VIAVI Solutions

White Paper

Network Slicing – test now, succeed later

This whitepaper will introduce the concept of network slicing, provide an overview of three primary 5G service types and core network functions, and highlight how operators and network equipment manufacturers (NEMs) can take a lead on the competition by adopting test and measurement (T&M) solutions available on the market today.

Overview

Second-generation mobile technology gave us a digital upgrade on 1G, with clear voice calls, SMS and data services – albeit very slow ones. The advent of Enhanced Data rates for GSM Evolution (EDGE) delivered (slightly) better data rates, and created a stepping stone to 3G.

Faster than 2G, 3G welcomed 2 mbps, supporting the first wave of smartphones which could enable a variety of data applications and internet browsing. Reliability and coverage of connectivity improved, but mobile broadband remained slow and clunky.

4G/LTE delivers maximum speeds of 80 Mbps in the real world, whilst LTE-Advanced can support theoretical speeds of 1 Gbps. LTE has ushered in HD voice and video calls using VoLTE. Today, it is the most widely used wireless cellular connectivity technology worldwide and supports almost all of the data applications we regularly use our phones for. Basic coverage challenges remain in some areas, yet there are more complex challenges affecting networks globally, which must be addressed to support the development and commercial roll-out of 5G.

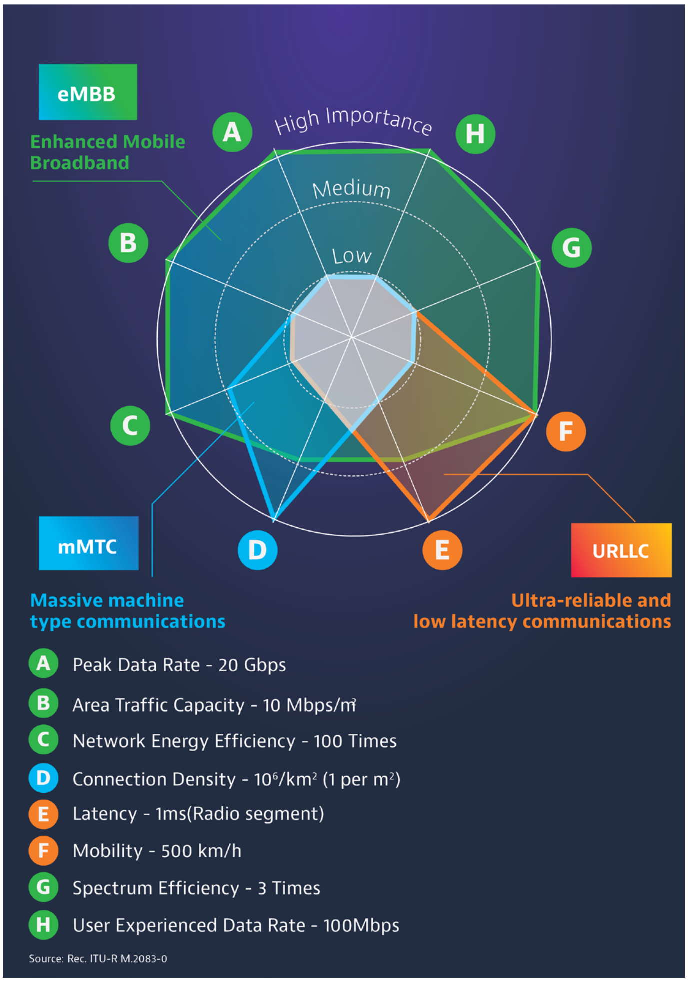

Figure 1: Network Slicing requirements

Overview con't

The latest standard in cellular connectivity supports new use cases such as massive machine type communications (mMTC), enhanced mobile broadband (eMBB), and ultra-reliable low latency communications (URLLC). Different verticals and 5G use cases will utilise different types of connectivity, with mobile operators required to deliver different service-level agreements (SLAs) to their customers depending on their specific requirements. And herein lies the challenge.

In 4G network architectures, all traffic follows the same path and traverses the same network nodes to fulfil its journey, via the same 4G RAN. There are mechanisms in place to prioritize difference types of traffic, such as QoS profiling, APNs (access network points) and virtual or separated core networks. However, these features are in their infancy and will not support the differing throughput, latency and availability demands of millions of IoT devices and use cases which 5G will bring about.

