EDGECLOUD

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Contents

CHAPTER 1

Introduction

This Edge Cloud Requirement Document is used for eliciting telecom network Edge Cloud Requirements of OPNFV, where telecom network edge clouds are edge clouds deployed into the telecommunication infrastructure. Edge clouds deployed beyond the borders of telecommunication networks are outside of the scope of this document. This document will define high-level telecom network edge cloud goals, including service reqirements, sites conditions, and translate them into detailed requirements on edge cloud infrastructure components. Moreover, this document can be used as reference for edge cloud testing scenario design.

CHAPTER 2

Definitions & Terminologies

The following terminologies will be used in this document:

Core site(s): Sites that are far away from end users/ base stations, completely virtualized, and mainly host control domain services (e.g. telco services: HSS, MME, IMS, EPC, etc).

Edge site(s): Sites that are closer to end users/ base stations, and mainly host control and compute services.

E2E delay: time of the transmission process between the user equipment and the edge cloud site. It contains four parts: time of radio transmission, time of optical fiber transmission, time of GW forwarding, and time of VM forwarding.

BBU: Building Baseband Unit. It's a centralized processing unit of radio signals. Together with RRU (Remote Radio Unit), it forms the distirbuted base station architecture. For example, a large stadium is usually separated into different districts. Each district would be provided with a RRU, which is close to user, to provide radio access. All RRUs would be linked to a BBU, which is located inside a remote site away from user and provide signal processing, using optical fiber.

BRAS: Broadband Remote Access Server. An Ethernet-centric IP edge router, and the aggregation point for the user traffic. It performs Ethernet aggregation and packets forwarding via IP/MPLS, and supports user management, access protocols termination, QoS and policy management, etc.

UPF: User Plane Function, which is a user plane gateway for user data transmission.

SAE-GW: SAE stands for System Architecture Evolution, which is the core network architecture of 3GPP's LTE wireless communication standard. SAE-GW includes Serving Gateway and PDN Gateway. Serving Gateway (SGW) routes and forwards user data packets,and also acts as the mobility anchor for LTE and other 3GPP technologies. PDN Gateway (PGW) provides connectivity from the UE to external packet data networks by being the point of exit and entry of traffic for the UE.

SAE-GW related definition link: https://en.wikipedia.org/wiki/System_Architecture_Evolution

CPE: In telecommunications, a customer-premises equipment or customer-provided equipment (CPE) is any terminal and associated equipment located at a subscriber's premises and connected with a carrier's telecommunication circuit. CPE generally refers to devices such as telephones, routers, network switches, residential gateways (RG), home networking adapters and Internet access gateways that enable consumers to access communications service providers' services and distribute them around their house via a local area network (LAN).

CPE definition: https://en.wikipedia.org/wiki/Customer-premises_equipment

enterprise vCPE: Usually CPE provides a number of network functions such as firewall, access control, policy management and discovering/connecting devices at home. enterprise vCPE stands for virtual CPE for enterprise, which is a software framework that virtualizes several CPE funcitons.

CHAPTER 3

Telco related Edge Use Cases

RAN Services: CRAN-CU

CRAN OPNFV project link: https://wiki.opnfv.org/pages/viewpage.action?pageId=20743420

CRAN stands for Cloud Radio Access Network or Centralized Radio Access Network. The basic concept is to consolidate compute resources to run some radio access functions virtually and remotely in a datacenter, rather than in a base station. CU stands for Centralized Unit, which holds the non-real-time protocol processing function of BBU (refer to *Definitions & Terminologies*) and supports the deployment of some functions of core networks. Its generic requirements are listed below:

- CRAN-CU has strict timing and performance requirements for signal processing to be compliant with RAN standards. The E2E delay should be less than 3ms.
- Required bandwidth of CRAN-CU is around 50 GB/s
- Acceleration technologies are recommended. Different technologies would be used under different deployment scenarios, different use cases and etc.
- No external storage is needed by CRAN-CU. Local disk is enough.

