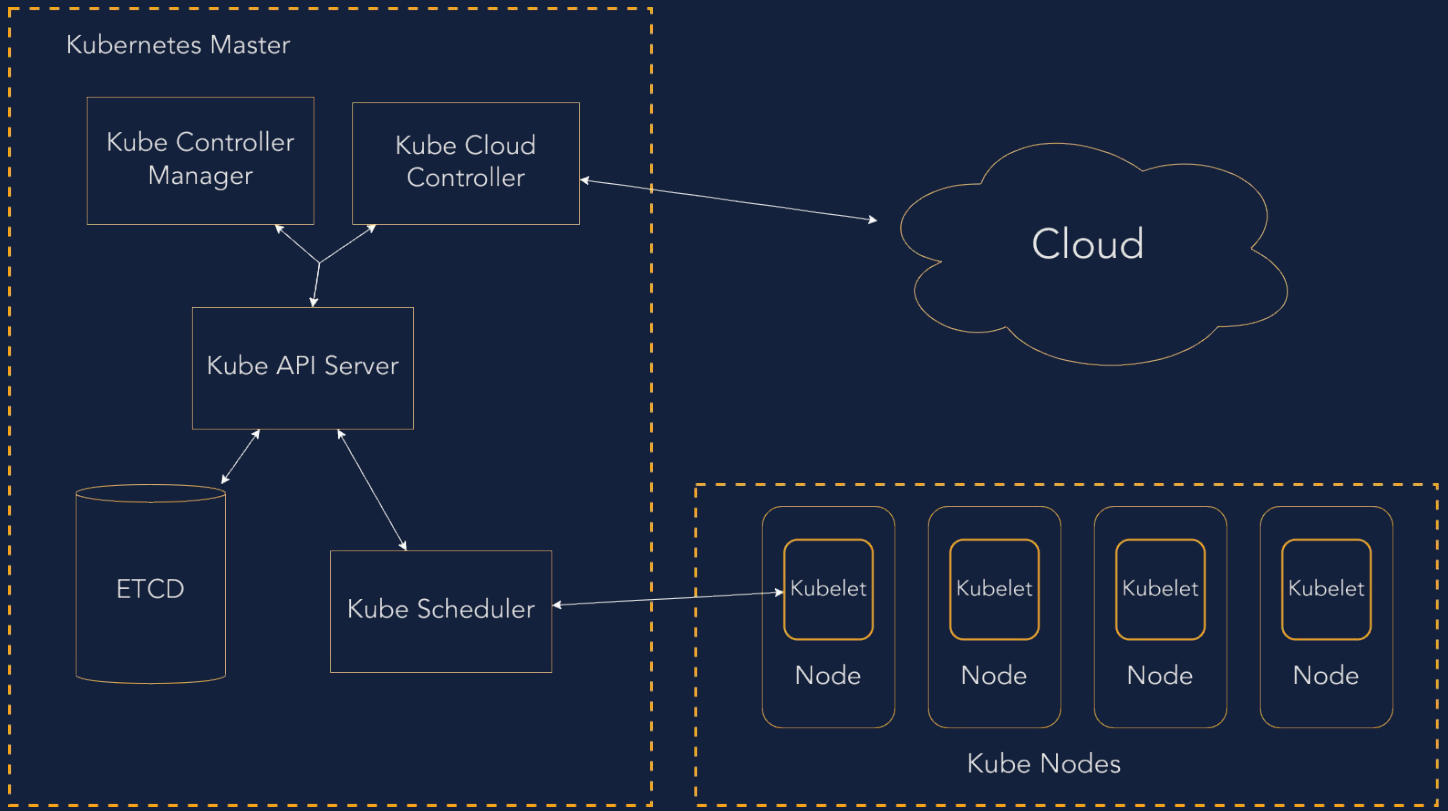
- Potential capabilities inside Edge Computing
- Lack of a centralized and unified solution
- Lack of a well documented and open source solution
- Current solutions (if any) are not scalable
- And very complex

