Technical Report

Cloud Native 5G Core

Samsung 5G Core Vol.2

Contents

Introduction

2019 heralded the 5G era. Starting with Korea, commercial mobile 5G services are operating globally, with GSA reporting 61 networks across 34 countries having 5G commercial services in operation at the beginning of 2020[1]. In Korea, which launched the world's first 5G mobile service in April 2019, the number of 5G subscribers surpassed 4.7 million in just nine months of commercialization, exceeding a 7% penetration rate, which is a faster growth rate than the customer adoption of LTE. 5G commercialized in 2019 using the 5G Non-Standalone (NSA) architecture, which connects 5G base stations with the existing Evolved Packet Core (EPC) to offer eMBB-oriented services. In the 5G Standalone (SA) architecture that will come to the market in 2020, the 5G network will include the new 5G core to enable full support of 5G use cases that not only increase throughput for mobile broadband services, but also offer Ultra-Reliable Low-Latency Communications (URLCC) that may also connect to edge computing platforms to support innovative services such as augmented or virtual reality (AR/VR,) streaming games, autonomous driving, and smart factories.

The 5G networks build on and leverage the experiences of LTE. With LTE, operators adopted and deployed an all-IP architecture, which allowed their voice-centered mobile networks to evolve into a data network that supports much more than voice services. As mobile traffic volumes exploded on LTE, the mobile core began migrating to the Network Functions Virtualization (NFV) architecture, in which network functions are virtualized and provided as software entities running on commercial off-the-shelf (COTS) servers instead of dedicated network appliances.

Furthermore, as the 5G mobile core evolves to enable a great variety of services, the 5G core is further leveraging the cloud concept by migrating to a cloud native core, in which network functions are modularized and containerized to enable highly flexible scaling and function lifecycle management. The cloud native core provides capabilities that allow the network to adapt to changing demands and support new services with minimal interactions required by operational teams.

1. http://gsacom.com/technology/5g/ - 5G Market Status: Snapshot January 2020", GSA, January 7, 2020

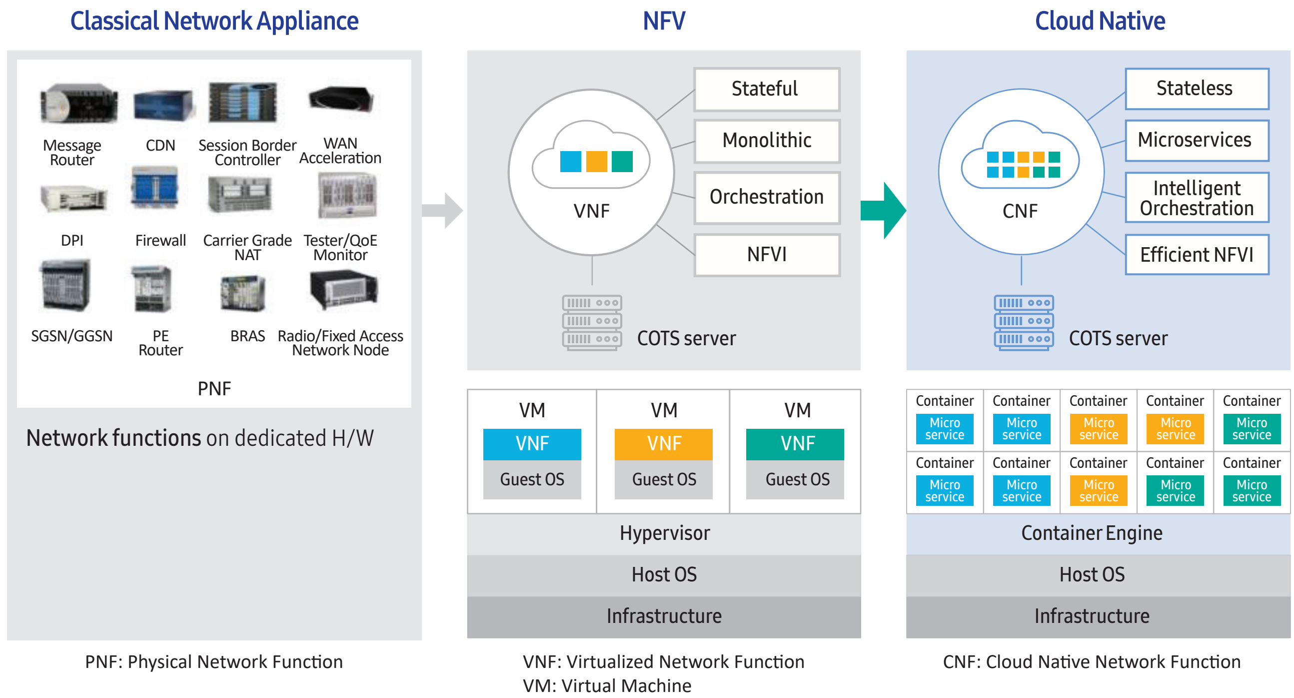


Figure 1-1 Evolving to Cloud Native

This means that the 5G core will enable operators to rapidly develop services, launch them on time, and adapt the network frequently according to market demands. Open source can accelerate this innovation by providing platform services with features commonly used by 5G core functions such as monitoring, data base activities, and high availability related features.

To this end, Samsung collaborates with many operators and partners in efforts to create 5G core solutions and to expand the 5G ecosystems through active participation in the following organizations:

1. Cloud Native Computing Foundation (CNCF), which leads the de-facto standard for cloud technology, and
2. Open Network Automation Platform (ONAP), a telco-oriented open source project

In addition, Samsung operates 5G Open Labs. With these efforts, Samsung is strengthening the interworking abilities and stability of its 5G core, resulting in highly efficient 5G solutions. These efforts and accomplishments provide the 5G network operators with the flexibility they desire to support the faster deployment of new services. This white paper first introduces the features and telco-grade capabilities of the cloud native Samsung 5G Core, which is ready for 5G SA commercialization and examines its benefits for network operators. Then it will discuss the impact of Samsung's open source activities on the development of the cloud native Samsung 5G Core and its global competitiveness.

Samsung's Cloud Native 5G Core

Why Cloud Native

As the operator's business paradigm shifts to service-oriented businesses, the challenge faced by network operators preparing for the 5G era is to build an environment in which they can launch services promptly and upgrade the services frequently, as influenced by market demands. Telco operators began introducing the Network Functions Virtualization (NFV) environment to reduce CAPEX and boost service agility. With the transformation to NFV allowing network functions to run as software on COTS servers, operators have been able to manage network capacity and optimize CAPEX to accommodate traffic/subscriber growth. On the other hand, the complexity of network operations has increased due to vendor-specific solutions that manage their implementations of Virtualized Network Functions (VNFs). In the 5G era, where everything from small sensors to high-speed automobiles is connected, innovation is a key factor in the network transformation. As the 5G radio provides not only eMBB but also URLLC and mMTC connectivity, the 5G core environment undergoes significant changes. First, the core must:

1. process a substantially higher volume of traffic,
2. reliably and quickly create connections that meet strict service level agreements, and
3. support massively more Internet of Things connectivity.

