

LoadCore™ 5G Core Testing

Problem: Scaling New Services and Preparing for 5G

5G deployments will enable enhanced mobile broadband services with higher data rates, increased capacity, and lower latencies. New business opportunities and increased revenue sources can be found with Network slicing, Mobile Edge Computing and Private 5G via massive and critical IoT services in sectors like automotive, manufacturing, energy and utilities.

But to ensure the carrier-grade quality required to carry this wireless traffic, service providers need to characterize and continuously validate their 5G Core (5GC) network in the lab and pre-production deployments. This requires extensive testing of 5G SA (Standalone) elements in the Core network.

Challenges include:

- Implementing virtualization technologies and cloud-optimized network functions
- Validating emerging architecture and standards: handling simultaneous protocol requests for tunneling-, session-, or HTTP2-based signaling

Solution: Pre-Deployment Validation Using Real-World Subscriber Simulation

Keysight's 5G LoadCore™ test solution addresses critical validation requirements for improved reliability and performance of 5G emerging architectures. With comprehensive performance testing of all nodes and interfaces, this powerful yet easy-to-use solution helps network operators deliver higher-performing services, greater scale, and lower-latency communications.

Using real-world subscriber modeling, testers do not need to be protocol experts to develop realistic test scenarios. From a single application, perform capacity tests, detail a device's throughput, measure voice and video quality, and model a wide variety of mobility scenarios.

Full automation via REST API and Python allows users to create regressions for continuous validation of product quality and to adapt their environments to the CI/CD lifecycle demands.

With 5G development and adoption progressing rapidly, *cloud native* is central to the 5GC architecture. With its microservice architecture and options to be deployed either as a virtual machine (VM) or Container, LoadCore is fully aligned to this new paradigm.

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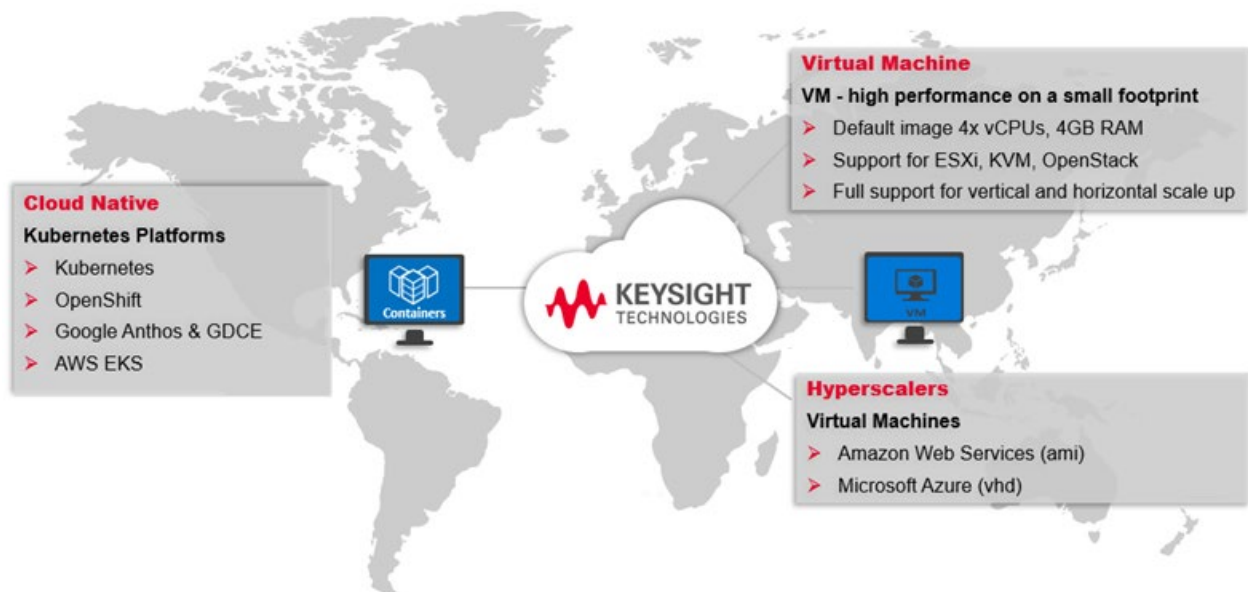
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Highlights

- Simulate UE behavior in multiple 5G use cases: Network slicing, multi-access edge computing (MEC) low latency and offloading, video optimization
- Scale up to millions of subscribers using stateful application traffic mixes that can interact with real servers and peers
- Perform service quality validation with subscriber modeling, multiplayer traffic, and quality of experience (QoE) measurements
- Validate complex scenarios for service-based architecture (SBA)
- Control test traffic mix and intensity using network objectives to independently manage control and user planes
- Deploy either as VM or containers on private, hybrid or public clouds. High flexibility in terms of supported platform, hypervisor and orchestration
- Available through AWS Marketplace either as BYOL (Bring Your Own License) or PAYG (Pay As You Go) – an industry first
- Automated test suites for 3GPP 5G Security Assurance Specification (SCAS) conformance validation

