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network-slicing

The essential building blocks of E2E network slicing

Leveraging network slicing for business model innovation

Network slicing enables business model innovation and new opportunities across a wide range of use cases and industry segments. To set up a well-designed network-slicing solution, an integrated approach is needed to combine the different building blocks required to create a flexible, efficient, and secure network infrastructure that can meet the diverse needs of various applications and services.

Network slicing[1] enables the creation of separate use case-specific virtual logical networks on a shared physical infrastructure. Each virtual network, or "slice", is designed to meet the specific requirements of different applications or services. This approach offers significant benefits, such as increased flexibility, improved efficiency, and enhanced user experience.

Together with our leading service providers partners, we have conducted several joint network slicing proofs of concepts and trials in commercially deployed 5G networks to explore and establish the required commercialization and technology strategies, as well as plans for monetization of 5G services, using network slicing as a business enabling platform to explore our various network slicing proof points[2].

To set up a network slicing solution, several building blocks are required and are enabled by technological advances in user equipment devices and network capabilities such as virtualization (NFV), cloud native, edge computing, radio access networks (RAN), transport, software-defined networking (SDN), artificial intelligence (AI), machine learning (ML), orchestration, and assurance. These technological advancements provide the needed impetus for the growth of end-to-end (E2E) network slicing so that growing demands surrounding 5G use cases can be met.

Our network-slicing solutions include end-to-end traffic and management aspects. Powered by our 5G RAN slicing capabilities, the dynamic network slice selection is enabled by User Equipment Route Selection Policy (URSP) and device ecosystem development. This technology is a stimulus for service providers, enabling E2E network slicing commercial trials and deployments for service differentiation and guaranteed network performance, accelerating the growth of network slicing.

In addition to 5G network capabilities, automation across business and operational processes is crucial for successfully monetizing the business models that network slicing enables. All systems involved in the process must seamlessly integrate. To scale up the enterprise business and optimize the benefits of investing, service providers must move from manual business processes to automated flows with a high degree of self-care.

There is no need to wait for every piece of this puzzle to come together—it is possible to start now and evolve from both a business and technical perspective in the consumer and enterprise segments. It is crucial that all players in the ecosystem start with sound business and operational strategies.

To support service providers in this journey, Ericsson offers an end-to-end network slicing portfolio with the building blocks necessary for exploring the full potential of 5G and network slicing for consumers and enterprises. Our specialized consulting services[3] can also help service providers define a winning strategy for monetizing network slicing that is tailored to their needs and market realities.

Contents

[1] For more information, please see 5G Network Slicing - Make Network Slicing easy

[2] For more information, please refer to Unlocking 5G network slicing opportunities with Business and Operations Support Systems

[3] For more information, please see Transform Business services

Network slicing offers attractive new business possibilities

The isolation and independence of network slices offer attractive new possibilities to enterprise customers. By leveraging network slicing, services can be delivered based on tailored service-level requirements.

Enterprise customers can gain control of key parameters such as location, number of connected devices, required bandwidth levels, security and latency, and facilitating expansion within borders regulated in the contract. The new flexibility and capabilities powered by network slicing enable a "network-as-a-service" (NaaS) business model, providing the customer with more visibility, control, and adaptability to suit their changing needs, as if they had their own network.

For example, for a broadcaster[4], the capacity of an operator providing live broadcast video service could be expanded to accommodate anticipated UL/DL bandwidth demand created by a major sporting event and the number of cameras that will be needed to cover the event and its location. Based on a prior commercial agreement between the customer and the network operator, the customer can perform the required service changes on the fly via self-care, potentially by switching HD video quality on or off in targeted cameras with reliable and stable performance. Through the introduction of virtualization and orchestration, customers can gain control of the assets within their service and even request new services on demand with the ability to characterize them for their specific needs, if it is within their contractual borders. All these services leverage the network-slicing capabilities of the network.

It is important to note that end user services, consumed by individual devices and applications, are realized within the network slice. The network slice may therefore contain instantiated management functions needed to supply or maintain the end-user service. In some business models, the NaaS customer may even take full operational responsibility for this service, using in-slice management functions. Although NaaS is proven as a successful business concept, we are moving into a new era of possibilities where use cases will regularly break new ground. As service providers start to grow their network-slicing business, the number of network slices and different types of slices will grow to meet the demands of various industries. Manual configuration of slices, manual management of contracts, manual handling of requests for slice adaptations, and manual updates of the billing cycle will hamper the growth of the business and increase cost and time to market, thereby impacting overall business growth. To meet the associated scale and complexity, it is essential to automate both business and operational processes with dynamic slicing capabilities.

