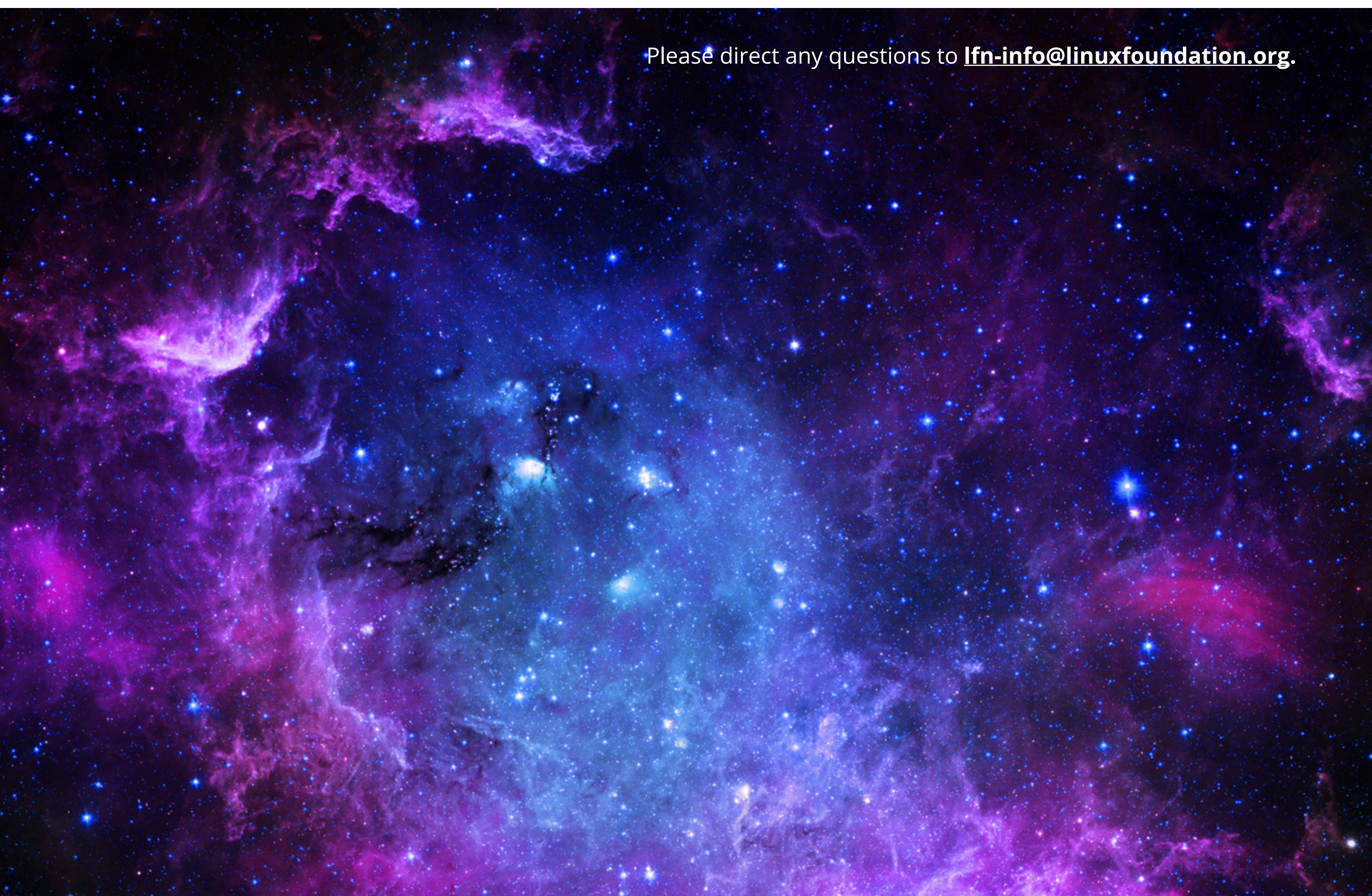
LF NETWORKING

Open Source Communities Demonstrate End-to-End 5G Cloud Native Network

Multiple organizations collaborate to achieve 5G in containers and find gaps for telecom cloud native services and use cases

Please direct any questions to **lfn-info@linuxfoundation.org**.



