Subscriber Data Management

Today's SDM for 5G, cloud and future networks

White paper

Subscriber data management (SDM) sits at the heart of the core network, storing valuable data used by diverse telecoms services. Today's SDM solution considers the new market requirements for 5G and cloud-native architectures as well as the operational needs of legacy access networks. This white paper provides an overview of SDM's ingredients and how they support telecom networks as they continue to evolve to cloud-native and 5G.

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Introduction

Subscriber data management (SDM) is a key component of the modern telecommunications network. It looks after the identity management of devices attaching to the network and grants access to network services where appropriate.

While SDM was originally developed for 3G and 4G networks that served billions of subscribers globally, it now also offers a complete solution for 5G. The number and diversity of devices connecting to networks is continuing to increase rapidly, especially with the growth of the Internet of Things (IoT), Industry 4.0 and 5G, all of which call for more data capacity from the network, but also impose different requirements such as ultra-low latency. The 3GPP standardization of 5G adds further specific requirements for SDM, including more secure access to the network and stringent availability and reliability requirements.

The new SDM supports 5G technologies and legacy 2G/3G/4G, as well as other access types such as unlicensed radio access, shared and fixed access. There is also a convergence of the services used by devices, regardless of access technology, requiring data consolidation. Furthermore, SDM provides communications service providers (CSPs) with new levels of deployment flexibility and integration to support the launch of their 5G-related services. New use cases need to be monetized and be integrated with different front ends.

Industry trends and market dynamics in SDM

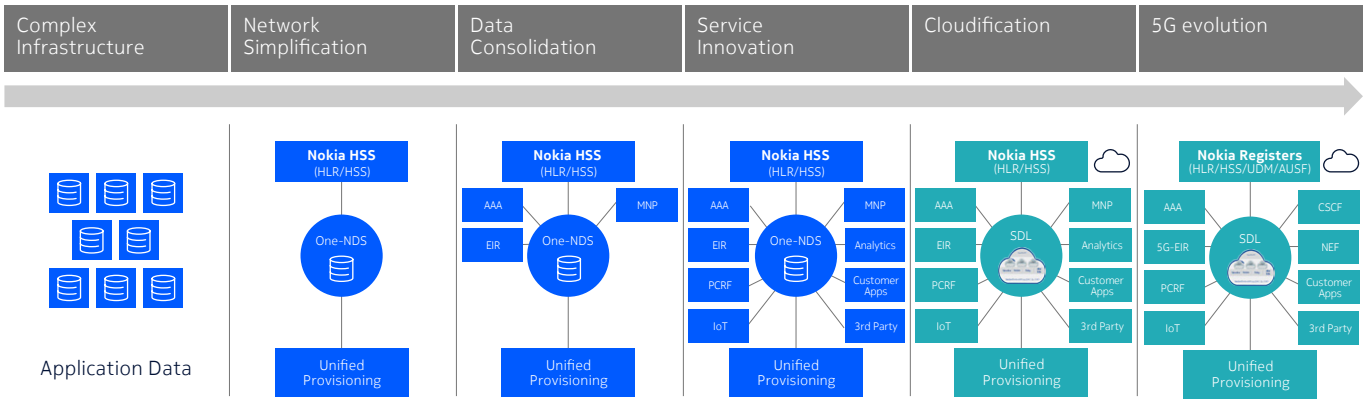
1. The first 5G standards, 3GPP Releases 15, 16 and 17, are already available, while Release 18 is scheduled for completion mid-2024
2. 5G services have been launched in many countries and more and more 5G devices are becoming available
3. By late 2023, more than 270+ CSPs are using SDM solutions in their networks, with 80+ 5G standalone (SA) cases
4. As telecommunication networks continue to evolve towards 5G, the ability of the Nokia SDM to scale protects CSP's existing investment and makes it possible to move resources from 4G to 5G in a fluid way.