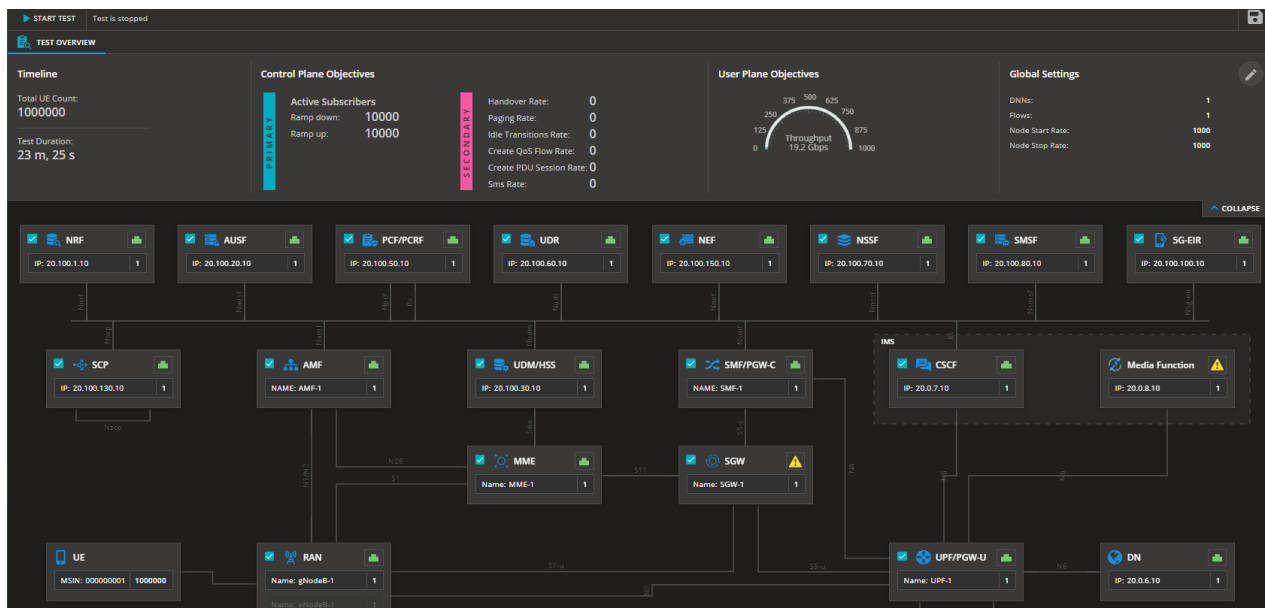


5G Core Validation

LoadCore is the one-stop-shop for testing 5G Core. From end-to-end to node isolation, the tool simultaneously simulates multiple nodes and interfaces, perfect for recreating entire networks in your lab by using a topology-based user interface (web UI).

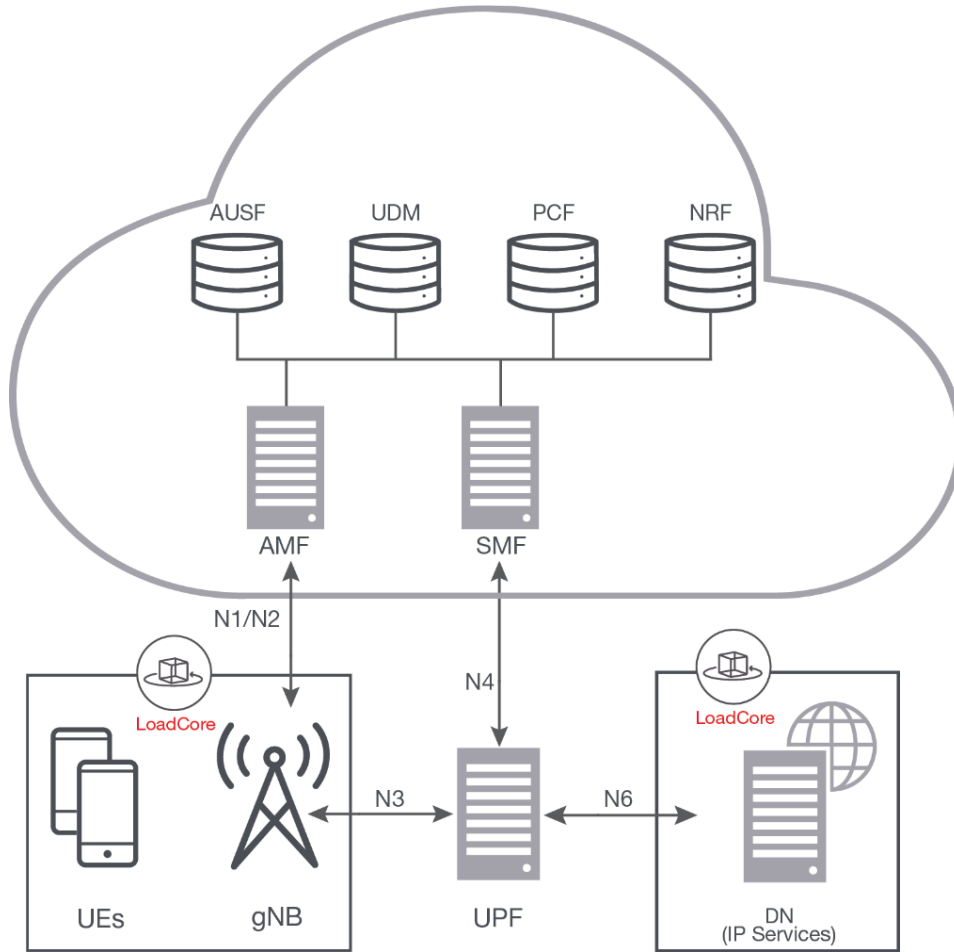
Currently available topologies are depicted below, with more to follow.

Entire core is simulated, with each node independently deployed. User equipment (UE) actions (Registration/PDU Session Establishment/Modification, Handovers, etc.) are simulated across all 5G Core nodes and interfaces, offering a complete end-to-end view. 4G, 5G NSA (Non Stand Alone) and 4G/5G iRAT procedures can also be simulated for a complete validation across multiple domains.



