SAMSUNG

Technical White Paper

Private Networks with Samsung Compact Core

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Contents

Introduction

One of the first things that people think of, when talking about mobile networks, is public networks. A public network is broadband network that is designed by Mobile Network Operators (MNO) to provide network services to the general public. In a public network, people choose an MNO of their choice and pay for services, which then allows people to use the network anytime, anywhere. In addition to public networks are also private networks. A private network, coined as a non-public network in 3GPP, is a type of network that is designed for typical enterprises, such as companies and schools, to provide their own services for their own purposes. In a private network, only authenticated people can access the network.

Figure 1 shows the use of a private network. The private network in Figure 1 can interwork with the public network to provide services. However, the private network is capable of providing its own network service without any interworking with the public network, depending on the customer's request. Private networks that do not connect with the public network can provide high levels of security and closed-down services. However, pure private networks may cost more than private networks that connect to the public network, as they may require more configuration and operation fees than the hybrid networks. Therefore, how a private network is configured depends on the network characteristics (e.g., security level, network latency for service, operating cost, etc.) required by the customer.

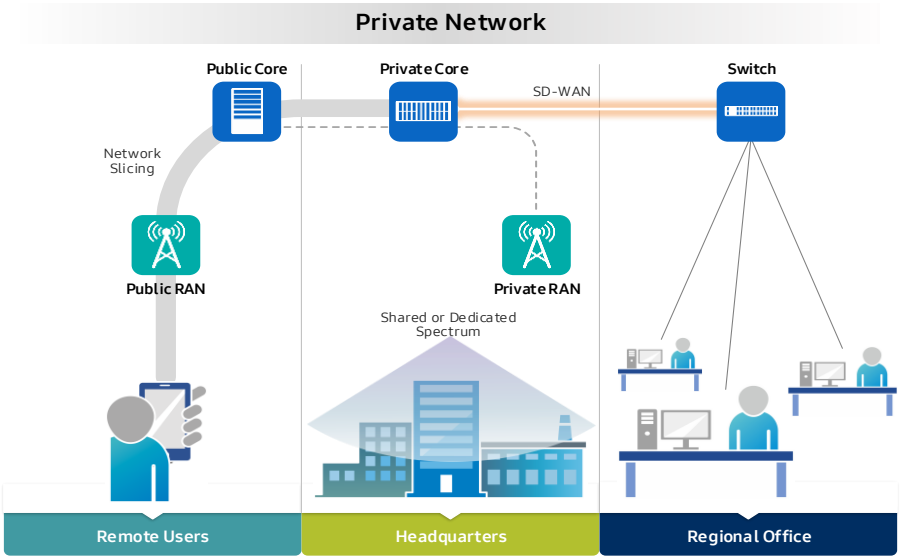

Figure 1. Private networks

Compared to 4G, a big challenge of 5G is how to support a broad range of devices and services that come from various verticals. Such services include private network, smart factory, and smart building for enterprises. Therefore, the 5G network should be designed in such a way to provide not only existing macro services but also private services.

The private network requires several features different from public network, such as easy installation, easy management, etc. To this end, Samsung has developed a private network solution called Compact Core. This paper outlines the private network using Samsung Compact Core, as well as the appropriate deployment plans and benefits.

Key Features of Private Networks

Compact sized network solution

Generally, the capacity requirement of a private network is smaller than that of a public network. Therefore, a compact sized network solution is required for private networks. Samsung Compact Core is a network-in-a-box solution which can be molded to fit a diverse case of deployment models and is differentiated from the macro core system. The Samsung Compact Core is a private core system for the enterprise customers that want to build an 'enterprise-only' private core.

The compact-core solution preserves key features of the macro core solution, while reducing the number of servers by using the public cloud and including enterprise-specific requirements. The biggest merit of the solution is its cost benefit. With such advantages, the Samsung Compact Core based on Long Term Evolution (LTE) technology has been deployed commercially in Railway networks in Korea. With the containerized Compact Core development, Samsung is seeing 5G Compact Core business opportunities for Local-5G in Japan and Citizen's Broadband Radio Services (CBRS) in the USA, etc. Samsung is cooperating with other companies to provide customized solutions for different customers as to ultimately extend its products and service portfolios to meet unique customer needs. Figure 2 below highlights the key features of Samsung Compact Core.

