



Best Practices for 5G Core Network Validation

Embracing virtualization to deliver the bold 5G promise

Overview

Mobile network operators (MNOs) are gearing up for the deployment of the most innovative wireless communication technology yet. 5G will enable them to bring new experiences to customers through virtual and augmented reality (VR/AR). It will give rise to amazing AR applications like remote surgery or machine-type communication (MTC) applications such as the remote control of industrial machines.

Multiple migration paths are at the operators' disposal to evolve to 5G, including non-standalone (NSA) and standalone (SA) deployment options. A virtualized core network is important to achieve dynamic scalability. The packet core network architecture is changing radically to enable operators to flexibly deploy new resources in their network. They are migrating from privately-owned data centers to cloud-native architectures — these are much more conducive to hybrid and public cloud deployments.

Multi-access edge computing (MEC), service-based architecture (SBA), and control user plane separation (CUPS) are other concepts MNOs can choose to implement. MEC enables off-loading traffic at the edge, saves network bandwidth, and makes achieving low-latency requirements possible. SBA and CUPS increase deployment flexibility and create new monetization opportunities.

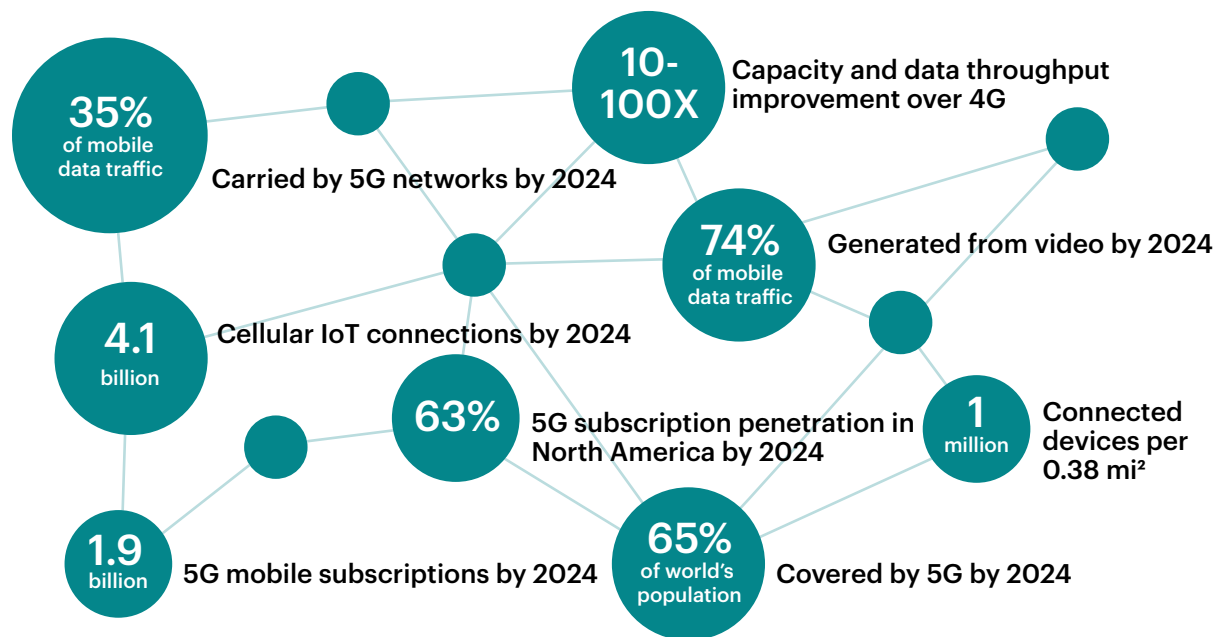
MNOs face various choices, each translating into significant challenges for their engineers. They must understand the implications of their decisions and validate the resulting network changes to succeed in the 5G core (5GC) network era.

In this paper, learn how you can succeed at 5GC implementation by:

- Performing realistic testing
- Testing nodes in isolation
- Addressing network delay
- Leveraging common measurement science
- Adopting a holistic approach

Performing Realistic Testing

The arrival of 5G is increasing network complexity exponentially. The number of devices on networks will increase dramatically. Mobile data traffic is growing at a double-digit rate, with a greater portion coming from video applications. Networks will also become more dense.



