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# IoT Edge Working Group Deep Dive

December 13, 2018



# Presenters



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# Agenda



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

# Some Use Case Examples

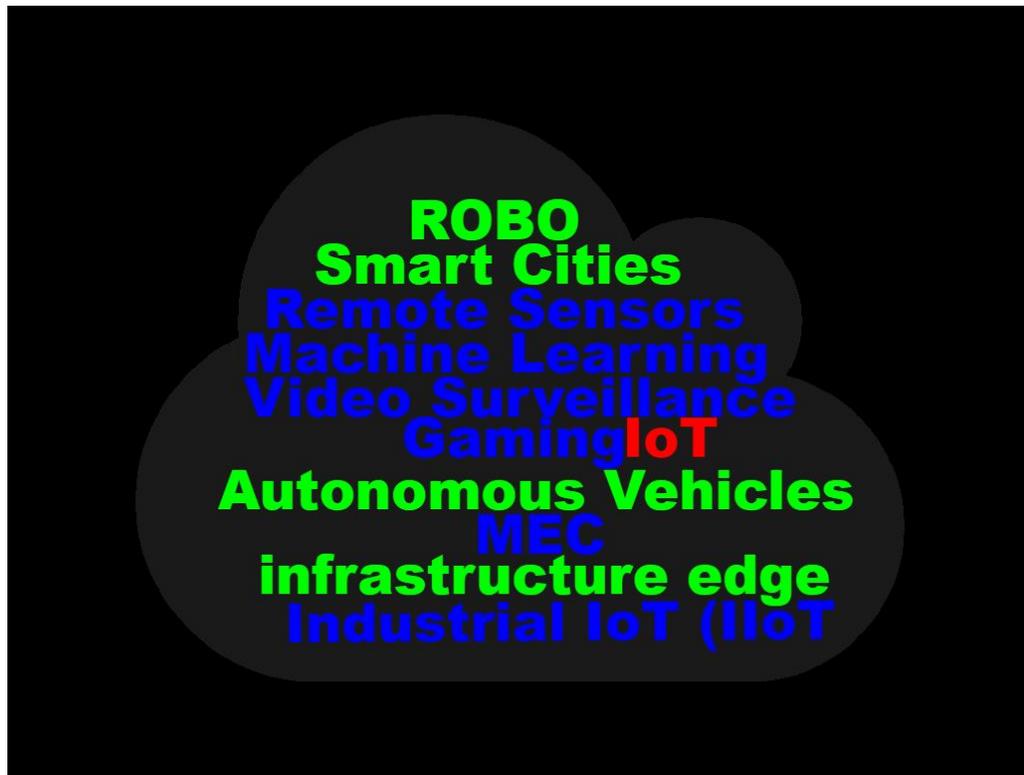


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Plus many more

# Edge/IoT vs Cloud Data Center

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



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## 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



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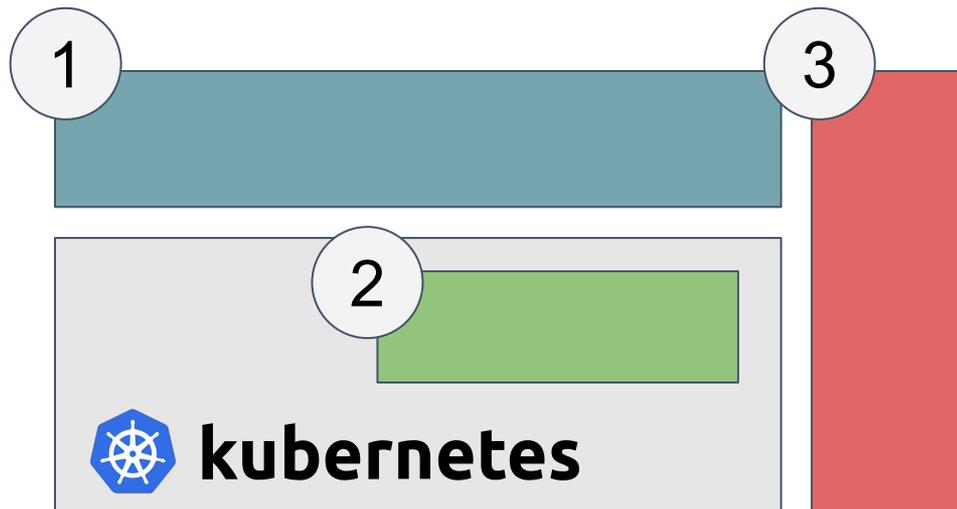


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How does Kubernetes interact with the Edge?

