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# THE FOUR CHALLENGES COMMUNICATIONS SERVICE PROVIDERS FACE AS THEY ROLL OUT THEIR 5G NETWORKS

It's a paradigm shift requiring new ways of testing and validating network services

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# Executive summary

Communications service providers (CSPs) are focused on delivering 5G service to their customers. 5G advanced technology enables much higher data rates, lower latency, and new use cases creating new business opportunities for CSPs in consumer and enterprise domains. CSPs initially piloted 5G services in their networks with legacy 2G, 3G, and 4G services. Now, they are using 5G New Radio (NR) and 5G Core to deliver basic 5G use cases, first for 5G standalone (SA) SIM and then to deliver complex use cases such as the same 5G SA SIM to work in existing 2G, 3G, and 4G networks. In parallel. CSPs are building use cases to retain existing customers and attract new ones by providing high-data-rate 5G services for new 5G-supported devices such as HD video and virtual reality (VR) that deliver superior network coverage, service availability, and cost savinas.

In 2020, CSPs started delivering 5G services to the consumer base and available network sites that easily integrated, deployed, and migrated new 5G services without interrupting existing network services to their customers. 5G NR RAN, and 5G Core are critical enablers, bringing 5G services and legacy services together where multiple network nodes are integrated to deliver all network services. CSPs have already launched 5G nonstandalone (NSA) service (i.e., 5G data service using existing LTE networks) to deliver partial 5G service where gNodeB is serving 5G user equipment (UE). However, 5G-system (5GS) deployment that caters to 5G subscribers is still in development. Hence, 5G solution providers are proposing per-site service deployment and subscriber migration to reduce service-outage risks.

The 5G UE providers are onboarding operator networks and testing the UEs capabilities for 5G SA, NSA, 2G, 3G, and 4G network data and voice services, including interworking with Wi-Fi and fixed-line networks. Currently, use cases are being tested to ensure that 5G speed, 5G mobility, low latency, and network slicing work for voice, SMS, enhanced public warning system (ePWS), and VR scenarios.

This whitepaper provides guidance for deploying 5G SA services in conjunction with legacy network services. It describes how to efficiently test and validate the 5G services in the lab, pre-production, and production environments. Also, the paper outlines how Capgemini Engineering can provide support to CSPs and 5GS solution providers in the design, integration, test, and deployment stages of network services.

# Introduction

The 3rd Generation Partnership Project (3GPP) has defined six architectures or options (standalone and non-standalone) to serve the network services to CSPs. Most CSPs use Option-3, i.e., 5G NR, with an existing LTE network, and Option-2 for 5G SA, i.e., 5GS (5G NR and 5G Core). (See Figure 1.) The 5G SA deployment serves the network services for applications and user demand for low latency and high throughput.





Source: Capgemini Engineering

#### 5G NSA service deployment

CSPs have already deployed 5G data services using Option-3/3a/3x. (See Figure 2.) The Option-3 family is an NSA option in which the en-gNB is deployed in the LTE network; hence it does not need a 5G Core.

Most operators use Option-3x for 4G and 5G data traffic transfer that will go directly to gNB and split between NR and LTE radio, where data is transmitted to the UE.

For 5G NSA service availability UE, gNB, and the 5G core network (MME, HSS, SGW, and PGW) should be configured for Dual Connectivity New Radio (DCNR) capability.

#### 5G SA service deployment

CSPs migrate 5G services directly from an evolved packet system (Option-1) to the standalone Option-2 with inter-RAT mobility mechanisms used to move devices between 4G LTE, under evolved packet core (EPC) coverage, and 5G NR.under 5G Core coverage. This SA architecture can take advantage of 5G end-toend (E2E) network capabilities supported by NR and 5G Core. This option makes it easy to deliver the 5G services at new sites for specific customer bases, but it does not easily fulfill the integration and migration of legacy services. So interworking with 3G/2G packet-switched and circuit switch network services with 5G SA is a challenge: hence the approach is designed by the 5GS suppliers. Figure 3 describes the migration of EPC to the 5GS.



Figure 2.5G NSA architecture variants in Option-3

Source: Capgemini Engineering



The 5GS solution contains 5G NR and 5G Core, benefiting CSPs, end-user enterprises, and consumers.