Gateways: UPF, SAE-GW, enterprise vCPE (refer to *Definitions & Terminologies*)

Gateway services like UPF, SAE-GW and enterprise vCPE used to be deployed in core sites. They usually do not have strict latency requirements. Latency requirements of UPF and SAE-GW are both 10ms. Minimum latency required by enterprise vCPE is around 50ms when transmitting video and voice data. The number is over a second if transmitting email. So latency requirements can always be satisfied theoretically. However, as these gateways usually serve over millions of users (every enterprise vCPE serves more than a thousand enterprise-level users), they have high throughput requirements: bandwidth (BW) of UPF > 300 GB/s, BW of SAE-GW is around 50 GB/s, BW of enterprise vCPE > 40 GB/s. Deploying these services separately in edge sites will help to achieve local data flow transmission, offload traffic flows from core networks, and reduce footprints of transmission resources and core computing resources.

Access technology independent service: edge CDN

According to China Mobile's data, every CDN unit can serve over 10 thousand customers and it requires bandwidth over one hundred GB. In order to reduce footprints of transmission resources and burden of the network, CDN is recommended to be deployed in edge sites, but not too close to users if taking deployment cost into consideration. It also requires fast compute ability to generate content distribution strategy quickly.

One edge CDN unit does not need to communicate with other edge CDN units at the same level, but need to be connected with CDN units at higher level for policy distribution and resource downloading.

MEC/Edge Computing Services

Besides requiring low-latency, high-bandwidth, and high reliability, newly generated edge computing services require the local deployment environment to be capable of doing fast computing to support some intelligence functions like real-time data analysis and optimal path calculation of services like V2X. The deployment of MEC and third-party applications running on it mainly depends on latency requirements. uRLLC requires E2E delay less than 3ms, which means it should be deployed at edge sites close to base station. eMBB requires E2E delay less than 10ms, which leads to more flexible deployment location.

Unlike traditional telco services which have relatively stable on-line and update cycle, MEC and the third-party applications have more flexible lifecycle, which means a more flexible infrastructure should be used such as container.

The table below summarizes the latency and bandwidth requirements of several typical telco related services:(x in table stands for 1~5)

Service	CND	enterprise vCPE	SAE-GW	5G-UPF	MEC	CRAN-CU
E2E delay	10 ms	50 ms	10 ms	10ms	URLLC < 3 ms, eMBB < 10 ms	3 ms
Bandwidth	>100 GB/s	10 * x GB/s	10 * x GB/s	>300 GB/s	10 * x GB/s	10 * x GB/s

CHAPTER 4

Features of Edge

4.1 Resource optimized control

As space and power resources are limited in edge sites and edge usually has fewer number of servers (the number varies from a few to several dozens), it is unnecessary to deploy orchestrator or VNFM. The depolyed VIM (e.g.: OpenStack or Kubernetes) and SDN would be optimized for low resource usage to save resources for services. Resource optimisation of VIM and SDN have not been discussed yet, but basic functions such as VM lifecycle management and automatic network management should be persisted.

4.2 Remote provisioning

As there is no professional maintenance staff at edge, remote provisioning should be provided so that virtual resources of distributed edge sites can obtain unified orchestration and maintenance. Orchestrator together with OSS/BSS, EMS and VNFM should be deployed remotely in some central offices to reduce the difficulty and cost of management as well as increasing edge resource utilization ratio. Multi region OpenStack could be considered as one of the VIM solution.

4.3 Resource diversity

With various applications running on edge, diverse resources, including VM, container and bare-metal could co-exist and form diverse resource pool. These resources should be managed by edge management components as well as core orchestration/management components.

4.4 Hardware/Software acceleration

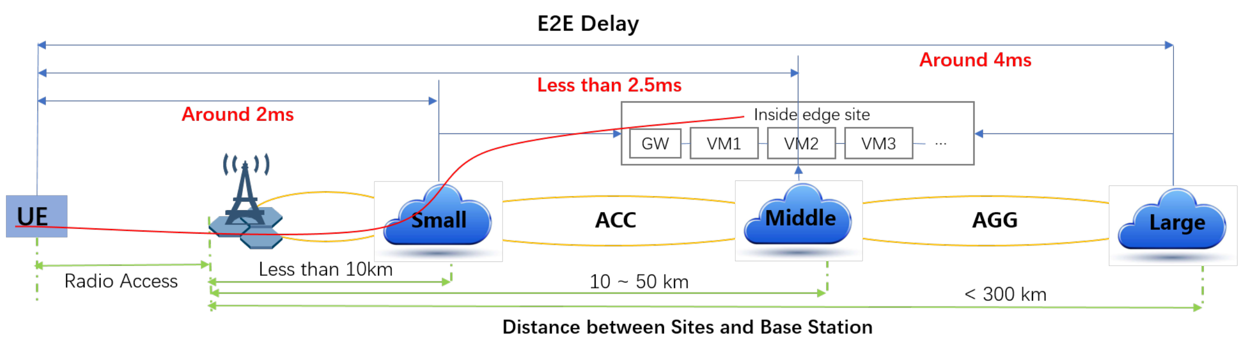
Edge services usually require strict low latency, high bandwidth, and fast computing and processing ability. Acceleration technology should be used in edge to maintain good service performance. OpenStack should fully expose these acceleration capabilities to services. The usage of different acceleration technologies (including DPDK, SR-IOV, GPU, Smart NIC, FPGA and etc.) varies from service to service.