Source: Ericsson Mobility Report, June 2019

Next-generation network nodes must be ready to handle more devices and latency-sensitive traffic. MNOs need to ensure traffic prioritization and quality of service (QoS) in a highly sophisticated environment. In this context, sending a dummy protocol is not enough to test the user plane function (UPF). Pushing out line rate throughput does not suffice to validate the QoS implementation. *Testing needs traffic that is as realistic as possible, and throughput that reflects the network conditions. It also must take into consideration real user equipment (UE) behavior.*

To validate the 5GC network, laboratory engineers must not only emulate subscribers and their behavior, but also the services phones access, and the traffic running on top. This behavior needs replication in a realistic and full-protocol stack way. Replicating real life in the laboratory is critical to:

- Solve quality issues that cause potential outages
- Conduct performance benchmarking to select the best network solutions for your network
- Validate software updates from network vendors for a smooth rollout in production

It is important to remember that data sheets typically provide basic numbers determined in simple conditions. Engineers need to validate the data sheets provided by network vendors, including configuration options, scaling, and performance. For instance, MNOs must know the number of mobile subscribers a physical network element or virtual network function (VNF) can support in their topology and network conditions. That number will vary depending on these factors. One thousand subscribers browsing the Internet will have a lower impact on network equipment than if they perform calls and watch Netflix during their daily commute.

Using Ixia's IxLoad real-world subscriber modeling, engineers can develop realistic test scenarios for their core network. From a single application, they can perform capacity tests, detail a device's throughput, measure voice and video quality, and model a wide variety of mobility scenarios. The solution features a topology-based user interface for comprehensive network re-creation in the laboratory. A multitude of test topologies are available — centered around node isolation, interface testing, or service validation. IxLoad is also the only test tool capable of simulating UEs over the radio and other core node or interface.



Testing Nodes in Isolation

With 5G, core network complexity has reached a whole new level. Complexity is prompting the move to test in isolation. *By isolating nodes, engineers can test individual interfaces, nodes, or groups of nodes and entire functionalities across the 5GC in an end-to-end approach.*

Simulating UEs across multiple nodes is critical to validate functionalities and services. Key areas of focus include testing the UPF, access and mobility management function (AMF), session management function (SMF), and SBA nodes in different node-level scenarios as well as for performance.

When testing the UPF with a node isolation approach, the nodes run on both the control and user planes. The test tool simulates the 5G base station (gNB), the session management function (SMF), and the data network (DN). Assessing UPF performance in a variety of scenarios is critical. Engineers need to validate key performance indicators (KPIs) per node and for multiple nodes. QoS validation is particularly important for the UPF.



For the AMF, the UEs send connection and session information over N1 and N2 interfaces. The AMF is responsible for handling connection and mobility management tasks. All messages related to session management are forwarded over the N11 reference interface through the SMF. When testing the AMF, the focus is on control plane functional and capacity testing. Testing the AMF in isolation requires testing coordination of the N1/N2 interfaces from the gNB and simulation of the SBA nodes. The AMF requires testing in different node-level scenarios and for performance.

Like UPF and AMF testing, testing the SBA nodes requires various node-level and performance test scenarios. At the node level, it is essential to test for registration to network repository function (NRF), node failover, and elastic scaling. From a performance perspective, it is important to validate the rate of various procedures for UE authentication and context management, as well as subscriber data management. SBA nodes have a dual role as producer and consumer. Validating both roles is essential.