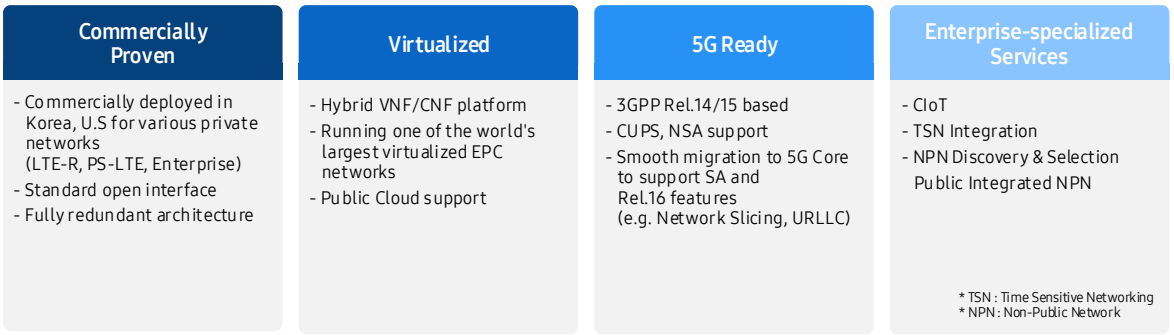

Figure 2. Samsung Compact Core key features

Remote management

Due to the nature of the private network, it is common for enterprise customers to build network facilities in their premises. As the number of customers that demand network infrastructure to be located within their campuses increases, the number of core stations that need to be managed also increases, thereby posing a challenge to network operators from an Operating Expenses (OPEX) point of view.

In comparison, the macro core business is larger in size and is equipped with professional technical personnel that can respond immediately when problems occur. In the price-sensitive enterprise market, however, customers do not allocate as much OPEX as that of the macro core. To reduce OPEX, remote monitoring capability (e.g., operating the status of network facilities located in local data centers) is mandated. Moreover, the ability to remotely access problems without having to physically visit a data center is also required.

In the macro core market, installation and commission is a time-consuming and capital-intensive undertaking that often requires arduous prerequisites such as acquisition of data centers and infrastructure. However, in the enterprise market, the IT environment of corporate customers can be recycled to the extent possible. And as mentioned earlier, the price-sensitive nature of the market calls for minimal installation personnel in the field. To this end, it must be possible to remotely install the virtualization infrastructure, network functions and

Operating System (OS) on a server located at the customer's premise. Samsung Compact Core supports such remote management functions to meet the demands of the market.

Multi-tenancy

Multi-tenancy is a software architecture in which multiple tenants occupy and operate on one server. Several clients share a single storage and OS of the same hardware server. Multi-tenancy is especially effective in cases where a MNO operates several tenants' network. The tenants that occupy the infrastructure are prohibited from accessing, sharing, or using other tenants' data such as Data Network Name (DNN) and Single Network Slice Selection Assistance Information (S-NSSAI). Under multi-tenancy, the system can allocate individual management options such as network function provisioning, state information and charging rule per each tenant. In addition, through multi-tenancy, a customized user ecosystem is possible and operators can analyze and summarize several clients' data with one data base server.

Public cloud

In line with recent virtualization trends, the core network functions have also begun transforming into a container based architecture. To support container based network functions, various cloud platforms are emerging. Each platform supports slightly different services above the cloud, giving clients options of platforms to choose from.

Samsung Compact Core is set to support diverse cloud platforms such as Amazon Web Service (AWS), MS Azure, GCP and IBM Cloud, etc. Overtime, the cloud platforms supported by Samsung will become more diverse and thus allow customers a wider pool of platforms to choose from.

Mobile Edge Computing (MEC)

MEC is a key feature that supports Ultra-Reliable Low Latency Communications (URLLC) in 5G. The primary concept of MEC is allowing high speed communication at extremely low latency by computing portions of the traffic at the edge data center rather than the central data center. That is to say that if the User Plane Function (UPF) is located at the edge data center along with applications, the physical distance between devices, servers, and applications in the company will decrease significantly.