Related project about acceleration: https://wiki.openstack.org/wiki/Cyborg

CHAPTER 5

Edge Sites Conditions/ Deployment Scenarios

Latency and distance to customer are taken as two main characters to separate different sites. The following figure shows three different sites.



5.1 Small Edge

- Distance to base station: around 10 km, closest site to end users / base station
- E2E delay(from UE to site): around 2 ms
- Maximum bandwidth can provide: 50 GB/s
- Minimum hardware specs: 1 unit of
  - 4 cores (two ARM or Xeon-D processors)
  - 8 GB RAM (4 DIMM)
  - 1 * 240 GB SSD (2 * 2.5)
- Maximum hardware specs: 5 unit of
  - 16 cores

  - 64 GB RAM
  - 1 * 1 TB storage
- Power for a site: < 10 kW
- Physical access of maintainer: Rare, maintenance staff may only show up in this kind of site when machines initialize for the first time or a machine is down. Maintenance staff is skilled in mechanical engineering and not in IT.
- Physical security: none (Optionally secure booting is needed)
- Expected frequency of updates to hardware: 3-4 year refresh cycle
- Expected frequency of updates to firmware: 6-12 months
- Expected frequency of updates to control systems (e.g. OpenStack or Kubernetes controllers): ~ 12 - 24 months, has to be possible from remote management
- Physical size: 482.6 mm (19 inch) witdth rack. Not all the sites will have 1000 mm (36 inch) depth capability. Some sites might be limited to 600 mm (12 inch) depth.
- Cooling: front cooling
- Access / cabling: front
- NEBS 3 compliant
- Number of edge cloud instances: depends on demands (3000+)
- Services might be deployed here: MEC, or other services which have strict requirements on latency. Services deployed in this kind of sites have huge regional deference
- Remote network connection reliability: No 100% uptime and variable connectivity expected.
- Orchestration: no orchestration component. MANO deployed in core site provide remote orchestration
- Degree of virtualization: it is possible that no virtualization technology would be used in small edge site if virtualization increases structure/network complexity, reduces service performance, or costs more resources. Bare-metal is common in small edge sites. Container would also be a future choice if virtualization was needed
- Smart NICs are supported
- Storage: mainly local storage.

5.2 Medium Edge

- Distance to base station: around 50 km
- E2E delay (from UE to site): less than 2.5 ms
- Maximum bandwidth can provide: 100 GB/s
- Minimum hardware specs: 2 Rack Unit (RU)
- Maximum hardware specs: 20 Rack Unit
- Power for a site: 10 - 20 10 kW
- Physical access of maintainer: Rare. Maintenance staff is skilled in mechanical engineering and not in IT.
- Physical security: Medium, probably not in a secure data center, probably in a semi-physically secure environment; each device has some authentication (such as certificate) to verify it's a legitimate piece of hardware deployed by operator; network access is all through security enhanced methods (vpn, connected back to dmz); VPN itself is not considered secure, so other mechanism such as https should be employed as well)

- Expected frequency of updates to hardware: 5-7 years
- Expected frequency of updates to firmware: Never unless required to fix blocker/critical bug(s)
- Expected frequency of updates to control systems (e.g. OpenStack or Kubernetes controllers): 12 - 24 months
- Physical size: TBD
- Cooling: front cooling
- Access / cabling: front
- NEBS 3 compliant
- Number of edge cloud instances: 3000+
- Services might be deployed here: MEC, RAN, CPE, etc.
- Remote network connection reliability: 24/7 (high uptime but connectivity is variable), 100% uptime expected
- Orchestration: no orchestration component. MANO deployed in core site provide remote orchestration.
- Degree of virtualization: depends on site conditions and service requirements. VM, container may form hybrid virtualization layer. Bare-metal is possible in middle sites
- Smart NICs are supported
- Storage: local storage and distributed storage, which depends on site conditions and services' needs

