



# Building a cloud native core for a 5G world

Realizing the promise of 5G

White paper

Only a cloud-native core network can deliver the agility, automation and efficiency that will enable Communications Service Providers (CSPs) to take full advantage of 5G technology. Cloud-native goes beyond simply virtualizing network functions. It implements Virtual Network Function (VNF) machines to host stateless and dataless microservices that access a common data layer. The cloud-native core supports network slicing, distributed edge computing, programmability, analytics and DevOps - all the capabilities that distinguish 5G.

In this white paper, we explain what cloud-native means, why it is needed, and what benefits CSPs can achieve with it. We show how a cloud-native 5G core leads to an agile, open platform for innovative, secure and reliable subscriber services.

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## The need for a cloud-native core network

The future of mobile communications will be very different from today’s experiences, with 5G connectivity affecting huge areas of our lives. 5G networks will offer data speeds in excess of 10 Gbps, extreme low latency and ultra-reliable connections in a secured and trusted environment, with greater privacy compared to today’s networks.

Moreover, 5G will be a key enabler in transforming our economy and society by providing connectivity in three broad areas:

- **Extreme mobile broadband:** Growing subscriber demands mean that future networks must deliver extreme capacity and performance.
- **Massive machine communication:** The Internet of Things (IoT) needs secure communication between billions of sensors and the core network.
- **Critical machine communication:** Ultra-reliable low latency communication will be increasingly required for the immediate control of robots and virtual reality/augmented reality services.

These 5G capabilities give CSPs an opportunity to win new revenue but will require the delivery of service-specific bandwidth and latency on demand with massive scalability.

The 3rd Generation Partnership Project (3GPP) has defined a new 5G Core architecture that supports service delivery over wireless, fixed, or converged networks. This new 5G Core uses a cloud-aligned Service Based Architecture (SBA) that supports control plane function interaction, reusability, flexible connections and service discovery that spans all functions. It also makes it easier to add new functions and scale them rapidly.

Figure 1. 5G takes advantage of multiple new technologies to deliver unprecedented capacity, latency, reliability and connectivity

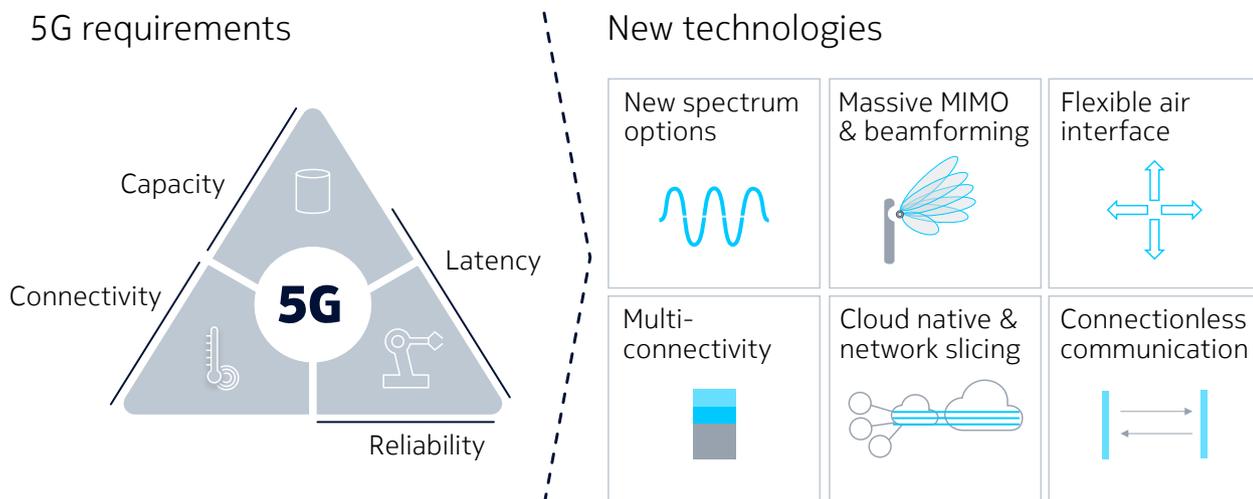


Figure 2. 5G will enable many new services that will enhance the way people work, play and relax in all walks of life



Achieving these objectives will take a cloud-native 5G core network that implements stateless and dataless network functions. These functions are built using microservices that run on a mix of containers, virtual machines (VMs), or bare metal.