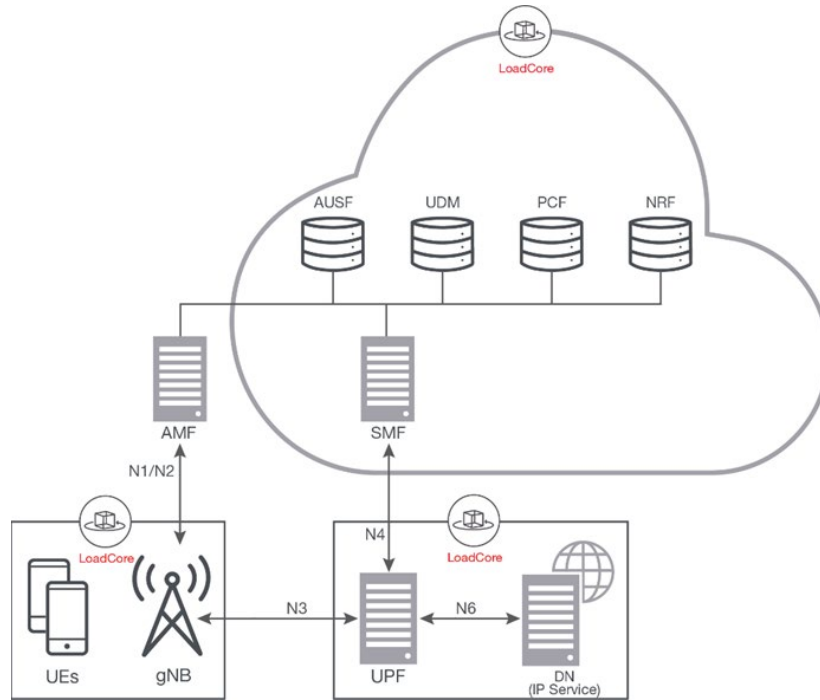
Entire Core simulation

NGRAN Simulation — Entire Core is Under Test

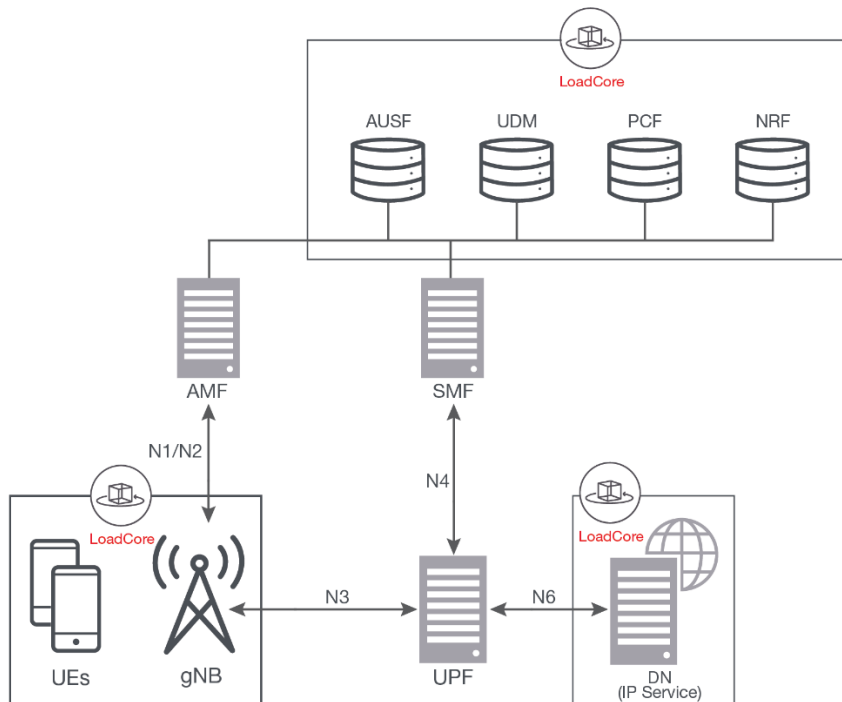


UE/gNB (NGRAN) simulation via coordinated N1/N2/N3

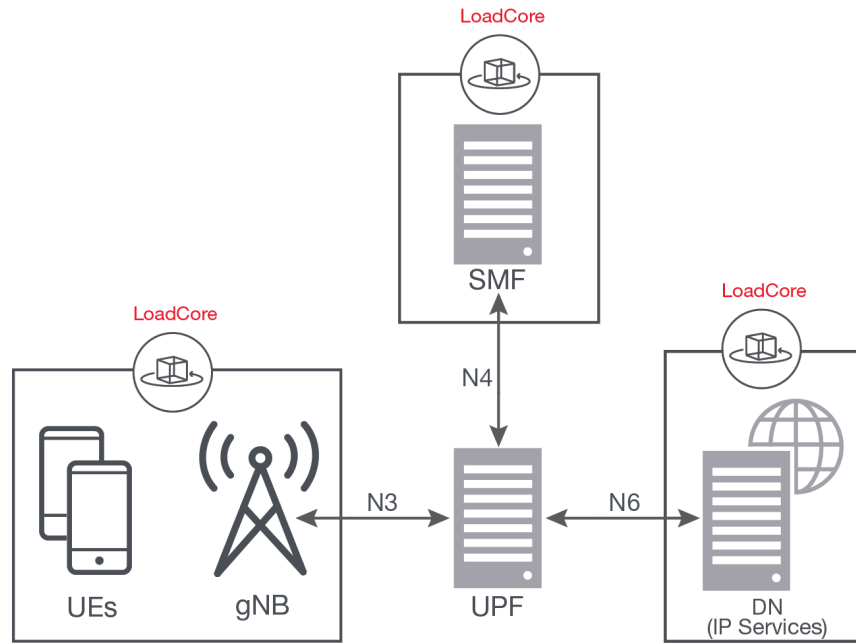
Node(s) Isolation Topologies



AMF isolation

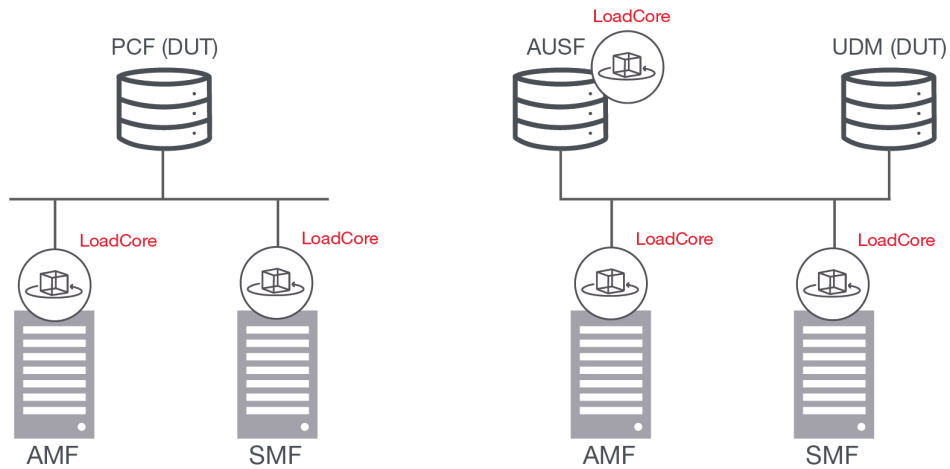


AMF+SMF+UPF isolation

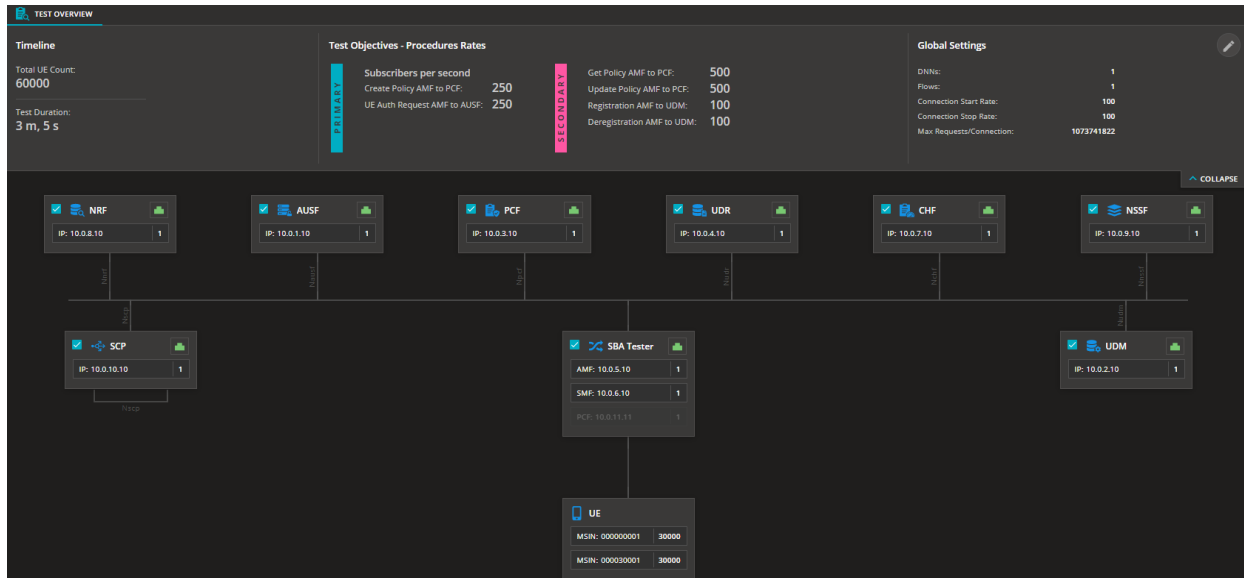


UPF-isolation topology via coordinated simulation of gNB/SMF (N3/N4)

SBA Node(s) Isolation



PCF or UDM isolations



Product Capabilities

Control Plane Features

- Simulate millions of sessions across multiple coordinated interfaces; perform UE Register/Deregister/Authentication/Session Establishment and Release
- Ability to simulate or place under test any of the 5G nodes and associated interfaces: gNB, AMF, SMF, UPF, AUSF, UDM, UDR, PCF, NSSF, CHF, NRF, SMSF, CHF, 5G-EIR, SCP, NEF, AF, IMS Core, DN
- Ability to simulate or place under test any of the 4G nodes and associated interfaces: eNB, MME, SGW, PGW, PCRF, HSS
- Topology-driven UI: start by defining your test topology by selecting your device(s) under test
- Validate PDU Sessions establishment, uplink and downlink flows, deletion and modification of the sessions
- Option to configure single or multiple PDU sessions per UE, with single or multiple DNNs
- Test any mix of IPv4 and IPv6 for control and user planes; support for PDN types IPv4, IPv6, IPv4v6 and Ethernet
- Perform isolation testing for SBA nodes: AUSF, UDM, PCF, NRF, NSSF, CHF, SMSF, 5G-EIR
- Perform isolation testing for UPF, including Intermediary or PDU Session Anchor UPFs exposing N9 interface
- Perform network function (NF) Register/Deregister/Discovery vs simulated or real NRF
- Ability to simulate coordinated HTTP/2.0 (SBI) and Diameter (4G) flows for validating combo boxes such as PCF/PCRF or HSS/AUSF
- Ease of use and intuitive definition of complex call models and traffic patterns via Control & User Planes Primary and Secondary test objectives
- Ability to perform Control Plane Impairment at IE or Message level on all protocols (SCTP, PFCP, HTTP2). Define negative behavior and reconfigure default state machine by having multiple UE groups with different behaviors

