Reinvent Digital Services with Nokia's digital design

White paper

The sheer complexity of 5G networks that address the needs of multiple and highly specific use cases will call for an innovative approach to network design - one that is driven by data analysis, automation and real-time simulation. The new 5G digital design process will also be more inclusive, involving all stakeholders and ensuring that, as the network design is optimized, the needs of the use case will be met.

In the race for 5G, there will be two sprints. The first sprint will be for eMBB and 5G use cases, applicable with Non-Standalone architecture. During the first sprint, the second sprint will also start, one aiming for stand-alone architecture use cases such as Industry 4.0. Operators must be more agile in the competition, while also considering their key business objectives. These factors will force the re-invention, improvement or transformation of business and engineering processes through the use of digital technologies and digitized data.

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1 Executive Summary: Focus on the use case, not the network

Until now, telecom network design has been largely static and based on creating a one-size-fits-all infrastructure. However, the arrival of 5G brings about a new focus on specific use cases and how they can be supported. A roll out of 5G infrastructure will support a wide range of use cases with varying performance needs. Network slices will create virtual instances of a network, using the same underlying hardware, to meet each use case's needs.

In addition, adding new technologies to legacy networks will bring more complexity that conventional design processes will be unable to deal with.

Digital design for 5G use cases is a new of way of working, a network design process that is dynamic, automated, uses real-time simulation and has a direct effect on the technology & business KPIs. The digital design process takes in huge amounts of data from a variety of sources to build up a 'digital twin' of the use case. An iterative process ensures a final design for the use case that meets the balanced QoS & ROI for the target use case.

2 Conventional network design does not work in 5G

There are three new service categories for 5G: enhanced mobile broadband (eMBB); ultra-reliable and low latency communications (URLLC); and massive machine type communications (mMTC).

There are also the related use cases such as high definition (HD) video, virtual/augmented reality, cloud gaming, vehicular communication and industry automation and IoT for smart cities. These all have diverse requirements for bandwidth, latency, mobility, connection density, and data rates.

In addition, 5G and its inter-working with existing networks makes network planning & design more complex than that seen in previous generations, requiring a clear spectrum strategy and an optimized anchor layer in the NSA architecture.

3 Introducing 5G technology has a severe effect on network planning and design

The introduction of new spectrum with very short wavelength bands brings the major challenge of attenuation due to foliage and people, requiring detailed models of the geo spatial environment. cmWave and mmWave bands need a higher density of cell sites compared with legacy bands and a traditional design approach may lead to expensive deployments in the first ‘sprint.’

In addition, the new antenna technology using massive Multiple Input Multiple Output (MIMO), beam forming and beam steering to ensure coverage in 5G poses additional challenges of optimization of the beam sets, performed in 3D for different configurations in the vertical plane. Multi-connectivity options of Wi-Fi, LTE & 5G require robust carrier aggregation and interworking. Further network slicing brings another layer of complexity, as each network slice will require separately defined parameters. The virtualization of radio networks requires the topology and configuration of Cloud RAN & edge computing nodes to be designed. The design must also ensure minimum latency in the network.

Thus, there is a need for an end-to-end design logic which is both fast and accurate and focused on the use case, meeting the capacity, coverage and performance needs which traditional planning cannot provide.

Solution and rollout decisions are likely to be taken at the level of micro markets, based on their individual economics use case requirements such as throughput, ultra-low latency and high reliability.

4 Use case focus calls for inclusive design

The traditional design process of ‘One size fit all’ approach does not work with 5G use cases with specific performance characteristics. The performance demands of these use cases vary tremendously in the capacity, coverage, throughput and latency required. The optimization of multiple network parameters also needs to be considered for each use case, such as antenna tilt, azimuth, slice parameterization, capacity, among others. The new approach is needed where business needs are considered alongside the requirements of the 5G use cases, ultimately making the design more inclusive.

5 A new approach to 5G network planning and design is needed

The new approach starts with an accurate understanding of the use case requirements. Many different sources should be used, including geospatial data, static data like terrain mapping, built environment databases, end user data and environmental data such as the location of trees and foliage that can affect radio signal propagation.

Real-time data from the existing networks (non-5G and 5G if deployed) and other data sources can also be considered. The use of real-time data will allow a more accurate assessment of how the final network would affect the use case and the potential impact on existing services.

