Building a cloud-native core for a 5G world
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Executive Summary: the need for a cloud-native core network

The future of mobile communications is likely to be very different to 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:** Continuing subscriber demand for better mobile broadband experiences is encouraging the telecommunications industry to examine how networks can meet future extreme capacity and performance demands.

- **Massive machine communication:** The Internet of Things (IoT) needs secure communication between billions of sensors and machines 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.

To meet all these needs, 5G core networks must be based on a cloud-native core that offers the flexibility, responsiveness and adaptability to meet the high speed, low latency demands of a business environment that will come to depend on 5G.

Figure 1. Networks in the 5G era will need to meet a wide diversity of requirements
In this white paper, we examine the major challenges that 5G core networks must address, the technologies and key components needed to meet those challenges and the many benefits that will arise for operators and their customers.

Seven challenging requirements for the 5G core network

The wide capabilities and promise of 5G technologies will mean that networks will have to meet seven key challenges:

Support a wide variety of business models: 5G embraces a multitude of use cases and a shift from a consumer focus towards the industry and enterprise markets. The convergence of services across fixed and mobile networks requires a more flexible approach to 5G core design.

Flexibility with service on demand: The somewhat monolithic, “one size fits all” architecture of the current mobile core network, in which network elements are dedicated to specific network functions, is unsuitable for the efficient delivery of all expected services.

Adapt in real-time to dynamic traffic changes: The nature of traffic has become very dynamic in the past few years. Mechanisms to better shape and size network resources when and where needed will help ensure 5G success.

Manage network complexity: 5G core networks will have to cope with a new level of complexity and handle different access technologies efficiently. Managing this network complexity requires simplified but powerful network management tools and processes. Automation will play a prominent role in achieving real-time network adaptation and simpler operational processes.

Enable an open services ecosystem: A 5G network should be an open network platform that enables growth in many industry segments and business models beyond the telecommunications industry. This will require the easier and more secure introduction of new services for a faster time to market.

Network security and privacy: With 5G supporting a wider range of applications and environments, security requirements will become even more stringent. In particular, critical communications depend on secure and resilient networks, able to deflect attacks and to cope with unexpected overloads.

Be eco-friendly: 5G networks are expected to play a key role in reducing overall mobile network power requirements and in limiting their carbon footprint. Operators will also benefit from reduced OPEX and subscribers will enjoy an improved device autonomy and battery life.
The key components of the cloud-native core network

It is likely that only a layered and highly modular programmable network architecture built with Network Function Virtualization (NFV) and Software Defined Network (SDN) capabilities will be able to deliver the flexibility and adaptability that are top of the agenda for 5G core network design. This approach will simplify future network functions and provide a unified structure in which functions can be activated where needed.

Consequently, operator costs will be minimized and business agility and flexibility will be maximized. In practice, this means that 5G network functions will run on a common cloud infrastructure and provide open Application Programming Interfaces (APIs), turning the entire network into an open ecosystem. In addition, the telecommunications industry will probably favor a system that is as “access agnostic” as possible for the 5G core.

Layered and modular architecture with a shared data repository

The many 5G use cases will best be served by a layered and modular architecture. Separating the user plane and the control plane removes overlaps, provides signaling efficiency, and allows the running of network functions at the right location to comply with latency requirements.

Moreover, a key evolutionary step will be to go beyond simple function virtualization and optimize the VNF machines for the cloud by making them state-less and data-less. A data-centric network with a shared data repository will be more robust, easier to manage and enable massive scaling, while also reducing signaling traffic substantially.

In addition, such a data layer could easily correlate all data to allow core network optimization and monetization. The shared data repository will also enable different redundancy schemes (redundancy Service Level Agreements (SLAs)) for Control Plane functions.

Figure 2: Layered architecture with stateless VNFs and a shared data repository


Core network slicing

Network slicing enables multiple end-to-end (across radio, core and transport) logical networks to be run on a common physical infrastructure.

These separate logical networks can be configured and run independently to provide connectivity, mobility, capacity, security and QoS on demand, and meet the needs of different businesses with different SLAs. They also allow operators and vendors to enable new business models by offering Network as a Service (NaaS) to provide the set of functionalities needed by different industries, including redundancy and security functions.