## Business challenges for CSPs

5G is far more than just a faster radio service. It supports new communication types such as machine-to-machine communications; enables network characteristics that were previously unavailable, like ultra-low latency communications; and embraces adjacent technologies like Artificial Intelligence (AI) and Analytics. Together, these create novel service opportunities, but also new business challenges for CSPs.

Some of the issues that CSPs will face as they adopt 5G networks are listed below.

### 1. Business model variation

5G technology enables many new use cases that may not easily fit the traditional mobile subscription service model. 5G also supports converged services across fixed and mobile networks and even across other networks not hosted by the CSP. A wide variety of business models will be required, all of which must be supported by the network.

### 2. Service flexibility and agility

Extreme 5G performance in the form of ultra-high mobile bandwidth on demand, low radio latency, network slicing and support for IoT enables many new services, including ones not yet conceived. CSPs will need the ability to launch these new services to subgroups of customers with varying SLAs. Allowing services to succeed or fail rapidly becomes more important than conventional large-scale service launches designed for high availability to all subscribers.

### 3. Real-time scale elasticity

5G accelerates the trend of more dynamic traffic on CSP networks caused by unpredictable traffic patterns of mobile broadband data. Network elasticity will become essential to enable CSPs to accommodate this change. Mechanisms to better shape and size network resources when and where necessary will be needed to ensure the success of new 5G services.

### 4. Increased network complexity

CSPs will face the challenge of managing 5G's greater complexity and handling different access technologies efficiently. Also, the evolution to 5G and its coexistence with 4G assets will need to be planned.

It will be important to have simplified but powerful network management tools and processes, along with automation that allows for real-time network adaptation and zero-touch operations.

### 5. Need for open ecosystems

5G is designed to greatly increase the types of services that can be offered to subscribers. CSPs will need to build open network platforms and provide APIs so that they can partner with third parties. This allows the CSP to take full advantage of industry innovations and to maximize the return on their network investments.

### 6. Network security and privacy

The increase in service types that 5G enables also increases the potential attack surface of the network. Security requirements are therefore more important and will become more stringent as 5G matures.

In addition, some new 5G use cases will offer built-in security, such as with critical machine communications. Hacks into essential systems such as autonomous vehicle control or remote medical systems could put lives at risk.

The core network must be able to deflect attacks, thwart unauthorized access or use of the network and cope with unexpected overloads. It must also deploy policy enforcement mechanisms that automate network responses to these situations.

## The cloud-native 5G core

A cloud-native 5G core network mitigates these challenges and helps the service provider take full advantage of the opportunities that 5G brings, while helping to reduce operational costs.

## What is a “cloud-native” core?

The term cloud-native core refers to the 5G core network in which the functional elements are designed with specific architectural considerations. These come from two sources:

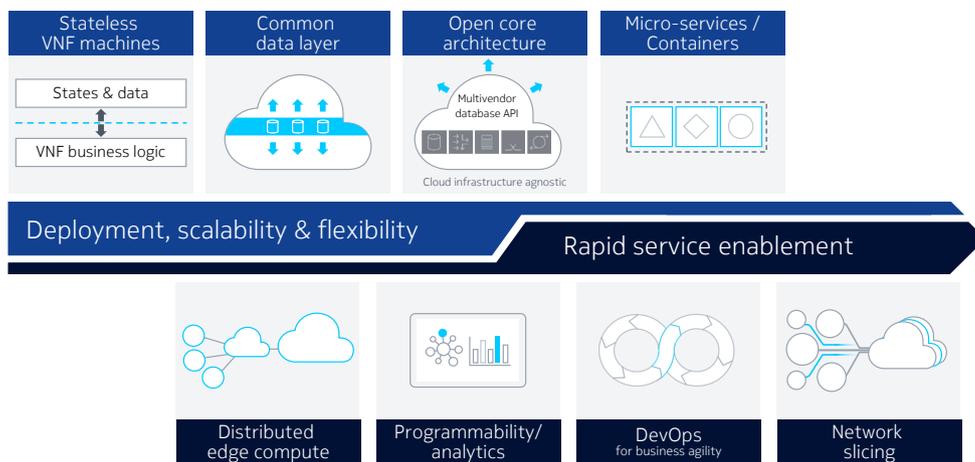
- 1) Cloud technology advances that improve deployment, scalability and flexibility
- 2) Deployment approach advances that allow rapid service enablement

All cloud-native applications generally exhibit the following characteristics:

- Software that is infrastructure agnostic and runs on a cloud platform
- Appropriate use of a microservices-based architecture with data decoupled from the application
- Open interfaces and APIs arranged to help create innovative services
- A DevOps mindset with a feedback loop and constant optimization

These definitions lack precision, so we have created a framework to clearly define “cloud-native”. In our framework, there are eight typical characteristics of a cloud-native core network - four that originate from cloud technology advances and another four that originate from CSP deployment approaches.