> Network slicing architecture is defined as an independent end-to-end logical network that runs on a shared infrastructure capable of providing a negotiated service quality

The mechanisms currently in place in 4G networks represent an early version of 'network slicing'. Network slicing will be a key component of 5G, partitioning network resources to multiple users or 'tenants' in order to fulfil very specific SLAs between operators and their customers.

5G use cases and challenges

Network slicing architecture is defined as an independent end-to-end logical network that runs on a shared infrastructure capable of providing a negotiated service quality. The network incorporates different elements and nodes, all of which are selected in order to serve the particular demands and functions of a specific use case or communication type. The resulting end-to-end networks are virtual, customizable and encompass both networking and storage functions.

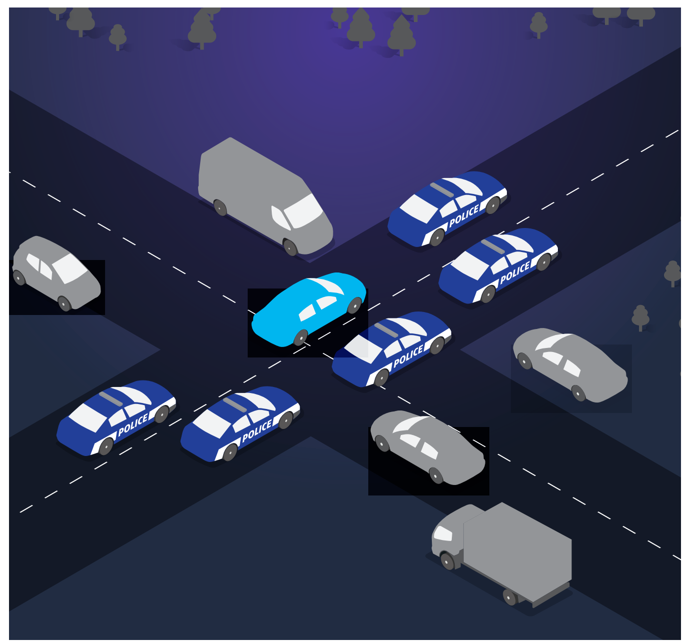

Figure 2: Clearing a path through congested traffic

Or, in simpler terms, network slicing can be considered akin to a police escort creating a clear path through congested traffic. The dedicated path is clear, and tailored specifically to the need of the police escort – to traverse a busy junction rapidly, reliably, and seamlessly, with other vehicles prioritizing this over their own movements. Telecommunications standards body, 3GPP, has released specifications on both the management and orchestration of network slicing and the tenancy concept in 5G networks. Yet despite being an essential component in the success of 5G networks and use cases, network slicing is still in its relative infancy.

Network slicing – test now, succeed later

It will take a while yet to fully evolve network slicing, but no matter how far along their 5G roadmap an operator or NEM is, it's important to test this concept with the standards and specifications defined today, to secure the best possible position to capitalise on 5G in the near-future.

When testing network slicing, a number of factors must be considered:

- Does each network slice select the correct nodes for set-up?
- Does the function of the network slice work correctly?
- Can the network support the volume and variety of systems and devices which characterises 5G networks?

As an enabler for 5G, operators must ensure that networks can support network slicing, and that traffic is successfully prioritised and delivered, despite the huge increase in data these 5G networks will be handling. Developing and investing in robust testing strategies now will deliver cost-savings in the long-term; not delivering on SLAs could risk financial penalties from both customers and regulators.

However, 5G architectures are complex, and testing a 5G network loaded with multiple types of data traffic in a real-world scenario, near impossible. Understanding the requirements of the three fundamental 5G service types is a crucial first step, and moving to virtualised testing solutions the only viable way for operators to evolve their infrastructure.

Network slicing architecture: use cases

S-NSSAI (Single-Network Slice Selection Assistance Information), sits in the UE subscription database and is used by the network to detect a particular NSI (Network Slice Instance). An S-NSSAI is composed of a slice/service type (which refers to how a network slice is expected to behave, depending on its specific features and service), and a slice differentiator (optional information that differentiates between multiple network slices of the same slice/service types.

