5G StandAlone

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5G SA (StandAlone) will exploit the true potential of 5G and will be the evolution of currently deployed 5G NSA networks, guaranteeing a better quality, minor cost and a more satisfying customer experience.
Among the main benefits we can mention significantly lower latency enabling for example industry 4.0 and self-driving car use cases, or massive IoT support and the introduction of 5G private networks through network slicing functionality.

Context and Introduction

Operators are increasingly experimenting with and deploying 5G StandAlone (SA) networks. Introduction of 5G SA is expected to simplify architectures, make network deployments easier, improve security and reduce costs.

5G SA is expected to enable customization and open up new services and revenue opportunities tailored to enterprise, industrial and government customers.

As well-known, SA enables the following three service categories:

- Ultra Reliable Low Latency Communications (URLLC);
- Enhanced Mobile Broadband (eMBB) services;
- Massive Machine Type Communication (mMTC);

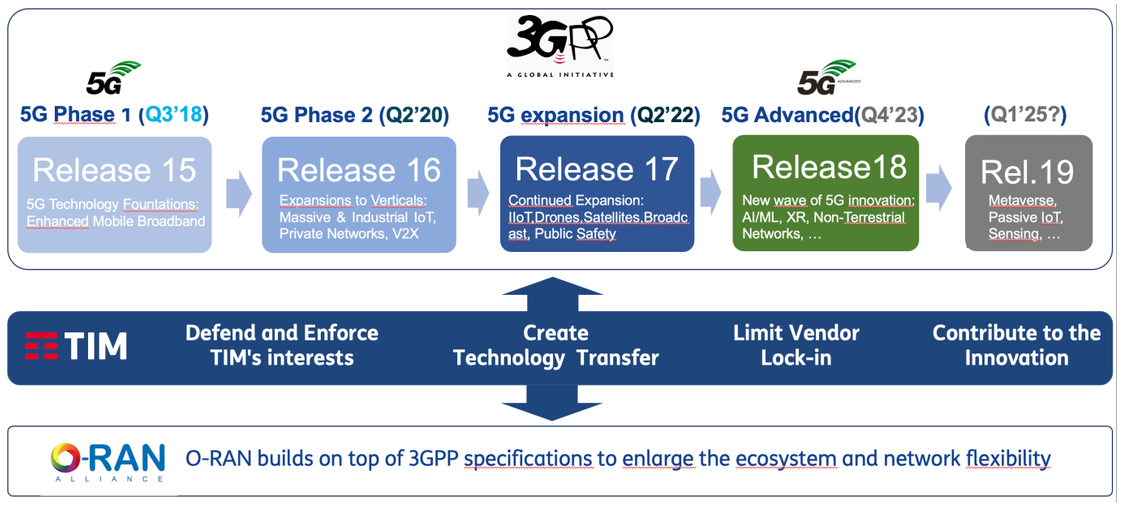
as well as the Network slicing capability, that is the possibility to offer customized service quality and privacy.

Standardization Roadmap

The first set of 3GPP 5G SA specifications were delivered as part of Release 15 in June 2018. Often referred to as “Phase 1” of 5G, it was mainly focused on enabling traditional mobile connectivity services (eMBB), including enhancements to LTE/EPC (e.g. for interworking aspects) as well as security and network management aspects related to the operation of the new radio and core.

Release 16, or 5G “Phase 2”, was completed in June 2020 aiming at improving the performance of the NR access and the 5G Core in terms of latency and reliability (URLLC) and high density of connections (mMTC), From Release 16 onwards, 3GPP scope also includes application layer standards defining new

Figure 1: 3GPP Roamap for 5G System



Application Enablers to help Verticals make best use of 3GPP systems.

"Phase 3" of 5G is currently being completed in 3GPP by March 2022, with a 9-months delay due to the pandemic.

It aims at enabling even more vertical markets (e.g. Satellite, Public Safety, …) in addition to the increase of radio performance and efficiency and to the definition of new architectural enablers (e.g. Multicast/Broadcast, Direct Communications, …).

In December 2021, 3GPP agreed the new package of Studies that will characterize the next phase of 5G, Release 18 (branded also as "5G Advanced").

Rel18 is expected to deliver some innovative technologies to further support vertical markets (e.g. Edge federation, AI/ML support, "Timing-as-a-service", XR and AR communications…) anticipating use cases / trends that will only see full maturity in 6G.

Market overview

Market is seeing the rising of a strong 5G SA ecosystem with chipsets and many types of devices (663 announced devices with claimed support for 5G SA).