Further, previous network deployments data and Key Performance Indicators (KPIs) for similar use cases can also be useful. Analysing this data manually would take a long time and risk cost and time overruns. Applying machine learning and data analytics would make it possible to digitally model specific use cases as a basis for a more dynamic 5G network design.

6 Creating the digital design

6.1 Going digital is the way forward

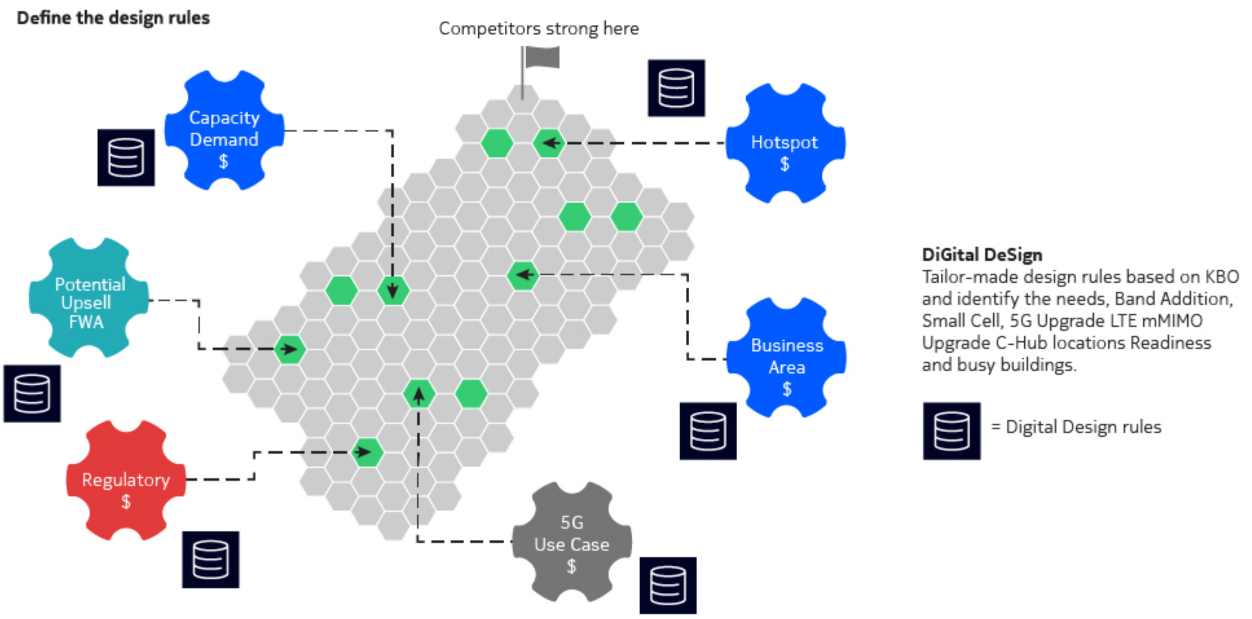


Figure 1. Each operator needs tailor-made design rules

The technique of 5G digital design makes extensive use of data analysis powered by AI & machine learning and will dramatically change the way future networks are designed. The replication of the use cases as a 'Digital Twin' is the heart of this new approach - the gathered data is used to create an exact digital replica of complex physical assets, processes and systems that also interact with the real system. The twin can be fed data so that it changes in the same way as the real thing. This then provides a detailed understanding of how the real system is behaving and predicts what it will do next.

