IoT Edge Working Group

Deep Dive

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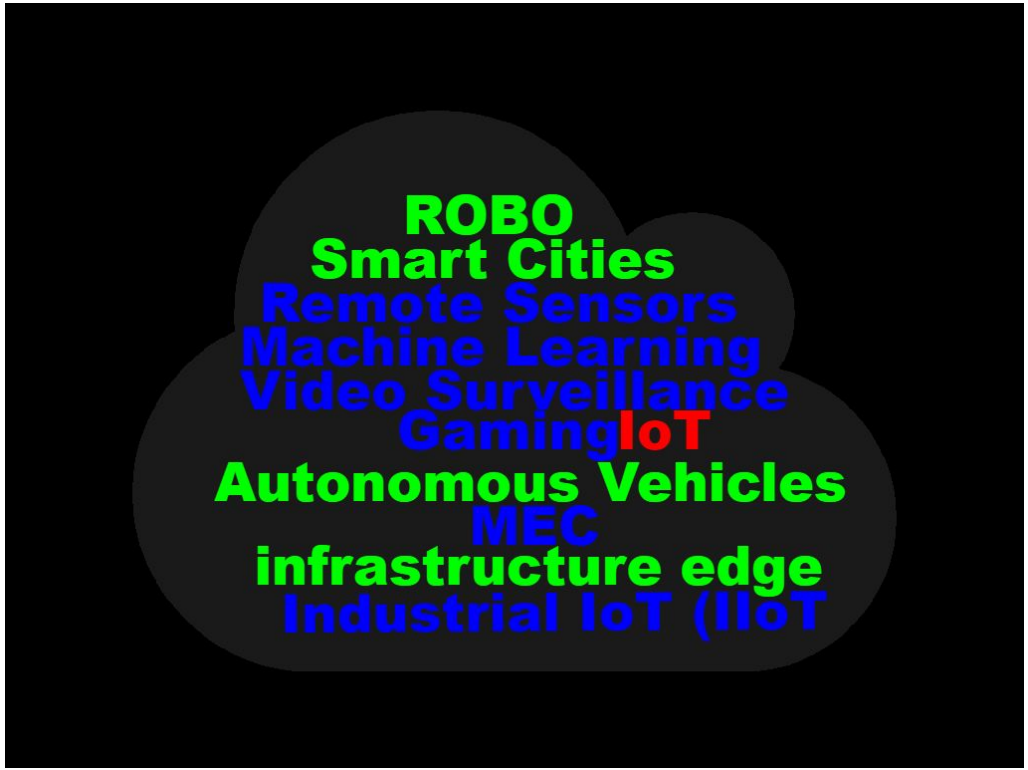
Agenda

- Intro
- Edge workloads
- Workload challenges
- Q&A

Some Use Case Examples



Plus many more

Edge/IoT vs Cloud Data Center

Kubernetes has limitations today..but can we fix this?

Similar

Manage many nodes with compute, storage, networking

Want to containerize apps and services

Want standardized APIs, tools

Want security features (encryption, authentication)

Different

Resource constrained (small node counts, low power CPUs, low resources)

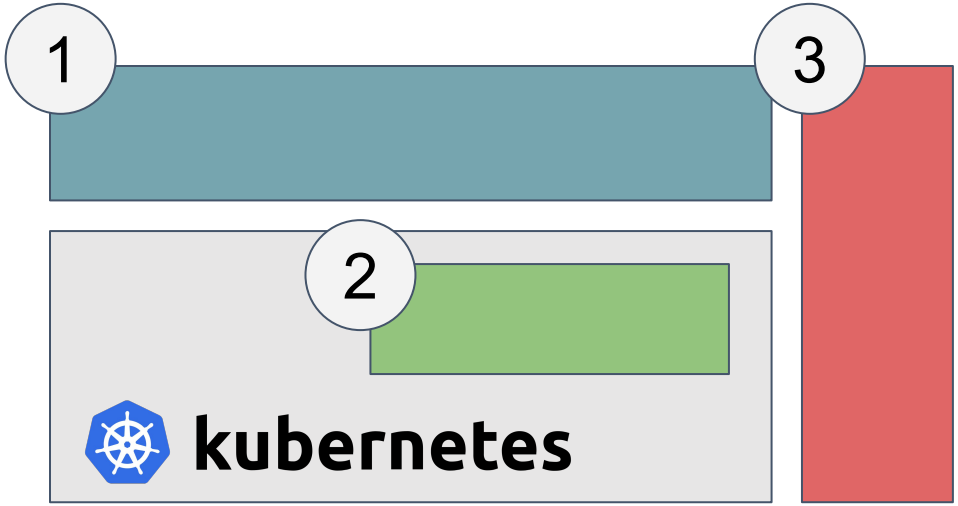
Special network requirements (protocols, topologies)