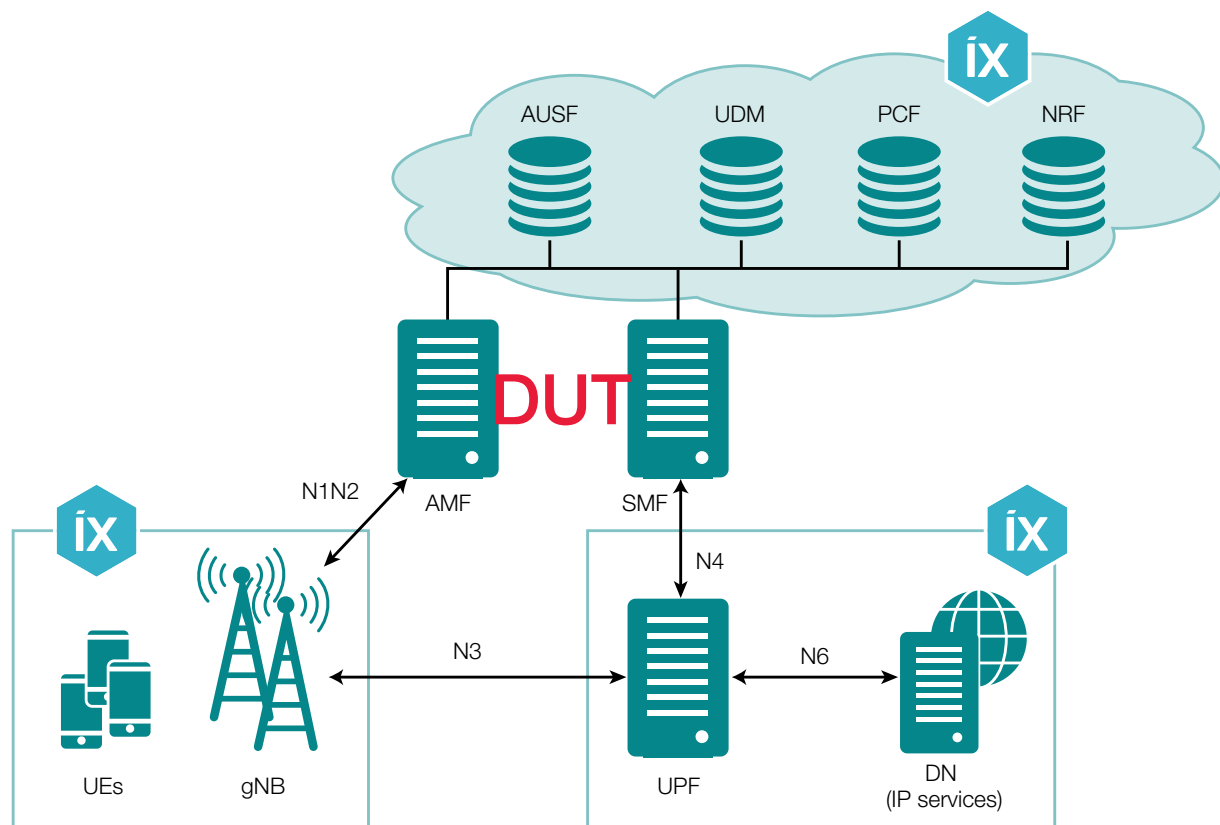


Figure 1. 5GC requires testing multiple use cases

Addressing Network Delay

The industry move towards virtualization enables the deployment of VNFs in public or private data centers. MNOs making this choice can achieve elastic scaling. For instance, operators might need to scale up capacity on a venue to provide bandwidth to hundreds of thousands of people attending a major sporting event. Instead of deploying trucks and equipment, they can rent out compute resources in a public cloud and deploy VNFs for a limited time. Using the cloud can generate significant cost savings for operators by eliminating capital expenditures (CapEx) in network equipment and the need to move that equipment when it is no longer required.

However, 5G applications like VR, AR, Industrial Internet of Things (IIoT), autonomous driving, and remote surgery demand latency in the millisecond range. The transport network and the network nodes need to process and send the data packets across the network efficiently. *Traffic offloading becomes important. QoS implementation and CUPS are also critical aspects to test and validate to reduce network delay.*

The definition of QoS has evolved tremendously since classic telephony when it focused on connection requirements. Today, it ensures that certain packets take precedence by providing different levels of priority to applications, users, or data flows. QoS can also guarantee a certain level of performance to a data flow. QoS implementation for the core network is also very different in 5G compared to 4G, with a move from evolved packet system (EPS) bearers to flows. There is a one-to-many relationship between the general packet radio services (GPRS) tunneling protocol user (GTPu) tunnel and the data rate bearers (DRBs) on the air interface. A QoS flow might map to one or more DRBs with additional ones allocated per network slice, multiplying the number of DRBs. 5G also introduces a new delay critical guaranteed bit rate (GBR) and the concept of reflective QoS indicator (RQI). RQI enables the UE to map uplink (UL) user plane traffic to QoS flows without SMS provided rules. These changes demand testing for successful deployment.