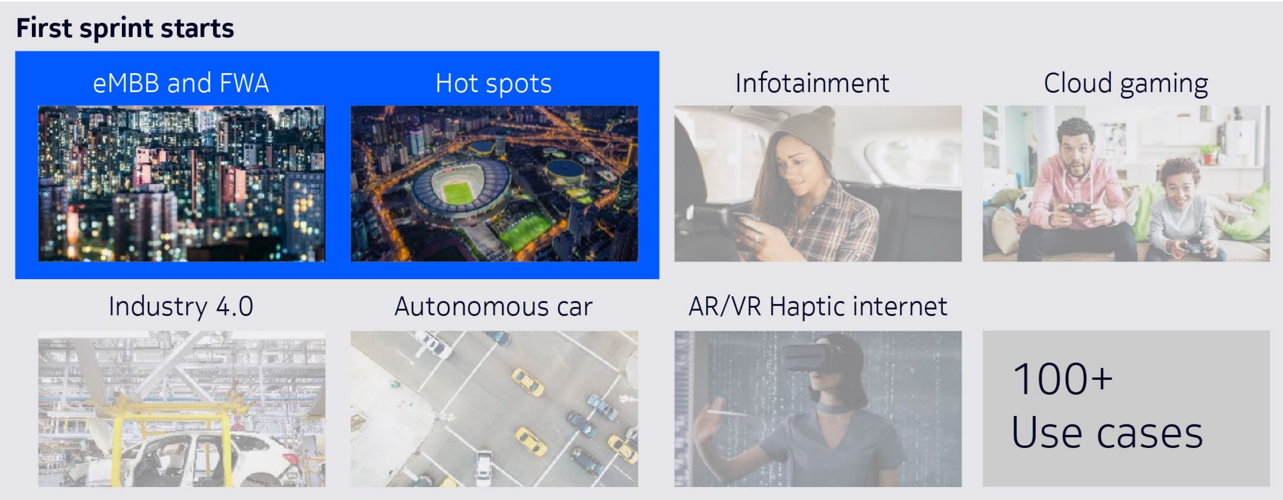


Figure 2: Current 5G use cases deployments

6.2 Business Case Analysis for 5G use-case library

The 5G future is use case driven, with each use case having its own target customer segment, its own Quality of Service model and Network Dimensioning principles. All these factors affect the TCO and projected Use Case Revenue. Achieving precise ROI predictions before making investments is crucial to CSPs' network evolution decisions.

The Nokia 5G use case business case analysis is based on these four pillars:

1. Prediction of the future 5G use case demand
2. QoS model analytics & design
3. Network dimensioning &TCO modeling
4. TCO & revenue modeling & business case analysis

To enable a precise and accurate business case prediction, Nokia aggregates many data sources, such as population segmentation, GIS data, geolocated UE forecast & actual information, crowdsourced QoE data and live L3 CSP network data. It brings these under one analytical engine to predict the 5G use case business case.

The figure below shows the business case framework for the Fixed Wireless use case.