Challenges of unattended, and disconnected operation

Kubernetes for the Edge

How does Kubernetes interact with the Edge?

1. Edge workloads that run ON Kuberenetes
2. Edge challenges mitigated BY Kubernetes
3. Edge capabilities not easily serviceable by Kubernetes

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Edge Workloads

Edge workloads - Why?

- Data ingestion and processing
  - Protocol conversion
  - Data preprocessing
- Reliability and availability
  - Buffer and batch
  - Caching
- Latency
  - Edge functions
  - Compute offloading
  - Machine learning

Protocol conversion

- Network level
  - Converting non-IP protocols to TCP/IP based ones
    - Modbus in IIoT
    - Bluetooth in consumer IoT
  - Usually converting to some widely used messaging protocol
    - MQTT
    - AMQP
    - HTTP

- Kubernetes supports "device plugins"
- Taints and tolerances can be used for scheduling to appropriate nodes
- New concepts for easier access to interfaces
  - https://www.networkservicemesh.io/

Data preprocessing

- Convert data to general structured messages
- Normalize data structure
  - Vorto, LWM2M
- Data analytics
  - Send only relevant data
  - Combine multiple sources
- Add metadata
  - Location
  - Identity
  - Security

Generic Kubernetes workloads

Needs to be properly containerized and orchestrated on the Edge nodes

Reliability and high availability

- Buffer and batch
  - Store and forward
  - Brokers on Edge nodes
- Caching
  - Local databases on Edge nodes
  - Sync data with the cloud and other Edge nodes

Edge Clusters may have limited storage volumes to hold data until it can be uploaded

Latency: Functions

- React locally on sensor or scheduled events

- Possible CNCF projects collaboration
  - Cloud Events - https://cloudevents.io/
  - Knative - https://github.com/knative/

Latency

- Compute offload
  - Schedule resource intensive tasks on the dedicated hardware on the Edge
  - Example AR/VR renderings
- Machine learning
  - Cloud trained models - executed on the Edge
  - Edge specific training (environment and data policies)

Taints and tolerances can be used for scheduling to appropriate nodes (e.g. GPU availability)


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Workload Challenges

Workload challenges

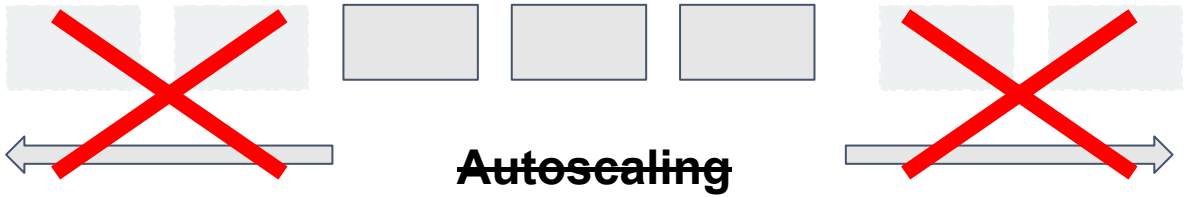
- Limited node resources
  - Workload prioritization
  - Alternative Kubelet implementations (Virtual Kubelet or KubeEdge)
- Unreliable/Limited network
  - Traffic shaping
  - KubeEdge Architecture (EdgeController and EdgeBus)

Workload prioritization - Why

- Limited number of nodes on the Edge
- No autoscaling
- Workloads with wide range of priorities
- Adds more emphasis on prioritization