The different challenges and approaches to network slicing can be examined by focussing on three core network slice/service types:

- enhanced mobile broadband (eMBB),
- massive machine type communications
- ultra-reliable low latency communications (URLLC)

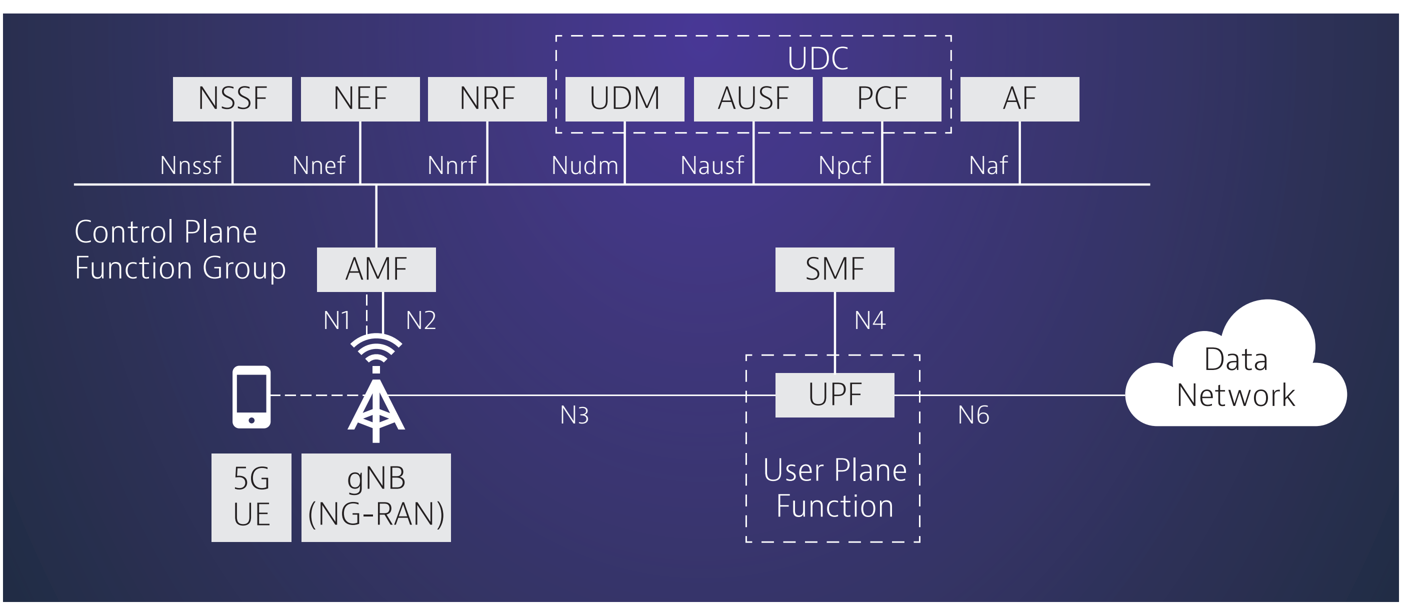

Figure 3: Service-based Architecture

eMBB

eMBB use cases incorporate anything that requires the transport of huge amounts of data across a wide coverage area. High throughput, high mobility and a scalable control plane are key features, with eMBB predicted to support millions of 5G smartphones and devices in dense urban and rural areas.

This is a faster, capacity-enhanced version of 4G, and will support applications like virtual reality in gaming and entertainment, as well as for training purposes in industries like healthcare, defence and aviation. Due to both the consumer- and enterprise-friendly use cases, this is a crucial monetization opportunity for operators and device manufacturers.

Operators must allocate a dedicated slice to eMBB, which can then be customised for different market needs. A high-performance user plane and scalable control plane are required, which can be optimized depending on different data load requirements at different times. We've already witnessed the launch of a number of 5G smartphones, so the clock is ticking on operators to ready their networks to support the significant volumes of traffic these will generate.

mMTC

mMTC will support IoT connectivity on a huge scale, enabling data transfer for a large number of often stationary devices. These devices will transmit small amounts of data, sporadically, over a wide area, consuming only small amounts of power.

mMTC will enable use cases like machine-to-machine connectivity in smart factories and processing plants, as well as supporting the advent of millions of connected consumer devices. These could range from connected dog collars, fridges, waste disposal units, utilities metres, sensors for environmental monitoring; almost anything with a chip and a SIM that can be connected to a network.

