What's next for 5G spectrum utilization?

Shifting gears with advanced traffic steering to give users the performance they expect

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5G introduces multiple frequency bands with different capacities and coverage. At the same time, the variety and capabilities of user equipment (UE) continue to increase. To manage the increasing complexity of steering every UE to the most adequate frequency layer, traffic steering needs to evolve.

Spectrum assets must be utilized in a way that gives users the expected performance and experiences according to UE capabilities, location, and services used, while utilizing the whole spectrum asset – a finite and expensive resource. This will bring operational savings and give communications service providers (CSPs) the opportunity to charge a premium for superior user experiences, while making way for service differentiation and energy optimization.

Ericsson new radio (NR) Multi-Layer Coordination enables CSPs to make the best use of their entire spectrum assets to deliver the experience users expect by considering the network deployment, the cell configurations, and the UE capabilities when optimizing for the services used.

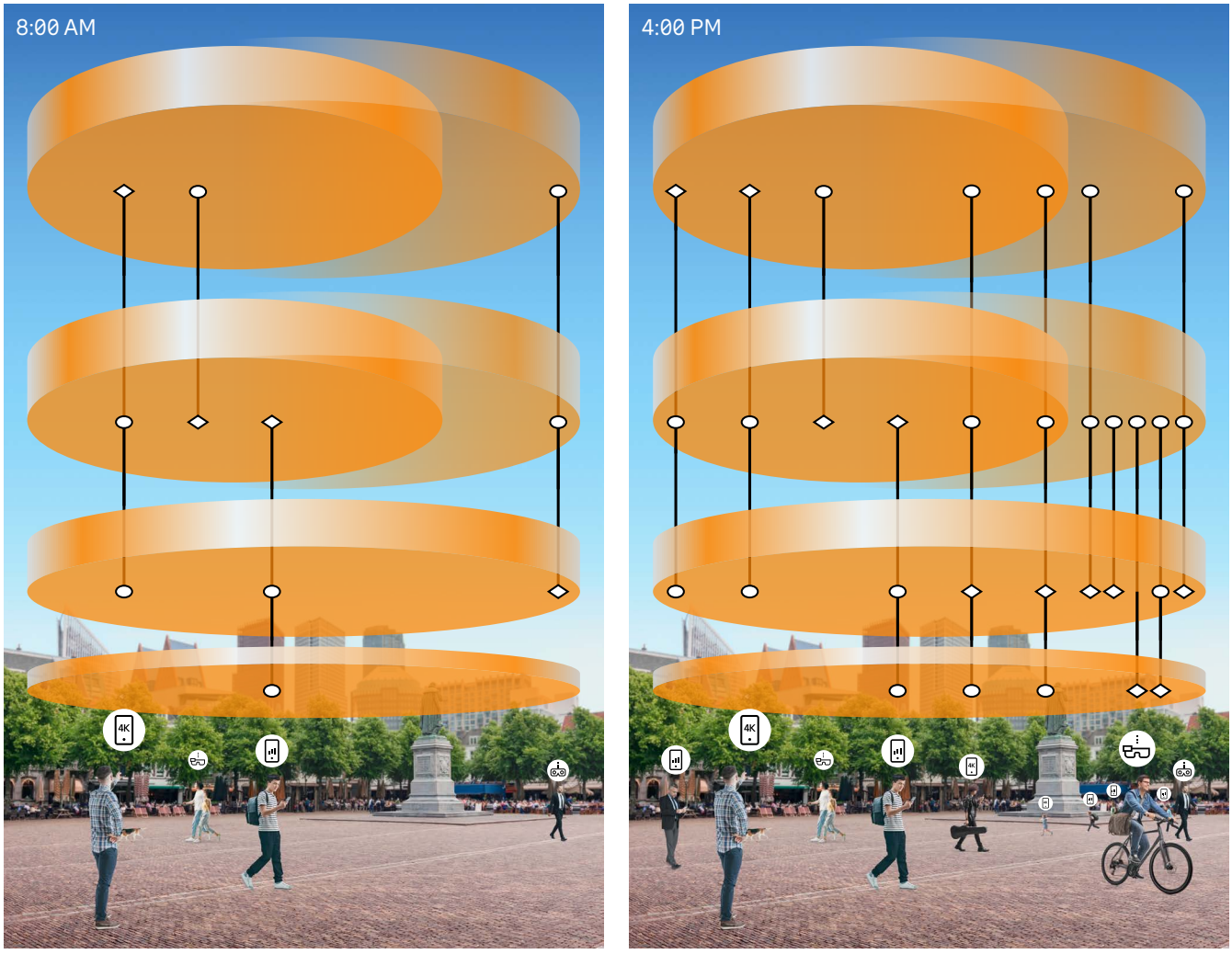
This paper shows why advanced traffic steering is essential in 5G and how Ericsson's unique approach with NR Advanced Multi-Layer Coordination benefits CSPs.