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KEY COMMUNITIES:

- CNCF
- LF Networking
- OpenAirInterface Software Alliance

KEY PROJECTS:

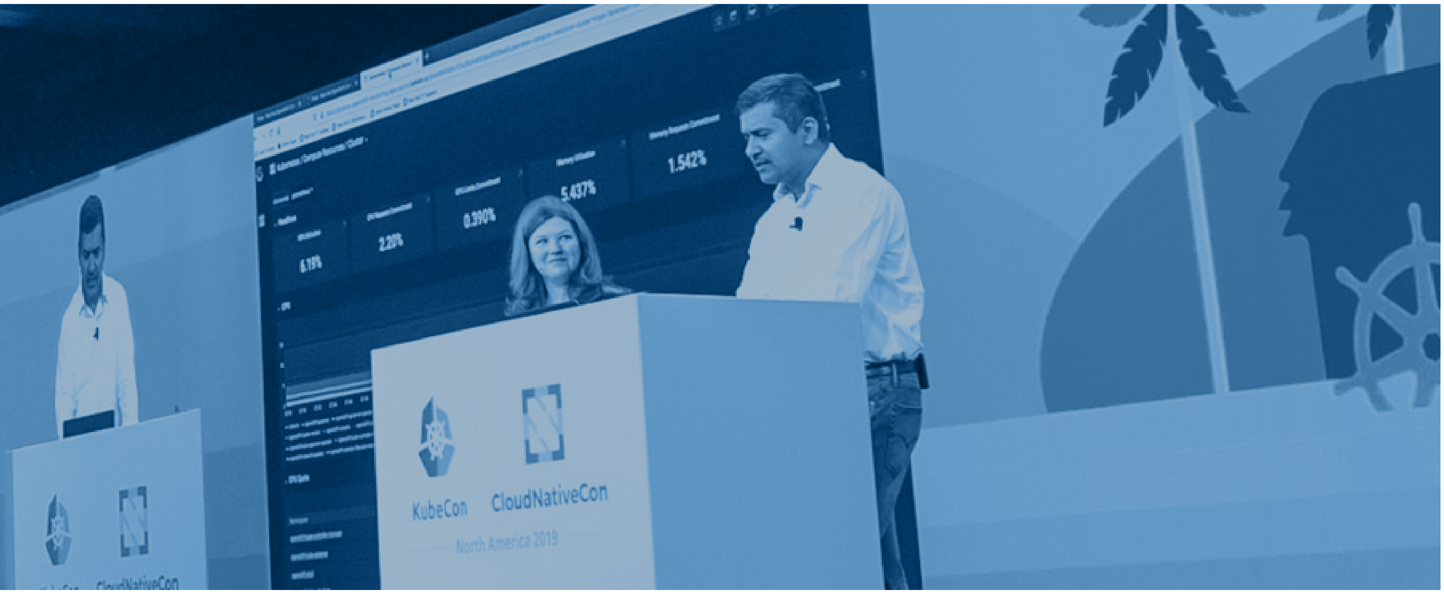
- Clearwater
- Kubernetes (K8s)
- Prometheus
- OpenAirInterface
- OPNFV Barometer

POINTS OF PRESENCE (POPs) / CLUSTERS

- San Diego On-site 5G POP
- Montreal 5G Core Lab From Kaloom and Lenovo
- Sophia Antipolis Lab From Eurecom and OAI
- Public Cloud Network on Alibaba

COLLABORATIVE DEVELOPMENT:

- 80+ Volunteers
- 15 Companies
- 20+ Open Source Projects
- 4 Month Effort



Heather Kirksey, Linux Foundation, and Azhar Sayeed, Red Hat, on stage at KubeCon + CloudNativeCon San Diego North America 2020

The Promise of 5G

5G brings speeds 50x faster than the current LTE technology, ultra reliable 10x lower latency, support for massive machine-to-machine communication for up to 1 million IoT devices per $1Km^2$, network slicing or the ability to carve up a 5G pipe into virtual pipes each with a different SLA, and greater radio efficiency allowing for a 10 year battery life on IoT devices. With these groundbreaking capabilities, 5G's impact will reverberate through the entire economy unleashing new use cases in industries such as connected healthcare, smart buildings/cities, autonomous vehicles, virtual reality, and more. According to Big Market Research, the 5G technology market will reach $668 billion by 2025.

The move from 4G to 5G is already in progress. As of Nov 2019, there were 50 commercial 5G networks in 27 countries[1]. The largest mobile operator in the world, China Mobile, began their 5G commercial service in October 2019 across 50 cities, and plan to spread 5G service across the whole country in 2020. China Mobile's view is that 5G is not only about faster connectivity but also about building a platform for innovative next generation services. Specifically, 5G will also enable AI, IoT, cloud, big data, and edge computing services (AICDE).