- Support for Ethernet PDU (User Plane StatelessUDP)
- Support for Private 5G TSN IEs
- Support for 3GPP versions Rel15/Sept2019 and Rel16/Sept2020

gNB/AMF N1/N2 Procedures

- UE Initial Registration/ Deregistration
- Authentication
- Security Mode Control
- PDU Session Establishment/Release
- PDU Session Modification (QoS Flow establishment/modification/release)
- UE initiated Service Request
- AMF/UDM initiated deregistration
- AMF initiated UE context release
- SMF initiated session release
- GUTI Registration
- Periodic Registration
- SMS over NAS
- Paging
- Intra-5G and iRAT Handovers
- IDLE Mobility
- EPS Fallback
- Emergency Registration
- NGAP Reroute support for network slicing
- Multiple PDU sessions support with different NSSAI values (network slicing)
- SQN resynchronization
- Secondary authentication with EAP-TTLS
- Secondary authentication with PAP/CHAP
- Support for SSC Modes 1, 2 and 3
- Support for ePCO IE in PDU session establishment request
- Location Report procedure
- Identity Procedure (IMEI, IMEISV, IMSI support)

N26 Procedures

- IRAT Handover
- IDLE iRAT Mobility

N14 Procedures

- Handover support with AMF change

4G Procedures (S1-MME, S11, S5)

- UE Attach/Detach
- Dedicated Bearers (Network Initiated)
- UE Requested PDN Connectivity
- UE Requested PDN Disconnect
- NSA DC-NC Option 3x (S1-MME)
- IRAT Handovers to 5G (with N26 interface); multiple PDU sessions and multiple dedicated bearers
- EPS Fallback
- Enter/exit idle and paging support for S11 interface (grouped MME)
- Network initiated bearer modification
- Identity Procedure (IMEI, IMEISV, IMSI support)

SMF/UPF N4 Procedures

- PFCP Node Association Setup/Update/Release (Initiated by CP or UP function)
- Association Update
- Association Setup Initiated by UPF
- PDU Session Establishment/ Release
- PDU Session Modification (Create/Delete QoS Flows, Xn Handover, Modify QoS Flow, Enter/Exit Idle)
- PDU Session Modification for ULCL (Uplink Classifier)
- Update QoS for non-GBR flows
- Paging
- Session Report
- Handovers
- Node report
- Heartbeat
- UE IPV6 SLAAC
- Support for Ethernet PDU

SBA tester serving the following topologies

- PCF isolation
- UDM isolation
- AUSF isolation
- CHF isolation
- SMSF isolation
- NSSF isolation
- 5G-EIR isolation
- SCP isolation
- Any combination of the above nodes

SBA Procedures

- Initial Registration/Deregistration
- Authentication
- PDU Session Establishment/Teardown
- Notifications
- Dedicated QoS Flow establishment/teardown
- iRAT Handovers
- EPS Fallback
- Indirect Communication without Delegated Discovery (Model C)

NRF Service Operations

- Nnrf_NFDiscovery
- Nnrf_NFManagement:
 - Register/Heartbeat/Deregister
 - NFStatusSubscribe/Unsubscribe
 - NFListRetrieval
 - NFProfileRetrieval

User Plane Features

- A modular system design allows LoadCore to scale with your infrastructure while real-time QoE metrics let you drill down to quickly identify network degradations and isolate breaking points
- Configure each UE group with a distinct objective consisting of single or multiple flows with the ability to specify overall throughput and distribution per flow
- Support for triple play fully stateful traffic (data, voice, video), able to terminate connections on simulated or real servers
- Validate network performance by assessing packet loss, One Way Delay (OWD), Delay Variation Jitter (DVJ), Mean Opinion Score (MOS)
- High performance capability for VoNR and Video OTT sessions
- Support for Video component of VoNR calls
- Full support for IMS Core simulation, exposing P-CSCF (coordinated Gm and Rx) and Media Function
- Support for VoLTE/VoNR over 3GPP IPsec, including Rel17 authentication("hmac-sha-1-96" / "aes-gmac" / "null") and encryption("aes-cbc" / "aes-gcm" / "null")
- Support for SIP over TLS 1.2 and 1.3 versions
- Highly customizable SIP and SDP headers via dynamic variables
- Support for VoLTE / VoNR and EPS Fallback scenarios
- Support for multiple QUIC versions:
 - IETF v27, v29, v34, v1 (RFC9000)
 - Google QUIC v43, v46, v50
- Validate QoS enforcement at UPF level by leveraging inbuilt per-UE detection mechanism
- Exercise UPF traffic selection & steering, QoS marking via configurable SNI for TLS traffic (HTTPS) and Video over QUIC
- Validate complex call models using various test objectives: Throughput, Concurrent Connections, Connection rate
- Ability to visualize Per-UE statistics (Control and User Plane) allowing QoE analysis for assessing services at UE and PDU session level
- Ability to achieve close to line rate throughput on various Network Interfaces (10/25/40/100 GE) with both UDP and TCP traffic (DPDK=on)