Many of these devices will be inactive a large proportion of the time, and only require low-throughout, infrequent data transmission. The challenge with this particular use case, however, is the density of devices.

Loads of nodes

There are three primary core network functions in 5G that were not present in LTE: AMF (access and mobility management function), SMF (session management function), and UPF (user plane function).

- AMF is considered the nerve centre of the 5G network. Located in the core, it's where the first instances of calls are captured and triggered from, and is responsible for access, authentication, authorisation, mobility registration, location updates etc. When you want to make a call and the base station makes contact with the core network, this is the first node it'll come into contact with.
- SMF controls the AMF, from which it receives session management requests. The SMF also 'asks' the UPF to set up data protection, requesting the IP address of UE and website domain (or whatever UE is connecting to). The UPF is aware of these two end points, and makes a connection, much like creating a channel.
- UPF is the connector point between user equipment (i.e. the mobile phone) and the data network. It sits in the core network and supports data transfer back and forth. The UPF allows the control and user plane separation, and can be moved closer to the edge of the network to optimize data rates.

There are a number of reasons why different nodes will be picked for different use cases; those for a smart metre will be different than those for a smart car, for example. Operators must test the functionality of the nodes, and ensure that the correct nodes are selected for each network slice to be set up.

URLLC – Ultra-reliable low latency communications

As the name suggests, use cases of this type require extremely low latency and extremely high reliability, and enable mission-critical data transmission. The characteristics of 5G will enable a range of innovative use cases, ranging from remote robotic surgery and industrial automation to V2X (vehicle-to-everything).

Any degradation in connectivity could be devastating – a failure to deliver the required peak data rates could result in a failure of a connected car's safety system to communicate with its environment, for instance. This information must be communicated not just to vehicles either side of the car, but to multiple cars, sensors and infrastructure over a wide area.

As with eMBB and mMTC, there are different attributes which must be considered for the URLLC network slice. The core network NSSAI will select the elements required to make the call connection, depending on the attributes of the network slice. So, for URLLC, the UPF – the data plane node – would ideally need to be located close to the network edge, in order to reduce latency. As such, data is only transmitted as far as the UPF on the edge and back again; it doesn't need to transfer deep into the core network and back.