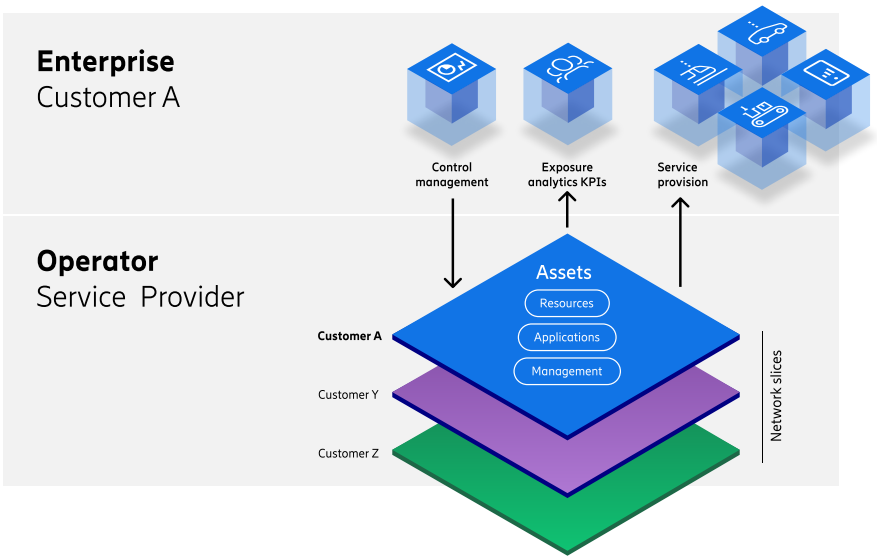


Figure 1 Providing customer control over network slices

[4] For more information, please see the report 5G Network slicing lets broadcasters cover more for less.

Management, orchestration, and monetization capabilities define and keep track of network slice resource allocation, take care of the life cycle management of the slices, and turn them into saleable offerings. These capabilities can be defined per network slice, permitting independent operations and management, resource reservations, as well as customized monitoring and analytics that allow service providers to offer their customers and their customers' partners superior experiences beyond basic connectivity services.

Network slicing is a journey

For service providers, embarking on a journey towards network slicing requires a stepwise approach. The first step is to focus on network connectivity as the major value proposition in use cases. However, as service providers gain experience and expand their role in the ecosystem, they can capture a larger share of the value chain. This journey is driven by both commercial and technical factors. Commercial aspects include factors such as local market demand, ecosystem readiness, use case scalability, and regulatory requirements. Technical considerations include device maturity, end-to-end solution readiness, and local system integration maturity..

We propose a three-step network-slicing journey based on commercial and technical maturity criteria[5]:

1. Pre-configured slicing
This involves pre-defined network slices that are configured based on the needs of specific use cases. The focus is on static configurations that can be reused across similar use cases.

2. Dynamic slicing
In this step, the network slices can be dynamically configured and optimized in response to changing demands. This requires more advanced automation and orchestration capabilities.

3. Exposed slicing
The final step involves exposing the network slices to third-party developers, enabling them to create their own applications and services on top of the network. This requires open APIs and a fully mature ecosystem.

By following this step-by-step journey, service providers can ensure they have the necessary commercial and technical capabilities to successfully implement network slicing and capture the full benefits of this technology.

Complete life cycle management

Business and operational processes work together: this involves the service provider defining the business strategy and commercial products, exposing the products to the market, customers placing orders, decomposing, and activating the order, service providers delivering the services, managing the services and then finally de-commissioning the services. The overall process can be split into eight steps, from the identification of service requirements to service assurance (figure 2).

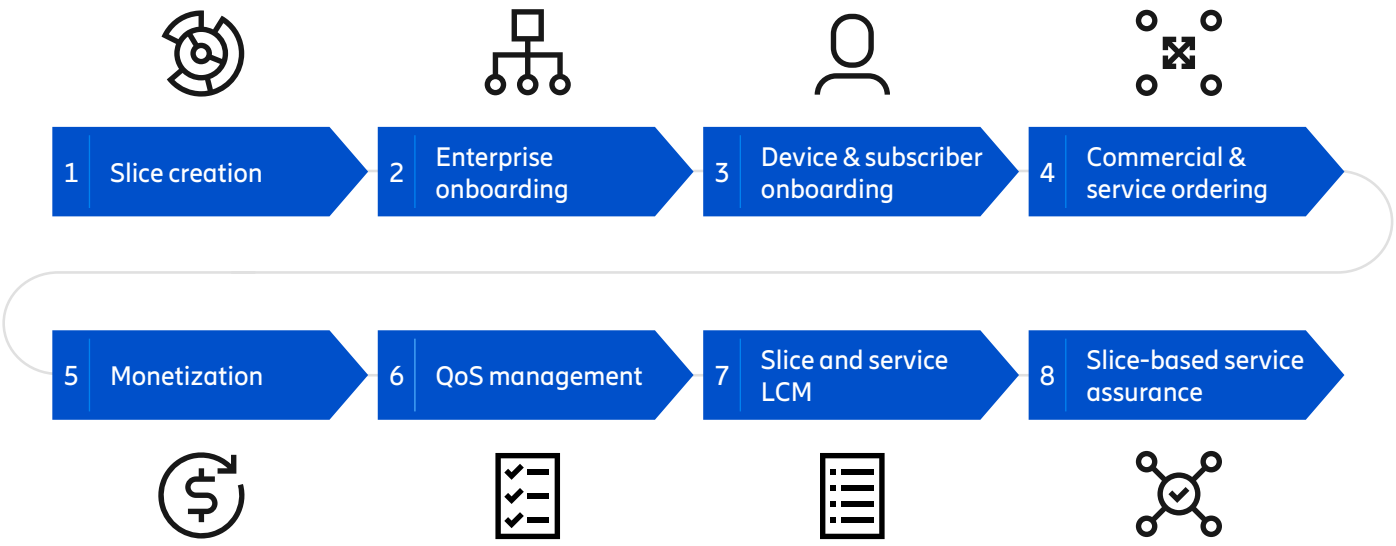


Figure 2 Network slicing E2E life cycle management

[5] For more information, please see The network slicing transformation journey report.