Cloud

Edge



Kubernetes prioritization toolkit

Prioritization

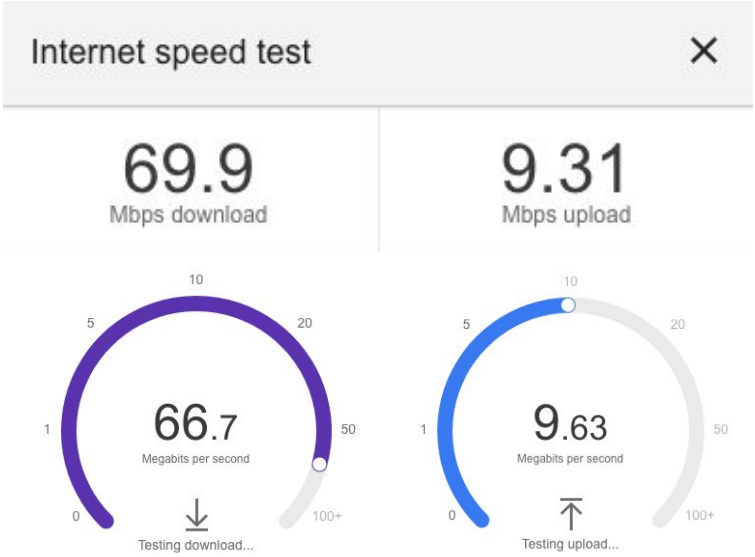
- Ranking of priority classes
- Input to pre-emption logic
- Applied to a pod, but acted on by node
- Different from resource based eviction

Quality of Service

- Three levels
  - Guaranteed
  - Burstable
  - Best Effort
- These are implicit from pod spec
- Is NOT considered for preemption
- IS considered in the case of eviction
- preemption != eviction

Traffic shaping - Why

- Managing bandwidth
- Network capacity can be limited
- Different workloads should have different network policies
- Related to "Workload Prioritization"



Traffic shaping

Policy

- Deals with what traffic is allowed
- Applied via Network Plugin
- Creates `NetworkPolicy` resource
- Based on 'cluster-external' IPs
- Based on SRC/DST and port
  - src/dst can be specified several ways
  - May be subject to cluster environment

```
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: test-network-policy
  namespace: default
spec:
  podSelector:
    matchLabels:
      role: db
  policyTypes:
  - Ingress
  - Egress
  ingress:
  - from:
    - ipBlock:
        cidr: 172.17.0.0/16
        except:
        - 172.17.1.0/24
    - namespaceSelector:
        matchLabels:
          project: myproject
    - podSelector:
        matchLabels:
          role: frontend
    ports:
    - protocol: TCP
```

Traffic shaping

Bandwidth

- Effected by a set of layers
- Does not manage bandwidth cluster wide

Pod: bandwidth annotations

CNI: Bandwidth Plugin

`tc` (Traffic Control)

Linux: Network Namespace

Traffic shaping

Bandwidth: CNI

- Can be enabled as a plugin without specific limits

```
{
  "type": "bandwidth",
  "capabilities": {"bandwidth": true}
}
```

- Can be chained to a specific network interface and limit interface bandwidth use

```
{
  "cniVersion": "0.3.1",
  "name": "mynet",
  "plugins": [
    {
      "type": "ptp",
      "ipMasq": true,
      "mtu": 512,
      "ipam": {
          "type": "host-local",
          "subnet": "10.0.0.0/24"
      },
      "dns": {
        "nameservers": [ "10.1.0.1" ]
      }
    },
    {
      "name": "slowdown",
      "type": "bandwidth",
      "ingressRate": 123,
      "ingressBurst": 456,
      "egressRate": 123,
      "egressBurst": 456
    }
```