A day in the life of Traffic Steering with Advanced Multi-Layer Coordination

Before we go into details, let us look at what traffic steering looks like in practice. Imagine the year is 2025, and you are crossing a square on your way to work before rush hour, so you are quite alone. You listen to your favorite podcast, others are scrolling through the latest social media app, and a bike messenger navigates the streets with the latest AR headset.

The square is covered with several 5G cells on different frequencies and a device may be connected to one or several cells to communicate with the radio network. As you enter the town square, different cells will already have devices allocated to them, but they will not yet be at their full capacity. The placement of each device will depend on things like keeping the AR headset in a low-latency cell, and your device in a cell with many aggregation possibilities in case the load increases.

When the square is packed with people a few hours later, however, the cells will be using much more of their available capacity. Clever algorithms are then needed to identify the best possible cells to place new devices entering the square, to offer the best possible user experience. This is the core of the Ericsson NR Advanced Multi-Layer Coordination.



01 Why is traffic steering key in a 5G network?

The diversity of cells with different capacities, coverage, and configurations, together with even more diverse devices with various capabilities and services used, adds a lot of complexity to optimizing network performance and spectrum utilization. Traffic steering has the potential to address these complexities while delivering on expected service requirements and user experiences. Next, we will look into these complexities in more detail and into how traffic steering can help solve them.

Diversity of frequency bands

5G is designed to work in different frequency ranges. As the number of frequencies increases, so does the importance of placing UEs in the best cells. Combined with CA, this means CSPs must consider multiple cells, or sets of cells, when selecting the most adequate cell set for each UE.

Diversity of 5G services and UEs

Some 5G services will require massive capacity and throughput, while others will be more dependent on latency and low-energy consumption in the UE. The UE may also be tailored to different types of use cases such as smartphones, simple sensors, augmented reality (AR) headsets, and fixed-wireless access (FWA) equipment, where different levels of feature support are required.