Depending on the selected network slicing solution, each step requires separate sets of capabilities to meet the target solution. A summary of each step and its capabilities is described in figure 3.

	Pre-configured network slicing	**Dynamic** network slicing	**Exposed** network slicing
1 Slice creation	Create few slices and provision services on top of them, service templates are optional	Define network service and enable service templates to create and dynamically orchestrate network slices on demand	Creation of slices and services using an API
2 Entrerprise onboarding	Onboard one or two enterprises manually configuring enterprise parameters	Onboard Enterprise users and other Enterprise parameters automatically	Partner management (add partner, update partner services) through API
3 Device and subscriber onboarding	Add an array of devices and subscribers to new slices using an attribute (e.g. APN) in manual mode	Enable service catalogue and create network slices on demand based on the data from the service catalogue	Onboard subscribers through exposed API
4 Commercial and service ordering	Use resource catalogue to enable basic order management, no need for COM	Configure, price and quote network services from a common commercial catalogue	Expose commercial catalogue to application function
5 Moneti-zation	Support real-time charging through an SBI interface	Provide common place for CDR generation and facilitate execution of policy decisions	Support for multi-sided business models (services provided both by CSP and Enterprise) and different business models in one bill
6 QoS manage-ment	Enable pre-configured QoS parameters and change them manually using slice service type	On-demand change of QoS parameters using service catalogue	On-demand invokation of QoS parameters creation/update/ change by external application using API
7 Slice and service LCM	Enable basic LCM operations (create, read, update, delete) using a pre-configured slice profile	On-demand creation, update and deletion of network slices and related services using service catalogue	On-demand slice LCM through an external application using API
8 Slice-based service assurance	Get basic fault management (FM) and performance management (PM) data for a pre-configured slice	Ability to specify KPIs that can be monitored for a slice and how KPIs are computed.	Allow standards-based API to consume topology augmented FM and PM

Figure 3 Slice life cycle management steps

The end-to-end network slicing solution and its functions

A complete network slicing solution considers all aspects from the moment a service is defined to when it is monetized, including its life cycle management. It spams though all different domains of the network.

The E2E solution comprises enablers in OSS/BSS[6], packet core, RAN, transport, and cloud infrastructure domains (figure 4).

A complete solution considers all aspects of the network slicing and automation transformation.

Monetization

In the **monetization** layer, contracts and service-level agreements can be managed with customers, partners, and suppliers. Retail and wholesale aspects of charging, billing, taxation, dunning, revenue assurance, and financial reporting are handled here too.

The **Charging** function caters to all ratings, balance management, usage threshold monitoring, and CDR generation.