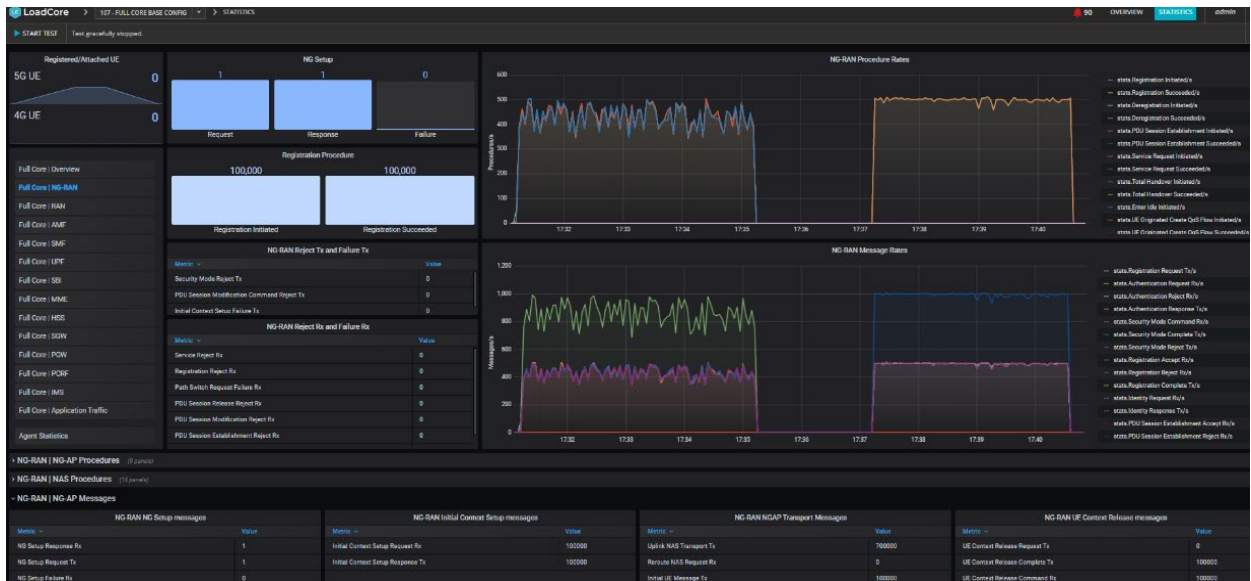
Web UI and REST API Browser

- LoadCore presents a web-based UI for controlling the test execution, allowing parameter configuration, and checking the statistics. Complemented by REST API Browser (see below), it allows users to conduct the entire testing process directly from a web browser in a client-free, Windows-free environment.
- Through REST API Browser, users can create and modify LoadCore configuration parameters and add/modify/delete components to build or adjust a test configuration just from a web browser. REST API Browser can be also used for automation, allowing users to easily identify embedded methods and internal parameters names by navigating, in a simple and intuitive way, the object structure of the test configurations.

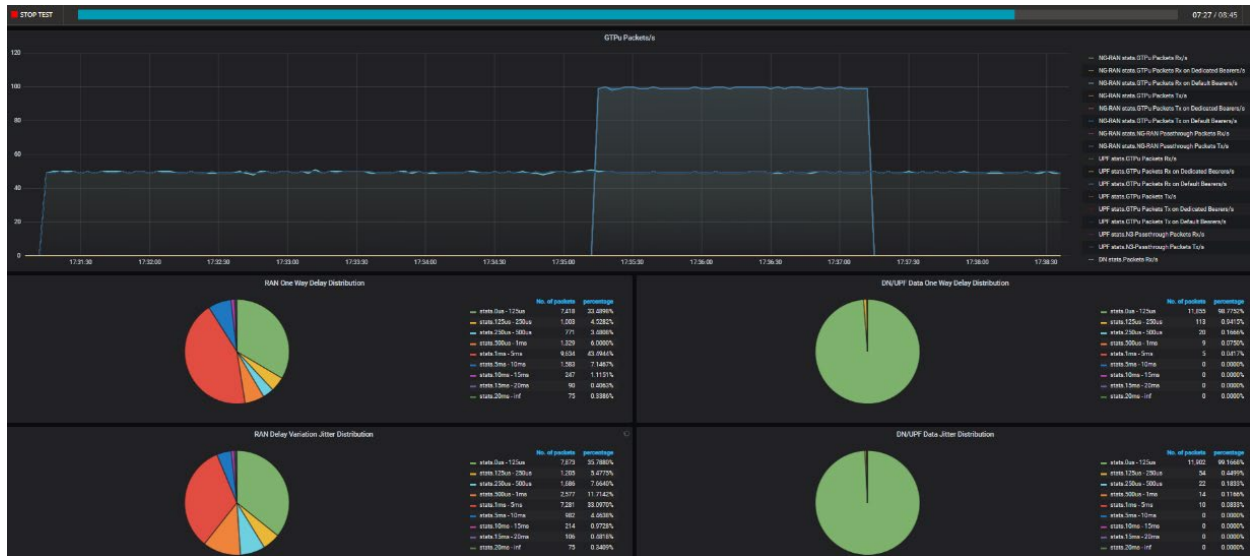
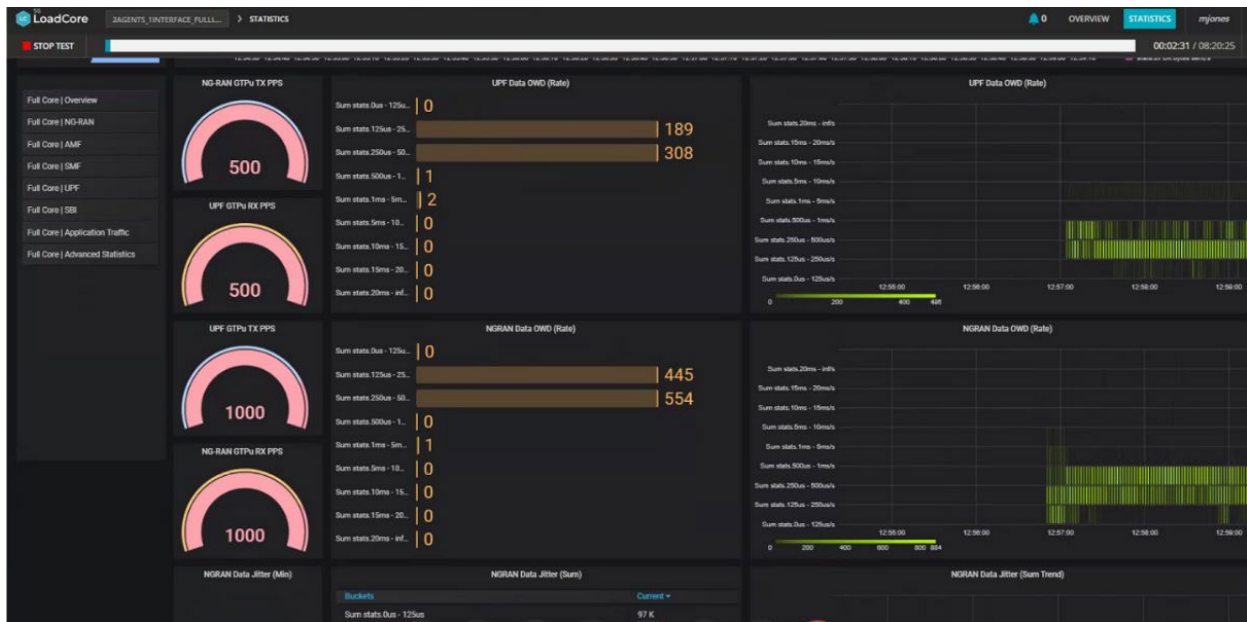
The screenshot shows the LoadCore API Browser interface. The main content area displays a table titled 'sessions' in 'Table View'. The table has columns for 'Attribute', 'Value', and 'Description'. The 'id' attribute is highlighted in blue. A sidebar on the left contains navigation links for various sections like 'APPSPEC', 'agents', 'config', etc. At the top right, there are buttons for 'Remove', 'Edit', 'Operations', 'History', and 'Help'.