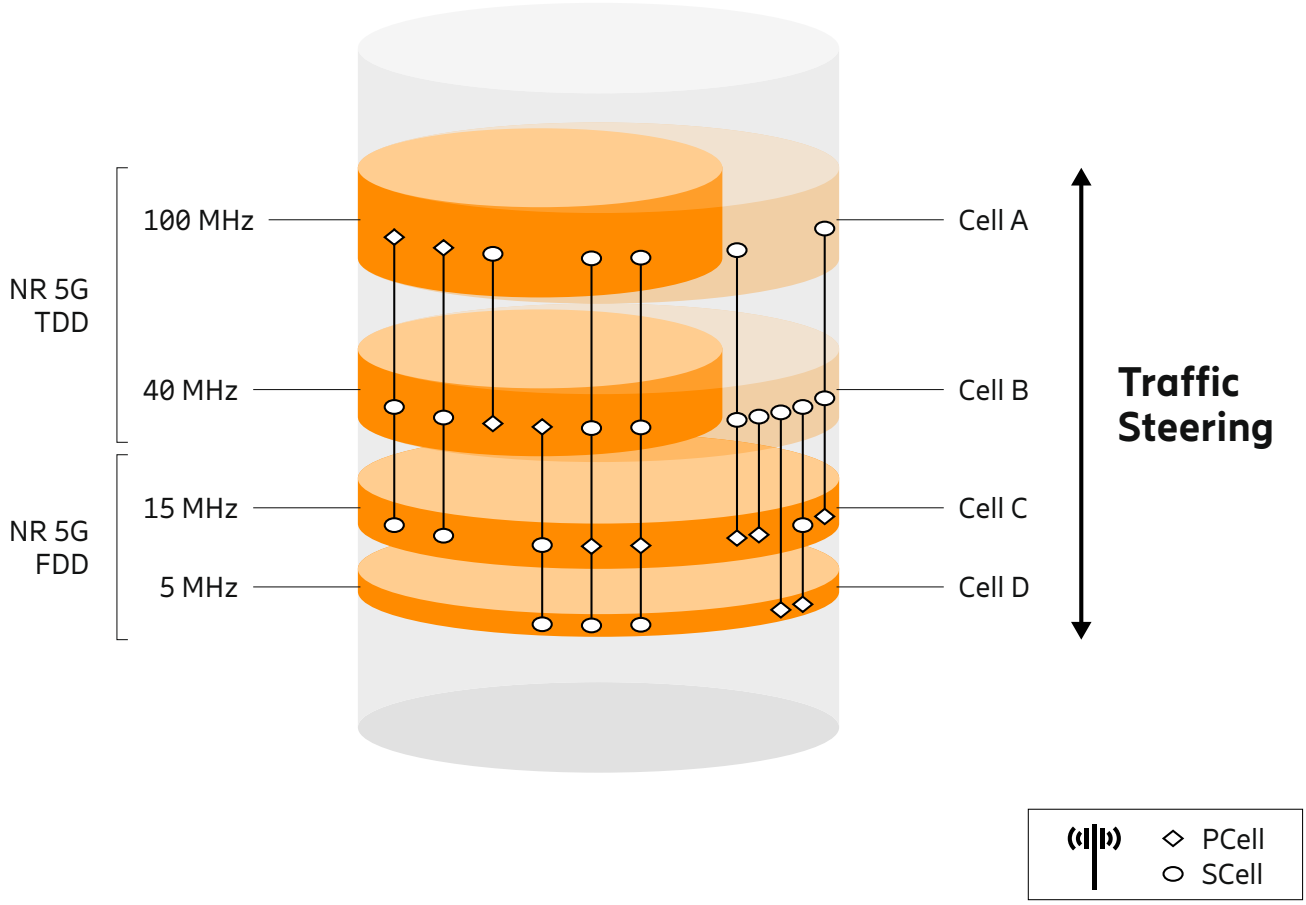
Carrier Aggregation

Carrier Aggregation was included in the first release of the 5G standard, making it possible to configure a PCell for UEs and then add one or more SCell(s) to increase their downlink (DL) or uplink (UL) throughput. The total UE throughput with CA is realized by the combination of the PCell and the SCell(s), instead of individual cells. But the number of combinations of PCell and SCell(s) to be aggregated could be huge and varies for different UEs, according to their capabilities. This brings complexity to finding the best UE configuration for each network deployment.

Load distribution

If all devices got the same set of PCell and SCell(s), those cells would quickly become fully loaded. When networks start adding more cells than what the devices can aggregate, traffic steering needs to consider the load on each cell and distribute the selected cells among the devices, otherwise each user will get completely different experiences. This increases the utilization of each cell while improving the throughput for each device.

These drivers of complexity make it increasingly difficult to build one function that can steer each device correctly, which calls for an efficient and advanced traffic steering solution.



The building blocks of traffic steering

Carrier – The modulated waveform conveying the physical channels.

Frequency layer – A number of cells on the same carrier frequency, distributed over a physical area.

Carrier Aggregation (CA) – Carrier Aggregation achieves higher peak rates by aggregating the spectrum of several component carriers (CCs). These consist of the Primary Cell (PCell) that carries traffic and signalling, and one or several Secondary Cells (SCell(s)), which are used to increase capacity or coverage.

Cell set – A set of cells at different frequencies used for Carrier Aggregation. A cell set includes a PCell and optional SCell(s) located in different frequencies.

Frequency division duplex (FDD) – Uses separate uplink and downlink frequency bands at the same time, typically better suited for coverage.