Related Works

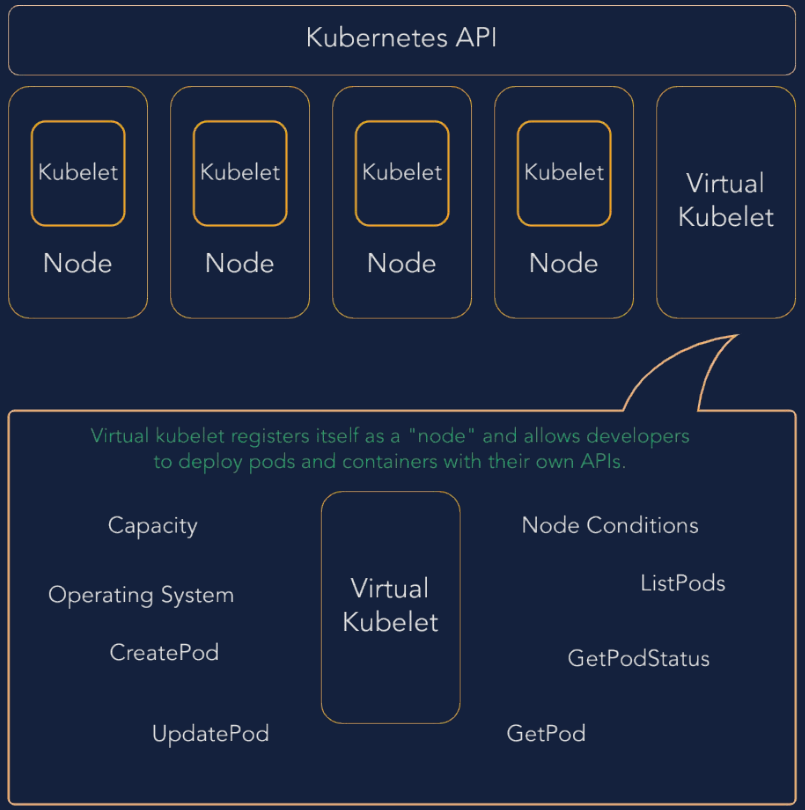
Related Works - Container Technologies

- Kubernetes
  - Highly scalable container platform
  - Battle-Tested
  - Fault Tolerant
  - Massive community
  - Basically the cloud we know today
- Virtual Kubelet
  - A Kubernetes node proxy
  - Registers itself as a node with a custom backend
  - Open source
  - Growing community

Kubernetes


Kubernetes Master
Kube Controller Manager
Kube Cloud Controller
Cloud
Kube API Server
ETCD
Kube Scheduler
Kubelet
Node
Kubelet
Node
Kubelet
Node
Kubelet
Node
Kube Nodes

Virtual Kubelet

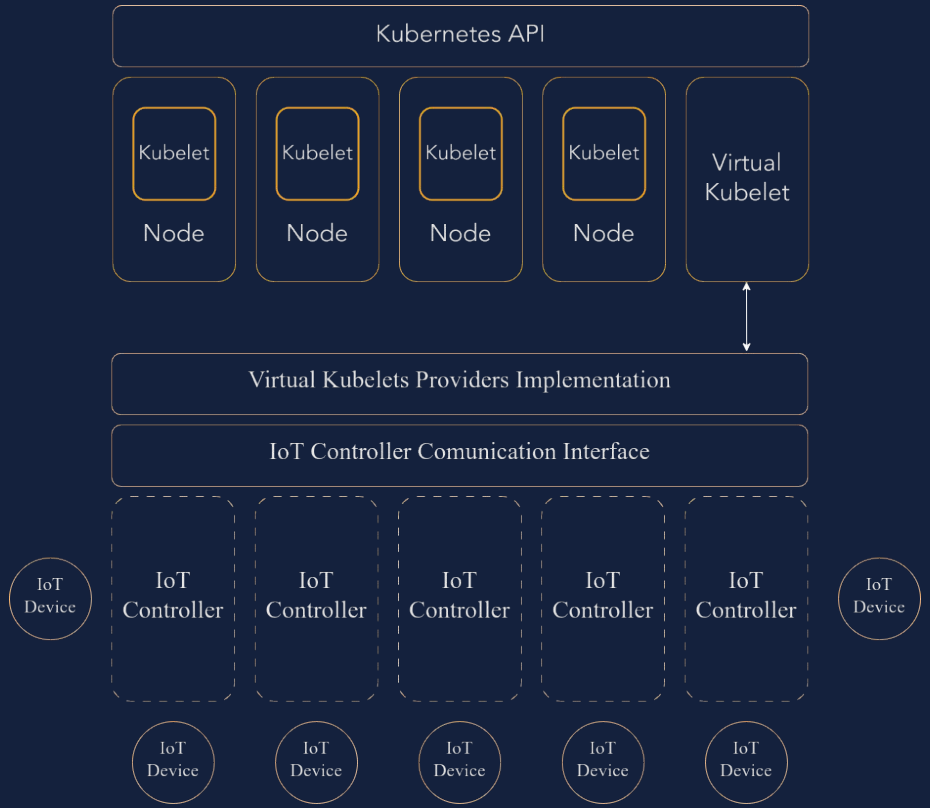


Design

Design

- Scalable
  - Kubernetes
  - Fan-Out design
- Simple
  - Used simple and popular transport protocols
    - HTTP
  - Used simple and popular data serialization
    - JSON
- Written in Golang
  - Massive concurrency support
  - Simple to learn
  - Massive community