[1] **5G - 50 5G Commercial Networks – November Snapshot, GSA**

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The Need for a Cloud Native Architecture

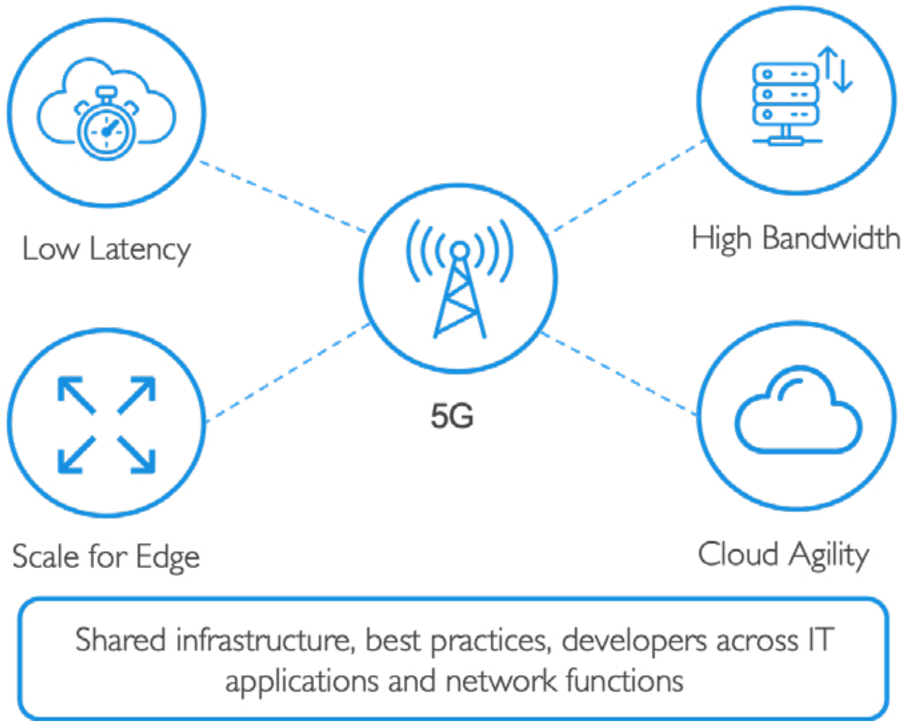
5G networks will be entirely software driven allowing Communication Service Providers (CSPs) to improve network responsiveness, introduce new services rapidly, cut operational expenses (OPEX) through automation, and slash capital expenditures (CAPEX) by using industry standard servers and switches. However, the software driven nature of 5G creates a number of new requirements. As per China Mobile, a 5G network needs:

Globally scheduled resources to allow workloads to move across clouds

- Elastically scalable capacity for on-demand requirements
- Flexible core to edge cloud implementations by varying the same underlying cloud architecture
- Rapidly deployed services; minutes instead of days, weeks, or months
- Fully open platform services (PaaS) shared across applications through common APIs

Fu Qiao, China Mobile, on stage at KubeCon + CloudNativeCon San Diego North America 2020

A cloud native network function (CNF) is a cloud native application that implements or facilitates network functionality. A cloud native network function consists of one or more microservices, and has been developed using Cloud Native Principles including the use of containers, immutable infrastructure, declarative APIs, and a repeatable deployment process. (Source: CNCF)



A cloud native architecture is superior for the following reasons:

- **Flexible:** The repeatable nature of cloud native applications means they can be deployed anywhere from the core to central offices to the RAN
- **Massive scale:** The light-weight footprint of containers (up to 10x smaller than VMs) allows them to be scaled-out with ease. In addition, the CNCF community performs scale testing on up to 150,000 containers.
- **Performance:** CNFs can be higher performing than VNFs. This was validated by performance testing conducted on the CNCF CNF testbed.
- **Resilience:** Systems such as Kubernetes natively include health checks and self-healing. Moreover, the rapid boot time of containers (up to 10x faster than VMs) means services can be restored in seconds instead of minutes.
- **Embracing Enterprise IT innovation:** A cloud native approach allows IT applications and CNFs to use the same infrastructure. More importantly, a sizable pool of developers and best practices in the areas of CI/CD, monitoring, logging, and new and exciting CNCF projects is now available across both enterprise IT and Networking.

Moreover, the 3GPP 5G Core specification is a Service-Based Architecture (SBA), where a catalog of common functions are disaggregated. This approach is naturally suited to a cloud native architecture.