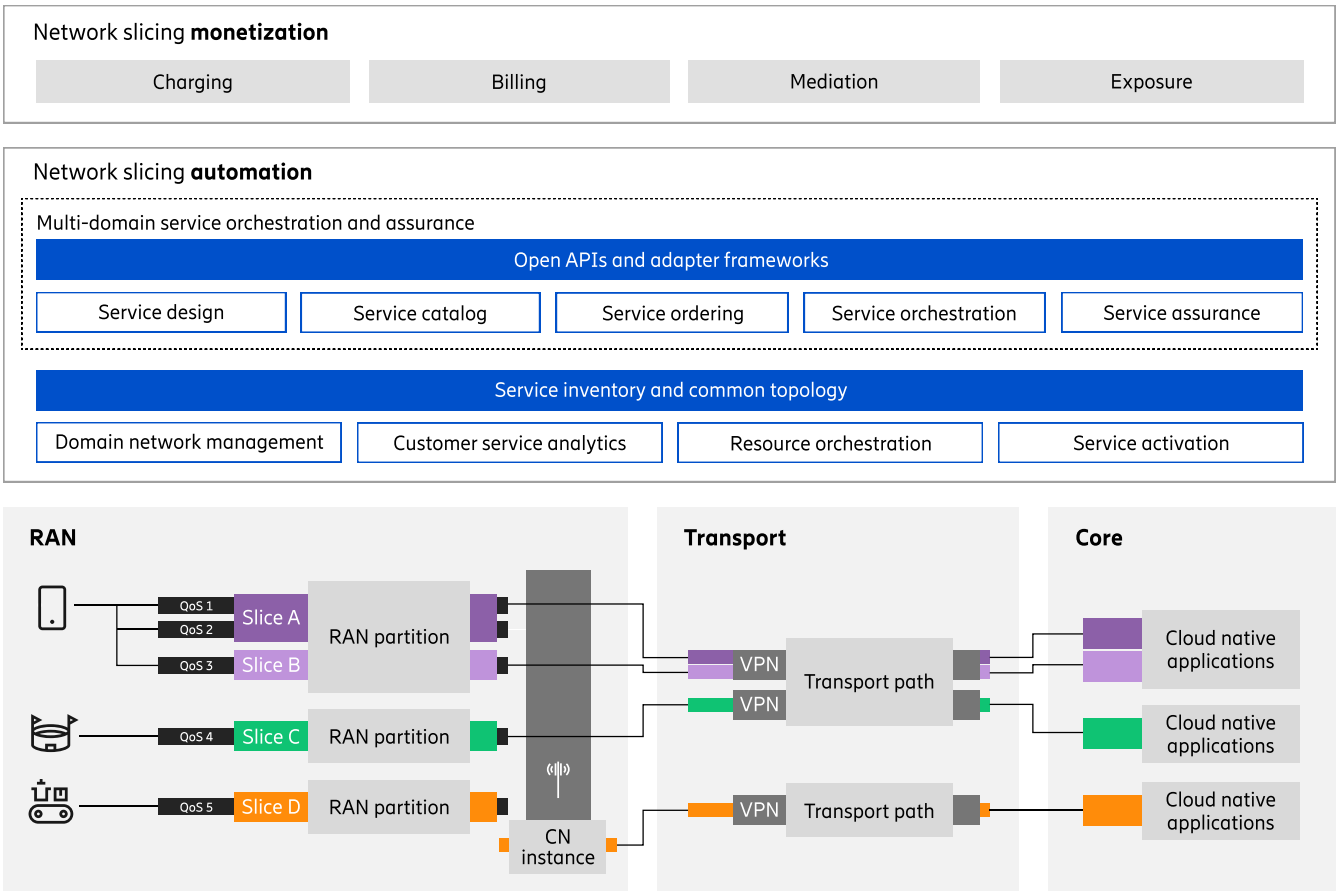


Figure 4 E2E network slicing architecture

[6] For more information, please see OSS/BSS evolution for successful 5G monetization

It supports charging for a network slice with different attributes, such as throughput, latency, number of attached devices, base data volume to be consumed, and more.

The functions in **Mediation** have grown from traditional CDR processing, distribution, and online mediation functions to a versatile integration enabling a toolbox that supports real-time stream data processing using modern streaming interfaces such as Kafka. In this way, it becomes possible to take full advantage of data collected from the network.

Billing, apart from providing obvious functions like bill cycle management, billing and finance, debt collection, and accounts payables and receivables, also caters to the advanced B2B contract, settlement, and relationship management aspects that are key in network slicing-based business models.

The **Exposure** function enables the service provider to grow its role in the value chain and monetize network-slicing capabilities to the broader ecosystem by exposing network attributes via APIs[7].

From a 3GPP perspective, **Charging** implements the Converged Charging System (CCS), including the 5GC Charging Function (CHF), while **Mediation** implements the Charging Gateway Function (CGF).

Automation

The purpose of the automation of network slicing is to enable service providers to provision new slices, adjust resources as needed, and optimize network performance to meet changing customer needs quickly and efficiently.

We provide **multi-domain service orchestration and assurance**[8], covering multi-vendor support and efficient workload placement with pre-integrated service design, ordering, fulfillment, and assurance workflows to provide E2E network slice-based service automation.

The capabilities in **multi-domain service orchestration and assurance** provide the service management and orchestration functions for E2E services, including 5G, IoT, and network slicing. This results in providing E2E network slice orchestration, including life cycle management and configuration using TOSCA templates. It enables cross-domain orchestration across access, transport, and core by interfacing with different domain managers and transport SDN controllers.

Service design enables service templates to be created and dynamically orchestrates network slices on demand in the **Service catalog**. Onboarding of the slice starts in the **Service catalog**, where it becomes a building block for the network service. The commercial product is then created in the commercial catalog, and the products are exposed for browsing via the channels.

When a customer has selected a network slice-based service and placed the order, **Service ordering** decomposes the order to spawn all related technical commands and actions for the network provisioning and activation management layer. Through automation, **Service orchestration** deploys the network slice across all network domains and delivers the network-based services and resources that realize the commercial product offering.

Finally, **Service assurance** monitors the service performance and system health to secure the SLAs. This is achieved primarily via closed-loop processes and secondarily via notifications sent when critical business KPIs are broken, and customer compensation is required. SLA definitions and service-level specifications are integrated with service orchestration and service assurance and connected to the contracted business SLA with customers.

From a 3GPP perspective, the functions of service design to assurance implement the NSMF and NSSMF for RAN, transport, and mobile core.

Other important components of the E2E architecture in the automation layer are:

- **Service inventory and common topology** to store and manage the physical, logical, virtual, and service resources a service provider needs to manage its network and service offerings.
- **Domain network management** implements the NSMF and provides the domain management function for Ericsson RAN, Core, and Transport network functions. It interworks with resource orchestration during the deployment of a network slice. It also provides fault-management, configuration, accounting, performance, and security (FCAPS) functions for the PNFs, VNFs, and CNFs.
- **Customer service analytics** delivers the key components for operational and business SLA fulfillment. Operational and commercial SLA management is a must in enterprise businesses, and this function provides the necessary analytics insights to act on contracted key KPI thresholds.
- **Resource orchestration** implements resource orchestration and lifecycle management of the VNFs, physical network functions (PNF), and cloud-native network functions (CNF) across hybrid cloud infrastructure.
- **Service activation** manages activation in the network components.