![Diagram: Network slicing to meet the performance requirements of different industries](image)

Figure 3: Network slicing to meet the performance requirements of different industries

Programmable core with an open eco-system

Only a core network that is modular and programmable will be able to support service and network on demand and deliver the right Quality of Experience.

With all network elements virtualized and sliced out as one integrated ‘service’, an operator will be able to create an entire virtual network for the needs of any industry or enterprise, using advanced programmability, and secure and robust interfaces. The emergence of open APIs enables the flexible and speedy creation and modification of services.

Microservices architecture and digital delivery

Software techniques developed by the IT industry can be re-used to help make service development simpler. Decomposing network functions into microservices helps to achieve the right level of software granularity when building network functions. It allows faster service introduction by making applications easier to design, develop and integrate into a live network system using digital and automated delivery. DevOps creates a new culture via the continuous integration of development with operations.
Distributed cloud core

The different characteristics of the wide range of services and applications that will appear will require an evolution to both centralized and distributed deployment architectures. For example, some mobile services will require low latency under full mobility conditions, such as autonomous vehicles that need a radio latency of around 1ms. Distributed data centers will host functions where they need to be, closer to the edge of the network to reduce latency. Similarly, the data layer might need to be instantiated closer to the access to improve reliability and response time.

Figure 4: Extremely low latency will be achieved by placing data processing servers closer to the network edge

Service chaining and SDN programmable transport

Service chaining will allow the configuration of network services as needed, optimizing the network and making better use of its resources. This in turn will allow easier monetization of the network.

A service chain organizes a series of network functions by defining and modeling how packets of a network service are to be treated. A number of primary building blocks are involved:

- Data modeling for standards-based definition of the service chain and constituent parts (including links, interfaces and functions)
- Orchestration for service function catalog and lifecycle management Service Policy Control for controlling what functions apply to what services
- Traffic Management for User Plane traffic forwarding into service chains
- Software defined networking within the data center to flexibly link the functions of the service chain
- Analytics and assurance to monitor and report network performance
- Policy enforcement of the network functions.
Automated and programmable network management layer

The increasing diversity of deployment models will also mean that more sophisticated and automated management solutions will be required.

The ETSI NFV MANO (Management and Orchestration) reference model introduces the Virtual Infrastructure Manager (VIM), the VNF Manager and the NFV Orchestrator. Enhanced MANO features support management and orchestration across a network with distributed data centers. It provides lifecycle management and coordination of slice functions, as well as SLA monitoring and service provisioning for services running within network slices, while automating the deployment/termination of VNFs and scaling in/out Virtual Machines (VMs) as requested.

Automation needs to provide capabilities for instantiating the required network functions and services (orchestration), for connecting these functions together (SDN), for customizing and personalizing the use of these functions (service chaining), for automating the configuration of these functions (SON), for optimizing the customer experience when using these functions (CEM) and for providing the cognition necessary for automated decision making (Analytics). This has to be achieved within and across multiple technology domains.

Increased security and privacy

Firewalls and the mitigation of Distributed Denial of Service (DDoS) attacks will be included in 5G networks, most likely virtualized. Just as for the cloud, one-stop automation solutions for managing all aspects of security across the network will become standard. Security analytics and prediction, paired with policy control for the administrative actions of their operational staff, will give operators full control of all security aspects of their network.
More secure, more adaptable and lower cost

When combined, the core technical enablers that we have described will bring substantial benefits:

**Versatile and open platform stimulating innovation**: With a more modular network and a distributed architecture, operators will be able to 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 signalling, longer device battery life) if many network mobility mechanisms are not activated.

A shared data repository will make it easier for operators to expose network and subscriber information to external third parties for use in content development. This will radically change how operators and content providers cooperate and will foster a more open ecosystem to stimulate innovation for the benefit of all players.

**Superfast adaptability and Simplified Management**: By removing the silos inherent in current mobile network architecture and by enabling cloud-native functions, virtualization technology has paved the way for more flexible mobile networks. 5G pushes the limits further by optimizing virtualization usage and enabling full telco cloud networks.

VNF instantiation and scaling on the fly provides a flexible way to cope with traffic unpredictability. The combination of distributed cloud structures managed by powerful orchestration tools and a common data repository delivering all required data to the VNFs will simplify the network logic to enable real-time responses to traffic changes or sudden network issues.