5.3 Large Edge

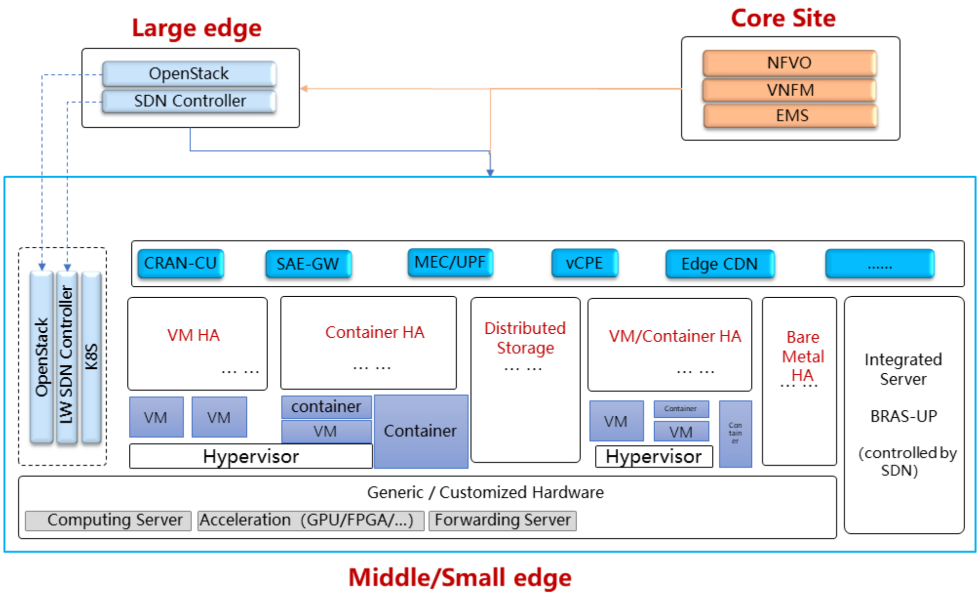
- Distance to base station: 80 - 300 km
- E2E delay: around 4 ms
- Maximum bandwidth can provide: 200 GB/s
- Minimum hardware specs: N/A
- Maximum hardware specs: 100+ servers
- Power for a site: 20 - 90 kW
- Physical access of maintainer: professional maintainer will monitor the site. Maintenance staff is skilled in mechanical engineering and not in IT.
- Physical security: High
- Expected frequency of updates to hardware: 36 month
- Expected frequency of updates to firmware: Never unless required to fix blocker/critical bug(s)
- Expected frequency of updates to control systems (e.g. OpenStack or Kubernetes controllers): 12 - 24 months
- Physical size: same as a normal DC
- Cooling: front cooling
- Access / cabling: front
- NEBS 3 compliant
- Number of edge cloud instances: 600+
- Services might be deployed here: CDN, SAE-GW, UPF, CPE and etc., which have large bandwidth requirements and relatively low latency requirements

- Remote network connection reliability: reliable and stable
- Orchestration: no orchestration component. MANO deployed in core site provide remote orchestration
- Degree of virtualization: almost completely virtualized in the form of VMs (if take CDN into consideration, which may not be virtualized, the virtualization degree would decrease in sites with CDN deployment)
- Smart NICs are supported
- Storage: distributed storage

CHAPTER 6

Edge Structure

Based on requirements of telco related use cases and edge sites conditions, the edge structure has been summarized as the figure below.



CHAPTER 7

Requirements & Features on NFV Components

7.1 Hardware

Customized server would be possible for edge because of limited space, power, temperature, vibration and etc. But if there were custom enclosures that can provide environmental controls, then non-customized server can be used, which is a cost tradeoff.

More derails: TBD

7.2 Acceleration

Hardware acceleration resources and acceleration software would be necessary for edge.