[7] For more information, please see Monetizing API exposure for enterprises with evolved BSS

[8] For more information, please see Service orchestration for better service quality

Core network

Ericsson's dual-mode 5G Core[9] solution is built on a cloud-native architecture that can be scaled and distributed optimally across different cloud infrastructure environments. The inherited support of network slicing in this solution is key for service providers to segment the network, allocating dedicated or shared user plane, control plane, and data layer network functions (NFs) to support services and deploy multiple logical networks for different service types over one common infrastructure. This allows service providers to offer tailor-made services to a variety of customers in a cost-efficient manner.

Figure 5 shows a network-slicing deployment model to cater to the unique needs of different business requirements. These network slices represent examples of real-life scenarios based on our ongoing engagement with service providers around the world.

Depending on the needs, one or many E2E network slices are deployed by the service provider. In addition to high-speed MBB services, the MBB slice also supports services such as cloud gaming. Different slices can have the same or different packet treatment for quality of service (QoS) differentiation. They can also have different PDU sessions with the same or different S-NSSAIs. Depending on the requirements, such as low latency, high bandwidth, and security, 5G Core NFs are distributed to meet the specific SLA needs.

For enterprises, the use cases will be fairly well-defined, including manufacturing robots, virtual reality (VR), and augmented reality (AR). As a result, the correct network slice(s) to use is decided at the point of order. In other scenarios, the users' needs may vary—in cases like this, a more dynamic network slice selection could be valuable. Some NFs are simpler to deploy on a dedicated basis.

Standardized enablers and flexible deployment options /or/ Deciding on network functions

The support of network slicing in Core networks consists of standardized enablers and flexible deployment options. The main 3GPP enablers are network slice selection assistant information (NSSAI) and data network name (DNN). During attach and session requests, single-NSSAI and DNN allocate the NF instances that will serve the user.

This enables various deployment models; for certain use cases, all NF instances can be shared between services, for others, dedicated NF instances are deployed. Dedicated NF instances give complete independence and, therefore, full isolation from any other service or its users.

One of the key NFs is a dedicated user plane function (UPF) since it isolates the user data traffic from any possible interference. Furthermore, a dedicated UPF also allows optimized deployment location to cater to low latency of user data traffic. In enterprise scenarios, a dedicated UPF can be deployed on-premises, resulting in user data traffic staying on-premises to avoid the risk of exposure fully.

The next NF to dedicate is session management function (SMF), which is chosen by the access and mobility function (AMF) and isolates the session management. A dedicated SMF allows for optimized deployment, and in enterprise scenarios, a dedicated SMF can be deployed on-premises to enhance the isolation even further.