In terms of private network, the Centralized Unit (CU) and UPF are located within the enterprise clients' data center. Therefore, an MEC environment would be naturally established meeting the requirements of latency sensitive services. Moreover, Samsung Edge Enabler Server (EES) which is defined on Rel.17 can expose the Quality of Service (QoS) of devices, mobility, and various network services to edge application.

CU Integration

The Samsung macro 5G network solution supports Centralized Radio Access Network (C-RAN) architecture, in which the Distributed Unit (DU) and CU of the radio access network are separated from each other. When a virtualized CU is constructed at the aggregation layer, advantages such as reducing data process time at L3 and improving efficiency of processing dual connectivity are reaped. Enterprises that want to control all traffic flow in their own network would also expect a high level of security. In order to fulfill such requests, the CU needs to be built inside the enterprise data center. To further elaborate, the CU needs to be made smaller and constructed with the UPF to manage their own traffic in the enterprise data center. Samsung Compact Core solution includes both the CU and the UPF.

Private Networks Architecture

The architecture and function of private network may vary according to the customer's requirement such as security level, service latency, and operating cost. Therefore, this whitepaper suggests a private network into two major deployment models depending on the customer's requirement, as shown in Figure 3.

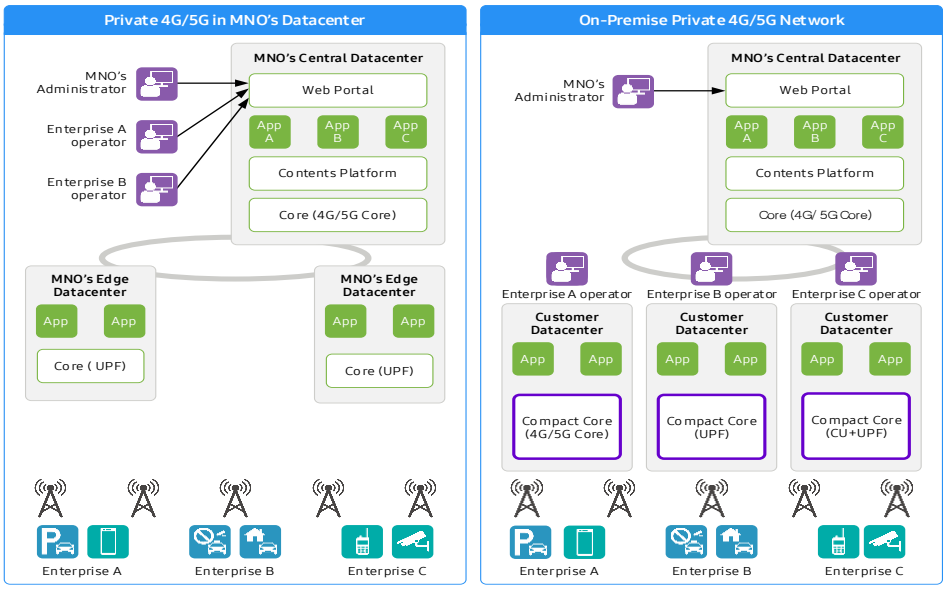

Figure 3. 5G private networks architecture

Case 1: MNO Datacenter

This option is suitable for the small enterprise customer that desires economic feasibility. There is no need to construct the data center within a company's premises, such that the private network can be deployed at the MNO's datacenter with the least initial cost. Companies are able to use the private network service at a minimal cost of periodic maintenance fees. Several companies use the same network facilities but with a logically isolated network. Since multiple companies use the same network facilities, the overall security could be more vulnerable than other options such as on-premise private network. This kind of private network is able to apply different QoS and billing policies. As such, a company utilizing this option can be provided with separated management for billing, monitoring, and statistics.

Therefore, in this option, the private network can be constructed within the public network and the public network operator manages the private network directly. The public network operator constructs the private networks – which is logically separated from the macro network in the data center – and then promotes them to attract various enterprise customers.

Case 2: Enterprise On-Premise

This case is where the private network is constructed with on-premise system in the customer's data center. In this case, there are two options according to the configuration of on-premise system.