Figure 3. The framework Nokia uses to define “cloud-native” as it applies to 5G core solutions



### Cloud technology related attributes

#### Stateless VNF Machines

Cloud-native applications are disaggregated into Virtual Network Functions (VNFs) that access the data they need from a common, shared data layer. The VNFs retain only the business logic for their respective function. They are dataless and stateless, simplifying operations with easier upgrades, elastic scalability, seamless failovers and optimized redundancy.

#### Common Data Layer

The Common Data Layer supports the state-efficient design, or stateless VNFs. It stores all data, including subscriber, charging, policy and session, from all mobile applications and moves it to one geo-redundant network entity.

Stateless VNF machines work hand-in-hand with the Common Data Layer to greatly increase the flexibility, modularity and scalability of the 5G core system.

## Open core architecture

The exposure of core network programmability using open APIs enables third parties to flexibly and quickly create and modify services. This allows the CSP to bring new ideas to market faster and respond more quickly to customer demands.

The open core architecture may also have a dedicated exposure function that acts as an API gateway, further hiding the complexity of the core network and providing a powerful programmable framework as packages that can be offered to the developer community. This helps to build effective partnerships that allow CSPs to be more innovative and grow their businesses.

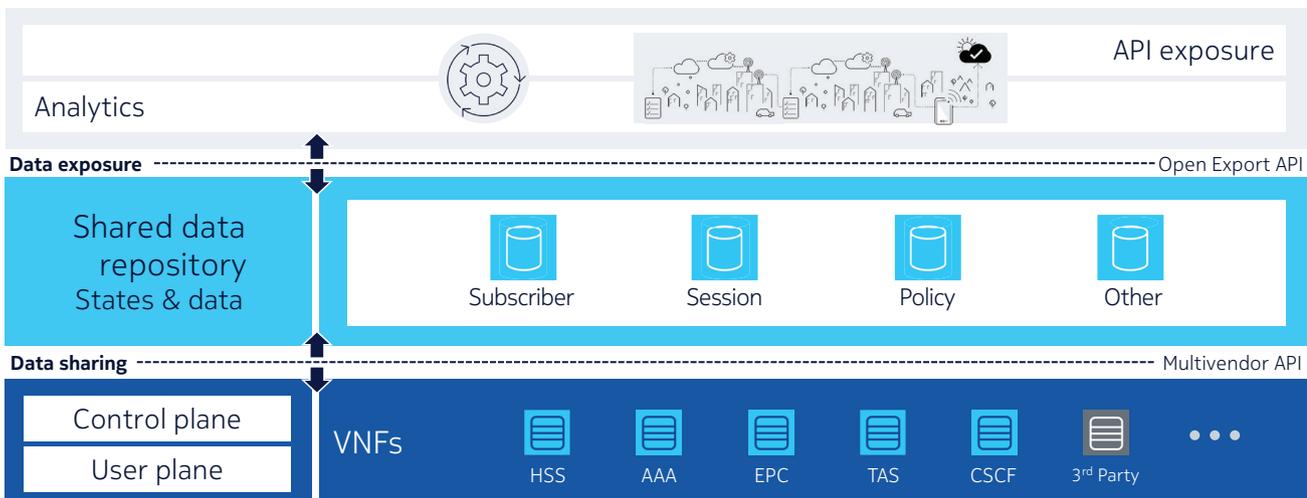
## Microservices based architecture with containers

A key attribute of cloud-native applications is a service-based architecture with small components (called microservices) that allow capabilities to be adapted, developed, scaled up and managed much more quickly and readily, particularly for control plane elements in the architecture<sup>1</sup>.