On January 2022, it has been identified 98 operators in 50 countries/territories worldwide [GSA] that have been investing in public 5G SA networks (in the form of trials, planned or actual deployments).

At least 20 operators in 16 countries/territories are now understood to have launched public 5G SA networks.

Current Situation

Currently in Italy operators are deploying NSA 5G networks. 5G is mainly associated with 3.7 GHz frequency band, thus identifying 5G with a boost in throughput.

One operator is massively using DSS (Dynamic Spectrum Sharing) to activate 5G on legacy frequencies and so enabling 5G logo to be displayed in most service area, even though with limited performances.

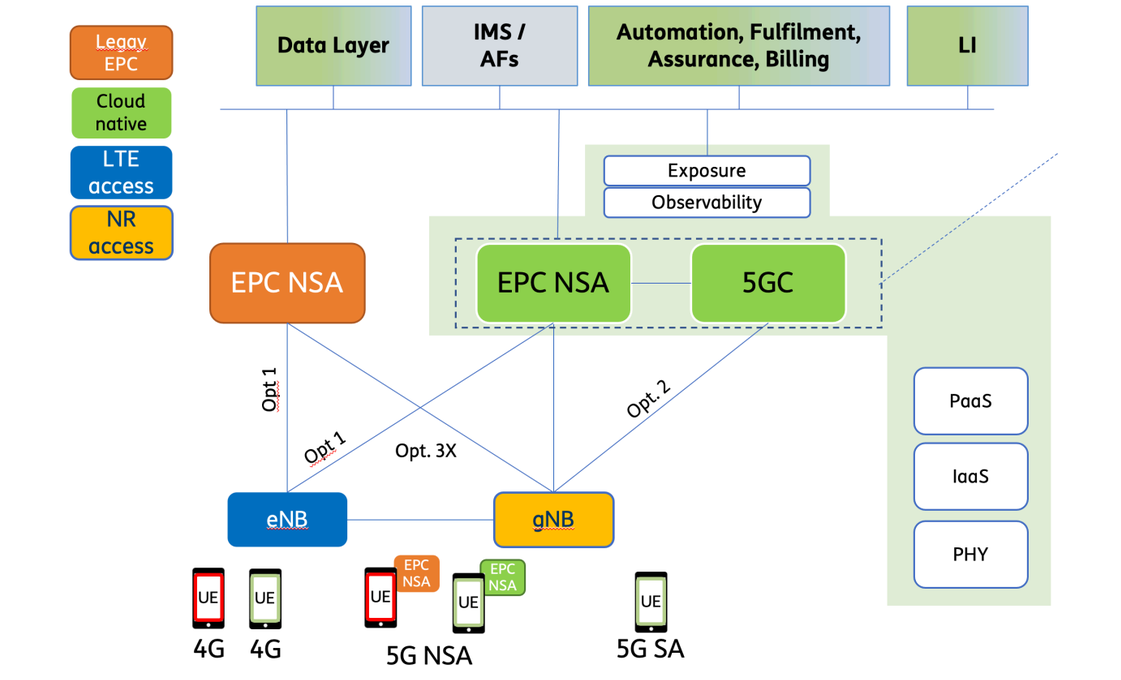
One operator has announced the use of 5G SA for FWA service. In Italy there isn't any regulatory push to deploy a 5G SA network: reasons for deployment should be found based on Market requirements, network costs reduction or technological positioning.
In Brazil there are few 5G DSS deployments. The newly assigned 3.5GHz band has many regulatory obligations associated, among which the duty to deploy a SA release 16 compliant network.

So, by mid-2022 in Brazil there will reasonably be at least four 5G SA networks.
The presence of a large LTE customer base, the current small penetration of 5G SA capable terminal and the necessity for the two technologies to coexist poses a series of issues and related costs that it is necessary to highlight.