Second, the single 5G infrastructure must provide a variety of innovative services, such as AR/VR, streaming games, autonomous driving, and smart factories, quickly and reliably. To fully adapt to this environment, Samsung 5G Core is driving 5G innovations with the following vision.

Flexible – Expand network functions and capacities flexibly as service demand grows
Agile – Timely launch and upgrade profitable services as market demands
Scalable – Provide rapid high-scalability with telco-grade reliability
Tunable – Boost operational efficiency by simplifying and automating complex network operations

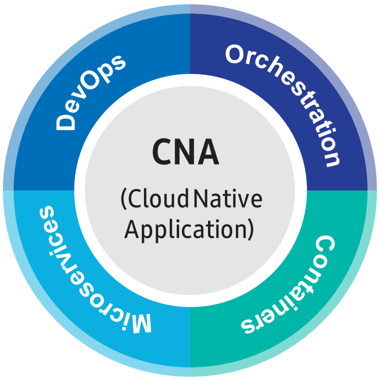
For more information on the vision and strategies of Samsung 5G Core, see the technical report "Samsung 5G Core Vol.1 : 5G Vision"

To commercialize the 5G core, the network operator is pursuing innovative changes that transform the 5G core into a service platform that can easily scale from small to large capacity by introducing cloud native design principles and IT-based development methodologies. The Samsung 5G Core adopts a cloud native architecture to modularize network functions in order to easily port them to any environment by making full use of containers and open source technologies. As a result, the 5G Core functions are quickly created, deployed, and scaled, using automated lifecycle management (LCM). The Samsung 5G Core also strengthens monitoring and analytics to provide high-quality services continuously and consistently and maximizes operational efficiency by performing closed-loop automation with automatic feedback. As a flexible service platform in the 5G era where everything is connected and mobility is integrated with all industries, the cloud native Samsung 5G Core will be the essential driver of business growth for telco operators.

What is Cloud Native

In general, "cloud native" is an approach to building and running applications that exploit the advantages of the cloud computing model. One key attribute of "cloud native" is how the system creates and deploys applications. According to the definition of CNCF, "cloud native" means that an application is containerized and uses open source software stack.

A cloud native application (CNA) is developed as loosely-coupled microservices to improve agility and manageability. Each microservice is packaged in a container, and a central dynamic orchestrator schedules the containers to efficiently manage server resources and reduce operational costs. CNAs also require a DevOps environment. DevOps refers to a type of development or operations methodology that integrates software development and IT operations. Traditionally, the development team tried to improve services by adding new features, while the operation team was reluctant to change to preserve reliable service operations.



In today's IT-centric environment, services must be released quickly and easily, and services are continuously updated with improvements that reflect market demands. In a DevOps environment, both the development team and the operations team work closely together under common business goals that include reducing the time for development and delivering improved services. Developers program and build new features, deploy them to the system, then run the service, and monitor it for improvement. For rapid development and improvement, DevOps continuously integrates and deploys services by automating existing manual processes.

The Cloud Native Samsung 5G Core

Telecom services, unlike IT services, demand strict performance and reliability characteristics. Based on its cloud native architecture, the Samsung 5G Core uses open source technologies to provide highly stable solutions that deliver the high reliability required for network operator applications. Figure 2-1 shows the cloud native Samsung 5G Core architecture.

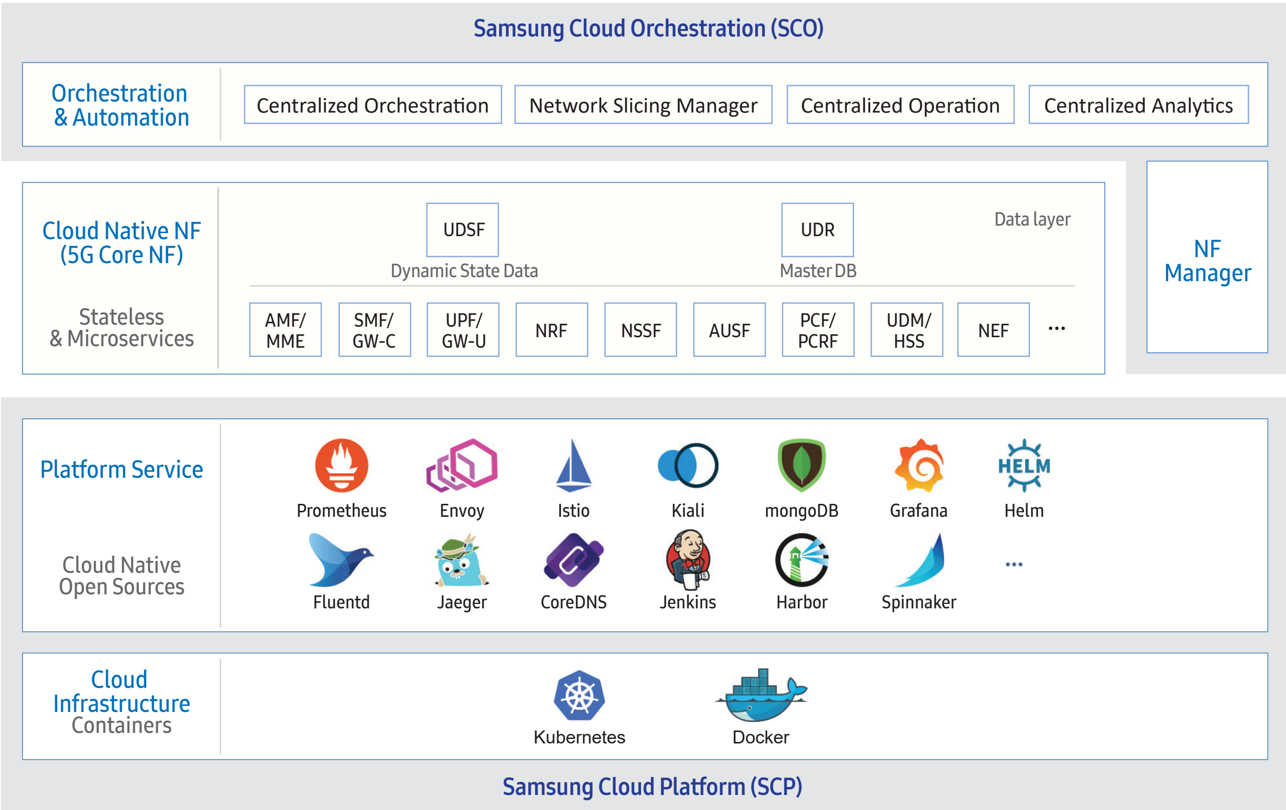


Figure 2-1 Samsung 5G Core's Cloud Native Enabled Architecture

The architecture of the cloud native Samsung 5G Core consists of Samsung Cloud Orchestration (SCO), Samsung Cloud Platform (SCP), and the use of Cloud Native Network Functions (CNFs). SCO contains "Orchestration & Automation" and "NF Manager" functions, and SCP consists of "Cloud Infrastructure" and "Platform Service." The CNF layer has two sub-layers - the data layer and the control/user plane layer.