Option 1: All network functions On-Premise

This option is where all network functions are built on premise. This option is a completely isolated case where all network facilities are constructed in the company's data center, not in the MNO's data center. Since the network completely isolated, both physically and logically, from other companies or services, the highest level

of security can be obtained through this option. Since the operating volume and costs are different from that of the macro core system for business to consumers (B2C), MNOs need appropriate private network solutions to adjust the service scale. To satisfy such needs, Samsung has developed the Compact Core. Samsung Compact Core integrates various features of core network functions, authentication, charging, and policing, into a single server. In addition to these features, Samsung has also integrated an Edge Enabler Server (EES) for mobile edge computing, application server, cloud platform, and Element Management System (EMS) to the single solution. With the Compact Core, clients can get access to network services which are isolated, private, high in performance and safety.

Option 2: Only user plane On-Premise

In this option, the user plane for the data traffic can be separated from the operator's data center and placed within each company's data center in order to improve security level and reduce latency unlike the first case. While the user plane is separated from the operators' data center and placed in the customer's data center, the control plane for signaling traffic is still located in the operators' data center.

Due to the hardware required for user plane – such as servers, routers, and switch immediacy in the company data center – the latency of network may be reduced. While the control plane of operators is shared, the user plane is physically separated, therefore improving the security levels compared to the first case. This option is suitable for delay sensitive private networks that have sufficient operating budget, as it would cost more compared to the first case. In this option, the operator is in charge of managing the signaling traffic and provides statistics and monitoring management system to the customer. Moreover, if a company constructs an application server in its own data center along with the user plane, this option can support high level security services such as secured network service (e.g., financial service), VIP Services (e.g., Premium User), and ultra-low latency services such as automotive, Industrial IoT Automation, etc.

And in this case, however, it is assumed that the company would operate businesses in several locations and that a private network would be constructed in each branch office. When the private network is constructed at each branch office, the communication with each branch is essential. Therefore, extra routers and switches need to be supplied. The internal switch is different from those used in the public network. The MNO that manages the private network has to determine whether or not the UPFs in the different branches are part of the same client's network. Moreover, since the control planes are located in public networks managed by the MNO, the operator must be able to distinguish if the two private networks are of the same network.

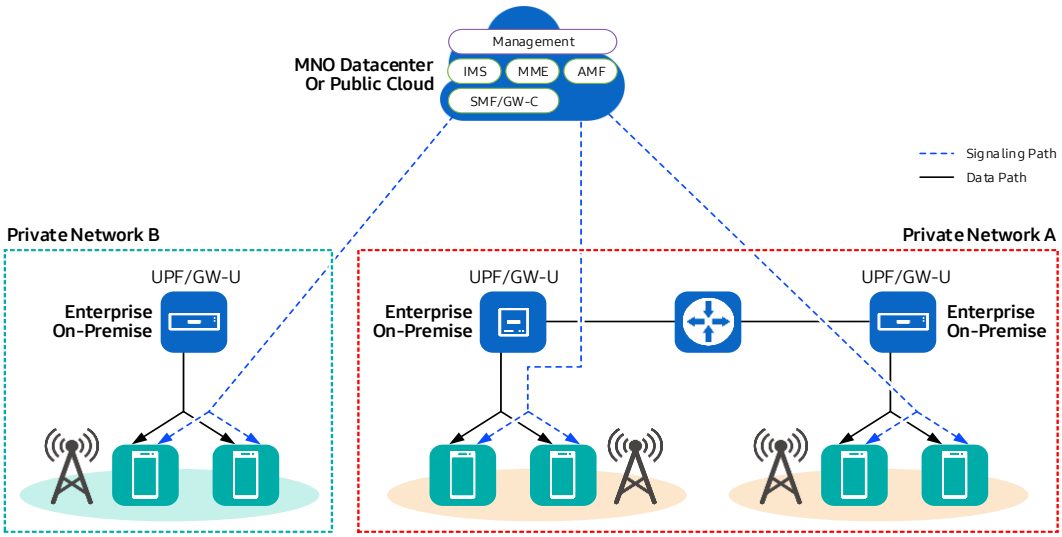

Figure 4. Private networks with user plane on-premise

Samsung’s Experience

Public safety network in Korea

Public safety network is utilized by agencies that deal with disaster relief as means to prevent, prepare, respond to, and recover from disasters. It is also used in dealing with emergencies, rescue efforts, and crime prevention on a daily basis.