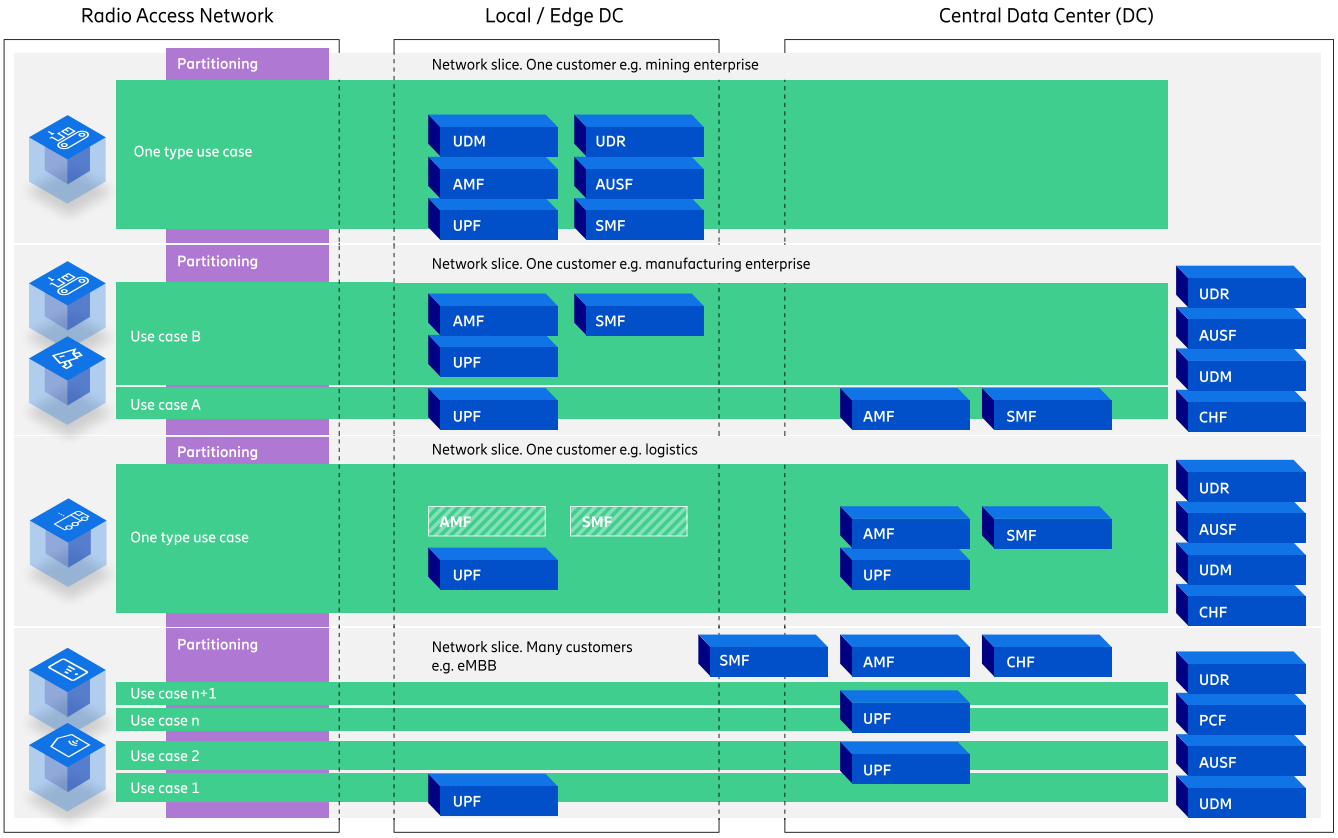


Figure 5 Deployment options for 5G Core network functions within network slices

[9] For more information, please see Ericsson's 5G Core (5GC)

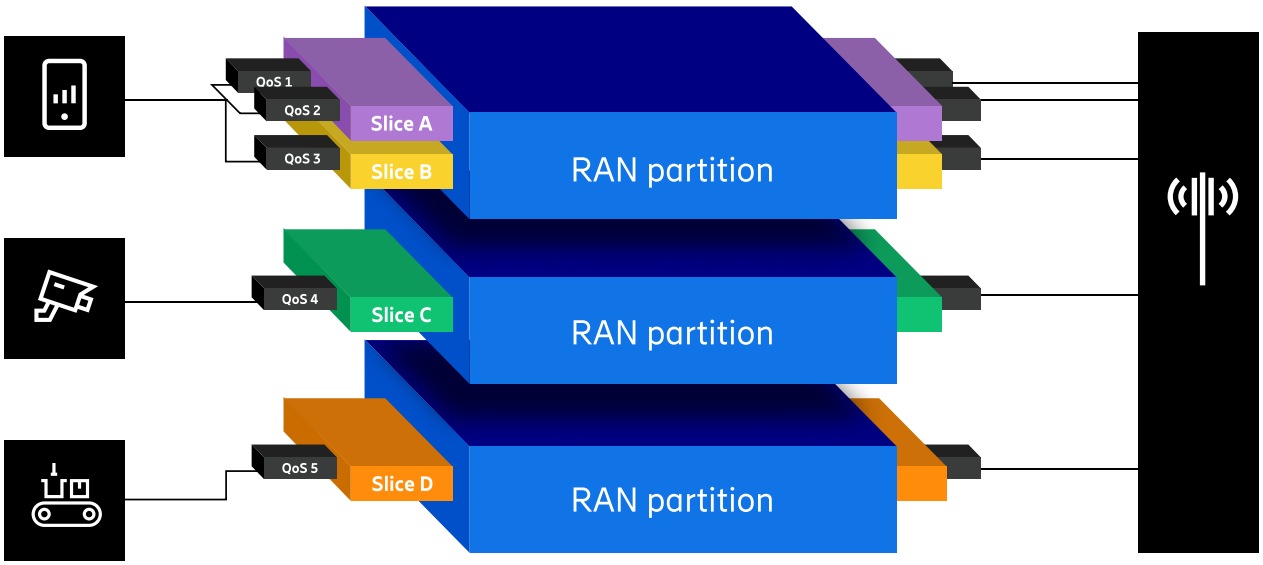


Figure 6 Slicing in RAN

Dedicated AMF isolates most user equipment (UE) control signaling, except during the initial UE attachment that will be sent to the default AMF before the dedicated AMF can be used. In enterprise scenarios, a dedicated AMF can be deployed on-premises to enhance the isolation even further.

To achieve complete isolation in specific scenarios, data management NFs such as UDM, AUSF, PCF, UDR, and other NFs can be dedicated.

Since the user-related information is stored in UDR and used by UDM, AUSF, and PCF during interactions with the possible default AMF, dedicated NFs might not be possible or desirable.

Automation becomes more valuable and necessary when the number of network slices increases. To cater to automation in dual-mode 5G Core, our NFs embrace cloud-native technology and are based on service-based architecture (SBA), where core network services can register themselves and subscribe to other services.

The 5G Core CNFs are delivered with Cloud Service Archive (CSAR) packages that allow orchestration based on MANO. Service orchestration defines artifacts that use the CSAR packages to validate instantiation, termination, and reconfiguration of services.

The 5G Core also includes capabilities like URSP to dynamically place a UE on a slice and to steer traffic from one slice to another according to defined policies to maximize quality-of-experience (QoE) on a single device.