The evolution of SDM

A constant aim of SDM has been to simplify network infrastructure and applications, which originally comprised multiple, siloed databases each storing subscriber data for a network element. Deploying a single SDM using a common user data repository was a substantial first step towards network simplification. It allowed multiple monolithic home location registers (HLRs) to be moved to a single logical HLR with data-less application front ends and a common subscriber database with a single point of provisioning. The second step was to add more data-less applications, all sharing a common subscriber database and the same provisioning interface, to support data consolidation and service innovation. CSPs then developed innovative services and business models that required the integration of their own and third-party applications, all sharing a unified data repository (UDR) and provisioning.

The telecom industry is in the middle of cloud adoption and is moving to 5G. CSPs are evolving their current SDM deployments with physical network functions (PNF) and virtualized network functions (VNFs) to true, cloud-native 5G-capable deployments with containerized network functions (CNF). Only a cloud-native core network can deliver the agility, automation and efficiency to enable CSPs to take full advantage of their 5G technology investments.

Figure 1. The evolution of SDM to 5G

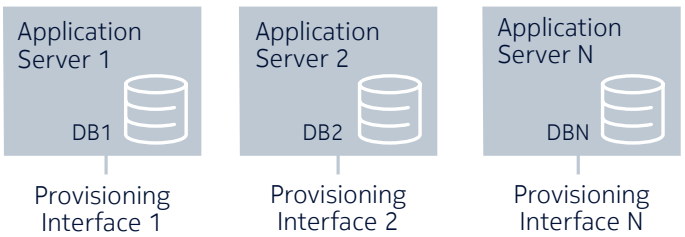


The principles of subscriber data management

When a user or device uses a service in a mobile, fixed or cable network, the relevant subscription information is referred to as subscriber data. These subscription data are stored in subscriber profiles and comprise identifiers like the mobile station ISDN (MSISDN), international mobile subscriber identity (IMSI), authentication data, mobility data and other information permitting or preventing the use of services in the home and visited networks. SDM solutions are network elements or functions that manage subscription data. These include the home location register (HLR) for 2G/3G networks, the home subscription services (HSS) for 3G/4G networks, unified data management (UDM) for 5G networks, policy control function and policy control resource function (PCF/PCRF) for policy data and other applications that manage subscription data.

In 2G/3G networks, application servers such as HLR, HSS and authentication, authorization and accounting (AAA) stored and managed subscriber data, but each had its own integrated database.

Figure 2. Monolithic silo architecture



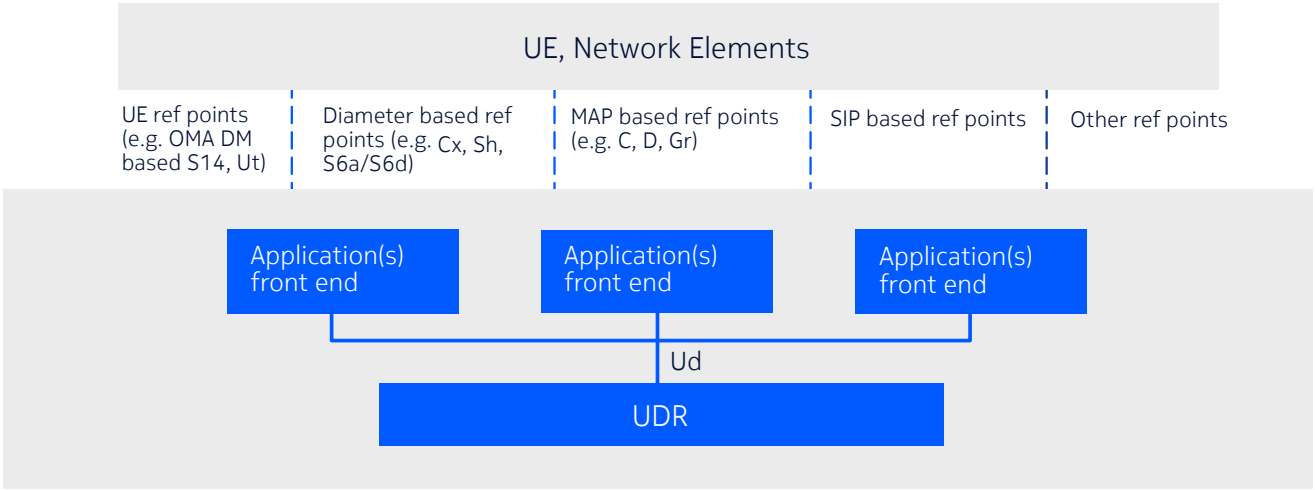
This monolithic silo architecture resulted in high operational costs, principally because:

- Subscriber data were stored in multiple databases, which could be of different types that used different data structures and included partially redundant data, and this complexity led to difficult provisioning and inconsistent data, making the introduction of new subscriber services expensive and slow
- The monolithic silo architecture supported only limited redundancy, so that when a network element with its integrated database failed, all subscribers served by this element lost service. So-called 1+1 redundancy reduced this weakness, but fell far short of N+k redundancy, which is needed for telco-grade availability.

SDM solutions solve these issues by:

- Consolidating all subscriber data in a highly available, geo-redundant UDR, providing a single point of provisioning and a reliable, real-time view of the entire database
- By separating application logic and data storage, enabling data-less application front ends deployed with N+k redundancy.

Figure 3. UDC reference architecture[1]



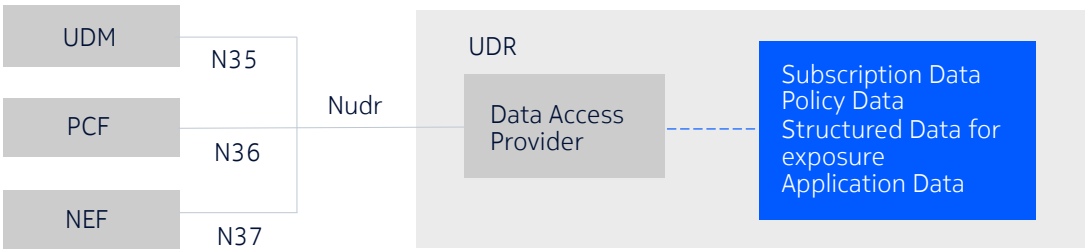
In 2009, 3GPP standardized the SDM architecture and its principles calling it user data convergence (UDC)[2], a development that Nokia actively drove. This SDM architecture has proven to be reliable and robust, with most CSPs having replaced their monolithic silo application servers with data-less application front ends and a common shared subscriber database. SDM architecture has since evolved from bare metal deployments to VNFs and cloud-native network functions (CNFs) using microservices in containers. With 5G standardization in 3GPP Releases 15 and 16, the UDC architecture has been evolved and extended with new 5G network functions, exposing new service-based interfaces and additional functions for unstructured data storage.

1. 3GPP TS 23.335
2. 3GPP TS 23.335: "User Data Convergence (UDC); Technical realization and information flows"

The new 3GPP standardized 5G SDM network functions include:

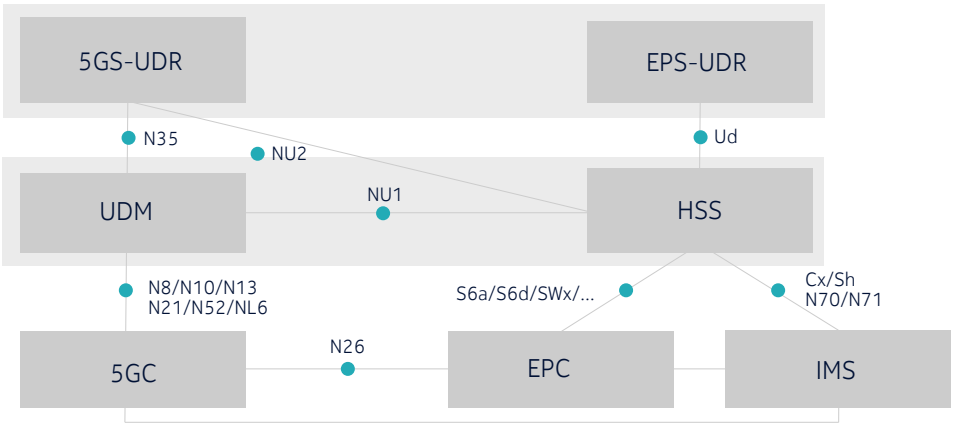
- Unified data management (UDM), the 5G evolution of the HLR/HSS
- Authentication server function (AUSF), a new 5G network function for authentication
- Policy control function (PCF), the 5G evolution of the PCRF
- 5G equipment identity register (5G-EIR), the 5G evolution of EIR for 3G/4G
- Unified data repository (UDR), the 5G evolution of the 3G and 4G user data repository
- Unstructured data repository function (UDSF), a new 5G network function enabling any 5G network function to store unstructured data and become data-less and state-less.

Figure 4. Data storage architecture



In most cases, 5G networks will run alongside 2G/3G and 4G networks. Even if a CSP uses only 5G technology in the home network, it will need to support pre-5G in the SDM to manage outbound roaming where 5G is not yet supported. Consequently, CSPs will usually have a pre-5G and 5G SDM. 3GPP specifies[3] how pre-5G (HSS) and 5G SDM (UDM) can interwork to enable multi-domain use cases such as SMS and mobility. This standardization, called user data interworking, coexistence and migration (UDICOM), aids the transition from pre-5G SDM to 5G SDM.

Figure 5. 1-2: Architecture for direct UDM-HSS interworking in reference point representation



3. 3GPP TS 23.632 and TS 29.563

The 5GS-UDR and EPS-UDR may be separate or co-located, forming a common repository. The HSS only uses the NU2 reference point for interworking with 5GS for a set of use cases; NU2 does not replace the Ud interface. The UDSF extends the SDM principle of separate application logic and application data to any 5G network function, which can now become data- and state-less by storing its data in UDSF.

Figure 6. 2.5-1: Data storage architecture for unstructured data from any network function

Nokia SDM implementation

From data consolidation and service innovation to telco cloud and 5G

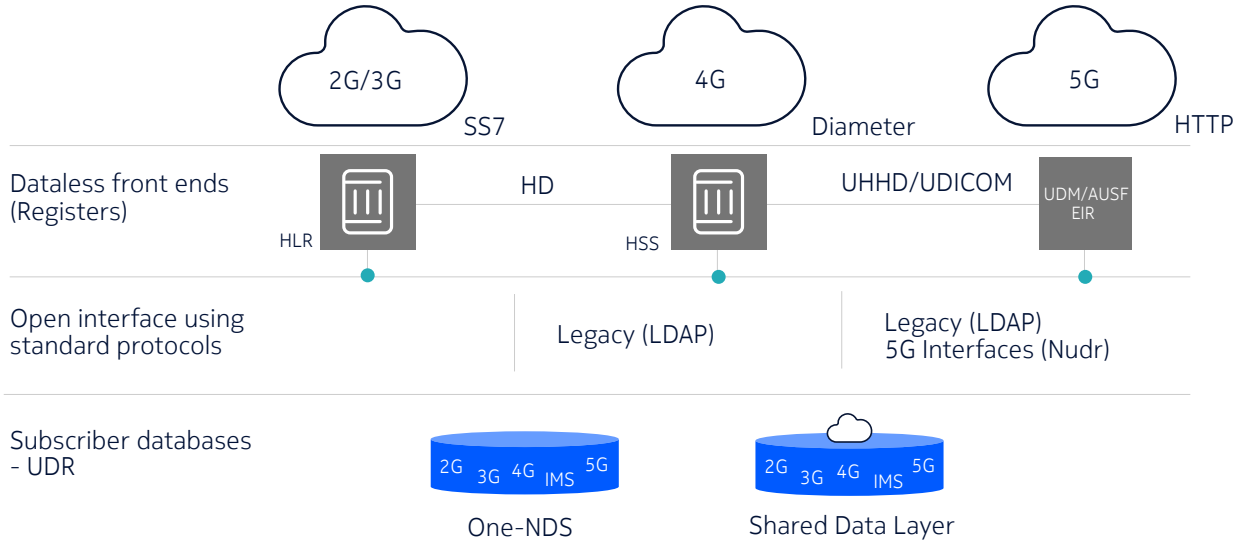
As described earlier in this paper, the SDM journey began with a single pilot application (HLR), using a common UDR. Since then, it has integrated other telco- and third-party applications. Nokia has been at the forefront of these developments.