Design


Kubernetes API
Kubelet
Node
Kubelet
Node
Kubelet
Node
Kubelet
Node
Virtual Kubelet
Virtual Kubelets Providers Implementation
IoT Controller Comunication Interface
IoT Device
IoT Controller
IoT Controller
IoT Controller
IoT Controller
IoT Controller
IoT Device
IoT Device
IoT Device
IoT Device
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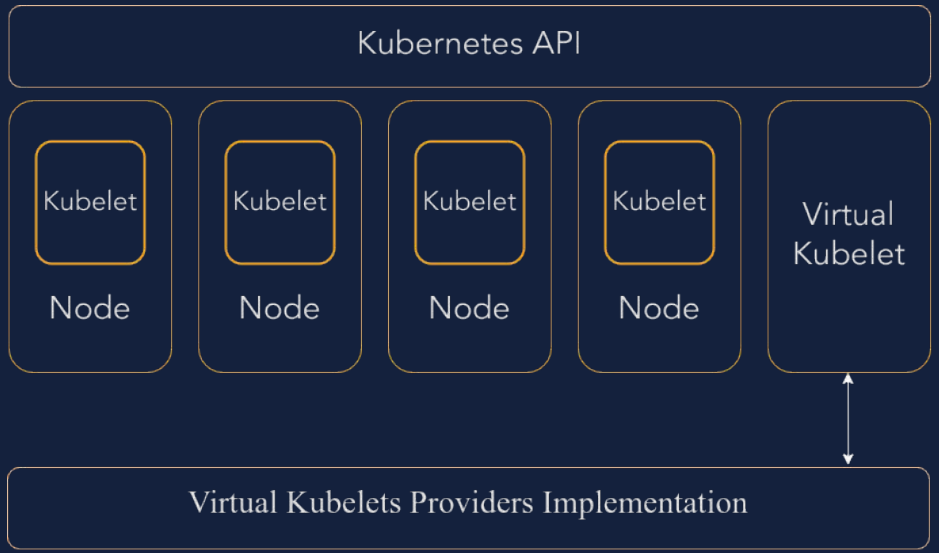
IoT Device

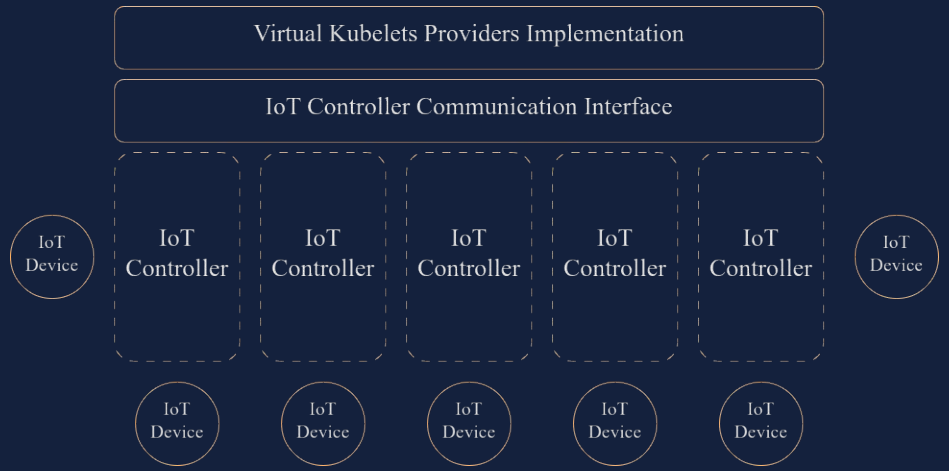
Design - Provider

By implementing virtual kubelet's provider interface, we can have kubernetes node with a custom backend that receives kubernetes client API calls.



Design - Communication Interface

- Provider communicates with Communication Interface through callbacks.
- Communication Interface then fetches Device states by sending HTTP requests to IoT Controllers.
- Communication Interface uses a Fan-Out technique.