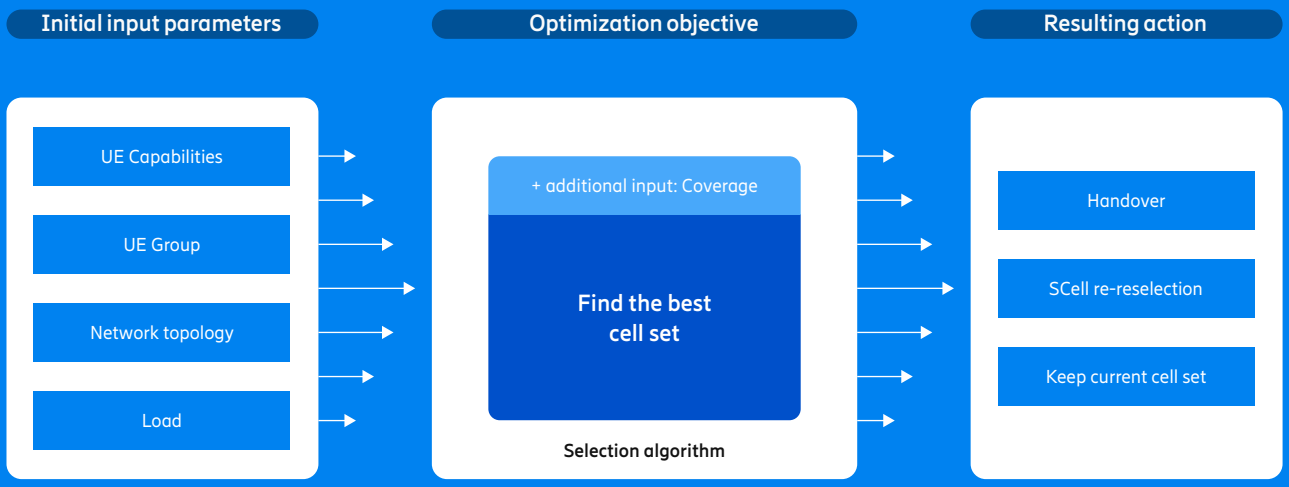
Time division duplex (TDD) – Uses the same frequency band for uplink and downlink but separated in time. TDD is typically better suited for capacity.

Low/mid/high-band – Low-band is for FDD and below 2.6 GHz, mid-bands are for TDD below 7 GHz and high-bands for TDD above 24 GHz, also referred to as mmWave.

02 Ericsson NR Traffic Steering with Multi-Layer Coordination – how it works

With that level of complexity in mind, Ericsson has developed NR Multi-Layer Coordination for 5G Standalone (SA). This solution includes an advanced NR Traffic Steering function that delivers spectrum optimization benefits today but will also evolve to adapt to different service requirements and performance expectations. It is built upon an advanced selection algorithm that considers input parameters and optimization objectives to deliver the best possible UE configuration.

This section explains input parameters, optimization objectives, the selection algorithm, and resulting actions of the Multi-Layer Coordination solution.



1. Input parameters
The main input parameters for finding the best cell set for a specific UE are:

UE capabilities – Which capabilities are supported by UEs – that is, which cell sets and functionality they support.

Network configuration – Regardless of the CSPs' choice of deployment for their cells, our framework takes it into account when steering UEs to the best cell set.

UE Grouping – Enabled by an Ericsson framework that handles demand for the differentiation of services, functions, and feature behavior. It allows CSPs to define different UE groups, apply configurations and observe the results per UE group – for example, limiting which frequencies a FWA user is allowed to use.

Coverage – If available, coverage information is used to reduce the possible cell sets, excluding cells that are not in coverage. Coverage information may be obtained by inter-frequency measurements started during the cell set evaluation. To limit the number of inter-frequency measurements, only frequencies with a potential to improve the cell set are measured.

2. Optimization objective
In the first iteration of the solution, Ericsson NR Traffic Steering with Multi-Layer Coordination will optimize for maximum DL throughput for any new device that enters a specific cell location. Going forward, the framework makes it possible to adjust the optimization goal – for instance, to different services' requirements, such as maximum UL throughput or latency-sensitivity, or to energy efficiency without sacrificing end-user experience.