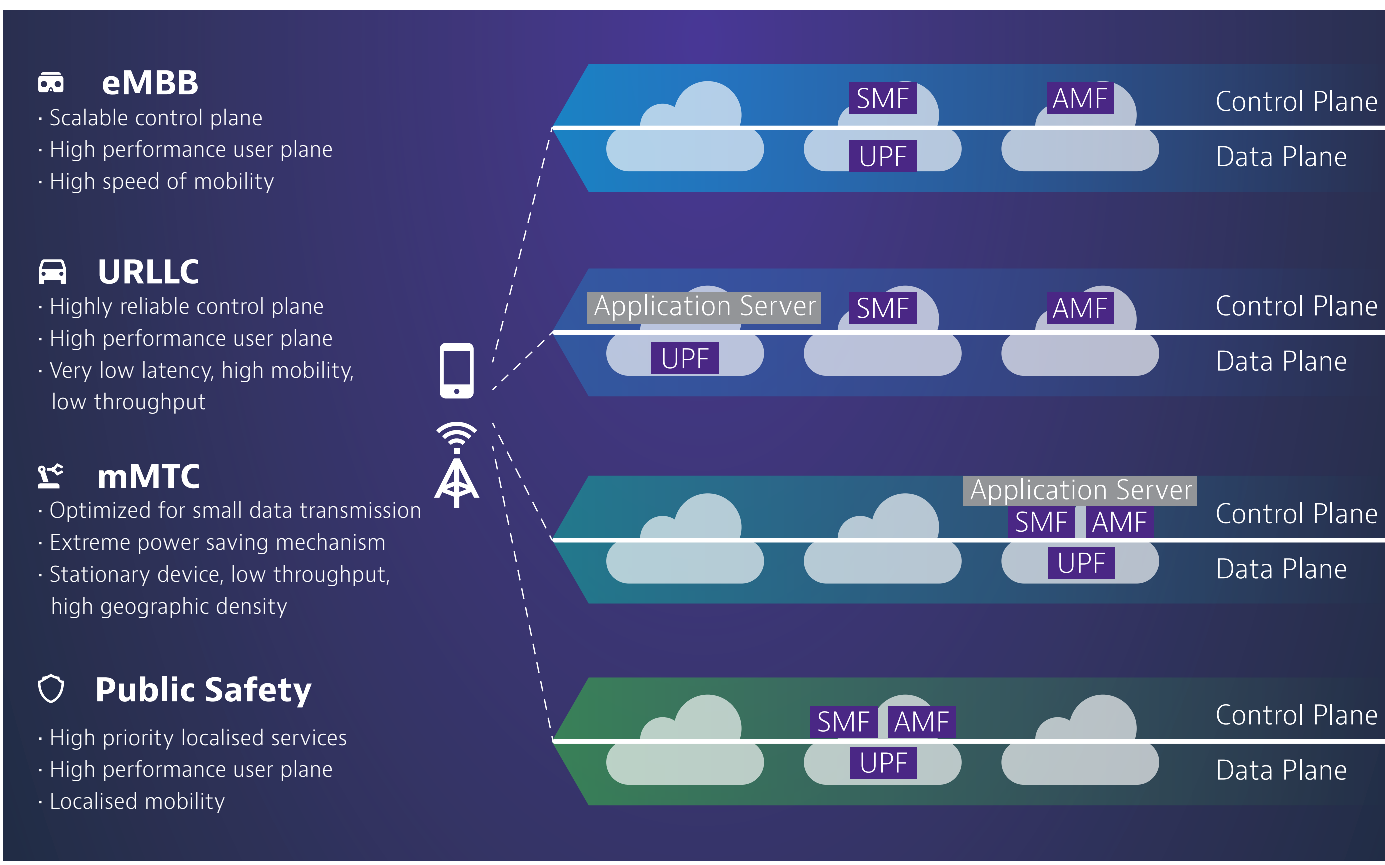

Figure 4: Sharing infrastructure, providing a negotiated service quality

The VIAVI approach

VIAVI has extensive experience helping operators and NEMs deploy, maintain, optimize, and evolve complex wireless networks. Our solutions and approach enable service providers to ready their networks for 5G, get ahead of the competition, ensure they can deliver on SLAs and future-proof their businesses.

Testing network slicing within real-world infrastructure with millions of physical devices is near-impossible. Instead, we've developed end-to-end, RANtoCore test and validation solutions capable of emulating the 5G core network as a whole, individual nodes such as the UPF, SMF, AMF as well as SBA functions. This allows engineers to fully wrap around the base station and ensure that signals are handled in the correct way and meet quality of service expectations. When testing a network slicing scenario, engineers must ensure that the NSSF selects the correct nodes for each network slice to be set up. Our TeraVM solution can emulate everything other than the NSSF, or one or two elements that the user wants to run, to ensure the network is functioning correctly. When developing a 5G core network, engineers must also ensure that the RAN sends and receives the correct signals and responses, which can be validated using our RAN emulator.

The VIAVI TM500 can emulate hundreds of thousands of UEs, as well as measuring latency and round-trip time of a 3GPP-compliant 5G core network in a virtualised, lab environment. This enables the user to test the UPF function in V2X signalling, for example, to ensure that data is transmitted from one car to another through the network within the required parameters of URLLC. Users can therefore ensure that, with the UPF positioned at the edge of the network, they can deliver on that particular SLA.

Finally, our solutions enable engineers to load a network with huge amounts of other types of traffic, such as voice, video, media streaming, and internet browsing. This helps engineers ensure that, even when a network is heavily-loaded, the network slice for V2X, for example, still stands up to its latency round-trip time.

Combining TM500 and TeraVM provides a comprehensive means of testing network slicing – a unique offering in the T&M market. Until relatively recently, the concept of testing network slicing has received little attention from operators and service providers. It is complex, but shouldn't be ignored, and now is the time to consider the most effective approaches address the most pressing challenges.

Through a combination of first-to-market solutions and deep sector expertise, VIAVI offers its partners a straightforward route through network testing and validation, allowing operators to prime their networks for the future, pioneer innovative use cases, and navigate into a leading position in the 5G race.

