Kubernetes Native Infrastructure and Operator Framework for 5G Edge Cloud Computing

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OpenShift on OpenStack NFV
B2B2X for SoE apps in OpenShift
(in VM) on top of DCN(NFVI)
Innovation

4G

All IP packet
Carrier
Grade
Linux

Network
Function
Virtualization

Distribute
Compute
Node

VNF

5G

5GC

Cloud native/Service Based Architecture
CP and UPF separation
Network slicing
UPF offload (FPGA, Edge Switch Fabric)
vRAN CU-DU split

Heterogeneous Computing

CNF

Autonomous micro edge cloud …. Local 5G
Edge AI platform(Intelligent Edge)
Data Lake/Data Hub
NFV Evolution to Kubernetes

Y2018-2019

- 70% VNF
- 30% Container
- Container
- K8s/OCP
- Hypervisor: OpenStack
- Bare Metal
- Data Lake

SoE: System of Engagement

Y2019-2020

- 50% VNF
- 50% Container
- Container
- CNF
- Hypervisor: OpenStack
- K8s/OCP4
- Bare Metal
- Data Lake

(Y2019-2020 - Stateless & Stateful)

Y2020-2021

- 30% VNF
- 70% Container
- Container
- CNF
- Hypervisor: OpenStack
- K8s/OCP4
- Bare Metal
- Data Lake

(Y2020-2021 - Stateless & Stateful)

OCP4: OpenShift Container Platform 4
Agenda

• OpenShift/K8s on BM and Operator Framework for CNF
• KNI for 5G core service based architecture
• KNI for 5G radio access network
• KNI (Kubernetes Native Infrastructure) for 5G edge
• Summary
OpenShift/k8s on BM deployment and Operator Framework for CNF
Kubernetes Operators

- Automate Day 2 lifecycle management of container applications in Kubernetes
- Leverage CRDs to deploy Kubernetes native services that can access Kube API events
- Operator SDK simplifies creation of Operators in Go (or leverage Helm or Ansible automation)
Full-Stack Automated Operations in OpenShift

- **APPLICATIONS AND SERVICES**
  - ISV/3rd party Operators
  - Custom Operators (built w/Operator SDK)

- **PLATFORM AND CLUSTER MANAGEMENT**
  - Automated updates for Kubernetes, monitoring, security, registry and more

- **LINUX HOST**
  - Over-the-air updates for Red Hat CoreOS

Any Infrastructure
Possibility for NFV architecture change by adapting Kubernetes Operator (OpenShift Operator framework)

5GC: Session Management Function Unified Data Management
5GC Service Based Architecture on Kubernetes
5GC system architecture
5G SBI and Service Mesh

- A dedicated network for service to service communications
- Observability and distributed tracing
- Policy-driven security
- Routing rules & chaos engineering
- Powerful visualization & monitoring
- Will be available via OperatorHub
Service Mesh & 5GC SBA (Service-Based Architecture)

- **5GC (core)**
  - NSSF
  - AUSF
  - UDM
  - SMF
  - AMF
  - PCF

**Operator Framework**
- MULTUS CNI setup
- Stateful management
- CNF LCM, K8s LCM
- GPU device plugin, DPDK, FPGA
- Serverless, Data lake

**User Equipment**
- AUthentication
- Server
- Function
- Network
- Slice
- Selection
- Function
- Unified
- Data
- Management
- Policy
- Control
- Function
- Access & Mobility mgmnt
- Function
- Session
- Management
- Function

Max 8 slice

User Equipment

gNB

Network slices

(slice1, slice2, slice3, UPF)

AI platform

DN

Data Network

Red Hat OpenShift

Istio service mesh

MULTUS
5G UPF and Network Slicing in Cloud edge fabric for B2B2X workloads and etc

Multi cluster for istio service mesh might be needed

Slice 1 for B2B2X workloads 1: SMF1 & UPF1

Slice 2 for B2B2X workloads 2: SMF2 & UPF2

* [https://www.youtube.com/watch?v=1X5U4Jo0Jlw](https://www.youtube.com/watch?v=1X5U4Jo0Jlw)

O-RAN alliance & RAN Cloudification w/ Kubernetes
3GPP & O-RAN alliance

RAN Intelligent Controller (RIC) near-RT

Applications
- 3rd party APP
- Mobility Mgmt
- QoS Mgmt
- Interference Mgmt
- Trained Model

Radio-Network Information Base

Multi-RAT O-CU Protocol Stack
- CU-CP
  - RRC
  - PDCP-C
- CU-UP
  - SDAP
  - PDCP-U

O-DU: RLC/MAC/PHY-high

O-RU: PHY-low/RF

NFVI Platform: Virtualization layer and COTS platform

Design
Inventory
Policy
Configuration
RAN Intelligent Controller (RIC) non-RT

Orchestration & Automation (e.g. ONAP): MANO, NMS

3GPP (e/g)NB

3GPP CU

Our focus
OpenStack, OpenShift/k8s

3GPP DU

E1
E2: btw RIC near-RT and O-CU/O-DU

A1
Decoupling of software from hardware for all RAN modules in all splits

All RAN modules
Support 10,000s of distributed cloud sites
Heterogeneous computing