The organizations that primarily rely on and use public safety networks are the police stations, fire departments, medical treatment facilities, military, local governments, and utilities. These organizations can choose to use public safety network or to interworking their private network with public safety network.

The public safety network project in Korea began in 2014 with the use of the 700MHz bandwidth for LTE. After the Korean government began constructing the public safety network, it chose a pre-commercial (pilot) project equipment vendor. By the end of the pre-commercial project, the technical demonstration of the public safety network was completed. In October of 2018, the Korean government signed a contract with Samsung to build the public safety network project. Samsung, as the prime operator of the public safety network, now takes more than 88% RAN coverage and the entirety of the core network equipment that run in two operating centers.

Despite the fact that the project was officially underway, the path it took to deploy the public safety network in Korea was a journey that was not only difficult but also long. In early stages of the project planning, non-virtualized core was the mainstream technology in the core market. But considering the future market of the network core, Samsung proposed a virtualized core system. In line with such efforts, Samsung has developed the world's first Mission Critical Push-To-All (MCPTX) system based on 3GPP standard Rel.12. Samsung continues to lead the public safety network market by giving group call trials which allow thousands of simultaneous transmissions using enhanced Multimedia Broadcast Multicast Services (eMBMS) in urgent circumstances.

LTE-R in Korea

In the current railway network systems, network services are limited to voice communications, meaning that response to data services is not available. For voice communications, general railways use VHF, whereas rapid transit railways use both TRS and VHF. A constantly surfacing issue is associated with the type of communication used in rapid transit railways that can be changed to VHF, TRS-ASTRO or TRS-TETRA depending on the location of operation.

To solve this problem, national R&D projects aimed at unifying all nation-wide railway systems by 2026 have been launched. These projects would also target to unite voice communications, data and video transmission, as well as train signal controlling. By changing the railway equipment to an All-IP system – as proposed by this project – system efficiency, high speed, simplicity and optimization of the system can be guaranteed.

On this front, Samsung is constantly pushing to secure competitiveness in the railway industry. At the moment, Samsung is working on train control based on a new radio train control system, Korea Train Control System (KTCS), that supports speeds higher than 350km/h. KTCS is a distinctive standard, yet it is compatible with the European Train Control System (ETCS). The next version of the train control system, the KTCS-2 standard, is currently undergoing test operation and is expected to run until 2021. Once being completed, it will be expanded to cover railway network systems at national scale.

Different railways are operated by different operators who all wish to control their own core systems. However, there are key requirements that are similar across the different operators – competitive pricing and minimized form factor. To satisfy these requirements, Samsung has developed a compact-sized core that runs virtual machine network functions. In 2016, the world's first LTE-R project began in KTX Gyeonggang line using

Samsung Compact Core (VNF version). Through this project, Samsung was able to demonstrate quality performance that led to the signing of further contracts with the other railway lines in Korea.

Other factors that determine the success of the railway network systems include resolving frequency interference – national disaster safety network based on band 28 and other public networks such as LTE-M (Maritime) – and ensuring service connectivity. Samsung has its sights set on extending this competent solution to all LTE based public safety network systems. Such networks, during non-emergency operations, can work efficiently on the integrated platform and support various services. In times of emergencies, the network can be integrated with incident command systems to save people's lives.