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





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**Edge Workloads**



# Edge workloads - Why?



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

# Protocol conversion



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- 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



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- 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



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- 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



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- React locally on sensor or scheduled events



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

# Latency



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- 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



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- 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



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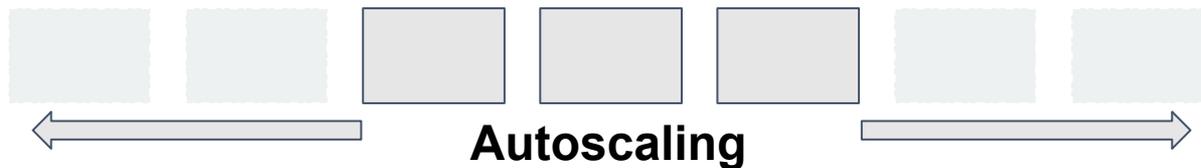


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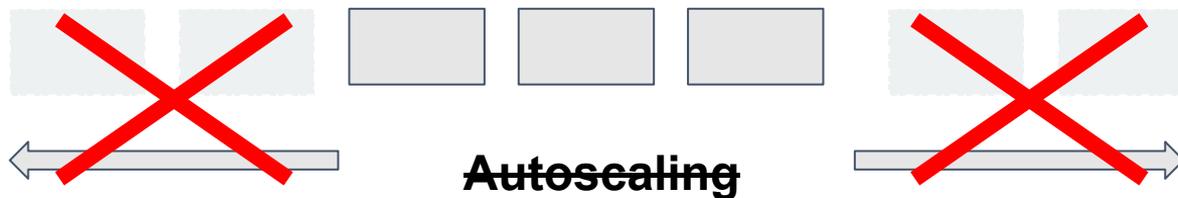
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- Limited number of nodes on the Edge
- No autoscaling
- Workloads with wide range of priorities
- Adds more emphasis on prioritization

**Cloud**



**Edge**



# Kubernetes prioritization toolkit



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## 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



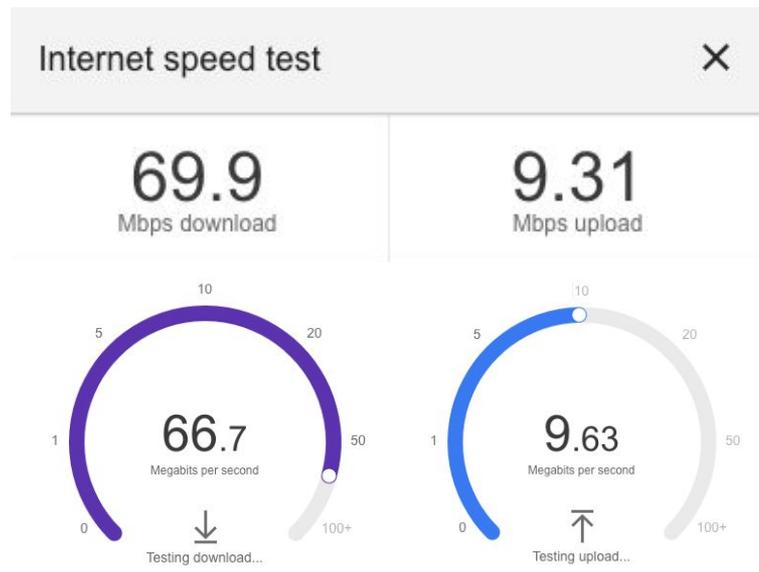
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- Managing bandwidth
- Network capacity can be limited
- Different workloads should have different network policies
- Related to "Workload Prioritization"



# Traffic shaping



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## 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



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## 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



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## 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



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## 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