3. Selection algorithms
Within the limitations posed by the input parameters, the selection algorithms select a cell set (PCell and one or more SCell(s)) that maximizes the optimization objective. This needs to be performed very quickly, as the base station must be able to handle many users selecting cells. However, with many frequencies and cells, the number of possible combinations that needs evaluating quickly increases. Our algorithm considers this complexity from the start and strikes a balance between speed and precision to offer the best outcome.

In addition, our solution considers the whole cell set – PCell and SCell(s). Without considering the whole cell set, the UE might be steered to what seems to be a good PCell, but one that offers few SCell possibilities and poor total throughput for the device.

4. Resulting action
Once a best cell set has been provided, it is evaluated. Only if the best cell set is significantly better than the current cell set is it configured, to reduce interruptions due to reconfiguration. This can result in either a handover (HO) from a PCell to another, or a reselection of SCell(s).

In addition, once the UE has been steered to a new cell set, we also keep it in place for the next session, with the use of cell reselection priorities in idle (or inactive) mode.

What about mmWave?

In the current 5G solution, mmWave is utilized through the use of dual connectivity. Multi-Layer Coordination is used to optimize the cell set below 7 GHz. In areas of mmWave coverage, NR Dual Connectivity (NR–DC) can be configured on top – providing even larger aggregated DL throughput.

03 Maximize return on investment while delivering superior experiences

These are the key benefits CSPs can expect from the Ericsson NR Traffic Steering with Multi-Layer Coordination framework in 5G SA networks:

Maximized spectrum return on investment (ROI)	With advanced traffic steering, CSPs can make the most out of the spectrum resources they have acquired. It optimizes spectrum utilization at high load and makes sure that no cells run empty while others are overloaded.
Increased UE peak DL throughput	By steering the UEs to where they can aggregate the most, CSPs can increase the achievable throughput.
Greater average revenue per user (ARPU) through 5G service differentiation	Delivering UEs the best possible performance will further support CSPs in offering both premium pricing for 5G and/or customized user experiences beyond best-effort connectivity. These include, for example, speed-based tariff plans for FWA or cloud gaming.
Support for energy saving	Today, CSPs face the challenge of radically limiting energy consumption in their networks to achieve sustainability goals and due to rising energy prices. Ericsson Multi-Layer Coordination will work together with energy saving features, selecting the best cell set among the currently available cells.
Future-proof 5G SA networks	Using today's functionalities, CSPs can already optimize spectrum utilization for DL throughput. Going forward, they will have a network that is ready to support optimization for UL throughput, latency, services, and more advanced energy efficiency. They will also be well prepared to handle any number of carriers supporting SA deployment expansions.

Simulations for a typical network scenario with a variety of UE shows potential gain in median user throughput of up to 80 percent at high load. NR Advanced Multi-Layer Coordination gives the largest gain when the network is highly loaded – the network capacity is expected to increase by 10–40 percent.

04 Our unique framework is flexible, powerful and future proof

Ericsson provides a generic and flexible framework that works with a multitude of UE capabilities, carriers, different services' requirements, and multiple objectives powered by UE grouping. It also has a powerful one selection algorithm that takes a great deal of inputs into account to converge into one optimum cell set for best UE performance. These are the key features our solution currently has:

Consideration of the whole cell set – Our features not only select PCell to match the UE capability, but they also consider the whole cell set – PCell and SCell(s) – to find the best cell set for each UE, matched to their capabilities.

Load-aware – Further improves the performance and spectrum utilization by considering the cell load for the configuration of both PCell and SCell(s).

UE grouping and service differentiation – Tying all traffic steering features into the UE grouping framework with differentiated behavior for different users and services (e.g., FWA, Time-Critical Communications, Voice over NR).

Supporting multiple frequency layers – Generic framework where we can evaluate the UE capability and steer it to any cell in the network, regardless of how many frequencies there are.

Our vision

Ericsson NR Advanced Multi-Layer Coordination is also future proof. Leveraging our in-depth RAN and industry expertise, we are already researching advanced functionalities to anticipate changing customer requirements. As new services are introduced and scaled, and more capacity is required and handled by the network, traffic steering can optimize for objectives beyond DL throughput, like service differentiation, UL throughput, latency, or energy consumption. Ericsson NR Advanced Multi-Layer Coordination will also support Cloud RAN going forward.