In a microservice architecture, developers break down functionality into small, self-contained modules (services). These services are independent of each other and can be updated without affecting the rest of the VNF. This allows faster service introduction by making applications easier to design, develop and integrate into a live network system using digital and automated delivery.

Microservices can be deployed into containers using Docker or Kubernetes technology, which can then be deployed into virtual machines. Bare metal container deployment is also possible.

Figure 4. Layered, open core architecture with stateless VNFs and a shared data repository



1. In its Release 14, the 3GPP adopted the architectural principle of Control and User Plane Separation (CUPS) and identified it as a key core network feature for many CSPs. When disaggregating functions into microservices, control plane functions will benefit greatly from feature velocity improvements with fine disaggregation. However fine disaggregation in the user plane could jeopardize performance and increase communication overhead. The microservices design for the control and user planes therefore needs to be treated with care to achieve maximum benefit in the respective planes.

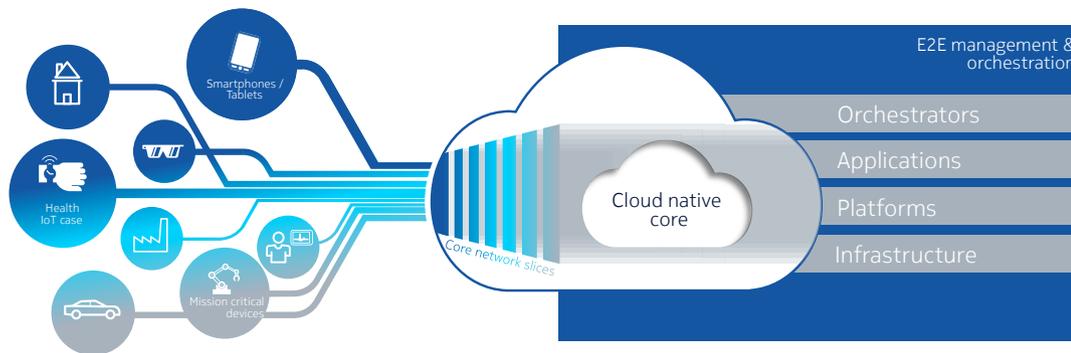
## Deployment approach related attributes

### Network slicing

Network slicing allows network partitions to be created with resources optimized to a specific service type or customer segment (for example, enhanced mobile broadband, ultra-low latency services, or a private 5G network for industrial IoT). Each network slice may differ in its achievable end-to-end latency, bandwidth, processing power, or other variables. Network slices are allocated from a common underlying infrastructure in which resources can be divided, shared and optimized.

With 5G, network slicing is extended end-to-end, even to the point of assigning devices to specific network slices. End-to-end network security is also maintained for each network slice.

Figure 5. Network slicing to meet the performance demands of different industries and 5G use cases



### Programmability and analytics

Cloud-native applications can take advantage of cognitive analytics and AI used in conjunction with orchestration tools to provide timely, detailed insights and automated network management. This is underpinned by the cloud-based platform's ability to provide big data storage, compute power on demand and high flexibility in how software assets are managed.

Current radio, core and transport network elements lack the correlation, data analysis and intelligence that's needed for the complex task of CSP network management. With massive data growth and multiple layers of network technology, the adoption of 5G and the rise of the IoT, networks will continue to grow even more complex. The addition of programmability and analytics enables a cognitive, predictive approach to network operations, making this an important attribute of cloud-native applications.

### Distributed edge compute

Distributed edge compute is an evolution to a hybrid centralized/distributed network design, allowing for optimization by placing some network functions close to the endpoints while centralizing others. Traditional networks are centralized and optimized to deliver bandwidth and capacity, but 5G enables a wide range of new service types, each with its own characteristics. For example, some mobile services will require low latency and high availability with full mobility, such as autonomous vehicles that need a radio latency of around 1ms. This is not achievable with a purely centralized network.