The nodes involved in controlling the QoS are the gNB, SMF, and UPF nodes. The SMF is responsible for session establishment. It is also accountable for UE internet protocol (IP) address allocation and management, configuring the traffic steering to route it to its intended destination, charging data collection, and providing support for charging interfaces. The UPF is responsible for QoS handling for the user plane, packet routing and forwarding, packet inspection and rule enforcement, as well as traffic counting and reporting. Using Keysight's 5G Core Testing Solution, engineers can validate critical 5G requirements to maximize network reliability and performance. They leverage the solution's built-in per UE detection mechanism to validate QoS enforcement at a high-performance level for the UPF.

Leveraging Common Measurement Science

MNOs face a tremendous technology evolution with 5G. The current mobile packet core is transforming into the 5GC, an increasingly virtualized core network that utilizes challenging concepts like MEC, SBA, and CUPS. At the same time, operators are under extreme time and cost pressure to win the 5G race. They strive to reduce the product and service lifecycle. For example, they need to move away from the rigid, sequential waterfall model and adopt agile methods. It is possible to discover and fix issues in the production part of the lifecycle instead of sending back to the laboratory.

However, many MNOs overlook the time to market and cost efficiencies they could gain by adopting a common measurement science across the product/service lifecycle. Most operators adopt a siloed approach to the testing and rollout of services, with dedicated teams for each phase — lab testing/ pre-production and production. Having slightly different requirements, each team typically selects test equipment best-suited for their phase of the workflow. Different requirements can lead to longer resolution time for issues found in the production stage of the lifecycle.

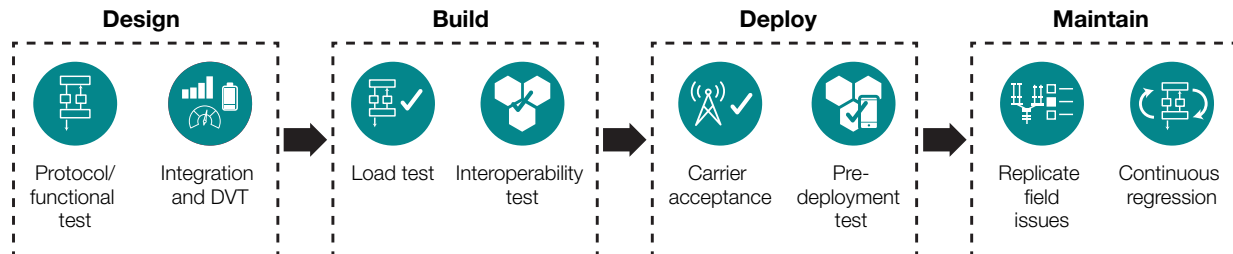


Figure 2. Typical product/service lifecycle at MNOs

MNO engineers need instruments tailored for each phase of the workflow to ensure measurement correlation. Keysight's 5G core test engine, for example, is used by carriers in the laboratory to perform trials and interoperability testing, validate network vendors' data sheets, build automation frameworks for the future, and validate cloud-native deployments via containers and microservices. It is also used in pre-deployment production testing to validate nodes and services in the production environment. The engine creates automated frameworks that typically integrate with the continuous integration/continuous delivery (CI/CD) ecosystem. Teams across the product/service lifecycle are familiar with the same test equipment, and common measurement science resolves issues faster. Consistency in measurements also reduces the chance of errors, accelerates time to market, and reduces costs.