SCO – SCO manages End-to-End (E2E) orchestration and lifecycle management of CNFs. It provides a variety of automation tools for monitoring and data analysis to mitigate network complexities and increase the automation and efficiency of network operations.

5G Core NF – The 5G Core NF is composed of CNFs that combine to enable 5G-specific features based on 5G standards and common features and services provided by the Platform Service. The basic components of a CNF are microservices, which can execute independently in separate containers, be deployed independently, and be re-composed when creating a new CNF. These microservice-based CNFs are highly scalable and can enable the deployment of new features quickly.

Platform Service – The Platform Service provides a container-based run-time environment that uses cloud native open source tools for the rapid development of CNFs. This approach allows developers to focus more on 5G Core NF development, while operators can improve their network operational efficiency and create new revenue streams by opening new business-to-business (B2B) and business-to-consumer (B2C) services.

Cloud Infrastructure – Cloud infrastructure uses containers to create virtualized components. Containers are highly efficient users of server resources, which makes them lightweight, fast to deploy, and highly portable. The deployment, networking, scaling, and management functions of containers are handled automatically by Kubernetes.

Design Principles of Samsung 5G Core Network Function

The 5G Core NF, as a cloud native NF, is designed using the cloud native principles to fully utilize the advantages of cloud native applications. The fundamental design of the Samsung 5G Core NF uses container and microservice technologies. Also, to use best-of-breed cloud native technologies for SCP, the 5G Core NF chose CNCF tools like Kubernetes, Istio/Envoy, Prometheus, among others, which are widely used solutions in cloud environments.

The following attributes comprise the design principles of Samsung 5G Core NF:

Stateless & Microservices – The 5G Core CNF uses stateless and loosely coupled software-based microservices. Stateless and loosely coupled software is appropriate for microservices and Kubernetes container environments, as they provide efficient support for failover handling, scaling in/out, and seamless upgrades. This approach also improves reusability by minimizing dependencies between microservices.

Open API – The 5G Core CNF also uses REST-based open APIs. Most web applications employ REST-based APIs; therefore, CNFs can take advantage of the extensive capabilities of existing tools designed for cloud native applications. Open APIs enable more convenient monitoring, debugging, and tracing, reducing the development time. Moreover, third parties can more easily integrate applications into Samsung 5G Core NF using open APIs.

Design concept of 5G Core NF

- Stateless & Microservices
- Open API
- Agnostic to Platform
- Resiliency

Agnostic to Platform – The 5G Core CNF remains agnostic to the tools provided by the Platform Service. CNFs frequently use well-known tools like Prometheus and EFK, but more suitable and optimized tools may be necessary for 5G Core CNFs depending on the network operator. For example, Istio/Envoy, a service mesh tool, may or may not be deployed depending on each operator's environment and may be replaced with a different stable and effective service mesh tool.

Resiliency – The 5G Core CNF should always be reliable and available whether the base infrastructures are stable or not. In cloud native environments, infrastructures are not always reliable, and all applications should adapt to these environments. To help with the availability, the careful design of the 5G Core CNF minimizes the size of its components to facilitate quick and easy recovery.

Platform Service

The 5G Core's Platform Service provides a development environment and set of functions for faster and more efficient 5G Core CNF development. It leverages cloud native open source tools and provides basic components commonly used by CNFs including package manager, logging capabilities, reporting services, CI/CD abilities, a variety of metrics, service mesh, container network, tracing, certificate manager, service discovery, and databases. By leveraging this Platform Service architecture, core network function developers can focus on improving operator-specific mobile core functions and implementing business-focused services logic. Likewise, operators can enhance operational efficiency using functions for monitoring, usage measurement, auto-scaling of resources based on service demand, and automatic recovery from failures.