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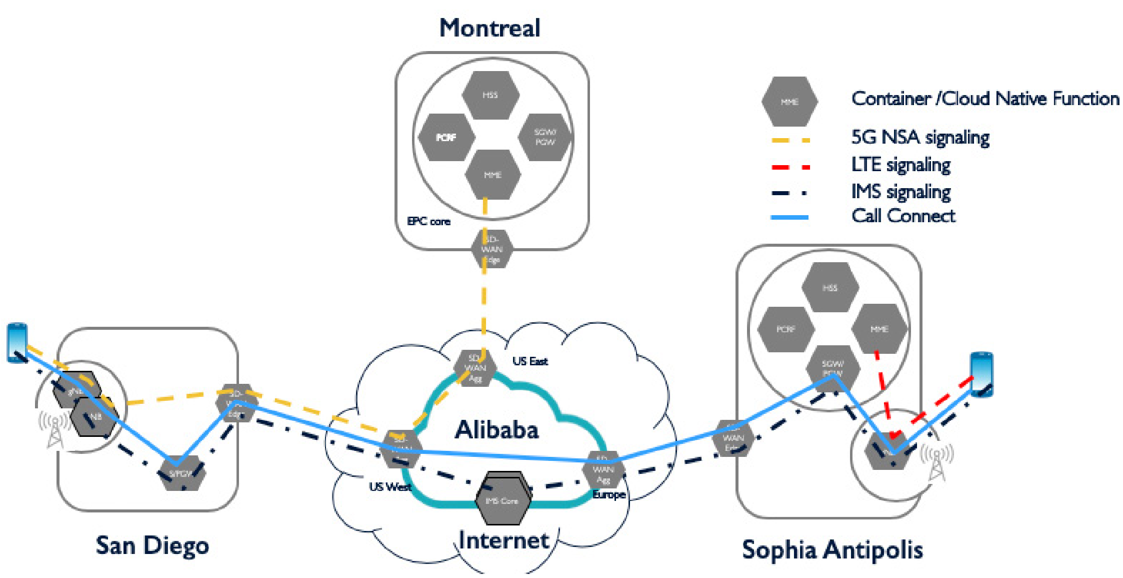
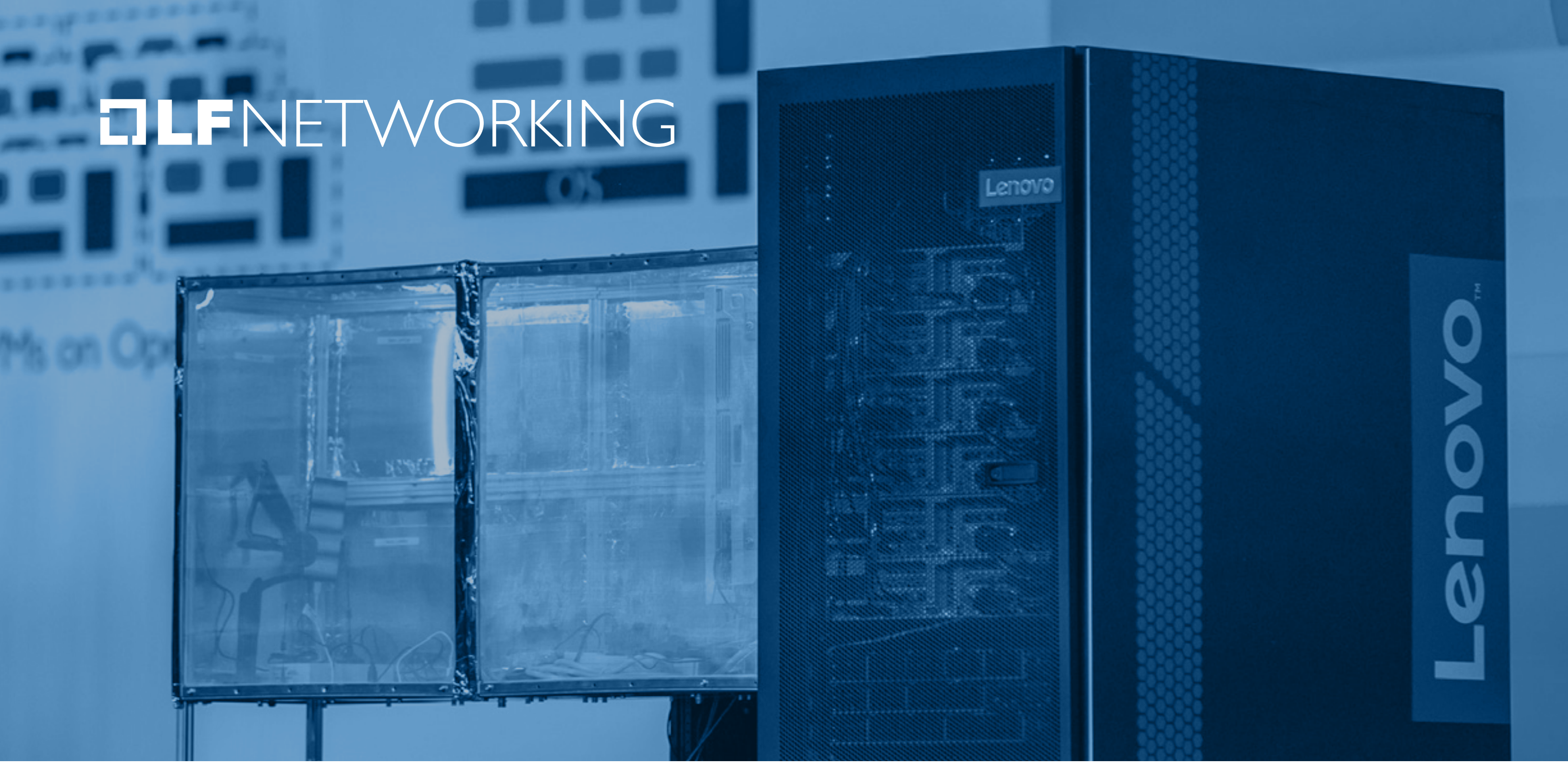
A 5G Cloud Native Network Demo