Hereafter a short list of higher priority topics:

- Coverage for eMBB in SA: 3.7 GHz frequency range allows a significant performance boost compared to 4G, but it appears barely suitable (unless a massive and capital intensive deployment is implemented) to provide nationwide and indoor coverage. For this reason, in order to offer a nation-wide SA coverage based on 3.7 GHz band, also providing throughput performances equal or greater than the ones offered by 4G networks, a concurrent deployment on low frequency bands must be considered by operators. This can be achieved using the 700 MHz band or the aforementioned Dynamic Spectrum Sharing (DSS), in order to use legacy 4G frequencies in 5G NR. Unfortunately, DSS introduces some inefficiencies, consuming 4G and 5G capacity. Therefore, widespread usage of DSS may imply, where necessary, not negligible investments on 4G capacity at least until 5G traffic is not dominant.
- Band aggregation: NSA users can benefit from the full 4G bands plus 5G NR bands. 5G SA users can benefit only from the NR bands, with some limitations (at least at the beginning) due to terminals capability in multiple bands carrier aggregation.
- Voice: until Voice over New Radio (VoNR) will not be available, 5G SA users will be redirected on VoLTE for voice calls, with some inefficiencies in terms of call set up time.
- 4G interworking: until NR SA coverage will not be continuous, 5G SA users will experiment frequent inter system handovers towards 4G.

Figure 2: NSA and SA planned architecture



- NB-IoT: currently 5G SA does not support narrow band IoT devices. So 4G will still be important for such kind of services. It is however commonly recognized that NB-IoT technology satisfies the 5G KPIs for massive IoT traffic (device density, power consumption, …), so it can be considered part of the 5G solutions for mMTC as well.

Roadmap towards 5G SA

TIM Italy Roadmap

Network

TIM is implementing the new 5G Cloud Native Core Architecture (Figure 2) to support 4 specific categories of service: 5G Verticals, FWA, MBB, IoT:

- 5G Verticals will be the first deployments of 5GC/5G SA;
- the next step will be FWA on 5G SA accesses with deployment of the 5GC slice for FWA;
- the deployments of 5GC slices for eMBB will be made based on the availability of 5G SA smartphones with voice support in VoNR mode and 5G NR carrier aggregation radio technologies;
- for IoT, the 5GC slice deployments are expected in accordance with the timing of the Release17.

5G SA cloud native service platforms make it more effective for TIM to “Platformize” its Network Functions (NFs), opening the 5G network to (internal and external) 3rd parties through the exposure of open, secure and programmable APIs (“Network as a Service” model).