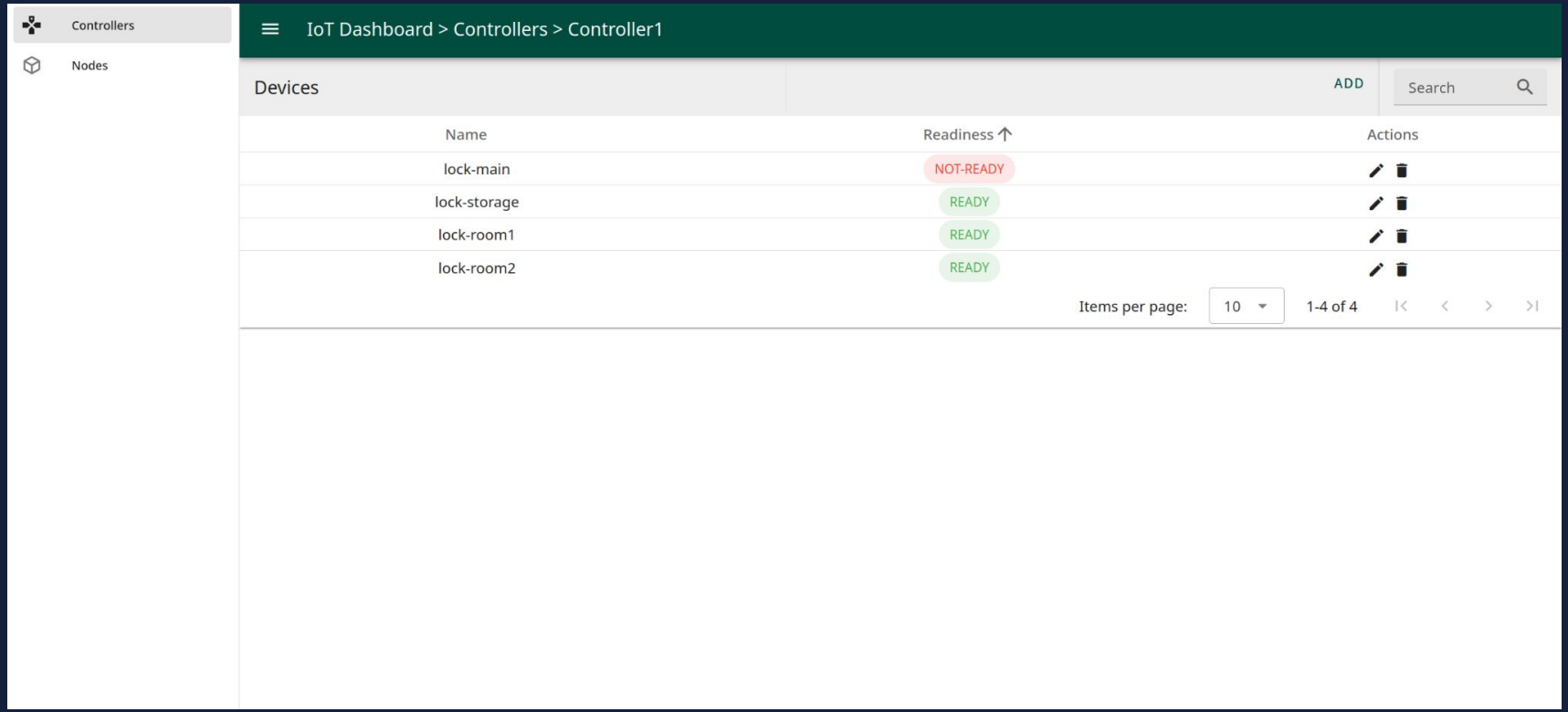
Design - Simulation Software

- Attempts to simulate a smart lock system
- Can have multiple controllers
- And multiple devices per controllers
- Written in Golang

Design - Graphical User Interface

- Was not the the goals of this project
- However provided to show the concept better
- Simple GUI with two main part
  - One that connects to Kubernetes and shows Pods and Nodes
  - One that connects to the simulation software and shows IoT Controllers and Devices
- Written with Vuejs