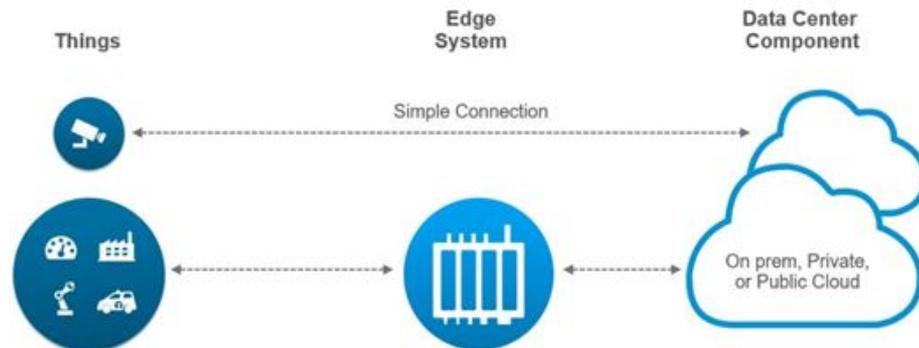
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- Large scale of remote edge nodes and devices
  - We are talking about hundreds of thousands, millions or more
  - Remote management for devops, sre, etc.
  - Multi-tenancy @cloud
  - Cloud/edge native
- Unreliable/Limited network
  - Network bandwidth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





- An opensource project contributed/started by Huawei:  
[github.com/kubeedge](https://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 v0.5

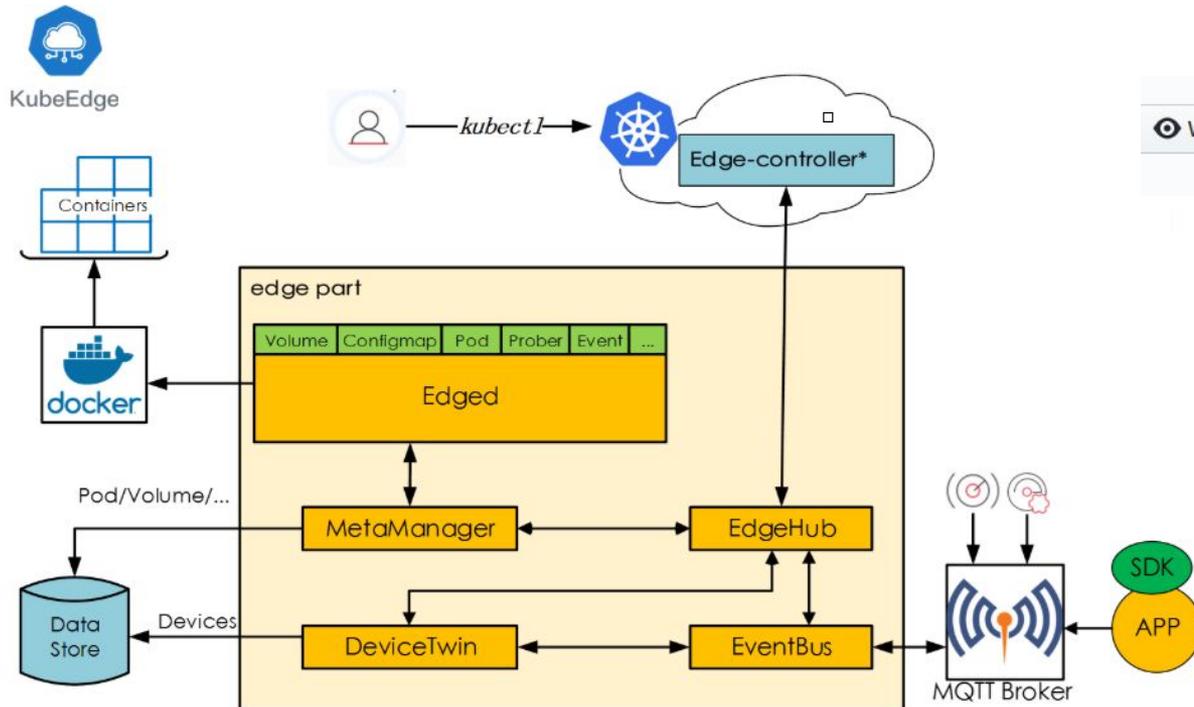


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Watch 27 Star 212 Fork 43

# KubeEdge - Roadmap



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## › 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 such 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...



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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