Figure 4. 5G SA service benefits Source: Capgemini Engineering

# Four key challenges

CSPs perform pilot, pre-commercial, and commercial launches to deploy 5G services for consumer and enterprise customers. They use 5G SA-supported devices and launch the 5G service to ensure that the network and services meet business requirements.

A major challenge is to deploy network services in conjunction with the new 5GS network successfully across the sites to serve the customer's requirements. Below are four important challenges CSPs need to address to keep the in-network service deployment plan on track.

- 1. UE and cell coverage challenges
- 2. 5GS SA service deployment challenges
- 3. 2G/3G/4G/5G network service integration challenges
- 4. Service testing challenges

#### UE and cell coverage challenges

5G UE devices and cell coverage are the most critical front-end elements that need to meet performance, stability, and latency standards for 5G and legacy network services. The challenge is business and user compliance in terms of service, which must be proven in UE cell coverage with a supported 5G core network.

Here are seven UE and cell coverage issues to be validated during 5GS service deployment:

- 3GPP NR RAN specification compliance, which requires effort and expertise and is difficult to achieve quickly
- Non-3GPP compliance for devices, apps, and endpoints; there is no clear strategy for achieving compliance

- UE registration and de-registration, and data throughput in 5G frequency bands; it is difficult to measure failure in all the possible scenarios and network selection options
- The UE network attach and re-selection at the edge of the cell must deliver consistently high throughput and low latency
- Voice-quality comparison in 5G NR is not measured according to codecs when calls fallback to the LTE and CS network. It should be verified for the various OEM devices and E2E-supported codec
- Ensure the 5G core network control plane and data plane performance and service continuity during mobility, and network slicing are working correctly according to the business requirement
- Test and validation of 5G UE interfaces and protocols; challenges include new interfaces and protocols, and understanding capability building

### 5GS SA service deployment challenges

5G service and new network migration is the most time-consuming and challenging activity to ensure the tested solution deployed in the production network meets operator business requirements. The primary technical and business requirement is also associated with the deployment of 5G solutions such as new service design, business requirements implementation, solution testing, operation, and network support.

Here are four SA service deployment issues to address:

 The solution integration challenge is to make the network available for 5G SA, NSA, and 4G, 3G, and 2G; however, there is no clear service deployment or subscriber migration strategy

- 5G network interfaces and protocols are new; hence gaining the knowledge and building domain expertise makes it very difficult to validate the vendor solution. The vendor and operator teams must combine their efforts to deliver the validated solution
- 5G Core network and operator services testing is a significant challenge that requires time and expertise to test the E2E solution
- OSS, BSS, charging, billing, and FCAPS management for 5G service operation and management can be challenging. This is where integration and migration with the new 5G system requires significant effort to test and accept the solution for customers

### 2G/3G/4G/5G network service integration challenges

CSPs deploy integrated solutions in the network to deliver both 5G and existing services (e.g., 4G). This kind of deployment contains various challenges, including the availability of existing 5G NSA, 4G, 3G, and 2G PS/CS services.

Here are four network service integration issues to address:

- 5GS solution integration with the existing network and all service availability can be challenging, such as UE re-registration, call drops, single radio voice call continuity (SRVCC) issues, and voice and data call access impact at the same time
- Mobility issue for 5G SA to NSA, 5G to 4G, and 5G to 3G and 2G
- There are challenges in country-specific network services availability support such as emergency, shortcode, unstructured

supplementary service data (USSD), and supplementary services. The goal is for all network services to work with 5G SA/ NSA/4G/3G/2G UE and subscribers in a 5G integrated network

• Validation and testing of all integrated components is a challenge because of the lack of solution-testing expertise

#### Service testing challenges

Testing is a critical function that 5G network service providers are working on for business and regulatory compliance requirements.