Design - Graphical User Interface



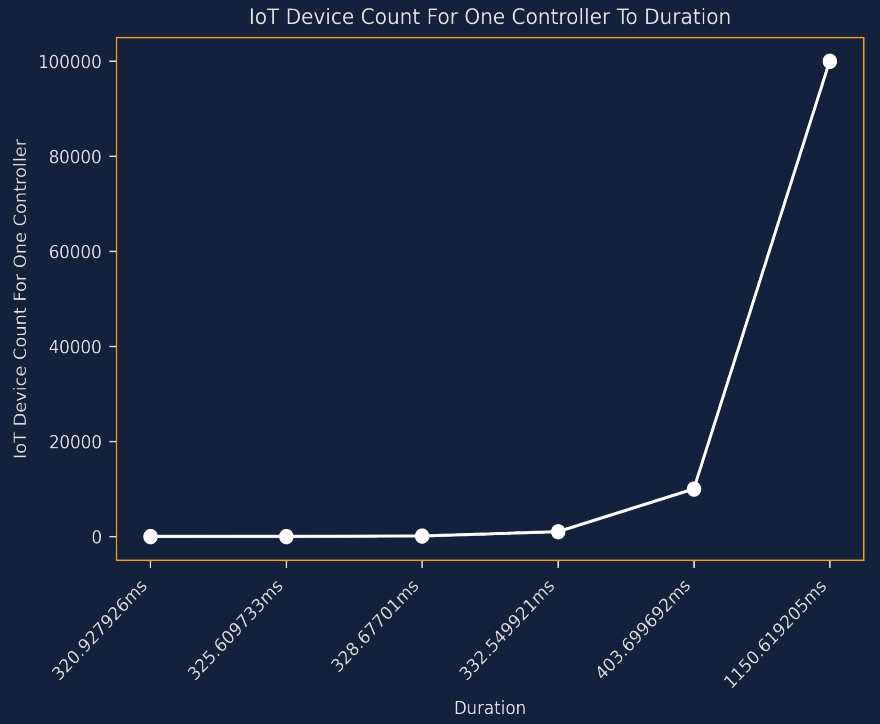
Performance Benchmark

Performance Benchmark

- Benchmarks are generated with custom software
- Benchmark software is written in Golang as for the rest of the project
- A shell script then takes this software and generates desired results
- The results are then fed to a python script that draws the charts using matplotlib
- The entire project ran on a single Raspberry Pi 4 Model B Rev 1.4 with 4 cores and 8GiBs of DDR3 memory.

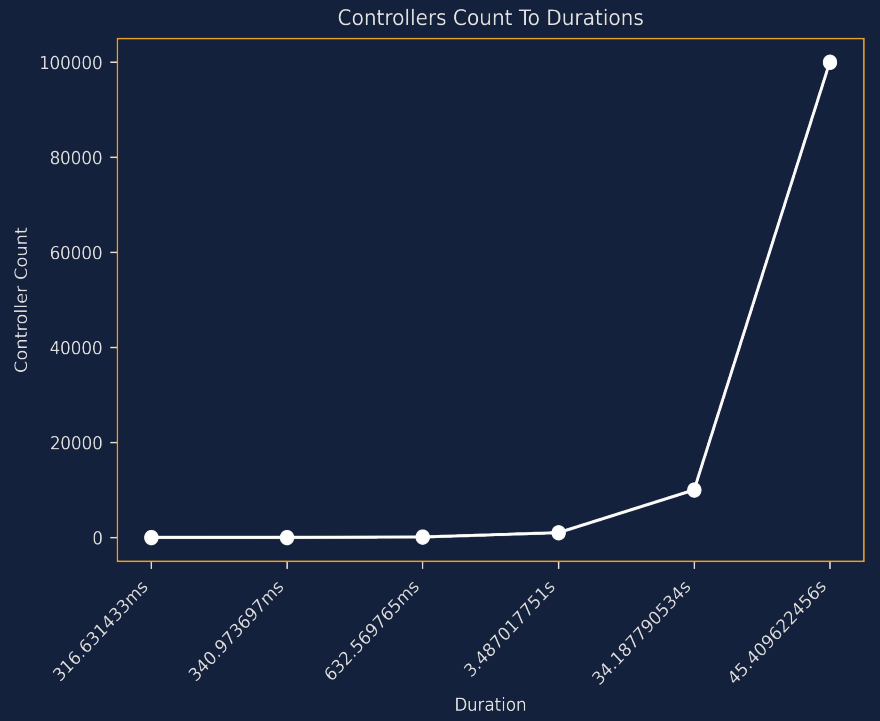
Performance Benchmark

- Only a single provider
- As you can see with a single controller we were able to control 100K IoT Devices with reasonable time.
- It took 1.15 seconds to fetch the state of 100K devices from a single controller
- This gives us a highly scalable and performant way of controlling IoT Devices.



Performance Benchmark

- Still a single provider
- This time we tested a single device per controllers and then changed controller's count.
- It takes Significantly more to fetch IoT Device states.
- Still reasonable.
- We have 10x HTTP traffic
- Easily scalable through adding more provider



Future Work

Future work

- Security
  - Authentication
  - TLS
  - WireGuard
- More performant transport protocols
  - Websockets
  - gRPC
- More performant data serialization
  - Protocol buffers
- Framework
  - Better developer experience
  - Better monetization

Any Questions?

Thanks.