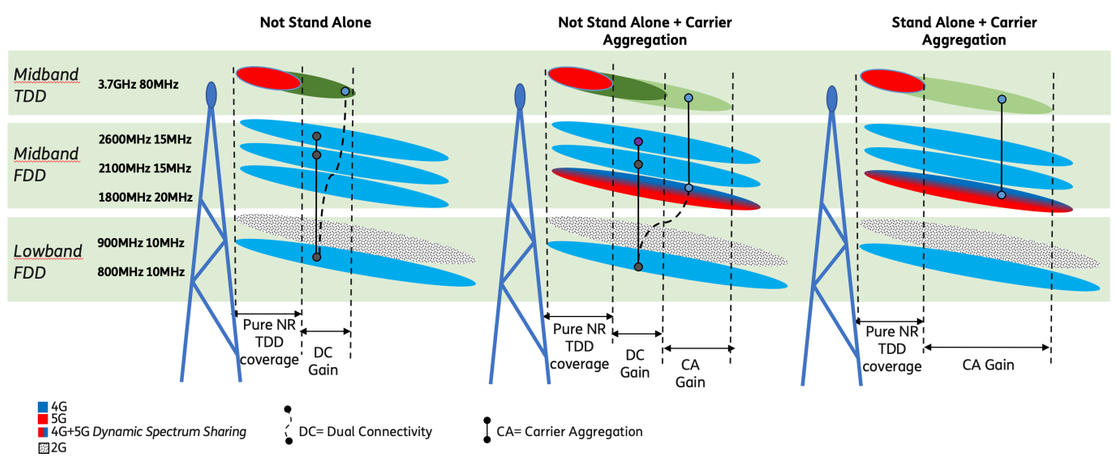


Figure 3: NSA and SA planned architecture

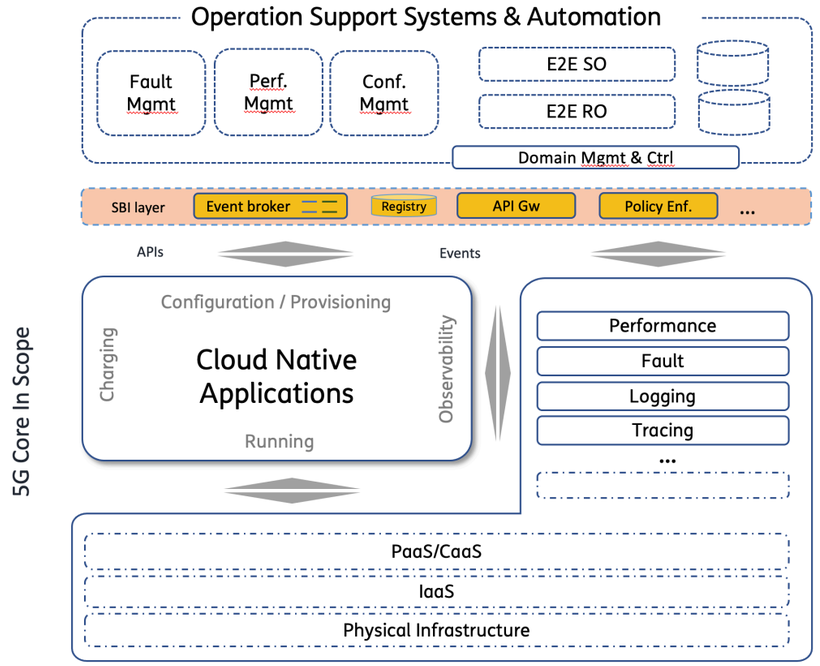


Figure 4: NSA and SA planned architecture

This will be made possible through the NEF (Network Exposure Function), that represents the natural evolution of the exposure path already in place in TIM.
Radio deployments will follow 5G Core Network plans and will be driven by specific Customer’s requirements (i.e. in particular low latency use cases).

As anticipated, if compared to NSA solution, SA cannot rely on LTE carriers: so, in order to boost performances, it is of fundamental importance to aggregate more NR carriers (Figure 3), for example Sub6GHz mid and low bands.

In terms of radio configurations, different scenarios could be of higher interest:

- SA using Sub6GHz TDD mid bands (3.7 GHz) + Sub6GHz FDD Mid/Low bands.

In this scenario, NR coverage and radio performances could be significantly enhanced by using Carrier Aggregation between 3.7 GHz and Sub-6GHz bands exploiting DSS (Dynamic Spectrum Sharing):

- SA using mmW TDD high bands (26 GHz) + Sub 6GHz Mid/Low bands.

This scenario represents a good solution to further enhance throughput performances, due to the introduction of mmW layer, typically very challenging in terms of coverage range.

Main driver for DSS implementation is 5G coverage extension, when coupled to a mid band layer (e.g. 3.7 GHz). In general, it can be noticed that:

- DSS allows massive extension of the area where 5G connectivity is perceived as available (the 5G icon on the terminal);
- DSS improves the NR TDD@3.7 GHz coverage for downlink, through NR carrier aggregation by using a lower frequency band in DSS mode as primary component carrier and the 3.7GHz mid-band as secondary component carrier.

Even though DSS can be implemented in both NSA and SA architecture , it must be considered an important enabler for the transition from NSA to SA, together with Carrier Aggregation.

Support Systems

OSS Architecture (Fault, Configuration & Performance Management)

In order to support FCAPS functionalities to guarantee Network Elements (NEs) Operation & Management (O&M) from 5GC as dual mode EPC-5GC cloud native, with support for all 4G and 5G SA/NSA accesses, TIM will utilize at first Vendor-provided Element Management System (EMS).

In a second phase, not yet planned, Target OSS Integration Architecture will be compliant with 3GPP-SA5 Service Based Architecture (SBA): 5G network functions and the related management functions will be implemented through innovative software development techniques such as microservices, containerization, etc.

The next figure represents one possible 5G target OSS integration architecture in a cloud-native environment.

BSS Architecture (Usage to Bill)

The introduction of the 5G SA core network requires an architectural re-engineering of the online mediation system in the Usage Collection domain and of the Online Charging System in the Billing area.

To this end, an architectural evolution roadmap has been defined in the Usage-To-Bill area, aimed at the native integration of the 5G SA core network, enabling the support of new 5G SA offer models and services.

In the target architecture the new online mediation component will have to allow integration with both the core 5G network and legacy networks for both prepaid and postpaid mobile customers.

The To-Be architecture will enable converged mobile rating, with the ability to extend it to wireline customers, enabling converged native billing.

The Charging and Billing capabilities supported by the platforms, deployed on cloud architecture to guarantee performances, scalability and resilience, will be accessible via Open API designed according to the main industry standards.

TIM Brasil Roadmap

As already mentioned, Anatel included in the 5G auction rules, published in February 2021, a set of obligations among which the requirement that the 3.5GHz frequencies should be used in 5G Stand Alone Release 16 or higher and specific coverage obligations in 3.5GHz.

This means that Brazilian operators are not allowed to rely on DSS technology to fulfill 5G coverage obligations, meaning that 5G SA networks must be deployed on 3.5GHz.