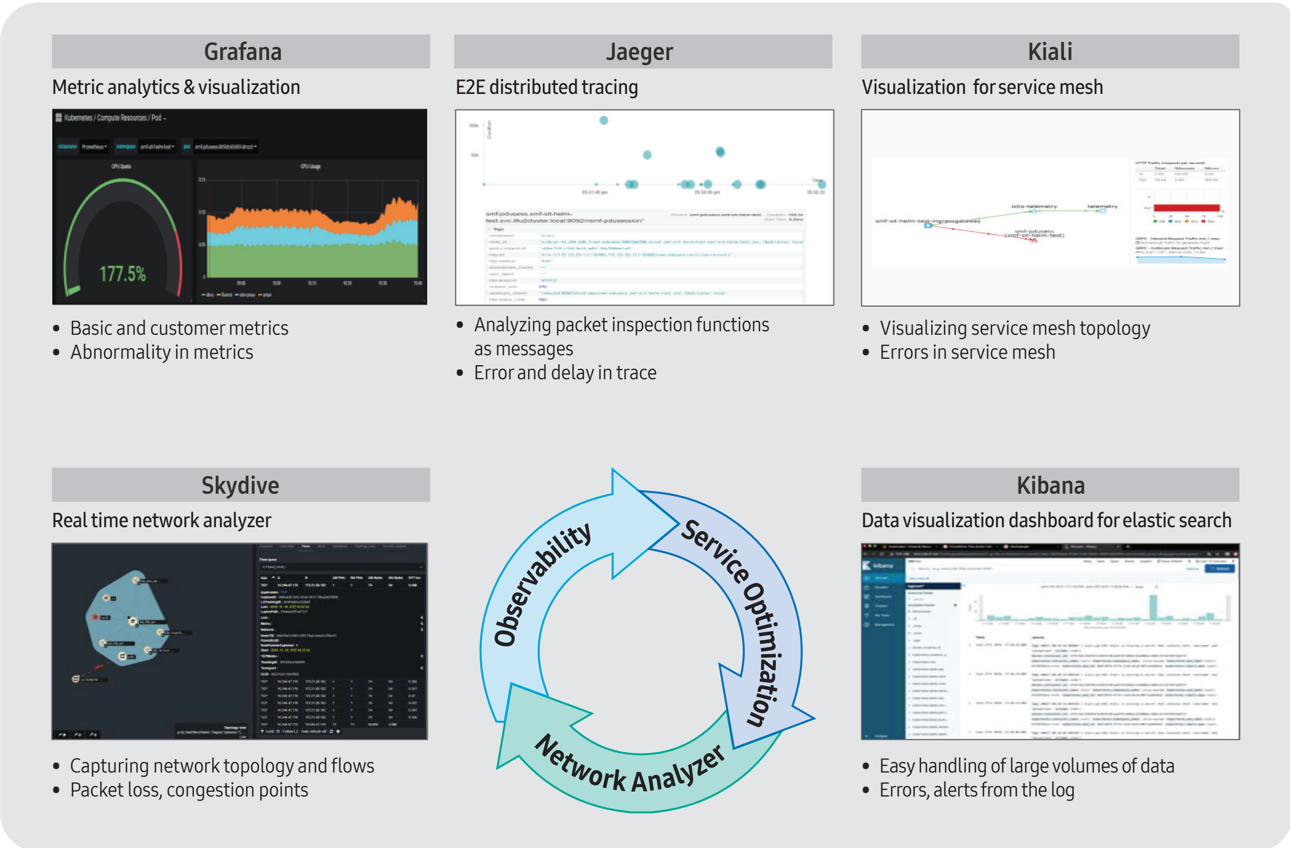


Figure 2-2 Open Source Tools for Proactive Problem Detection and Troubleshooting

Figure 2-2 shows the GUI screens of some of the major open source tools used for proactive problem detection and troubleshooting available on the Platform Service of the cloud native Samsung 5G Core system. These tools provide operators with superior visualization and comprehensive understandings of their 5G network. When a problem occurs in the 5G network, the operator can try to optimize the service by correlating data from tools that enable observability (e.g., monitoring, tracing, logging) and tools that provide metric-based network analytics. For example, if a Grafana dashboard reports a degradation in the KPIs it is monitoring, the operator can troubleshoot the situation by tracing with Jaeger, checking the network status with Kiali/Skydive, and examining the log data for the part suspected of causing the problem with Kibana.

DevOps Environment

Microservice Architecture – The mobile core system traditionally resided in a monolithic architecture. The main disadvantage of this type of architecture is that modules of an application are tightly coupled, which means it is difficult for operators to timely deploy new service packages. As well, troubleshooting and resolving problems could be very time-consuming and complex to fix. To solve this problem, Samsung transformed its 5G Core architecture into an architecture built on microservices. By applying this new architecture that leverages agile methodologies during the complete 5G Core development process, the result was a core network application that reduced the dependencies between software modules, which helps with troubleshooting. Being comprised of these small applications performing particular functions, the network function architecture uses services that can be quickly changed and scaled easily, which enables operators to deploy network functions to meet the demands for that service.

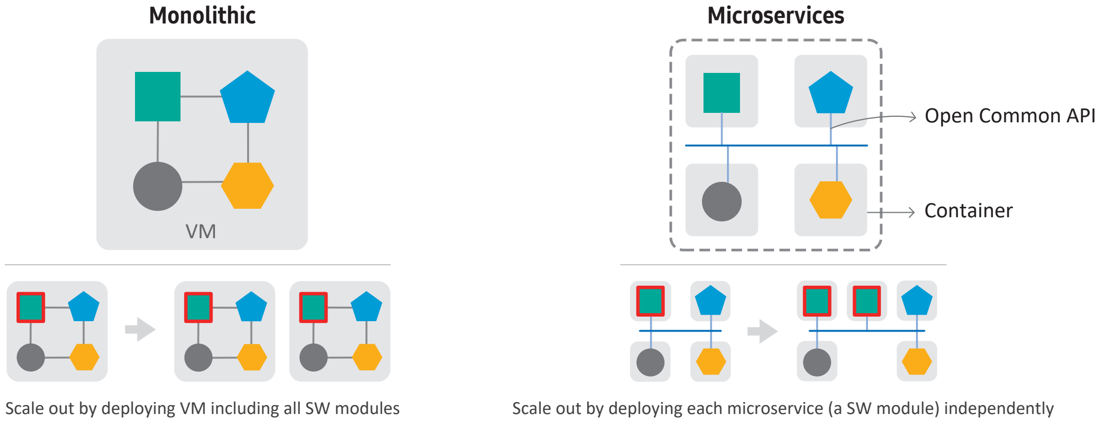


Figure 2-3 Comparison of Scaling Modules in the Monolithic and Microservice Architectures

Continuous Integration and Continuous Deployment (CI/CD) – For frequent network function/service updates, the integration and deployment process must use automation. The cloud native Samsung 5G Core includes CI/CD process in support of DevOps activities that allow fast updates and recoveries of 5G Core functions. CI is the process of building software modules for automated testing that verifies and confirms the correct operation of the complete software system that includes the updates. CD is the process that produces and automatically distributes the new software updates for service deployment. The CI/CD cycle is entirely automated. The software updates reside on containers, and various testing and analysis of these containers are automatically performed during the test phase. After the test phase, the verified application will package the new updates into containers for automatic delivery to the operator. The operator completes the acceptance testing of the application, then deploys the updated functionality into the production environment. The operator reports any problems that arise during their testing or from their network operations to Samsung as feedback to be reflected in subsequent service updates.

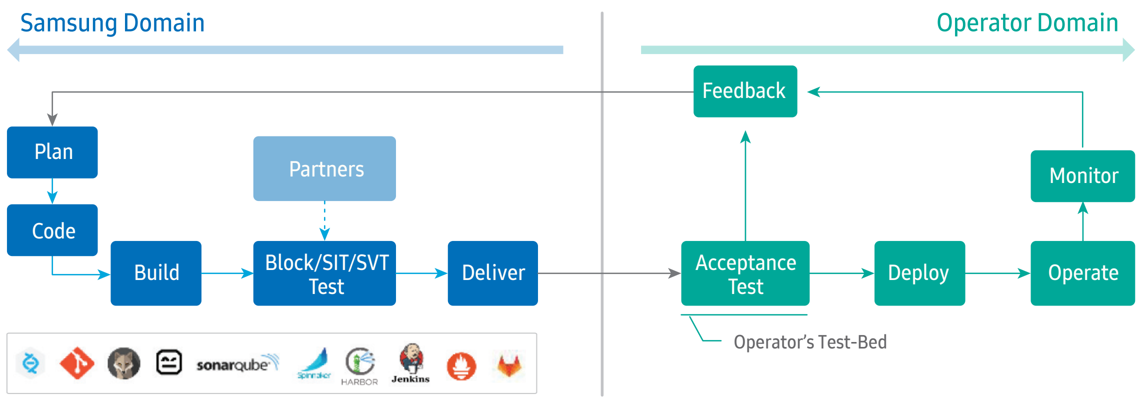


Figure 2-4 Continuous Integration and Continuous Deployment (CI/CD)

Through these processes implemented using microservices that support CI/CD, the Samsung 5G Core can support the continuous deployment of on-demand software updates, quick recovery, and organic scaling based on the needs of the applications, which contributes to the reduction of the CAPEX and OPEX of operators.