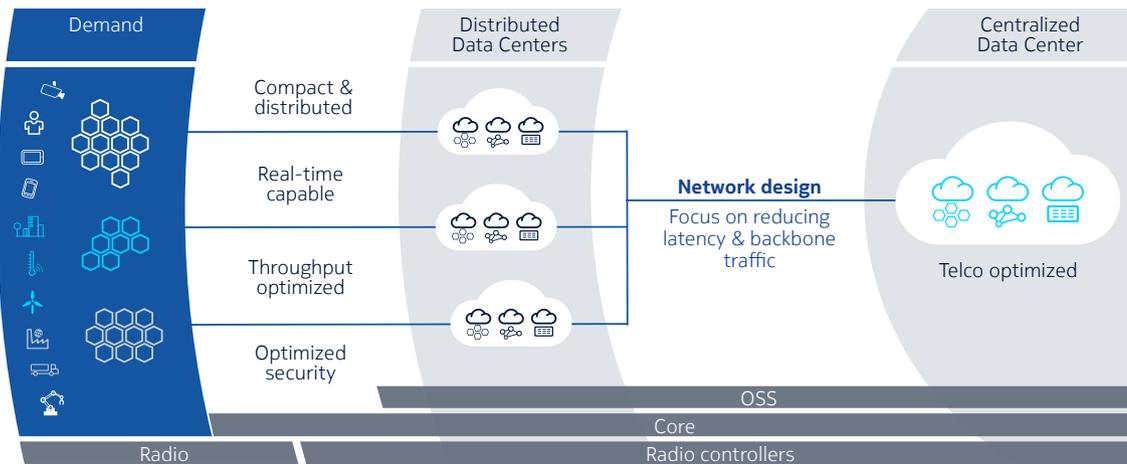


Figure 6. Distributed edge compute allows extremely low latency communications by placing data processing servers closer to the network edge

## DevOps for business agility

DevOps is a methodology in which development and operations work together to integrate and deliver software into production continuously. This is also known as Continuous Integration/Continuous Delivery (CI/CD). DevOps also automates tasks such as testing, error notification, correction and software updates.

DevOps applies the following practices:

- Continuous integration and delivery of new features and software improvements
- Workflow automation and continuous feedback collection
- Digital delivery

The everyday use of DevOps is a cloud-native deployment approach that reduces time to market, improves operational efficiency and cuts software failures by up to a factor of 10 for each area.

## 3GPP built cloud-native into the 5G core specifications

The 5G core network, as standardized by 3GPP, is fundamentally designed to be implemented with cloud-native technology.

In the 5G core standards, the 3GPP introduced a major philosophical change - a move away from defining architecture as functional nodes and reference points, and toward service-based architectures. The 3GPP also codified modern virtualization techniques into the 5G specifications, such as NFV and Software-Defined Networking (SDN).

The 3GPP explicitly included a range of cloud-native principles such as separating user plane and control plane functions, network slicing, stateless network functions, open interfaces and APIs and concurrent access to local and centralized services (distributed cloud functions).

## CSP benefits of a cloud-native 5G core

CSPs will ensure they can achieve the following business benefits by deploying a truly cloud-native 5G core as part of their overall 5G strategy.

### Monetize new 5G services

A 5G cloud-native core removes the silos in the current mobile network architecture and paves the way for more flexible mobile networks.

With a microservices-based approach, applications are easier to deploy and update and are more resilient. Functional modules are easy to add and scale, which makes launching new services faster at much lower cost. This leads to a more flexible network that allows the CSP to optimize its service portfolio for its market and business goals.

Network slicing enables CSPs to create and scale new services rapidly on a per service or tenant basis while efficiently and cost-effectively using their network resources.

With a more modular network and a distributed architecture, CSPs can invoke functions on demand, where and when needed, depending on each use case. For example, stationary services and telemetry services that do not need mobility will perform better (less signaling, longer device battery life) if many network mobility mechanisms are not activated.

### Right-size the network in real time

One of the main benefits of cloud technology is the ability to rapidly spin up additional capacity to meet real-time traffic needs. VNF instantiation and scaling on the fly provides a flexible way to cope with unpredictable traffic.

The combination of distributed cloud structures and a common data repository simplifies the network logic to enable real-time responses to traffic changes or sudden network issues. These tools also provide automated lifecycle management, greatly reducing the effort required to manage the network.

### Stimulate innovation

An exposure framework coupled with a shared data repository makes it easier for CSPs to expose network and subscriber information to external third parties for use in content development. This radically changes how CSPs and content providers cooperate and will foster a more open ecosystem to stimulate innovation for the benefit of all players. It also enables a smooth and uninterrupted high-quality experience for subscribers.

### Protect revenue streams and the business

The combination of automation and orchestration provides the right set of tools to prevent overload situations and react in real time to network equipment failures. Moreover, the microservices-based architecture using a shared data repository also contributes to network resilience. If a microservice module fails, it can be quickly replaced without loss of service continuity, since the state and data are saved in the shared data layer.