Channel quality-aware – Further improve the performance for any given device by disregarding cells that are, for example, suffering from temporary or permanent interference on UL or DL. Consider per-UE channel quality in the best cell set selection to maximize MIMO benefit and further optimize UE throughput and performance.

UL and DL-preferred differentiation – Be able to, on a session level, give advantage to UL performance above DL performance. Support for maximized UL throughput selection will be beneficial for all sorts of UL-heavy traffic, such as extended reality (XR) and virtual reality (VR). Flexibility to enable per cell, service, user supporting differentiation by UE groups.

Energy performance – Converge traffic to limited carriers, maintaining a minimum service level for admitted users in the network and allowing for further energy savings in a predictable manner.

Intelligent predictions, AI-powered – Aggregate the inputs and learn from the network and UE behavior with regards to data demand, speed and coverage, to reduce UE measurements and the need for network configuration.

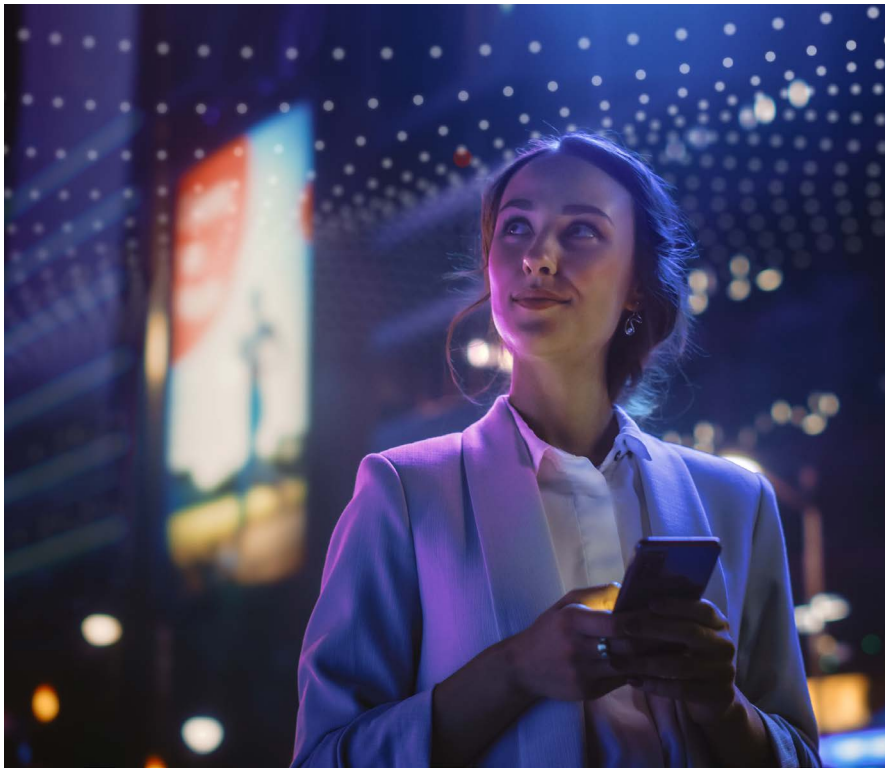
05 Key takeaways

Service providers are faced with the increasing challenge of maximizing the value of spectrum investment while providing superior user experiences. The complexity posed by more frequencies in 5G, diverse devices with different capabilities, and service requirements only add to that challenge, which requires a capable traffic steering solution.

Our Ericsson Multi-Layer Coordination framework comes in to utilize CSPs' entire spectrum assets in the most efficient way. It uses clever algorithms that consider several input parameters to select and re-select the best cell set for UEs, not only delivering the expected performance, but also the expected user experiences. Whether there is one user chasing after the bus in the morning or a huge crowd and many users at peak hour, traffic steering ensures all users get the performance they need according to their device, location, and services used.

Today, our framework optimizes for maximum DL throughput. However, we are constantly in conversation with CSPs to understand their needs and expectations and develop solutions that can, over time, adapt to new service requirements and performance expectations.

With Ericsson NR Advanced Multi-Layer Coordination, you can make the most out of your spectrum investments while achieving 5G service differentiation and keeping your 5G SA networks future-proof.



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