Attribute	Value	Description
application	wireless	rw The user-friendly name of this Application
configName	Full Core Base Config	rw The name of the configuration that was loaded when creating the session
configUrl	wireless-fullcore-config	rw The URL of the configuration that was loaded when creating the session
createdAt	1620271480	r A timestamp in Unix seconds that indicates when the session was created
createdAsString	2021-06-18T08:31:20Z	r The RFC3339 formatted value of createdAt
dataModelUrl	/api/v2/sessions/wireless-86c14d6e-9f73-d655-8b0c-e2d75f916171/config	r The URL of the data model loaded in this session
id	wireless-86c14d6e-9f73-d655-8b0c-e2d75f916171	r The session's unique identifier
index	1	r The session's index
name	Full Core Base Config	rw The user-friendly name of this session
owner	admin@cam.ac.uk	r A friendly display name for this session's owner
ownerID	441916a3-f8a4-4719-753236671099	r The unique identifier of this session's owner
state	CREATED	rw The state of the session. Must be one of: CREATING, CREATED or ERROR

Statistics



Main dashboards



User Plane statistics dashboard – One Way Delay, Delay Variation Jitter

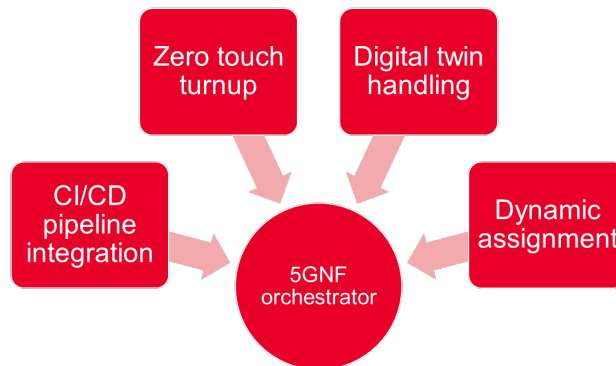
Per-UE stats (Control & User Plane) and Network Slicing statistics (N1/N2) provide in-depth capability of analyzing traffic results with enhanced granularity.

5G Security SCAS test support

- LoadCore offers support for 3GPP 5G Security Assurance Specification (SCAS) using OpenTap automation platform. The tests are pre-defined according to the standard specification and offered as test library for each NF.
- Includes Pass / Fail criteria for each test, offering a complete picture for SCAS spec compliance
- Support for AMF (TS 33.512), UDM (TS 33.514), SMF (TS 33.515), NRF (TS 33.518) test suites

Lab2Live service assurance

- LoadCore offers support for 5G NF Orchestration for closed loop automation. Responsible for initial orchestration, lifecycle management (configuration, performance, fault) the orchestrator (delivered as a separate package) helps customers with dynamic creation of infrastructure in public or private cloud, as well as the deployment and end-to-end operation of the cloud-native applications. It performs automatic onboarding via Helm charts or terraforms, updates test config to match the 5GNF environment and assigns dynamically compute resources to the test.
- Coupled with OpenTap test orchestration and campaign manager, this tool is easy to scale up and down and provides a smooth integration with the CI/CD pipeline helping customer reduce OPEX through complete automation



Supported platforms

Alicloud	AWS	AWS EKS	Azure	Container agent	Google Anthos	KVM	OpenShift	OpenStack	VMware ESX
✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Supported drivers