Today's customer focus is on SDM cloud transformation and 5G. Bare metal SDM deployments are moving to CNFs with additional 5G support. Cloud native allows the 5G core and radio access to flexibly scale according to service demands.

The Nokia cloud-native core portfolio offers CSPs distinct capabilities:

- **Shared data layer:** The Nokia cloud-native shared data layer offers unparalleled network scalability and reliability to help manage telco network functions (NFs) and is now contributing to standardization
- **Stateless NFs:** UDSF enables Nokia to achieve leading cloud packet core performance because of its application of stateless NFs and state efficient call processing capabilities
- **Open ecosystems:** Open APIs introduced in 4G and 5G enable innovative service creation, and secure exposure of subscriber data for authenticated applications enables new use cases
- **Distributed cloud:** Distributing SDM components reduces latency and increases reliability.

Figure 7. Nokia databases and front-end applications of SDM



Since there is no standard defined interface for 3G/4G (HLR - HSS) interworking use cases, Nokia defined the Hd (Diameter-based) interface. UDICOM standard interfaces are supported for 4G/5G (HSS - UDM) interworking scenarios.

Table 1. Nokia 5G SDM solution

Nokia 5G SDM solution	
Registers - UDM/AUSF	• Unified data management and authentication server function manage the user data and perform the user authentication in the 5G network
Registers - HLR/HSS	• Home location registers and home subscriber server manage the user data and perform the user authentication in the 2G/3G/4G and IMS networks
One-EIR	• Equipment identity register functionality for 2G/3G/4G and 5G networks
AAA	• The authentication, authorization and accounting function enables interworking with legacy domains, including 4G voice over WiFi (VoWiFi) support and other 3GPP AAA use cases
Shared Data Layer	• A geo-redundant, highly reliable, resilient and scalable data-base supports the 3GPP functions unified data repository and user data repository and unstructured data storage func-tion for data-less and stateless 2G, 3G, 4G and 5G network applications.

The benefits of Nokia SDM

Today's Nokia SDM represents a seamless evolution from the Nokia-pioneered centralized data store and data-less front-end applications with business logic, which have become the norm in SDM. The Nokia SDM supports network technologies across generations from 2G to 5G and provides unrivalled benefits to CSPs:

- Suite of data and stateless, cloud-native applications with support for all fixed and mobile accesses, all network domains (2G/3G/4G/5G/IMS) and all IoT verticals, integrated with a common UDR for storing and sharing data
- Highest services availability and robustness due to geo-redundant deployment with separation of service logic and data storage
- Full support of new 5G service-based architecture with service-based interfaces for fast introduction of new services and devices
- Unified and real-time data provisioning via single provisioning interface prevents redundant and inconsistent data
- Open and standardized interfaces enable fast network and third-party application integration
- A consolidated view of all subscriber profile data, shared across any application, enables an easy data exposure and monetization
- Automated software delivery, test and deployment via a continuous integration and continuous delivery (CI/CD) pipeline accelerates the introduction of new functionality for services and saves operational cost.