Competitiveness of Cloud Native Samsung 5G Core

In the 5G core, the transition from VM-based cloud infrastructure to container-based cloud native infrastructure boosts the system performance and operational efficiencies. The fundamental challenges in VM-based cloud infrastructure include increased latency, longer loading times, and higher costs due to VM overload. To solve these problems, cloud native introduced lightweight containers that operate more efficiently than VMs, leveraging the experience of Kubernetes as a container orchestrator. Cloud native Samsung 5G core can integrate with existing VNF infrastructures to facilitate seamless migration to CNF and support telco-specific networking to provide telco-grade performance and reliability. To these ends, the Samsung 5G Core leverages the following technologies:

Multi-interface – The components of the 5G CNF can connect to multiple planes (user, control, management) and VM-based legacy networks. Samsung 5G Core supports:

- Kuryr container network interface (CNI) to use OpenStack Neutron,
- Layer 2 communication between VMs and containers using Kuryr CNI.

Furthermore, Samsung 5G Core extends Kuryr CNI to support multi-interface in a pod, supporting Open vSwtich (OVS) and Single Root I/O Virtualization (SR-IOV) simultaneously. It can also use Multus CNI to interface with other containers.

Load Balancer – The load balancer, essential for high scalability, should support the following Layer 4 protocols: SCTP, UDP, HTTP/2 and TCP. The Samsung 5G Core configures a load balancer in the form of a pod that meets the stated conditions. By creating load balancer pods for each service, the Samsung 5G Core provides excellent scalability.

Geo-redundancy (GR) – The Samsung 5G Core supports geo-redundancy (GR) for CNFs for stateful session continuity. Samsung designs and deploys AMFs and SMFs with all active (N+K) GR, where AMF/SMF set interworks with the same UDSFs and NRF. If some NFs within the set fail, then the other normal NFs within the same set retrieve the existing session information through UDSFs and NRF to continue the service without interruption. User Plane Functions (UPFs) are designed as active/standby (1:1) GR for fast recovery. When any active UPF fails, the standby UPF becomes the active UPF and ensures session continuity by updating BGP routing to the new active UPF to ensure it receives subsequent packets for all forwarding activities.

Inline Upgrade – The CNF uses ProtoBuf to support different software versions (version N and version N+1) simultaneously to enable inline upgrades without any service termination. Within the same CNF, different versions of the identical type of microservice can run separately, allowing inline upgrades. This feature also serves to perform canary tests more efficiently.

UPF Performance Improvement – Samsung 5G Core provides packet acceleration technologies such as SR-IOV and OVS-DPDK for telco-grade I/O performance. It also improves packet transfer performance by leveraging parallel packet processing that processes both QoS control and packet transfer stipulations simultaneously and data acceleration through traffic offloading.

Open Tracing – Jaeger is an open tracing tool that performs DPI functions based on message analysis. Through Jaeger's traffic tracing, Samsung 5G Core can support network assurance by analyzing pod-to-pod communication.

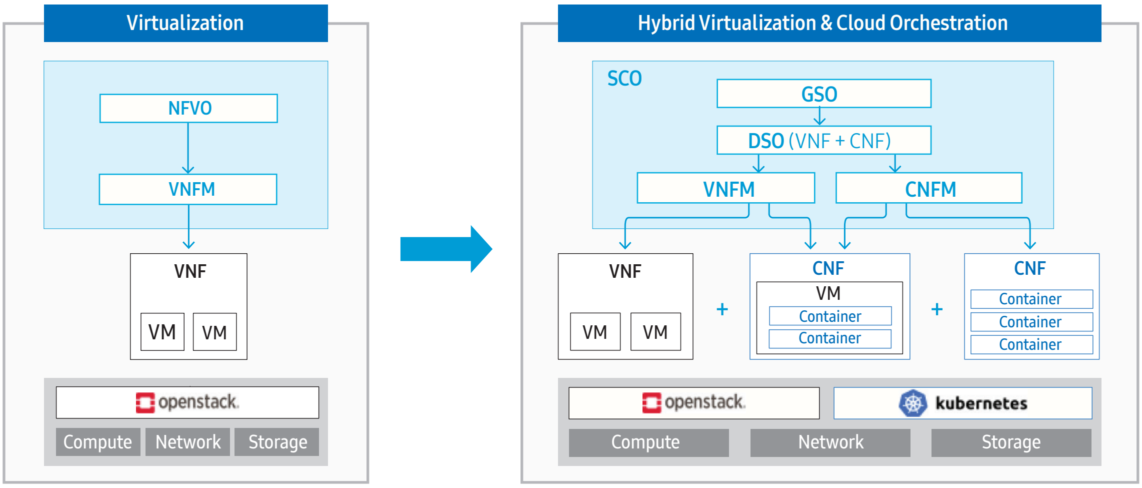
Things to Consider when Developing Cloud Native 5G Core

Many network operators and vendors refer to the cloud native 5G core architecture to take advantage of the phrase “cloud native,” but they are only now in the very early stages of implementing the principles of cloud native. To develop a telco-grade cloud native application, the application must be a completely new design – one that starts from scratch and incorporates cloud native principles.
Initiating the first 5G standard in 3GPP Release 15, 3GPP defined a service-based architecture (SBA) for the control plane of 5G core. For Release 17, it is considering expanding the SBA to the user plane, which changes the N4 interface between decomposed UPFs and the control plane to a service-based interface (SBI) that lets UPFs report events directly. This new approach would allow the user plane to leverage the benefits of cloud native. One of the important factors in the SBA design is the size of the service, which varies depending on the degree of granularity of network functions. Generally, smaller sized services require an increase in signaling messages, which increases overall latency, whereas bigger sized services result in network functions that would be similar to the existing VNFs, which diminishes the benefits of microservices. Therefore, it is essential to derive the optimal size of the service.

The core principles behind the cloud native design of the Samsung 5G Core are:

- Break down of network functions into the smallest possible capability;
- Develop needed services by leveraging open source components as much as possible; and
- Identify and solve the bottleneck points for telco-grade reliability and stability.