vmxnet3, mlx4_core, mlx5_core, ixgbe, ixgbev, i40, i40e, i40evf, ena, virtio

Specifications

Standard body	Specification
3GPP Technical Specifications	<p>Supported 3GPP versions: Rel15 – September 2019, Rel16 – September 2020</p> <ul style="list-style-type: none"> • TS 23.501: "System Architecture for the 5G System; Stage 2" • TS 23.502: "Procedures for the 5G System; Stage 2" • TS 23.503: "Policy and Charging Control Framework for the 5G System" • TS 23.214: "Architecture enhancements for control and user plane separation of EPC nodes; Stage 2" • TS 24.526: "User Equipment (UE) policies for 5G System (5GS); Stage 3" • TS 29.571 - 5G System; Common Data Types for Service Based Interfaces; Stage 3 • TS 23.003: "Numbering, Addressing and Identification" • TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3" TS 24.502: "Access to the 5G System (5GS) via non-3GPP access networks; Stage 3" TS 29.122: "T8 reference point for Northbound APIs" • TS 29.281: "General Packet Radio System (GPRS) Tunnelling Protocol User Plane (GTPv1-U)" • TS 29.244: "Interface between the Control Plane and the User Plane Nodes; Stage 3" • TS 29.500: "5G System; Technical Realization of Service Based Architecture; Stage 3" • TS 29.501: "5G System; Principles and Guidelines for Services Definition; Stage 3" • TS 29.502: "5G System; Session Management Services; Stage 3" • TS 29.503: "5G System; Unified Data Management Services; Stage 3" • TS 29.504: "5G System; Unified Data Repository Services; Stage 3" • TS 29.507: "5G System; Access and Mobility Policy Control Service; Stage 3" • TS 29.508: "5G System; Session Management Event Exposure Service; Stage 3" • TS 29.509: "5G System; Authentication Server Services; Stage 3" • TS 29.510: "5G System; Network function repository services; Stage 3" • TS 29.512: "5G System; Session Management Policy Control Service; Stage 3" • TS 29.513: "5G System; Policy and Charging Control signaling flows and QoS parameter mapping; Stage 3" • TS 29.518: "5G System; Access and Mobility Management Services; Stage 3" • TS 29.519: "5G System; Usage of the Unified Data Repository Service for Policy Data, Application Data and Structured Data for Exposure" • TS 29.518: "5G System; Access and Mobility Management Services; Stage 3" • TS 29.522: "5G System; Network Exposure Function Northbound APIs; Stage 3" • TS 29.525: "5G System; UE Policy Control Service; Stage 3" • TS 29.531 "5G System; Network Slice Selection Services; Stage 3" • TS 29.540: "5G System; SMS Services; Stage 3" • TS 33.501: "Security architecture and procedures for 5G System" • TS 33.220: "Generic Authentication Architecture (GAA); Generic Bootstrapping Architecture (GBA)" • TS 33.512: "5G Security Assurance Specification (SCAS); Access and Mobility management Function (AMF)" • TS 33.514: "5G Security Assurance Specification (SCAS) for the Unified Data Management (UDM) network product class" • TS 33.515: "5G Security Assurance Specification (SCAS) for the Session Management Function (SMF) network product class" • TS 33.518: "5G Security Assurance Specification (SCAS) for the Network Repository Function (NRF) network product class" • TS 37.324: "Evolved Universal Terrestrial Radio Access (E-UTRA) and NR; Service Data Adaptation Protocol (SDAP) specification" • TS 38.300: "NR; NR and NG-RAN Overall Description" • TS 38.331: "NR; Radio Resource Control (RRC); Protocol Specification" • TS 38.401: "NG-RAN Architecture description" • TS 38.410: "NG-RAN; NG general aspects and principles" • TS 38.412: "NG-RAN; NG signaling transport" • TS 38.413: "NG-RAN; NG Application Protocol (NGAP)" • TS 38.415: "NG-RAN; PDU Session User Plane protocol"

Standard body	Specification
RFC	<ul style="list-style-type: none"> • RFC 768: User Datagram Protocol • RFC 2131 Dynamic Host Configuration Protocol • RFC 2616: Hypertext Transfer Protocol HTTP/1.1 • RFC 3736 Stateless Dynamic Host Configuration Protocol (DHCP) Service for IPv6 • RFC 2818: HTTP Over TLS • RFC 4627: The application/json Media Type for JavaScript Object Notation (JSON) • RFC 4861 Neighbor Discovery for IP Version 6 (IPv6) • RFC 4862 IPv6 Stateless Address Autoconfiguration • RFC 4960 Stream Control Transmission Protocol • RFC 5246: The Transport Layer Security Protocol 1.2 • RFC 6101: The Secure Sockets Layer (SSL) Protocol Version 3.0 • RFC 7540: Hypertext Transfer Protocol HTTP/2.0

Performance Metrics

LoadCore

Performance per VM (*) for N4 (PFCP)	Performance per VM (*) for NGRAN (N1/N2/N3)
<ul style="list-style-type: none"> • Max active Sessions: 5M • Procedure Rate: 25k/sec 	<ul style="list-style-type: none"> • Max active Sessions: 1.2M • Procedure Rate: 4k/sec

(*) high performance COTS server, default image 4x vCPUs, 4GB RAM

Performance per VM (**) for N3/N6 (User Plane)
<ul style="list-style-type: none"> • 9 Gbps on 10G NIC • 22 Gbps on 25G NIC • 36 Gbps on 40G NIC • 80 Gbps on 100G NIC • Support for: 10/25/40G/100G Intel/Mellanox <p>(**) high performance COTS server, vCPUs and RAM requirements vary depending on NIC. DPDK = ON</p>

Ordering Information

Part numbers

P89033A	LoadCore Floating License, Single Interface emulation (Control Plane)
P89034A	LoadCore Floating License, Performance enabler (1M UEs, 10k Procedures/sec)
P89056A	LoadCore Floating License, reduced performance (100k UEs, 1k Procedures/sec)
P89055A	LoadCore Floating License, basic User Plane capability (10Gbps)
P89037A	LoadCore Floating License, User Plane capability (10Gbps)
P89044A	LoadCore Floating License, User Plane capability (100Gbps)
P89045A	LoadCore Floating License, User Plane capability (500Gbps)
P89046A	LoadCore Floating License, User Plane capability (1Tbps)
P89040A	LoadCore Floating License, Control Plane Impairment
P89054A	LoadCore, Debug tools

Performance bundles are available on request

Pre-canned functional test libraries:

P89900A	LoadCore gNB-sim Test Library
P89901A	LoadCore UPF Test Library
P89902A	LoadCore AMF Test Library
P89903A	LoadCore SMF Test Library
P89904A	LoadCore PCF Test Library
P89905A	LoadCore UDM Test Library

5G Security (3GPP SCAS) pre-canned test libraries:

P89047A	LoadCore, SCAS AMF 33512 test library
P89049A	LoadCore, SCAS UDM 33514 test library
P89051A	LoadCore, SCAS SMF 33515 test library
P89052A	LoadCore, SCAS NRF 33518 test library

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