Service reliability: The Nokia cloud-native SDL is a highly robust and highly scalable database for telco applications. It offers market-leading storage resiliency. Built-in capabilities, such as Quality of Service (QoS)-based traffic prioritization and rate control mechanisms, manage unexpected traffic spikes that help avoid service disruption. Geographically distributed and with multiple levels of redundancy, the Nokia SDL provides high availability of data that enables data-less and stateless NFs to deliver reliable services to users.

High scalability and investment protection: The Nokia SDM architecture provides seamless scalability, resiliency and operability without limits. Front-end applications and the SDL database can be independently upgraded and scaled and have their own built-in redundancy capabilities.

Supports open innovation: The Nokia SDM uses open interfaces that comply with standards and support the integration of third-party applications through application extension packages. The deployment architecture is flexible to support emerging new use cases and future scenarios.

Supports any access: The Nokia SDM uses N-site architecture and provides storage-agnostic access. The common storage layer enables data to be accessed via any protocol such as lightweight directory access protocol (LDAP), representational state transfer (REST) or any future protocols yet to be developed. This also helps to optimize storage.

High security: Complies with security requirements, such as Nokia design for security (DFSEC), which covers important security requirements from CSPs across the globe.

Supports automation: Cloud deployments with potentially hundreds of virtual machines spread across sites need efficient operational support. The Nokia SDM follows 'zero-touch' principles with built-in support for intelligent automatic fallback and rollback.

Supports CI/CD and DevOps: CI/CD and DevOps automate the delivery of software images and acceptance of software releases for cloud-native products. The Nokia SDM releases comply with Nokia core DevOps concepts.

The forward-looking SDM solution

Nokia SDM addresses current and future network needs. With more than 9 billion subscriber licenses, this is a proven solution that has been tested to network extremes. As networks evolve, they will increasingly integrate applications using standards-based open APIs to enable rapid innovation. The Nokia SDM supports open standard APIs to integrate third-party applications and all management and orchestration interfaces.

Networks will also become more complex as they grow to support billions (and perhaps trillions) of devices. Continuing to shift to cloud-native technology, in which large monolithic software is decomposed into smaller, flexible and resilient microservices, will lead to a boom in the number of network elements to be managed. This will be beyond the capabilities of manual human intervention. Automation will be vital to ensure future network operability at reduced cost.

Nokia SDM builds in automation based on three key principles:

Zero-touch service layer provides common, harmonized operability and serviceability support for all Nokia SDM CNFs. It exposes uniform operation, administration and maintenance (OAM) interfaces to the application management systems, reducing complexity and saving operational effort, time and cost.

DevOps and CI/CD

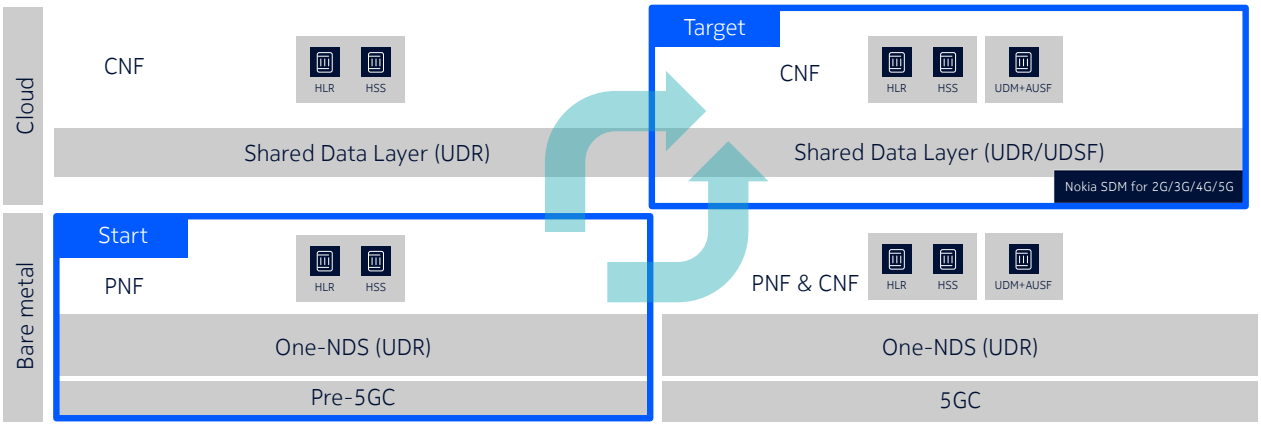
With its automated orchestration and lifecycle management (LCM), Nokia SDM's market leadership is fuelled by the constant evolution of cutting-edge technologies that enable CSPs to meet the massive growth in demand on their networks, especially as Industry 4.0 is adopted.