Hybrid Virtualization and Cloud Orchestration – Samsung's microservice architecture is well-matched with containers and cloud native technology in terms of infrastructure. With the development of cloud native technology, the telco infrastructure is on a path to leverage the container-based architecture. But until then, solutions will incorporate a mixture of VMs and containers. In virtualized legacy networks like the EPC and 5G NSA Core, network functions that create real-time services and manage the user plane traffic typically run on VMs, which is appropriate for supporting services that do not have strict latency requirements or network configurations. Meanwhile, operators use containers for broadband services that need scalability or services that are not susceptible to failures. Therefore, to support interworking with existing networks, the 5G Core requires virtualization and orchestration technology that can support both VMs and containers at the same time. The Samsung 5G Core does; it can support hybrid virtualization that enables seamless migration from VNF to CNF; it can also support hybrid cloud orchestration that integrates and manages all physical, virtualized, and containerized resources.



CNF	: Cloud native Network Function	**NFV**	: Network Function Virtualization	**VNF**	: Virtualized Network Function
CNFM	: CNF Manager	**NFVM**	: NFV Manager	**VNFM**	: VNF Manager
DSO	: Domain Service Orchestrator	**NFVO**	: NFV Orchestrator	**SCO**	: Samsung Cloud Orchestration
GSO	: Global Service Orchestrator	**VM**	: Virtual Machine		

Figure 2-5 Samsung Hybrid Virtualization and Cloud Orchestration

High Availability – One of the risks of cloud native-based technology is that, due to the rise in transactions among loosely coupled services, the chances of failures also increase. For decades, Samsung has developed and deployed network elements that interwork with a wide variety of legacy network equipment. This experience creates a comprehensive knowledge of issues that may arise in the interworking of unstable systems, as well as the expertise to resolve them. Samsung has rich experience in building anti-fragile systems where predicting signaling traffic volume is difficult. For example, when one network element is congested and affects other network elements, existing Samsung implementations prevent malfunctions through signaling throttling.

Telco-specific Platform Service Support – In cloud environments, monitoring is critical for operational efficiency. Although there are many open monitoring tools available, there is still insufficient support for telco-specific protocols, like SCTP, Diameter, and GTP. Samsung is leveraging its strength in telco-specific protocols and applications to ensure that these open-monitoring tools meet the needs of telco operators. With telco-grade software pursuing cloud-based software architecture using microservices, these solutions will suffer more and different problems than IT-based software. In telco-grade solutions, strict reliability and availability are critical, so finding the right solution for the new architecture is a challenging and essential task. Samsung has many references in the mobile core, available tools, and rich development experience. Such legacy combined with Samsung's decades of technical carrier-focused innovation positions Samsung as a leader in the evolution of cloud native 5G.

The Next Step of Cloud Native Samsung 5G Core

With cloud native, 5G networks will continue to evolve with the proliferation of 5G. In line with this growth, the cloud native Samsung 5G Core keeps evolving to the architectures that can provide multi-cloud and serverless solutions.

Multi-cloud – The 5G standard is evolving to define ultra-low latency connectivity and edge computing. To efficiently provide low latency services and mobile edge services in environments where public clouds are prevalent, the 5G network environment is changing to multi-cloud environments that simultaneously use on-premise, private, and public clouds.

By using public clouds, 5G operators can quickly introduce multi-access edge computing (MEC) applications and enterprise environments. To meet the needs of 5G operators, the Samsung 5G Core will support multi-cloud. To enable private cloud platforms, in addition to Samsung Cloud Platform (SCP), VMware and RedHat OpenShift will be supported in the first half and the second half of 2020 respectively. Similarly, to leverage public cloud platforms, the Samsung 5G Core is developing support for AWS with EKS/SCP and MS Azure with AKS in the second half of 2020. Samsung 5G CNFs will be easily ported across these cloud platforms, and Samsung Cloud Orchestration (SCO) will offer hybrid orchestration to deploy and manage Samsung 5G CNFs across the cloud platforms. Figure 2-6 shows examples of multi-cloud environments. The left figure shows a hybrid based multi-cloud that combines private and public cloud environments. The operator builds its private cloud on COTS servers and runs 5G CNFs (vRAN and basic vCore) on those servers. The vCore operates at a defined level of capacity on the private cloud, and if the vCore traffic suddenly exceeds planned limits, the system can offload the excess traffic to the public cloud. Operators can deploy and run Samsung 5G CNFs on both clouds without being affected by the private and public cloud infrastructure. The figure on the right illustrates a public cloud-based multi-cloud combining public cloud environments. In this architecture, operators deploy Samsung 5G CNFs (vRAN and vCore) across multiple public clouds. Latency sensitive DU and user plane functions run on-premise, which is also a public cloud built on the servers provided by a public cloud provider. In this configuration, operators can deploy Samsung 5G CNFs to run seamlessly across both public clouds. If the public cloud environments are identical, the operator can use the same infrastructure and a consistent set of services and tools.

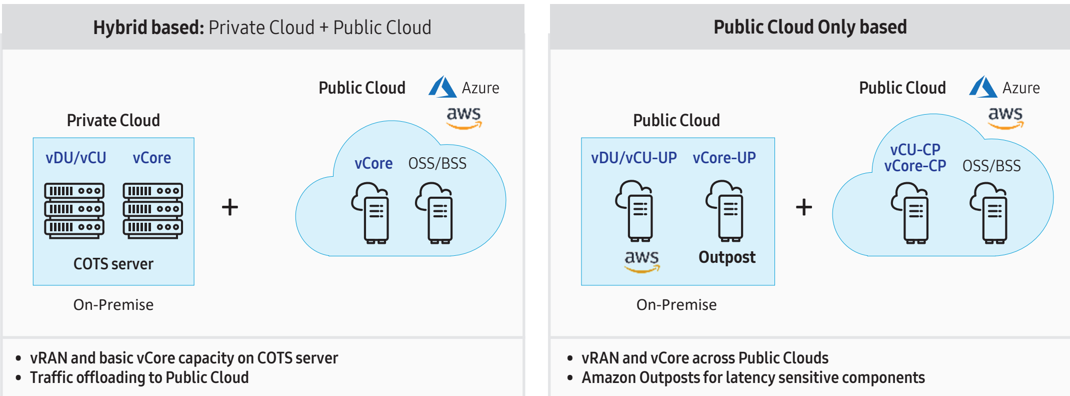


Figure 2-6 Examples of the Evolution of Samsung 5G Core: Multi-cloud

By building multi-cloud environments and leveraging public clouds with high scalability and better operational efficiency, 5G operators and enterprises can improve service agility and flexibility. To support multi-cloud solutions, the Samsung 5G Core utilizes open source technology to automate and optimize the management of its 5G CNFs across multiple cloud platforms. These enhancements will strengthen the monitoring and analytics and by providing automatic feedback.