The continuous improvement of network security appliances, network-based endpoint security solutions, as well as further improved security standards in 5G, provides a solid base to guarantee trust in next generation networks. With a cloud-native 5G core architecture and using analytics and AI, attacks can be prevented by an automated security infrastructure.

## Minimize the total cost of ownership (TCO)

CSPs can expect dramatic TCO savings with a cloud-native core. The extensive use of virtualization combined with automation and Management and Orchestration (MANO) will optimize the creation and use of network resources.

In addition, the greater modularity of programmable core networks and the improved resilience of the core will make it easier for mobile CSPs to run and upgrade their networks.

Cloud-native 5G networks optimize the use of resources, which reduces their energy requirements and therefore their carbon footprints. This also makes room for the connection of additional billions of IoT devices to the network, as well as unconnected people.

A cloud-native core network relies on telco cloud data centers, with distributed architecture, multitenancy and automated management of virtualized functions, which are more power efficient than traditional dedicated core network equipment.

## Key components of the Nokia solution

Nokia is leading the way in creating and delivering cloud-native core network technology to CSPs. Nokia AirGile 5G cloud-native core supports all network generations (including 5G), for both fixed and mobile and addresses every part of the network with a consistent end-to-end approach. Nokia also provides graceful migration paths from current 4G deployments to help CSPs realize their 5G goals. These capabilities have enabled Nokia to win a growing list of dozens of 5G contracts with major CSPs globally.

Figure 7. Nokia offers a complete 5G cloud-native core solution built with a Service Based Architecture (SBA) that simplifies communication and signaling

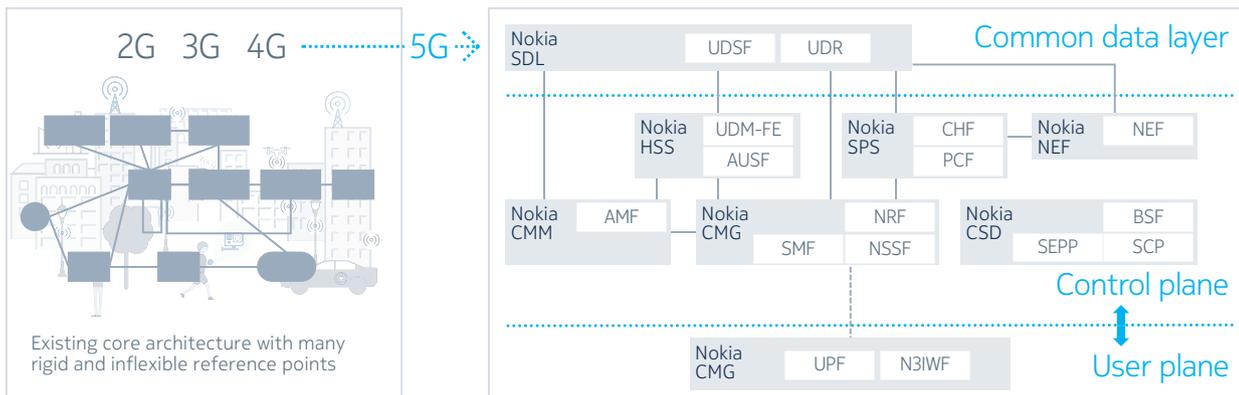


Figure 7 shows the Nokia AirGile 5G cloud-native core network elements, mapped to the core network functions defined by the 3GPP. The Nokia core portfolio covers all 5G core products described by 3GPP standardization. Nokia has the most comprehensive 5G core portfolio available worldwide. Some of the key Nokia products and solutions are as follows:

### Nokia AirGile cloud-native core

The Nokia AirGile cloud-native core portfolio provides the 3GPP specified functions for mobile and fixed communication networks. A comprehensive set of functional elements ranging from authentication server, cloud mobile gateway and cloud signaling director, to telephony application server and subscriber data

management, combine to provide all the capabilities that CSPs need for a high-performance, robust 5G cloud-native core network.

## Nokia AirFrame

The Nokia AirFrame Data Center Solution will run any cloud-based application with ease. Enhancements including advanced packet and crypto acceleration help to ensure that AirFrame performs better than traditional IT servers. In addition, hyperscale Nokia Airframe data centers exhibit industry leading power usage efficiency (PUE), which reduces operational costs and helps the environment.