Radio Access Network

Built on a flexible and scalable architecture, Ericsson RAN[10] dynamically optimizes radio resource allocation and prioritization across slices to secure SLA fulfillment of associated services for end users. 5G RAN slicing adds a range of new capabilities to the RAN, strengthening E2E slicing support for dynamic resource management and orchestration. It also offers the possibility of selecting RAN functions in situations with multiple users and groups of users, running multiple services in accordance with the objectives of the operator.

On a high level, one or many E2E network slices may be associated with a RAN partition, as shown in Figure 6. This is realized by E2E network slicing awareness in key functionality areas in RAN, including observability, radio resource management, user plane, transport network traffic management, and mobility.

Radio resource management

Slice-aware RAN QoS implementation enables service providers to create differentiation in their networks. It allows them to allocate adequate resources (including spectrum and hardware) based on subscriber and service requirements.

Important functional areas in the QoS implementation are gNodeB scheduler configuration, with several scheduling algorithms to provide appropriate service differentiation, and radio resource partitioning.

With slice awareness in these areas, the available resources can be allocated according to traffic conditions to meet the service performance requirements for different traffic categories.

The scheduler function, together with admission control, are fundamental to meeting service requirements with efficient use of spectrum resources. The slicing framework provides full flexibility to configure the desired connection handling, such as scheduling priority and scheduling strategy, for the QoS to flow independently for each E2E network slice.

At very high load, admission control protects the scheduler resources to secure desired QoS treatment of all admitted users. Slice awareness in admission control differentiates admitted users based on E2E network slicing.

In addition to admission control, radio resource partitioning provides logical isolation and differentiated performance levels between different traffic groups. It secures that the performance of each traffic group meets SLA requirements. The SLA needs to be described according to the dimensioning of the partition.

Dynamic Radio Resource Partitioning (RRP) enables resources to be dynamically shared between different slices without statically reserving them. Other slices can use any free resources to avoid performance degradation in unloaded conditions by deploying Dynamic RRP.

[10] For more information, please see Ericsson 5G RAN.

The RAN slicing[11] function has been enhanced by adding service-level observability, which acts as the fundamental building block to monitor the E2E SLA and drive the RAN Radio Resource Management function to meet these SLAs. The RAN Slicing function is being further enhanced to add meaningful automation functions so that slicing observability can trigger the RAN Radio Resource Management function for dynamic adjustment to meet the E2E SLA.

Transport network

Traffic from one network slice, or a group of network slices, should be mapped into transport resources using proper identifiers and match the required SLA for the slice or group. Possible identifiers are being worked on in the relevant standardization bodies and may include a QoS indication if needed. There are multiple enablers in the transport domain to support network slicing use cases, and it is important to consider both what the network slice deployment requires as well as the transport infrastructure's capabilities and capacity when selecting which enablers to use.

For the vast majority of use-cases using standard transport services and packet technologies for the network slices or group of network slices (e.g., VPNs over IP-MPLS, SR-MPLS or SRv6, and differentiated services), QoS principles will give adequate support in the transport domain. For network slices, or groups of network slices with multiple internal traffic classes, the use of H-QoS at the transport edge nodes can be beneficial. For network slices or groups of network slices with highly specific SLA requirements, e.g., ULLC services, adding traffic steering principles may be necessary if the transport network[12] consists of multiple possible paths.

Management and orchestration of the transport domain, using domain SDN controllers and a hierarchical transport orchestrator connected to the RAN and Core management domains, are recommended to ensure efficient network slice creation, deployment, mapping to transport resources, and assurance of SLA fulfillment over multiple transport domains. Introduction of support for network slicing in the transport domain can be done using a stepwise approach, using more advanced transport deployment options as the number of network slices with different characteristics increases.

End-to-end network slicing provides service flexibility and makes it possible to deliver services faster with high security, isolation, and applicable characteristics to meet the contracted SLA.

[11] For more information, please see Know how 5G RAN slicing shapes business growth.

[12] For more information, please see Ericsson's Mobile transport solutions.

Summary

Network slicing will play a key role in creating collective wealth across many industry segments by unleashing business model innovation.