**High network security**: The continuous improvement of network security appliances, network-based endpoint security solutions, as well as further improved security standards in 5G will provide a solid base to guarantee trust in next generation networks. It will become possible to prevent attacks by automated and error-free security infrastructure.

**Robustness**: 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 shared data repository will also contribute to network resiliency. Not only will it enable VNFs to be massively and rapidly scaled, but it will also provide a more robust, data-centric network.

**Energy efficiency**: 5G networks are expected to limit their carbon footprint by optimizing their use of resources. This is essential to preserve the environment and be able to connect the billions of IoT devices and all remaining unconnected people. Reducing power consumption is one of the most important targets.
A cloud-native core network will rely on telco cloud data centers, with distributed architecture, multitenancy and automated management of virtualized functions, which are more power efficient than traditional and dedicated core network equipment.

**Total Cost of Ownership (TCO) savings:** Operators can expect dramatic TCO savings with a cloud-native core. The extensive use of virtualization technology combined with automation and MANO will optimize network resource creation and usage.

In addition, the greater modularity of such programmable core networks and the better core resiliency will make it easier for mobile operators to run and upgrade their networks.

**Key components of the Nokia solution**

To achieve the desired architecture, Nokia has introduced or is developing the following key solutions:

**Nokia Telco Cloud solution:** As an early promoter of virtualized network functions, Nokia now has one of the broadest ranges of VNFs available for the Telco Cloud. These can run on Nokia AirFrame Data Center servers or various Commercial Off-The-Shelf (COTS) servers.

**Nokia AirFrame:** The 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.

**Nokia AirGile cloud-native core,** which includes among others Cloud Packet Core, IMS, TAS, SBC, PCRF and registers, has adopted several key capabilities to support massive IoT, mobile broadband and onwards to 5G:

- New “cloud-native” modular software architecture built with cloud capabilities and technologies
- Software disaggregation including separation of the control and data plane functions
- Improved cloud redundancy models and software overload control protection
- Distributed and centralized deployment
- A new “state efficient” VNF design together with a shared data layer (SDL)
- Lower TCO with increased computing efficiency
- Move to a DevOps model allowing the automation and life-cycle management of resources
Nokia Shared Data Layer (SDL): The Nokia shared data repository is part of an end-to-end cloud-based ecosystem. It stores and makes available all the data required by all the VNFs including subscription data, policy data, charging data and session data, which includes VNF state information. This provides a native cloud database suitable for real-time, low latency and high throughput applications. SDL will be instrumental in preparing networks for 5G.

Nokia CloudBand™ software portfolio is an ETSI compliant management and orchestration (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.

Nokia also offers a comprehensive cloud portfolio of solutions that includes technologies for cloud RAN, for SDN with Nuage Networks™, and security and enterprise services.

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

Summary: on the path to more flexible, more efficient core networks

5G core networks will need to run in heterogeneous environments, interacting with multiple types of access network and serving a wide ecosystem of applications and players.

Today’s mobile core networks will need to evolve in key areas to deliver on the promise of an innovation engine for business and society transformation. Some of these changes have already started to be implemented in today’s networks as we move beyond 4G (eg SDN, Telco Cloud).

A 5G core will make use of and improve these new capabilities, driving them to the next level. As presented in this white paper, solutions to make core networks more flexible, more efficient and more open exist, and are being developed as 5G standards firm up. They will transform the way mobile core networks are designed and managed, and the way operators, application providers and subscribers work together. The journey toward 5G has already begun.
Acronyms

API Application Programming Interfaces
CEM Customer Experience Management
COTS Commercial Off-The-Shelf
DDoS Distributed Denial of Service
DevOps Development and Operations
ETSI European Telecommunications Standards Institute
IMS IP Multimedia Subsystem
IoT Internet of Things
IT Information Technology
MANO Management and Orchestration
NFV Network Function Virtualization
NFVO NFV orchestrator
OPEX Operational Expenses
PCRF Policy and Charging Rules Function
QoS Quality of Service
RAN Radio Access Network
SBC Session Border Controller
SDL Shared Data Layer
SDN Software Defined Network
SLA Service Level Agreement
SON Self Organizing Networks
TAS Telephony Application Server
TCO Total Cost of Ownership
VIM Virtual Infrastructure manager
VM Virtual Machine
VNFM VNF lifecycle manager