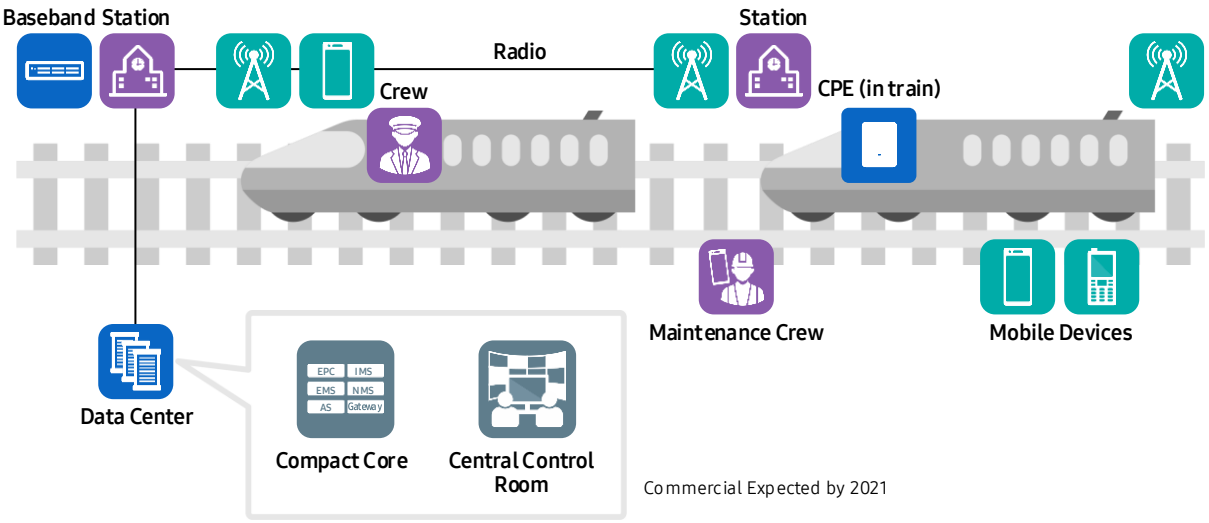

Figure 5. LTE-R in Korea

Enterprise 5G service in smart factory

Samsung have provided 5G service in cooperation with KT, a Korean carrier, in the existing plant since 2019.

The signaling plane and management system were placed in the data center of the mobile carrier, and the user plane dedicated for smart factory was placed in the factory near the base station to secure low latency, a major KPI of smart factory applications.

By separating the traffic between commercial and corporate terminals, the security requirement has been solved. Moreover, low latency was secured through the UPF installed in the factory, to guarantee the performance required for the major use case of smart factory such as robot control or Automated Guided Vehicle (AGV).

The Samsung Compact Core provides a small, flexible form factor that meets to the needs of the enterprise. In addition, it is a solution that can greatly increase network quality from problematic Wi-Fi, in terms of speed, delay, and network reliability. Based on the smart factory experience in Korea, it is expected to expand to global 5G enterprise markets such as Local 5G in Japan.

Summary

Following the launch of 5G services, the market's interest in private networks has increased steadily. The private network in and of itself is not a new technology. It was constructed and used well before 5G services, and many companies have relied on it to prevent sensitive information from being exposed to the outside world. Today, with the introduction of remote control services such as smart factory and smart building, private networks require large data processing powers with extremely low latencies. Given that the characteristics of the 5G technology, such as enhanced Mobile BroadBand (eMBB), URLLC and network slicing, meet the list of requirements demanded by the private networks, it is no surprise that enterprises are looking to incorporate 5G as part of its network. Further, the introduction of 5G is expected to drive the growth of the enterprise market as well.

In preparation for such growth, Samsung has developed the Compact Core. Samsung Compact Core is a product optimized for private networks that include all or some of the network functions required of private networks on a single server, as needed. The Samsung Compact Core can be configured on a single server meaning that it can be installed without limitations in space. Such differentiating factors would make the Samsung Compact Core the most suitable solution for the private network deployment options described in this paper. In addition to the existing solutions, Samsung continues to provide new solutions to meet the growing needs of the private network market.

Abbreviations

3GPP	3rd Generation Partnership Project
AWS	Amazon Web Service
B2C	Business to Consumer
CBRS	Citizen Broadband Radio Service
CPE	Customer Premises Equipment
C-RAN	Centralized Radio Access Network
CU	Centralized Unit
DNN	Data Domain Name
DU	Distributed Unit
eMBB	enhanced Mobile BroadBand
eMBMS	enhanced Multimedia Broadcast Multicast Services
EMS	Element Management System
IMS	IP Multimedia Subsystem
LMR	Land Mobile Radio
LTE	Long Term Evolution
MCPTX	Mission Critical Push-To-All
MEC	Mobile Edge Computing
MNO	Mobile Network Operator
NF	Network Function
OS	Operating System
PTT	Push To Talk
QoS	Quality of Service
RAN	Radio Access Network
RoIP-GW	Radio over IP Gateway
S-NSSAI	Single Network Slice Selection Assistance Information
TETRA	Terrestrial Trunked Radio
UE	User Equipment
UHF	Ultra High Frequency
UPF	User Plane Function
URLLC	Ultra Reliable Low Latency Communications
VHF	Very High Frequency

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