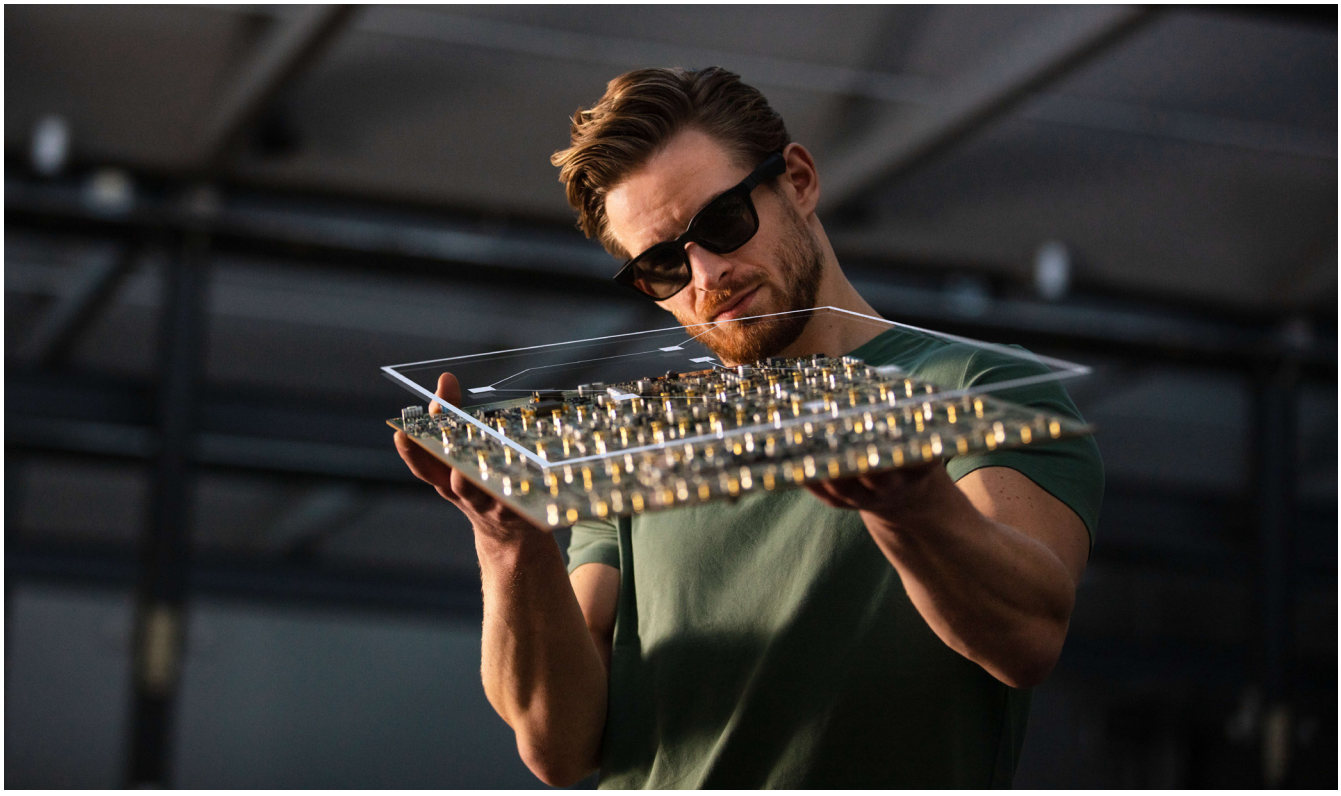
By leveraging advanced capabilities from 5G RAN, Core and Transport solutions and E2E orchestration, network slicing creates tailored and isolated logical networks for individual use cases, apps, or business needs, built on top of the public mobile network. But beyond the underlying technologies, it is business model innovation—brought by network slicing—that will enable various use cases.

Network slicing is a new paradigm and introduces a completely new way of specifying services and delivering them in a flexible, agile, and automated way.

We can provide a full solution, including OSS, BSS, 5G Core, transport and RAN, and cloud infrastructure to automate the process of network slice creation and management and quickly address the swathe of emerging business opportunities.

We work side by side with customers in a collaborative manner, leveraging experience gained from other deployments around the world to address a wide spectrum of use cases with an almost infinite range of possible service characteristics and performance requirements. We have partnered with many global operators in developing and delivering network-slicing-based business solutions[13]. For service providers, the time is right to deploy network slicing, build experience with delivering services in a completely new way, and prepare to maximize the full business potential of 5G. Network slicing will be a significant transformation, with a gradual introduction and maturity, developing new capabilities and adapting to new business models.

Always a first mover with new network-related technologies partner, we can help our customers by defining operator business strategy, monetization models, pricing strategy, identifying use cases, incremental revenue and economic analysis, operating models, and design to build the network slicing journey ultimately.



[13] To learn more, check our public list of network slicing customer engagements

Glossary

AMF	Access & Mobility Function
AUSF	Authentication Service Function
BSS	Business Support System
CHF	Charging Function
CNF	Cloud-native Network Function
DNN	Date Network Name
MANO	Management and Orchestration
MBB	Mobile Broadband
NF	Network Functions
NSMF	Network Slice Management Function
NSSAI	Network Slice Selection Assistant Information
NSSMF	Network Slice Subnetwork Management Function
OSS	Operations Support System
PCF	Policy Control Function
PNF	Physical Network Function
QoS	Quality of Service
RRP	Radio Resource Partitioning
S-NSSAI	Single Network Slice Selection Assistant Information
SLA	Service Level Agreement
SMF	Session Management Function
UDM	Unified Data Management
UDR	Unified Data Repository
UPF	User Plane Function
URSP	UE Route Selection Policy
VLAN	Virtual Local Area Network
VNF	Virtual Network Function
WAN	Wide Area Network

About Ericsson

Ericsson enables communications service providers and enterprises to capture the full value of connectivity. The company's portfolio spans the following business areas: Networks, Cloud Software and Services, Enterprise Wireless Solutions, Global Communications Platform, and Technologies and New Businesses. It is designed to help our customers go digital, increase efficiency and find new revenue streams. Ericsson's innovation investments have delivered the benefits of mobility and mobile broadband to billions of people globally. Ericsson stock is listed on Nasdaq Stockholm and on Nasdaq New York.

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