Simplifying complex 5G test scenarios, our solutions

Inter-work: Across multiple technologies and RATS

Work at scale: Emulate 1000's of devices and applications

Work under stress: Manage a robust network under extreme scenarios

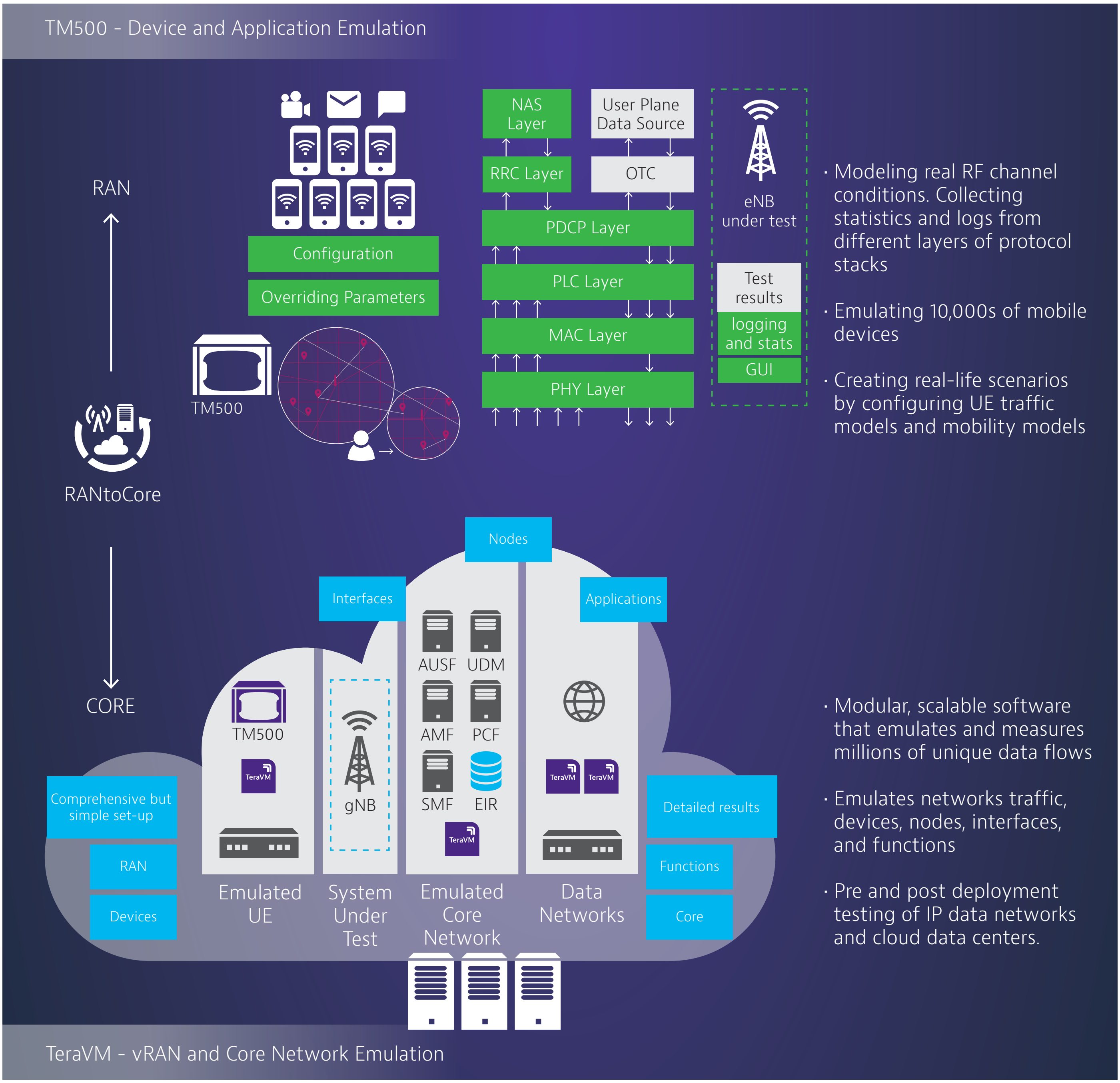

Figure 5: Comprehensive RANtoCore testing

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