Serverless – Serverless refers to a cloud computing model whereby application developers do not need to perform server provisioning or manage the scale of their applications. By reducing the burden on server provisioning and management tasks, operators can focus their developers on developing their applications, and by automating management tasks, operators also reduce their OPEX by minimizing dependencies on the operating environment. In the public cloud service, currently available serverless solutions include AWS Lambda, Azure Functions, and Google Cloud Functions; for on-premise clouds, there is KNative/KEDA. Samsung Cloud Native 5G Core plans to further strengthen platform service functions such as monitoring, debugging, testing, and analytics to support easier implementation of network functions and services. Samsung will continue to follow and apply could native principles and architectures in line with business models pursued by operators while also innovating and showcasing new technologies for 5G solutions.

Open Source Activity

Why Open Source

With the 5G Core, 3GPP revolutionized the mobile core architecture by introducing the concept of virtualization and cloud. The 5G core architecture that adopts the recent technologies of cloud and web is a service-based architecture (SBA), where microservices combine to form network functions that are packed in containers and deployed automatically.

5G, where everything is connected, aspires to be the next-generation network platform that connects and integrates solutions across industrial sectors. Thus, 5G mobile network should not only be rolled out and managed dynamically to meet the diverse needs of customers, but also open to third parties to integrate across industries. Above all, it must quickly build its network infrastructure and expedite service launches and upgrades that support and enable customers' business successes.

Open source is a powerful enabler of innovation that transforms telecom networks into a service platform. Collaboration using open source can accelerate the development of sustainable services cost-effectively. The telecom industry is moving toward this direction by adopting open source technology. Many players are actively opening up their development solutions to open source communities that are becoming the de-facto standards, which allows their products to be further improved by third parties and enables the expansion of sustainable 5G ecosystems. At the center of this movement are the Cloud Native Computing Foundation (CNCF) and Linux Foundation Networking (LFN), which facilitates collaboration and operations across open networking projects.

Samsung Open Source Activity

Samsung began working with various open source projects in the 2000s, having embedded open source software in a variety of IT, Mobile, and Consumer Electronics products. Currently, open source is applied to 80 to 90% of its software development, and Samsung is expanding its open source activities to future technologies like 5G, AI and Robotics.

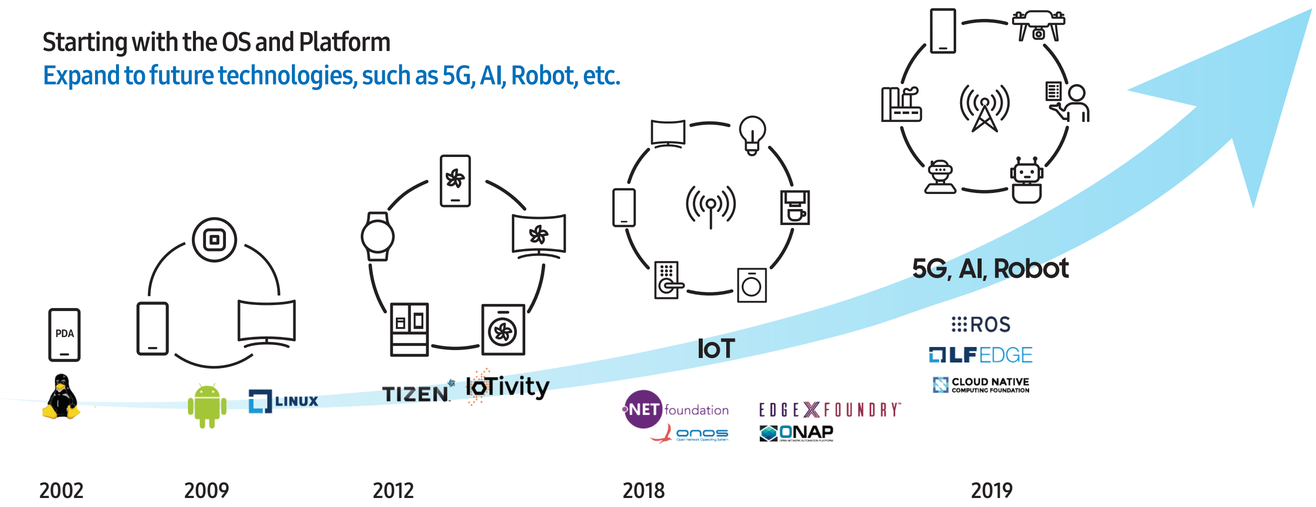


Figure 3-1 Samsung Open Source Progress (Keynote, SOSCON 2019)

In the area of 5G core and network automation, Samsung is focusing on securing and expanding 5G core ecosystems by actively working on CNCF and Open Network Automation Platform (ONAP,) a project under LFN. Samsung benefits from adopting open source practices because:

- Using an open source approach reduces development costs and accelerates time-to-market;
- Being involved in open source projects allows Samsung to understand current trends and developments in the technology; and
- Participating in open source communities enables Samsung to identify the needs of potential customers.

CNCF – CNCF is leading the de-facto standards for cloud native technology. It adopted Kubernetes as the default open source for container cluster management and aims to apply container-packaged, microservice-oriented applications to enable enterprise scale. To adapt to the rapidly evolving open source and telco environment and to introduce cloud native environments into its future technologies, Samsung joined CNCF in August 2019 and has been working on the Telecom User Group (TUG), a standard group under CNCF, as well as other projects.

The main goal of the TUG is to derive the specialized functions and requirements of telco networks and to identify and analyze the gap between solutions for IT and telco systems. TUG also

- builds testbeds for apple-to-apple performance comparison between VNF and CNF,
- designates CNCF open sources associated with the telco requirements, and
- delivers monitoring information and the requirements to be reflected in de-facto standards.

Through TUG activities, Samsung is contributing to integrating cloud native environment into telco environment by cooperating with global telco operators and equipment manufacturers.

Besides TUG, Samsung is contributing to the development and improvement of open sources in various projects. Samsung is a reviewer for the Kuryr project at OpenStack to support Kubernetes and is also proposing and developing the functions that support resource management that optimize the performance of 5G CNFs in Kubernetes environments. Examples of these contributions include the Node Topology Manager, support for Non-Uniform Memory Access (NUMA), and improvements in Linux huge pages that are being developed in the Kubernetes improvement projects. Through these activities, Samsung strives to make significant contributions that will deliver improvements that bring telco-grade performance for 5G CNFs.

ONAP – ONAP is a representative open source networking project hosted by the LFN. It is currently developing a massive scale automation platform that orchestrates and automates xNFs from central data centers to edge/on-premise data centers through the E2E lifecycle management of network services.