Over the past three years, the OPNFV community has built a vibrant Virtual Central Office (VCO) Proof of Concept (PoC) by validating residential, enterprise, and mobile (LTE) use cases using open source and proprietary NFV/SDN technologies. In mid 2019, this working group set out to prove an End-to-End 5G cloud native network could be built on open source infrastructure. More than 80 volunteers across 4 open source communities, 15 partner companies, and 2 end users stepped forward to create a live demo prototype in four months to be unveiled at KubeCon North America 2019.

The community decided to build two separate cloud native networks—5G and LTE. The demo showed an end-to-end video call across the two networks in addition to 5G data connectivity. The 5G network was built across two clouds (San Diego and Montreal) and the LTE network was built in one cloud (Sophia Antipolis). There was also a public cloud (Alibaba) utilized for hosting vIMS and other software components and providing network connectivity. The vIMS software created end-to-end signaling across the two networks. The below figure shows the demo topology.

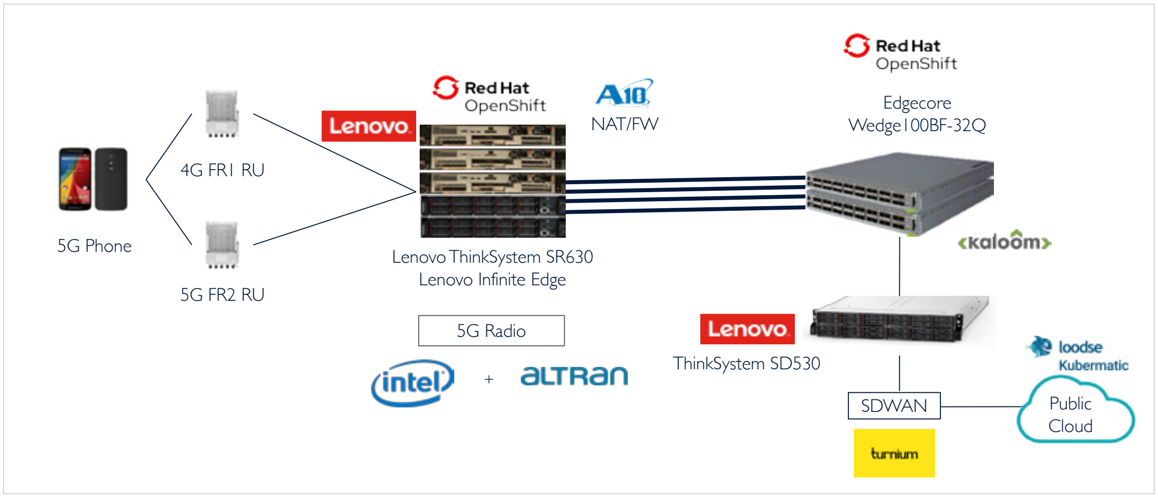


End-to-end Topology of the 5G Cloud Native Network Demo

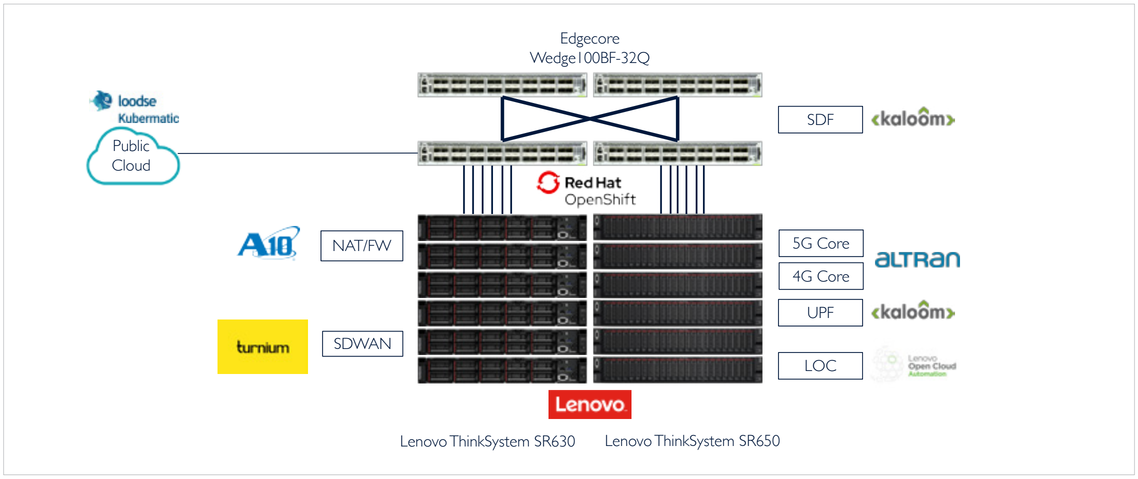


San Diego Edge Cloud with LTE + 5G Radio Hardware and Phones in a Faraday Cage

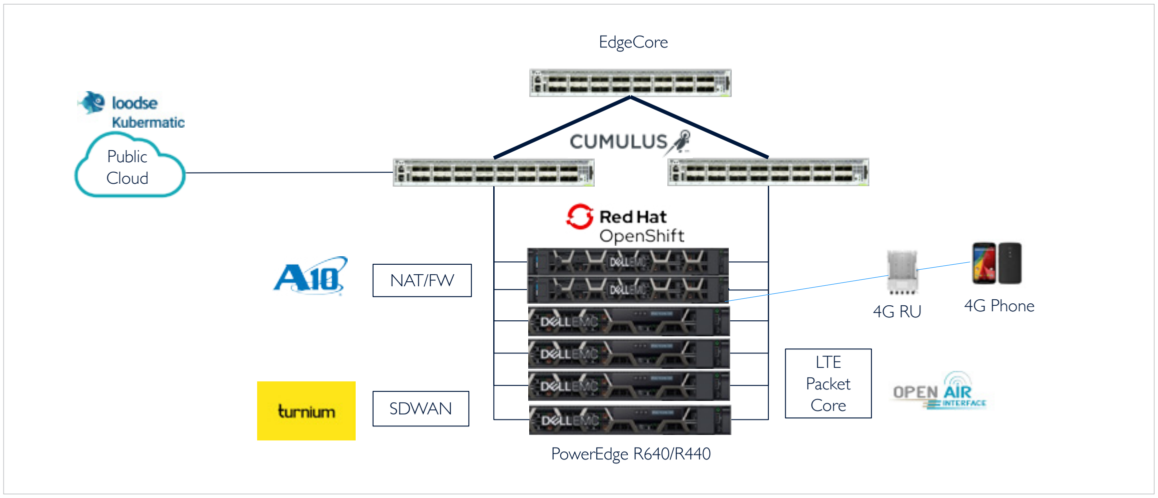
The San Diego, Montreal, and Sophia Antipolis clusters were constructed as follows:



Cluster#1 (San Diego)



Cluster#2 (Montreal)



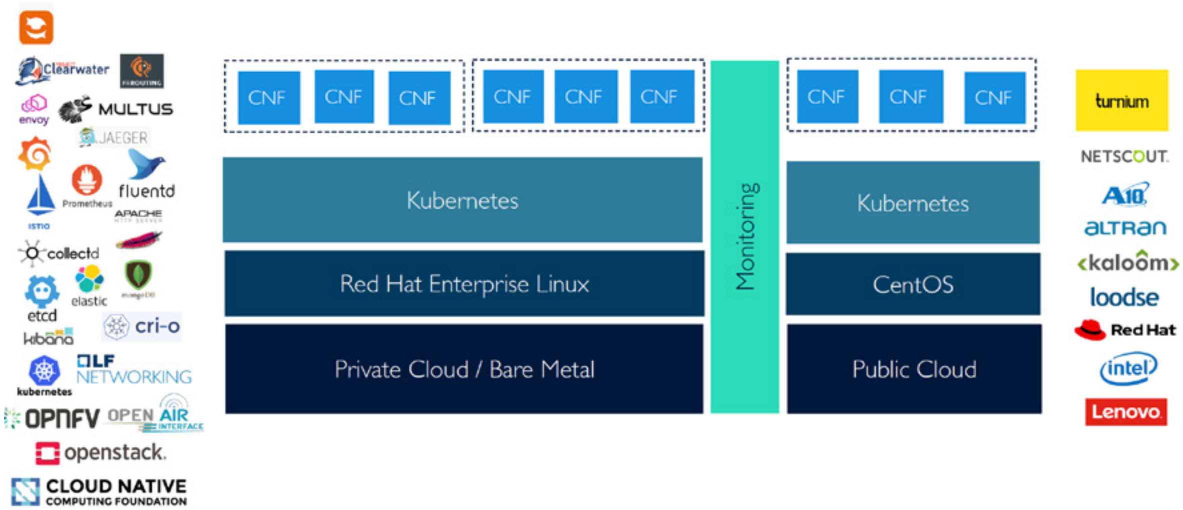
Cluster#3 (Sophia Antipolis)

Each of the clouds included the following hardware and software components:

Cluster	Purpose	Hardware Infrastructure	Software Infrastructure	CNFs
#1 (San Diego @ Kubecon)	Edge	• Lenovo ThinkSystem SR630, SD530 and Infinite Edge servers • Edgecore Wedge100BF-32Q switches • 5G phone • LTE & 5G NR radios	• Red Hat Enterprise Linux • Red Hat OpenShift Container Platform(K8s) • Kaloom Software Defined Fabric	• Intel FlexRAN (L1) • Altran vRAN (L2, L3) • Altran 4G SPGW-U (User Plane) • Kaloom 5G UPF (Data Plane) • Turnium SD-WAN • A10 Networks Thunder® Convergent Firewall (CFW)
Cloud#2 (Montreal @ Kaloom)	Core	• Lenovo ThinkSystem SR630/SR650 • Edgecore Wedge100BF-32Q	• Red Hat Enterprise Linux • Red Hat OpenShift Container Platform • Kaloom Software Defined Fabric • Lenovo Open Cloud Automation	• Kaloom 5G UPF • Altran vEPC/5G Core Control Plane • Turnium SD-WAN • A10 CFW
#3 (Sophia Antipolis @ Eurecom)	Edge+Core	• Dell PowerEdge R640/R440 • Edgecore switches • LTE radio • LTE phone	• Red Hat Enterprise Linux • Red Hat OpenShift Container Platform • Cumulus Linux (Network OS)	• OAI LTE Radio Access Network (OAI-RAN) • OAI LTE Core Network (OAI-CN) • Turnium SD-WAN • A10 CFW
#4 (Alibaba)	Public	• - Enterprise network connectivity	• CentOS • Loodse Kubermatic (K8s)	• Clearwater vIMS • Turnium SD-WAN • NetScout nGeniusONE service assurance

The above table shows the various CNFs and other technologies used to create the two networks. These networks were connected to a Clearwater IMS to provide video connectivity across them. The different edge clouds were connected to the Alibaba cloud which in turn provided network connectivity between the US West, Canada East, and Europe regions. The connectivity between the Alibaba cloud and the various sites was through the Turnium SD-WAN cloud native solution.

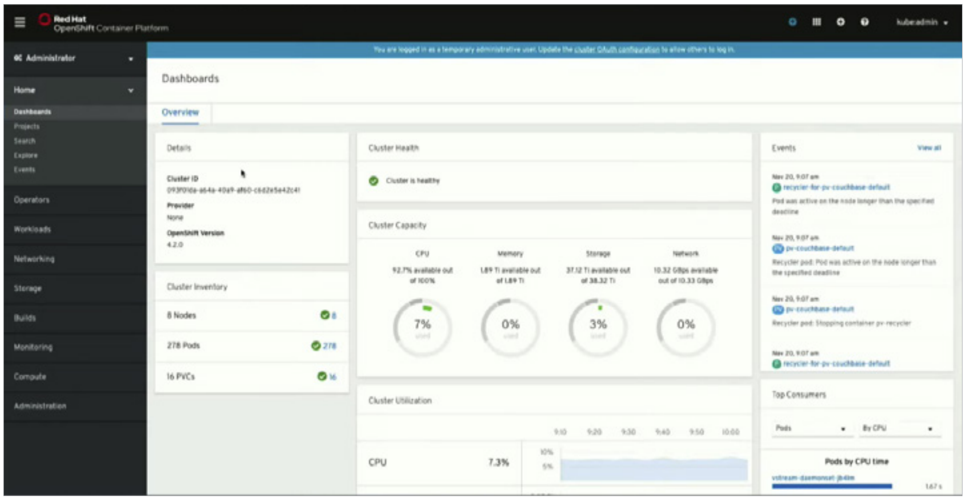
The overall software stack was as follows:



5G Cloud Native Network Software Stack: Open Source & Proprietary

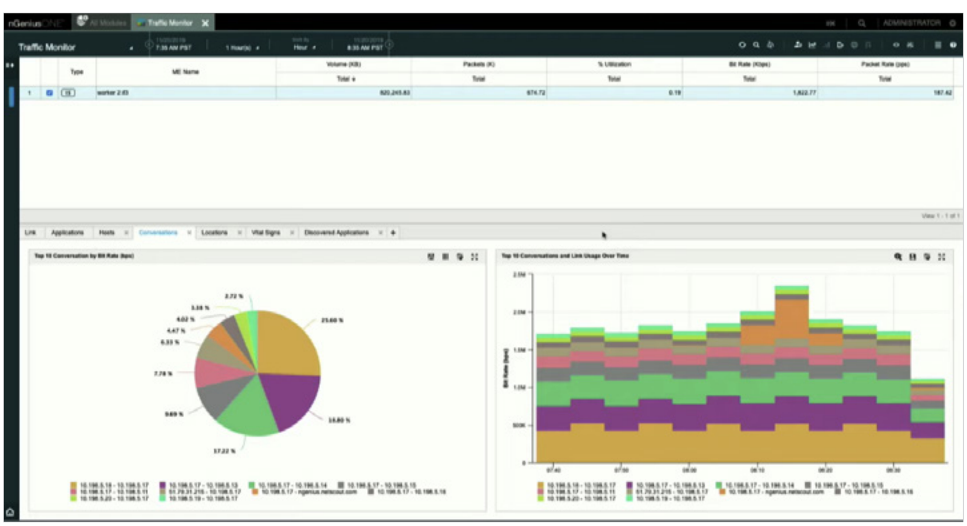
The demo comprised both open source and proprietary technologies. The main open source projects were K8s (and related CNCF technologies such as Prometheus, Fluentd, Jaeger, and others), OpenAirInterface, Clearwater, and OPNFV Barometer. As the diagram shows, the deployment used a hybrid architecture. Hybrid not only across public and private clouds, but also where Kubernetes was deployed on bare-metal vs. on a virtual machine.