Traffic shaping

Bandwidth: Pod Spec

```
{
    "kind": "Pod",
    "metadata": {
        "name": "iperf-slow",
        "annotations": {
            "kubernetes.io/ingress-bandwidth": "10M",
            "kubernetes.io/egress-bandwidth": "10M"
        }
    }
}
```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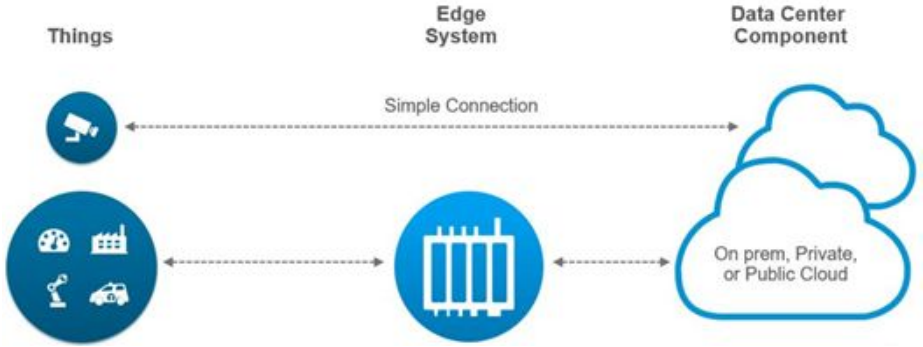
Beyond Kubernetes

Distance from mission accomplished

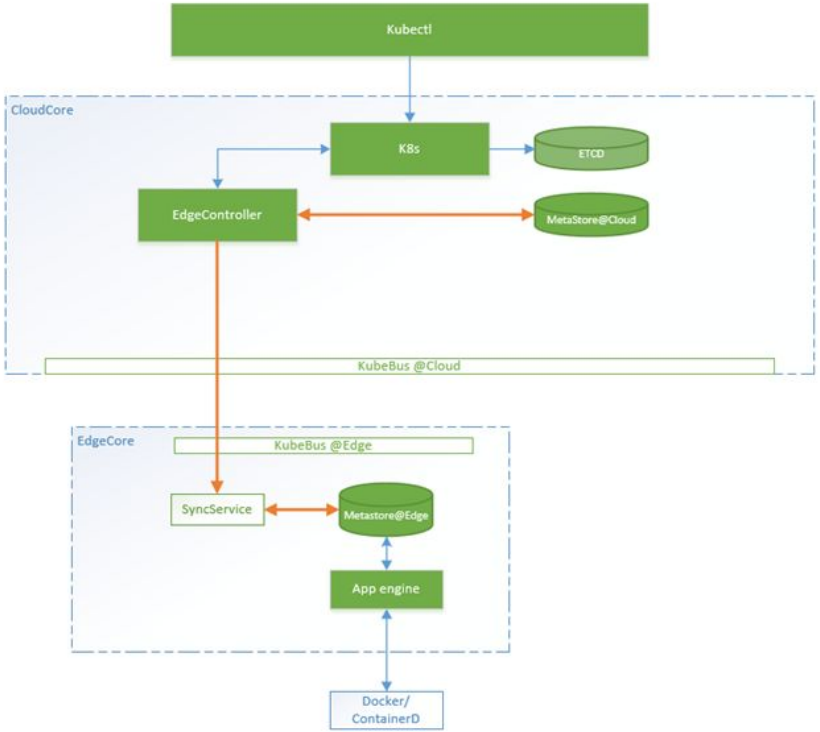
- Large scale of remote edge nodes and devices
  - We are talking about hundreds of thousands, millions or more
  - Remote management for devops, sre, etc.
  - Multi-tenancy @cloud
  - Cloud/edge native
- Unreliable/Limited network
  - Network bandwidth and topology
  - Edge autonomy
- Heterogeneous hardware config.
- Limited node resources
  - Kubelet
  - Container runtime
- Diversified device connection & protocol
  - pub/sub
  - Device state



KubeEdge

- An opensource project contributed/started by Huawei: github.com/kubeedge
- KubeEdge allows customers (devops, SRE, etc.) to manage edge nodes, deploy/orchestrate/monitor apps, etc. the same way as in the cloud
- KubeEdge contains components running at cloud and edge. Currently the edge part is opensourced and cloud will be very soon