Operational efficiency is one of the key factors driving the transition to cloud native, which allows operators to focus on service development by simplifying the complexity of network operation and management. For deployment of cloud native applications, CNCF Kubernetes is regarded as a robust de-facto standard, that improves portability among various cloud environments. On the other hand, for end-to-end network management and orchestration, CNCF Kubernetes struggles to obtain operational efficiency due to the lack of any successful de-facto standards. ONAP is emerging as a compelling candidate for a de-facto standard in network automation and orchestration to manage 5G core functions as it can reduce integration and deployment costs of operators' heterogeneous equipment.

Samsung joined LFN as a platinum member in 2018 and has been proactively pushing for ONAP standards as an ONAP board member. Samsung is contributing to the development of ONAP's main components, such as service design, service orchestration, and policy framework. In addition, Samsung's areas of interest in ONAP include security hardening and provisioning. In security hardening, Samsung led the activity to perform penetration tests on the software, and in provisioning, it contributed to the adaptation of ONAP provisioning tools (offline installer) to fit production network deployments without having access to external networks. Thanks to such active effort, Samsung has become a driving force in the ONAP community, ranking second in number of commits for ONAP for 2019.

For more information on Samsung's activity on ONAP, see the LFN Blog "LFN Member Spotlight: Samsung"

Samsung 5G Open Labs

Simplifying the complexity of multi-vendor environments is critical for the commercialization and growth of 5G. In addition, securing the interoperability of E2E 5G core solutions in multi-vendor environments can optimize the operator's CAPEX and OPEX.

Currently, Samsung is operating 5G Open Labs in Suwon, Korea, and Samsung Electronics America (SEA) Plano in the United States. The purpose of operating these 5G Open Labs is to confirm interoperability and robustness of 5G core solutions and to integrate Samsung Cloud Platform (SCP) and its partners' CNFs. Samsung will obtain the best of breed components in the E2E Samsung 5G Core through partnerships with top-tier vendors for each 5G Core function, including data layer, policy, charging, to name a few.

Suwon 5G Open Lab, located at the headquarters of Samsung, provides optimized test environments for 5G/4G xNFs and performs integration for IOT and commercialization with all partners. Samsung Electronics America Plano 5G Open Lab offers optimized test environments for 5G/4G RAN and Core. It is also responsible for conducting various 5G/4G tests for North American operators, including demos and commercial trials.

During the process of IOT and integration, any ambiguities found in 3GPP 5G standards are clarified, which strengthens the openness and reliability of Samsung 5G core solutions. Samsung is preparing for 5G SA commercialization scheduled for 2020 through partnerships with both Korean and global telco operators based on the 5G core solutions verified through 5G Open Labs and is establishing a strong position in 5G core market.

Through 5G Open Lab activities, Samsung continues updating IOT specifications with existing partners in line with 3GPP 5G standard timeline. At the same time, Samsung continues to search and discover new partners and new network functions to expand E2E 5G ecosystems that encompass SA device – NR – SDN – Core – Platform – Orchestrator.

For more information on 5G SA Core, see the article
"Samsung Completes Multivendor Interoperability of Cloud-Native 5G Standalone Core with HPE & Openet"

The success of open source depends on building and expanding ecosystems. Samsung will accelerate the development of 5G Core solutions and the expansion of E2E 5G ecosystems by further strengthening open source project activities and boosting Samsung 5G Open Lab operations. These efforts by Samsung are hastening the commercialization of 5G SA Core by fortifying its openness and reliability. In addition, Samsung will secure future technologies in the evolutionary path of 5G Core and provide customers with truly new values and unprecedented experiences of the 5G era.

Closing

Samsung will offer a commercialized 5G SA solution in the first half of 2020. With the commercial availability of 5G SA, which introduces 5G core functions, innovative 5G services fully utilizing the characteristics of ultra-high speed, ultra-low latency, and massive connections will finally be possible.

Samsung's 5G SA-ready cloud native 5G Core allows network operators to launch new services quickly and upgrade frequently according to their business needs while reducing OPEX by providing higher operational efficiency. The cloud native Samsung 5G Core solutions using microservices architecture, container-based execution environment, E2E dynamic orchestration and automation, CI/CD, open source platform services, telco-grade performance support, and telco-oriented open sources will deliver an E2E solution that drives success for network operators. With the adoption of cloud native architecture, Samsung 5G Core transforms into a service platform that can scale easily from small to large capacity. In the era of 5G that will soon come into full force, Samsung 5G Core will continue to pioneer the 5G innovation success for operators.

Abbreviations

AKS	Azure Kubernetes Service
AWS	Amazon Web Services
AMF	Access and Mobility Management Function
API	Application Programming Interface
AR	Augmented Reality
AUSF	Authentication Server Function
B2B	Business-to-business applications or services
B2C	Business-to-consumer applications or services
CD	Continuous Deployment
CI	Continuous Integration
CNCF	Cloud Native Computing Foundation
CNF	Cloud native Network Function
CNFM	CNF Manager
CNI	Container Network Interface
COTS	Commercial Off-The-Shelf
DPDK	Data Plane Development Kit
DSO	Domain Service Orchestrator
E2E	End-to-End
EKS	Elastic Kubernetes Service
eMBB	Enhanced Mobile Broadband
EPC	Evolved Packet Core
GCP	Google Cloud Platform
GSO	Global Service Orchestrator
GTP	GPRS Tunneling Protocol
IT	Information Technology
IoT	Internet of Things
LTE	Long Term Evolution
LFN	Linux Foundation Networking
MME	Mobility Management Entity
NEF	Network Exposure Function
NF	Network Function
NFV	Network Functions Virtualization
NFVM	NFV Manager
NFVI	NFV Infrastructure
NFVO	NFV Orchestrator
NR	New Radio
NRF	Network Repository Function
NSA	Non-Standalone
NUMA	Non-Uniform Memory Access
mMTC	Massive Machine Type Communications
ONAP	Open Network Automation Platform
OVS	Open vSwitch
PCF	Policy Control Function
PCRF	Policy and Charging Rules Function
PNF	Physical Network Function
RAN	Radio Access Network
REST	REpresentational State Transfer
SA	Standalone
SBA	Service Based Architecture
SBI	Service Based Interface
SCO	Samsung Cloud Orchestration
SCTP	Stream Control Transmission Protocol
SDN	Software Defined Networking
SMF	Session Management Function
SR-IOV	Single Root I/O Virtualization
UDM	Unified Data Management
UDR	Unified Data Repository
UDSF	Unstructured Data Storage Function
UE	User Equipment
UPF	User Plane Function
vCore	Virtualized Core
URLLC	Ultra-Reliable Low-Latency Communication
VM	Virtual Machine
VNF	Virtualized Network Function
VR	Virtual Reality
vRAN	Virtualized RAN

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Samsung inspires the world and shapes the future with transformative ideas and technologies. The company is redefining the worlds of TVs, smartphones, wearable devices, tablets, digital appliances, network systems, and memory, system LSI, foundry and LED solutions.

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