Ready-to-go services

Nokia's professional services for 4G to 5G evolution help to ensure seamless deployment and 4G-5G evolution in two categories:

- SDM for 5G functions. This involves design services, 5G functions deployment services and data migration from 4G to 5G databases. This helps to ensure evolution of HSS/HLR functions to 5G-UDM/5G -EIR functions
- SDM evolution to the cloud.

Figure 8. Smooth evolution to cloud-native and 5G support



The Nokia professional services portfolio includes:

5G deployment services: Encompass greenfield deployments of 5G SDM and overlay deployments for seamless SDM evolution to 5G

Modernization services: For evolving bare-metal deployments to virtualized deployment and VNF to CNF migration services

Migration services: Applied when there is a change in deployment either due to modernization or network consolidation, including database migration services for migrating data from source to destination (for example VNF to CNF migration) and traffic migration to ensure applications can use the migrated data.

Consolidation services: Consolidate CSP subscriber databases.

Conclusion

SDM technology has evolved substantially since its early deployments, wherein it helped to simplify rising network complexity. Today, as that deployment roll-out continues into 5G and the cloud, SDM remains a vital part of any CSP's business success, ensuring its customers are reliably served with the correct services regardless of the access technology used. There are more than 270 Nokia SDM deployments across the world, serving more than 9 billion subscriber licenses. This puts Nokia into a market-leading position able to provide CSPs with a robust futureproof and automated SDM solution that will free up their resources to focus on creating and launching innovative, revenue-winning services.

Further reading

Getting the 5G core right for successful 5G deployments & monetization

Nokia Shared Data Layer

What is cloud native?

Abbreviations

3GPP	3rd Generation Partnership Project
4G	4th Generation (mobile radio)
5G	5th Generation (mobile radio)
5GC	5G Core
5G-EIR	5G Equipment Identity Register
5G NR	5G New Radio
AAA	Authentication, Authorization and Accounting
API	Application Programming Interface
AUSF	Authentication Server Function
CI/CD	Continuous Integration and Deployment
CNF	Cloud native Network Function
CS	Circuit Switched
CSFB	CS Fallback
CSP	Communications Service Provider
EPC	Evolved Packet Core (4G)
GSMA	GSM Association
HLR	Home Location Register
HSS	Home Subscriber Server
IoT	Internet of Things
LDAP	Lightweight Directory Access Protocol
MSISDN	Mobile Station ISDN
NF	Network Function
NR	New Radio
NSA	Non-Stand Alone
OAM	Operation, Administration and Maintenance
PCF	Policy Control Function
PCRF	Policy Control Resource Function
QoS	Quality of Service
REST	Representational State Transfer
SDL	Shared Data Layer
SDM	Subscriber Data Management
UDC	User Data Convergence
UDICOM	User Data Interworking, Coexistence and Migration
UDM	Unified Data Management
UDR	Unified Data Repository
UDSF	Unstructured Data Repository Function
VNF	Virtualized Network Function

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Document code: CID210421 (December)