Here are five service testing issues CSPs face, covering system integration testing (SIT), interoperability testing (IOT), production integration testing (PIT), device testing, E2E testing, stress testing, and security testing:

- Testing all the functions against the service that CSPs plan to deploy according to the business requirement due to new applications such as VR, high throughput, and real-time-based use cases
- Testing new 5G NR and core protocols, interfaces, and all possible integration points (e.g., 5G SA, NSA, and EPC), which are built on a new platform architecture
- Resolving the service outage and early detection of a fault in production
- Automation for 5G to 2G data and voice service features, bug fixes, and regression tests in the lab or production for physical network function (PNF) and virtual network function (VNF) elements
- Ensuring the test team has the expertise building in a diversified network environment and can upgrade their skills as required

# The solutions

CSPs have experience deploying 5G SA, NSA, and all existing network services at macronetwork and enterprise-network customer sites. Operators in the UK and Europe use service deployment solutions containing 5G SA and NSA combined with legacy 4G, 3G, and 2G to serve all CSP services. service and interwork with legacy EPC for 4G data and voice services. (See Figure 5.) In the later phase, all network services and features should be delivered, including mobility across 2G, 3G, 4G, 5G, Volte, Voice over Wi-Fi (VoWiFi), single radio voice call continuity, network slicing, dedicated core, country- and operator-specific service, and interwork with other networks.

#### 1. Network service deployment roadmap

This roadmap is the phased-order deployment plan in which 5G SA subscribers have 5G SA



Figure 5. Deployment approach for 5G SA service in a communications service provider network Source: Capgemini Engineering

# 2. Integrated 5G SA, 5G NSA, 4G, 3G, and 2G voice and data services deployment solution

The 5G New Radio (NR) and 5G Core network elements interconnect with the rest of the network functions across a single API calling interface and provide the service-based architecture in the 5G SA service deployment, maintaining service availability and reliability. This 5G SA solution must be integrated with the existing 5G NSA, 4G, 3G, 2G, and fixed-line network for operator customers.

Here are the main activities required to deploy all network services successfully:

- Deployment of the 5G hardware and software solution in the operator lab and production network sites
- Integration of the 5G SA solution independently to ensure 5G SA service is working successfully
- Test the 5G SA UE with provisioned subscribers on the 5G SA provisioning and subscriber management system
- Integrate the 5G SA solution with the existing 4G, 3G, 2G network and provision the subscriber on the respective systems
- Test the 4G, 3G, 2G, and Wi-Fi services using 5G SA subscribers, including mobility management
- Configure the network features such as dedicated core and network slicing, and test all services based on the customer requirements

#### 3. Service testing solution

Testing 5GS is a challenge. However, building a new SIT E2E test strategy, including the user journey and use-case-driven test approach, is the best way to cover the business requirement. The highest priority for CSPs is to test vendor solutions and services so that customers have network service availability with minimal service outages.

Achieving faster, defect-free service deliveries requires three strategies:

- Manual testing strategy: Build the test strategy and script to test E2E services and validate the business requirement, such as very-high throughput, submillisecond latency, UE attach/detach, mobility scenarios, simultaneous data and call access, emergency services, VR, a public warning system, and cell broadcast. The manual test strategy also validates UE, new radio, and network capabilities such as dedicated core (DECORE) and network slicing
- Feature testing strategy: DECORE and network slicing are two important network feature configurations, and their testing is crucial to meet business objectives
- Automation testing and CI/CD strategy: Analytics-driven automation is a prerequisite for 5G test environments and assurance. Various use cases are testable using automated acceptance tests (AATs), such as static and dynamic network slicing, DECORE, resiliency, redundancy, service chaining, security, deep-packet inspection (DPI), mobility, capacity, and capability. Using AAT dynamic behavior of network testing is possible only through automation. Since changes are bound to happen faster than humans can comprehend, analytics and machinelearning-based automation are essential for testing and deploying 5G systems. The test system needs to proactively sense when the system under test will go down or have degradation in service, so it can automatically take corrective action. The DevOps and CI/CD method enables AAT performance to regress upgrades and fix buas auicklv

Capgemini Engineering has developed rich experience and insight covering the complete life cycle of mobile networks and related services with an end-to-end perspective: Product and solutions, ideation and development, system integration, testing and validation in labs, deployment, and maintenance and support. The offerings cover the global ecosystem of telecommunications companies, including CSPs, NEPs, and industrial companies:

- **Product development services** covering all network elements, including 5G RAN (O-RAN and vRAN), and 5G NGC
- Uniaue licensable software frameworks covering all key domains: networking, wireless and wireline cloud and orchestration, and edge computing. These buildina blocks enable telecommunications companies to accelerate the development of their connectivity products and solutions. As a result, Capgemini Engineering clients can reduce their development time by 30% to 60%. In particular, we support 2G, 3G,