Anatel stated that 5G SA will be available in the capitals of all 27 states of Brazil by July 2022. This will be the first 5G coverage obligation to be fulfilled by the winning bidders.

The target architecture for 5G SA is a fully 4G/5G Convergent infrastructure, contemplating all the network functions specified by 3GPP for the 5G Core, as well as the evolutions foreseen for the RAN layers and with a high degree of automation, orchestration, and programmability.

Having as initial base the functionalities specified by 3GPP in Release 16, TIM Brasil will follow the evolutions foreseen for the subsequent releases, aiming, in particular, to ensure the use of the new functionalities to support the new applications and monetization opportunities brought by the eMBB, URLLC and mMTC dimensions.

The access layer infrastructure will evolve gradually to explore also O-RAN solutions, establishing a hybrid environment, combining O-RAN with traditional RAN architectures and the coverage will be expanded based on, mainly, the 3.5 GHz and 26 GHz, and later, the 2.3GHz that will, initially, be used for the LTE Network.

New services such as mMTC and URLLC will be added as the Network and Transmission grid evolves and reduction on latency is inherent to the 5G SA technology.
Another highly probable new service will be the Private Networks, that had an evolutionary leapfrog with the launch of the 5G Network, Network Slicing and Edge Computing.

The coming challenge will be the layer management, as LTE traffic will continue growing until 2025 and refarming from 4G to 5G will gradually be done. Providing the best possible experience to the subscribers will be the key, regardless of the type of terminal they use.
NR brings new antenna configurations that shall be applied to the different coverage scenarios as MIMO 32x32 and 64x64 for outdoor or 8x8, mainly for indoor use.

Voice Services (VoNR), Network slices and Exposure will be supported and an E2E automation framework for operation, dynamic network slices implementations, allowing to explore new business models and the fully potential that new functions like NWDAF and NEF can offer.

In BSS environment, the service-based architecture for charging and billing systems for 5G SA and the corresponding functions and interfaces

that support this new architecture will need to evolve significantly and will be service based interfaces (SBI).

There will be a convergent billing interface covering online charging, automatic charging, and data recording.
As part of 5G SA evolution support some of IT BSS ongoing and in planning initiatives are listed below:

- 5G CHF – 5G Charging function implementation;
- 5G CCS – Convergent Charging System;
- MIoT – Massive Internet of Things platform;
- Network Exposure Function (NEF) Northbound APIs / Open Telco API Management.

Conclusions

Introduction of 5G SA is expected to simplify architectures, make network deployments easier, improve security, reduce costs and empower new use cases.
5G SA will be enabled by the new 5G Cloud Native Core Network. Regarding network access, considering that 3,7GHz band will take long time in order to provide a nationwide outdoor/indoor coverage, the support of existing 4G frequency bands and the new 700MHz one need to be considered in order to provide a good quality of service also through the use of Dynamic Spectrum Sharing (DSS).

TIM Italy will deploy SA in conjunction with Telco Cloud Continuum, starting from specific areas, mainly focused on some vertical use cases, and afterwards, gradually, in other areas using a business driven approach.
TIM Brasil will comply with the regulatory rules and the synergistic use between 5G SA and the 3.5GHz band.■

Contributing Companies

Contributing companies to this article are:
TIM Italy and TIM Brasil.

Acronyms

3GPP	Third Generation Partnership Project
5G NR	5G New Radio
5G SA	5G StandAlone
BSS	Business Support System
CCS	Convergent Charging System
CNFs	Cloud-native Network Functions
DSS	Dynamic Spectrum Sharing
eMBB	enhanced Mobile Broadband
EMS	Element Management System
EPC	Evolved Packet Core
EPC- 5GC	Evolved Packet Core - 5G Core
FDD	Frequency Division Duplex
FCAPS	Fault Configuration Accounting Performance Security
IoT	Internet of Thing
LTE	Long Term Evolution
MBB	Mobile Broadband
MIMO	Multiple Input Multiple Output
MIoT	Massive Internet of Things platform
mmW	millimeter Wawe
NEF	Network Exposure Function
NR	New Radio
NSA	Non-StandAlone
NWDAF	Network Data Analytics Function
O-RAN	Open Radio Access Network
OSS	Operation Support System
SBA	Service-Based Architecture
SBI	Service Based Interfaces
TDD	Time Division Duplex
URLLC	Ultra Reliable Low Latency Communications
VoLTE	Voice over LTE
VoNR	Voice over New Radio