## Nokia AirScale Cloud RAN

Nokia AirScale cloud RAN meets the radio needs of CSPs with virtualized radio functions that can be run in a distributed cloud at the network's edge to deliver ultra-low latency and high bit rates for demanding services. Meanwhile, other radio functionality can be centralized for highest spectral efficiency and cell site simplicity.

## Nokia CloudBand

The Nokia CloudBand software portfolio is an ETSI compliant MANO software suite which provides modules for VNF management, VNF infrastructure management and NFV orchestration. It manages the lifecycle of any VNF and is agnostic to hardware.

## Nuage Networks Virtualized Services Platform

The Nuage Networks Virtualized Services Platform is a Software Defined Networking (SDN) product suite that provides the foundation for cloud networking and policy-based automation. With Nuage's SDN products, CSPs can reduce infrastructure costs and learning, in order to realize the promise of cloud.

## Nokia Professional Services

The Nokia services portfolio helps to ease the transition to cloud and extending it to 5G. As part of the transformation services portfolio, Nokia's 5G Acceleration Services help CSPs make objective decisions on 5G network investments and prepare for the required operational changes, allowing them to evolve to 5G and grow revenue step-by-step.

## On the path to more flexible, more efficient core networks

Whichever migration path CSPs choose from their current networks, deploying a cloud-native core network will enable them to take full advantage of the capabilities of 5G. This is the only way they will be able to deliver on the promise of an innovation engine to transform business and society.

Cloud-native principles are deeply embedded in the 3GPP's vision for 5G networks. They address the business challenges faced by CSPs and provide the network agility, elasticity, innovation, security and reduced TCO that are vital for CSP success. They will be critically important as new services emerge from IoT, enhanced mobile broadband and massive machine-type communications.

Nokia is leading the way in this transformation with a comprehensive, end-to-end set of products and capabilities that are already helping CSPs enter the new 5G world.

The journey to 5G is well underway.

## Abbreviations

3GPP	3rd Generation Partnership Project
AI	Artificial Intelligence
AMF	Access and mobility Management Function
API	Application Programming Interface
AUSF	Authentication Server Function
BSF	Binding Support Function
CHF	Charging Function
CI/CD	Continuous Integration/Continuous Delivery
CMG	Cloud Mobile Gateway
CMM	Cloud Mobility Manager
CSD	Cloud Signaling Director
CSP	Communications Service Provider
DevOps	Development and Operations
eMBB	Enhanced Mobile Broadband
eMTC	Enhanced Machine Type Communications
ETSI	European Telecommunications Standards Institute
Gbps	Gigabits per second
HSS	Home Subscriber Server
IoT	Internet of Things
IP	Internet Protocol
MANO	Management and Orchestration
Mbps	Megabits per second
MIMO	Multiple-Input Multiple-Output
mMTC	Massive Machine Type Communications
N3/WF	Non 3GPP Interworking Function
NEF	Network Exposure Function
NFV	Network Functions Virtualization
NRF	Network Repository Function
NSSF	Network Slice Selection Function
PCF	Policy Control Function
OPEX	Operational Expense
PUE	Power Usage Efficiency
QoS	Quality of Service
RAN	Radio Access Network
SBA	Service Based Architecture



SCP	Service Communication Proxy
SDL	Shared Data Layer
SDN	Software Defined Network
SEPP	Security Edge Protection Proxy
SLA	Service Level Agreement
SMF	Session Management Function
SPS	Smart Plan Suite
TCO	Total Cost of Ownership
UDM	Unified Data Management
UDR	Unified Data Repository
UDSF	Unstructured Data Storage Function
UPF	User Plane Function
URLLC	Ultra-Reliable Low Latency Communications
VM	Virtual Machine
VNF	Virtual Network Function
VR	Virtual Reality

## About Nokia

We create the technology to connect the world. Powered by the research and innovation of Nokia Bell Labs, we serve communications service providers, governments, large enterprises and consumers, with the industry's most complete, end-to-end portfolio of products, services and licensing.

From the enabling infrastructure for 5G and the Internet of Things, to emerging applications in digital health, we are shaping the future of technology to transform the human experience. [networks.nokia.com](https://networks.nokia.com)

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