Responding to the challenge of operational enablement, the project team included several management dashboards. A centralized OpenShift dashboard showed node statistics across the different edge clouds. The Kubermatic dashboard managed Kubernetes cluster state in the Alibaba cloud. The OPNFV Barometer collectd component was integrated with the OpenShift clusters and a Grafana window to show infrastructure and NFVI related telemetry. The next layer above node level statistics is service level management. The NetScout dashboard addressed this layer by displaying service assurance metrics. Lenovo Open Cloud Automation software was used to deploy the infrastructure.



OpenShift Dashboard Showing Cluster Status

OPNFV Barometer Dashboard Showing Node Level Telemetry



NetScout Dashboard Service Level Management

Gap Analysis and Future Considerations

Building this proof of concept served two important purposes. First, it showed that an end-to-end cloud native network is feasible with tools available today. As the first demo of its kind, this is a proof-point offering valuable learnings in the areas of operations, technology readiness, and 5G CNF code maturity. Second, the demo enabled the project team to uncover a number of critical gaps in K8s infrastructure and CNFs around real-time guarantees, CNF descriptors, CNF design, networking, use of hardware acceleration, IPv6, networking interfaces and protocol support such as SCTP, and CNF lifecycle management. The team is providing active feedback to other LFN and CNCF projects and initiatives setting the stage for future cooperation:

Project/ Initiative	Areas of collaboration
CNTT	CNTT's Reference Architecture 2 is based on K8s and the feedback from this demo will help guide this definition.
ONAP	ONAP supports K8s as an NFVI. The feedback around CNF descriptors and related topics will help guide ONAP's roadmap in this area.
CNCF	The above feedback will help CNCF projects better cater to 5G requirements. The CNCF Telco User Group (TUG) and CNF Testbed can also be used for performance and interoperability testing moving forward.
O-RAN	Having deployed vRAN on commodity hardware aligned with O-RAN split specifications and cloud architecture requirements, the VCO project can provide real-world feedback to the O-RAN community.
FD.io	A future version of VCO can take advantage of FD.io for accelerating 5G user plane CNFs.

The demo was made possible by active community participation from the following organizations:

A10
Alibaba Cloud
altran
Bell
中国移动 China Mobile
COMMSCOPE
CUMULUS
GSMA
intel
kaloom
Lenovo
loodse
NETSCOUT
Red Hat
turnium

The key open source and standards organizations with underlying projects and initiatives are:

LF NETWORKING

OPNFV

OPEN AIR INTERFACE

CLOUD NATIVE COMPUTING FOUNDATION

GSMA

O-RAN ALLIANCE

Summary

5G brings with it a tremendous promise but also new requirements. Cloud native technologies can be used to meet several of these demands by providing benefits in the areas of flexibility, scalability, performance, and resilience. To prove that a 5G cloud native approach can work and to identify new requirements, the VCO community created a proof-of-concept (PoC) powered solely by CNFs running on K8s. This effort demonstrates the power of an open source community approach when applied to integration and interoperability efforts. The diverse group of participating companies built and showcased a demo in just a few short months, something no individual company would have attempted or achieved on their own. The showcase is a starting point for cloud native 5G — more work is needed on the 5G CNF design and to build a common platform to enable network efficiency and flexibility. This will help the open source community exploit the service innovation inspired by 5G. Learn more with the resources below and join the effort.

Resources

5G Cloud Native Network Keynote:
www.youtube.com/watch?v=IL4nxbmUIX8

CNTT Reference Architecture 2:
cntt-n.github.io/CNTT/doc/ref_arch/kubernetes

Links to VCO 3.0 presentations and videos:
opnfv.org/resources/virtual-central-office

VCO Demo Discussion Home:
wiki.opnfv.org/display/OSDD/OPNFV+VCO+Demo+Discussion+Home

VCO Mailing List:
opnfv-vco@lists.opnfv.org