More details:TBD

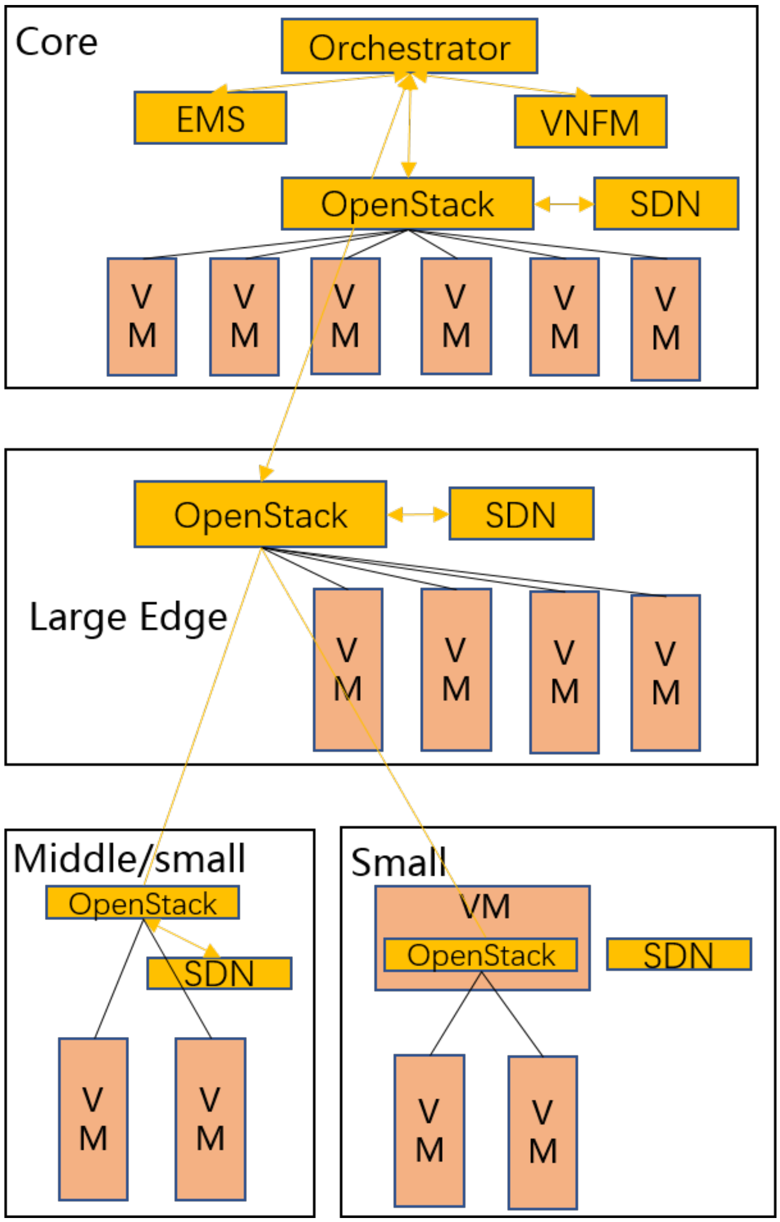
7.3 OpenStack

Edge OpenStack would be in hierarchical structure. Remote provisioning like multi-region OpenStack would exist in large edge sites with professional maintenance staff and provide remote management on several middle/small edge sites. Middle and small edge sites would not only have their own resource management components to provide local resource and network management, but also under the remote provisioning of OpenStack in large edge sites.

Optionally for large edge sites, OpenStack would be fully deployed. Its Keystone and Horizon would provide unified tenant and UI management for both itself and remote middle and small edge sites. In this case middle edge sites would have OpenStack with neccessary services like Nova, Neutron and Glance. While small edge site would use resource optimized weight OpenStack.

Other option is to use different instances of the same resource optimized OpenStack to control both large, medium and small edge sites.

More detalis: TBD


Core
Orchestrator
EMS
VNFM
OpenStack
SDN
V M
V M
V M
V M
V M
V M
OpenStack
SDN
Large Edge
V M
V M
V M
V M
Middle/small
OpenStack
SDN
V M
V M
Small
VM
OpenStack
SDN
V M
V M

7.4 SDN

TBD

7.5 Orchestration & Management

Orchestration and VNF lifecycle management: NFVO, VNFM, EMS exist in core cloud and provide remote lifecycle management.

More details: TBD

7.6 Container

VM, container and bare-metal would exist as three different types of infrastructure resources. Which type of resources to use depends on services' requirements and sites conditions. The introduction of container would be a future topic.