Multitude of deployment models: CloudRAN, CU-DU split, dRAN on whitebox or DC

Centralized CU/DU (C-RAN)

Distributed CU/DU (D-RAN)
Candidate WG6 Scenarios B,C

**Scenario B: Distributed vO-CU and vO-DU**

- To UPF & MEC
- Near-RT RIC
- vBBU vO-CU + vO-DU
- O-DU
- O-RU
- Regional cloud
- Open fronthaul 1:m, local
- Open chassis and blade spec
- Cell site area
- BBU chassis at cell site
- E2 1:N, remote

The O-CU/O-DU functionality can be pooled from multiple O-RUs, and meet O-DU latency requirements. Near-RT RIC can serve a very large number of O-RUs.

**Scenario C: Centralized vO-CU with distributed vO-DU**

- To UPF & MEC
- Near-RT RIC
- vO-CU
- vO-DU
- O-RU
- Regional cloud
- Open fronthaul 1:m, local
- Open chassis and blade spec
- Cell site area

The O-DU functionality can be pooled from multiple O-RUs, and meet O-DU latency requirements. Near-RT RIC can serve a very large number of O-RUs, and O-CU is very centralized.
KNI Edge
Kubernetes Native Infrastructure for Edge
Akraino Edge Stack project
KNI-Edge Blueprints (in Progress)

Provider Access Edge (PAE)
Optimized for real-time and networking performance for Containerized vRAN and MEC workloads.

Industrial Edge (IE)
Optimized for small footprint and low-latency for IoT, serverless, and machine learning workloads.

https://wiki.akraino.org/display/AK/Kubernetes-Native+Infrastructure+%28KNI%29+Blueprint+Family
IoT Apps - Eclipse IoT project

**CONNECTED “THINGS”**

**IoT EDGE**

**IoT INTEGRATION HUB**

**APPLICATION DEVELOPMENT, DELIVERY, & INTEGRATION**

**DATA MANAGEMENT & ANALYTICS**

CloudERA’s distribution including Hadoop (CDH)

Machine learning model
ML Apps - OPEN DATA HUB
Collaborate on a Data & AI platform for the Edge Cloud & Core

A collection of open source and cloud components packaged in a “machine learning-as-a-service” platform to solve business problems.
OPEN DATA HUB

AI as a Service
OpenShift reference architecture

Model Lifecycle
- Seldon
- MLFlow

ML Applications
- Open Data Hub AI Library

Interactive Notebooks
- JupyterHub
- Hue

Business Intelligence
- Superset

Big Data Processing
- Spark
- Spark SQL
- Thrift

Streaming
- Kafka Streams
- Elasticsearch

Data Exploration
- Hue
- Kibana

Hive Metastore

Data Lake
- Red Hat® Ceph Storage

In-Memory
- Red Hat® Data Grid (Infinispan)

Relational Databases
- PostgreSQL
- MySQL

Red Hat® AMQ Streams
- (Kafka Strimzi)

Red Hat® Ceph S3 API

Kafka Connect

Logstash

Fluentd

rsyslog

Data Steward

DevOps Engineer

Red Hat® OpenShift Operator

Red Hat® OpenShift

GPU


Security & Governance

Red Hat® OpenShift OAuth

Red Hat® Single Sign-On (Keycloak)

Red Hat® Ceph Object Gateway

Red Hat® 3scale

Prometheus

Grafana

Argo Workflows

Jenkins CI/CD

Monitoring & Orchestration
Red Hat OpenShift Hybrid Serverless

Developer experience
APIs, CLI, service binding

Building blocks for serverless
Source-centric and container-based

The leading enterprise Kubernetes platform
Automated Operations
Build an run anywhere (Hybrid Cloud)

Red Hat OpenShift

Knative

Events
Build
Serving

RH MW Services (Operator backed)

Operator Framework
Istio

Hybrid Install / Ops
Install / Upgrade
Network / CNI

Ops & Dev Consoles
Security / Auth
Storage / CSI

Kubernetes

Red Hat Enterprise Linux or Red Hat CoreOS

https://github.com/knative/eventing-sources
Serverless : IoT & Sensor

EDGE

IoT Gateway

Reports

API

Archiving

Java

Python

JavaScript (NodeJS)

Private

Hybrid

Public
Summary
Summary

Kubernetes Native Infrastructure on Bare metal across Telco Core and Telco Edge

a. Operator Framework for Site Reliability Engineering and Provider extension
   i. Autonomous micro-cloud at Telco edge
   ii. Digital Service Provider driven CNF apps management
b. Service mesh for 5GC SBA
c. UPF and Network slicing
d. O-RAN CU/DU cloudification
e. KNI for edge
   i. ML as a Service and Open Data Hub at Telco node
   ii. Challenge for Serverless at Telco edge node
Reference

- https://github.com/operator-framework/getting-started
- https://github.com/operator-framework/community-operators
- https://commons.openshift.org/sig/operators.html
- #kubernetes-operators on the kubernetes slack
- https://groups.google.com/forum/#!forum/operator-framework
Thank you!

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