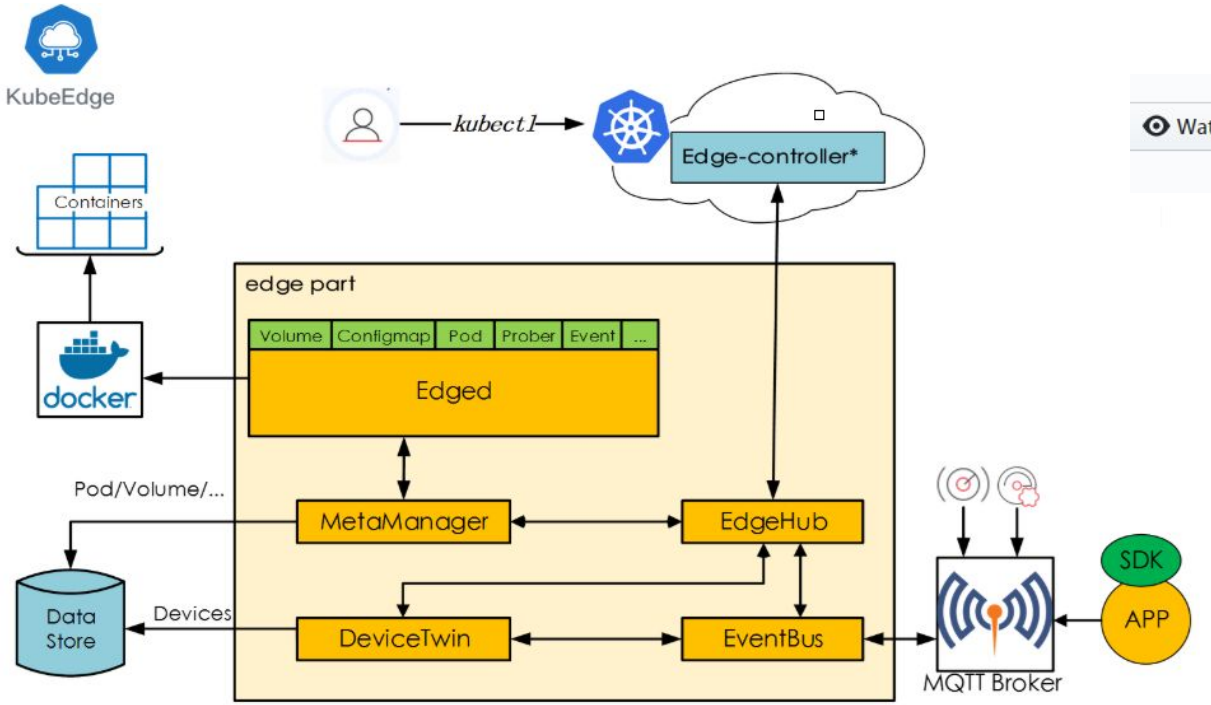
KubeEdge - Architecture



KubeEdge supports

- multi-tenancy, large scale of distributed edge nodes/apps.,
- lightweight agent, container native,
- duplex/multiplex cloud/edge network connection,
- device twin, mqtt/http device & edge connection
- Edge side autonomy

KubeEdge v0.5



KubeEdge - Roadmap

Release 1.0

KubeEdge will provide the fundamental infrastructure and basic functionalities for IOT/Edge workload. This includes:

- K8s Application deployment through kubectl from Cloud to Edge node(s)
- K8s configmap, secret deployment through kubectl from Cloud to Edge node(s) and their applications in Pod
- Bi-directional and multiplex network communication between Cloud and edge nodes
- K8s Pod and Node status querying with kubectl at Cloud with data collected/reported from Edge
- Edge node autonomy when its getting offline and recover post reconnection to Cloud
- Device twin and MQTT protocol for IOT devices talking to Edge node

Release 2.0 and Future

- Build service mesh with KubeEdge and Istio
- Enable function as a service at Edge
- Support more types of device protocols to Edge node sunch as AMQP, BlueTooth, ZigBee, etc.
- Evaluate and enable super large scale of Edge clusters with thousands of Edge nodes and millions of devices
- Enable intelligent scheduling of apps. to large scale of Edge nodes
- etc.

Questions?

How to get involved in the Working Group, learn more...

Regular Work Group Meeting: Fridays at 8:00am Pacific (bi-weekly)

- Meeting notes and agenda

Link to join the group

- https://groups.google.com/forum/#!forum/kubernetes-wg-iot-edge

Link to join Slack

- https://kubernetes.slack.com/messages/wg-iot-edge

White Paper

- http://bit.ly/iot-edge-whitepaper
  - Workloads being considered
  - Technical challenges
  - Available architectural solutions