4G, 5G RAN, and 5G core network testing frameworks and test tools to validate network services, features, and protocols with an end-to-end perspective

- **Testing services** offer sound expertise in mobile networks (2G to 5G), fixed network testing, device testing, and field trial testing in physical and virtual network environments
- SG labs supporting the overall ecosystem: Network labs with Lab-as-a-Service (LaaS) offer interoperability and integration support, testing and certification, hosting services, and support 5G usecase development and integration for vertical industries. In addition, Capgemini Engineering supports managed testing and production service labs based on the client's needs
- **Centers of expertise** focusing on advanced networks and supporting the transition towards 5G and edge worldwide



### Conclusion

In 2021, CSPs started deploying 5G SA service in their networks as a pilot, pre-commercial launch and strategic solution. The strategic solution is the execution of a long-term delivery plan to cover each aspect of 5G service deployment.

5G service deployments will pick up pace in the coming years; by 2023, about 20% of all traffic will be on 5G SA, according to current forecasts by UK and European operators. It will create unlimited opportunities for new use cases, businesses, devices, and applications. However, the journey from 4G to 5G is complex. It is not just a move to a new generation of mobile communication. Instead, it is a paradigm shift that requires new ways of understanding the design changes. These include single databases to store subscriber data, serve all network services, new features, lower latency, higher throughput, and fault tolerance. The challenge is proving how these new ways of testing and validating network services should be designed.

CSPs and equipment vendors have to change the service deployment and testing methods in the lab and production environment. They need to build a new strategy that focuses on using automation to test and deploy network services quickly. Early planning to identify the activities for automation is the best approach to save time, effort, and cost in service deployment.

### Capgemini Engineering Services

Capgemini Engineering relies on our team of more than 10,000 telecommunications engineers, including 3,000 5G and edge experts, to support more than 500 companies and their global ecosystems, including communications service providers, network equipment providers, and industrial companies. As a result, we have deep experience in the network service domain acquired over more than twenty years. In addition, we have a sound understanding of operator network management, vendor solutions management, services deployment process management, and regulatory requirements.

Capgemini Engineering has radio, core networking, and testing expertise, including device testing, subscriber migration, and service testing in labs and production. We offer system integration services with a neutral approach, leveraging multi-vendor tools and open-source integration, intelligent support, and automation services. As a result, we provide customized, pointed solutions for each network use case and leverage our significant artificial intelligence and machine learning experience.

We deliver 5G NR and 5G Core tested solutions and contribute to integration, test, and validation of 5G SA, NSA, 4G, 3G, and 2G network service deployments for pre-commercial launch and strategic launch solution delivery.

Currently, Capgemini Engineering is validating design changes for 5G SA at the network architecture level. And we are validating network services for business requirements, user experience, user journey, technical implementation verification, such as interface and protocols, and ensuring solution and service delivery are 3GPP compliant.

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Since 2003, Arif has focused on creating high-value digital experiences and strengthening customer relationships by being responsive, building trust, and delivering quality technical solutions in the operator network. He has worked on project teams with communications service providers around the world, including Vodafone in the UK, STCS in India, and Société Française du Radiotéléphone in France, spanning legacy to cloud technologies for voice and data core networks. Currently, Arif is working on cloud-native 5G SA/NSA, 3G/4G CS, and PS network end-to-end solution-delivery projects.

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#### About Capgemini Engineering

Capgemini Engineering combines, under one brand, a unique set of strengths from across the Capgemini Group: the world leading engineering and R&D services of Altran – acquired by Capgemini in 2020 – and Capgemini's digital manufacturing expertize. With broad industry knowledge and cutting-edge technologies in digital and software, Capgemini Engineering supports the convergence of the physical and digital worlds. We help clients unleash the potential of R&D, a key component of accelerating their journey towards Intelligent Industry. Capgemini Engineering has more than 52,000 engineer and scientist team members in over 30 countries across sectors including aeronautics, space and defense, automotive, railway, communications, energy, life sciences, semiconductors, software, and internet and consumer products.

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