Adopting a Holistic Approach

New protocols are in use in the 5GC network, and the role of nodes has evolved. HTTP/2 has replaced diameter-based control protocols. Nodes interact in stateless mode and can produce, consume, or perform both functions at the same time. Also, MNOs are building the core network differently in the 5G era. It is no longer built in incremental steps, with months between adding nodes and interfaces. Since the 3rd Generation Partnership Project (3GPP)'s Release 15 (Rel-15) in December 2017, the industry must implement the entire core network at once.

Validating the 5GC network requires a holistic approach. MNOs need to start with simple scenarios by testing a node in isolation and build towards more complex ones. You can then see how the nodes interact with each other under stress or in the face of unexpected events. Keysight's 5G Core Testing Solution enables engineers to simulate multiple nodes and interfaces simultaneously to recreate entire networks in their laboratories.

Partnering with an expert in core network testing helps accelerate time to market to ensure deployment success. Keysight has developed a broad range of use cases for the 5GC — starting with the launch of core testing capabilities for the gNB simulation use case in early 2018. Other use cases include AMF and SMF isolation, SBA nodes isolation, and AMF isolation. Upcoming use cases addressing network slicing, the uplink classifier (UPCL) at the UPF level, and traffic steering will enable operators to test or emulate any signal network element or function in the 5G core end to end.

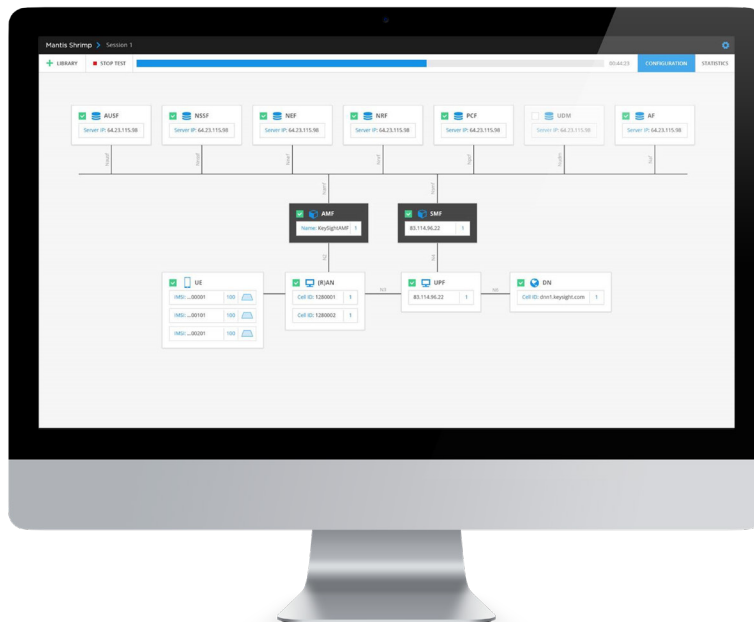


Figure 3. User interface for 5G core test engine

The 5GC Network Demands Innovative Test Solutions

5G is revolutionizing the mobile core network. MNOs need to virtualize their core network and implement challenging concepts like MEC, SBA, and CUPS to achieve true elastic scalability and optimize costs.

These technologies increase core network complexity exponentially. MNOs need to ensure traffic prioritization and QoS in a highly sophisticated environment. To succeed at core network testing in the 5G era, operators' engineers need to:

1. Replicate real life in the laboratory to eliminate quality issues, benchmark network solutions, and validate network vendors' software updates
2. Test nodes in isolation to ensure all network elements perform as expected
3. Test and validate the QoS implementation and CUPS to reduce network delay
4. Leverage common measurement science across the product lifecycle to accelerate time to market and reduce costs
5. Adopt a holistic approach to address new protocols and understand node interaction at the network level

Solutions exist to overcome these challenges. For more information on 5G core network testing challenges and solutions, review the following resources:

- [5G Solutions for Mobile Network Operators](#) brochure
- [IxLoad Wireless - 5G Core Testing](#) datasheet
- [5G Lab Testing with High-Performance UE Simulation](#) webinar
- [Validating the 5GC Network for Maximum Performance](#) webinar

You can also find out more information by visiting the following web pages:

- Keysight's [5G Service Providers](#) web page
- Keysight's [5G Core Testing Solution](#) web page

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