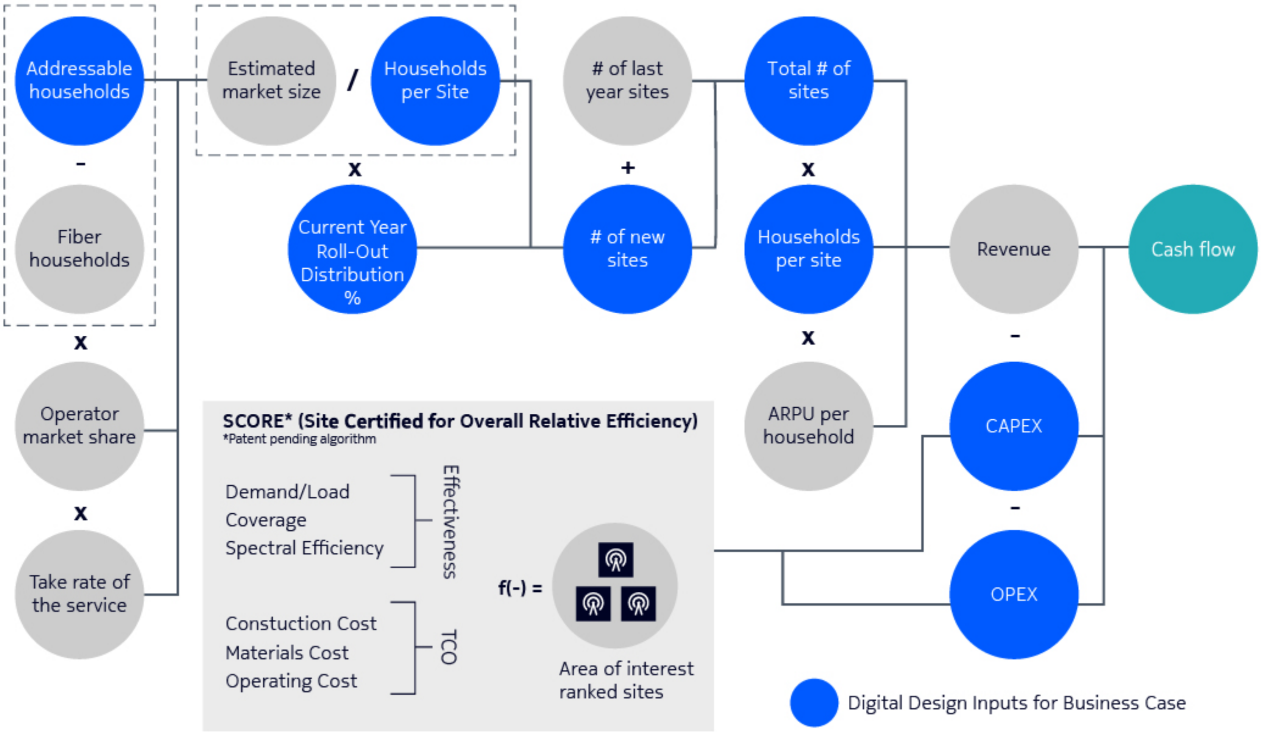


Figure 3:. Business Case Framework for Fixed Wireless Access (FWA)

Figure 4: Bandwidth modelling Fixed Wireless Access (FWA) / developed bell labs

6.3 3D Traffic Analysis

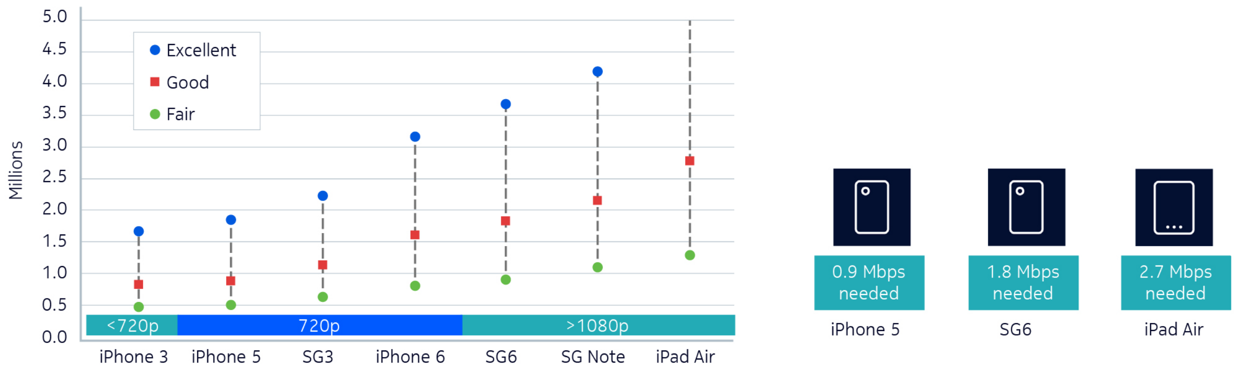
The 3D analysis is particularly significant for 5G, due to the use of higher bands and mMIMO. 3D traffic analysis will be used initially to determine the 3D distribution of 4G traffic, so that an estimate of relative traffic density in (x,y,z) can be achieved. In the picture below, the hotter colours indicate a higher level of traffic for an analysis performed in the central London area.

Figure 5: 3D traffic map showing DL Payload

In places where it is not necessary to use 3D traffic maps, 2D traffic maps can be generated using various techniques such as Minimize Drive Test (MDT), Social Media and Crowdsourcing. The 2D analysis is generally enough for suburban areas if mid-bands or lower bands are used for deployment.

6.4 Growth and Unserved Analysis

Device Characteristics determine the network performance requirements – the device trend is increasing the network performance requirements to maintain QoE.



Source: Bell Labs

Figure 6: Device MOS as function of encoding rate

One of the uses for 5G is relieving future congestion on many 4G networks. Given that 4G traffic is increasing very rapidly at a pace which ranges from 30 percent to 80 percent annually depending on the geography, 4G networks will not be able to keep up with future demand in about 2-3 years. If the demand continues to rise, 4G networks will have to drop user throughputs. This will lead to unhappy users who will potentially churn.

Using the unserved demand technique, a precise model for every sector in the network can be created, which can predict when the capacity of that sector will be exhausted as well as how much traffic will not be served. Figure 7 shows an example of a network where the demand is growing very rapidly, at 80 percent year-on-year.

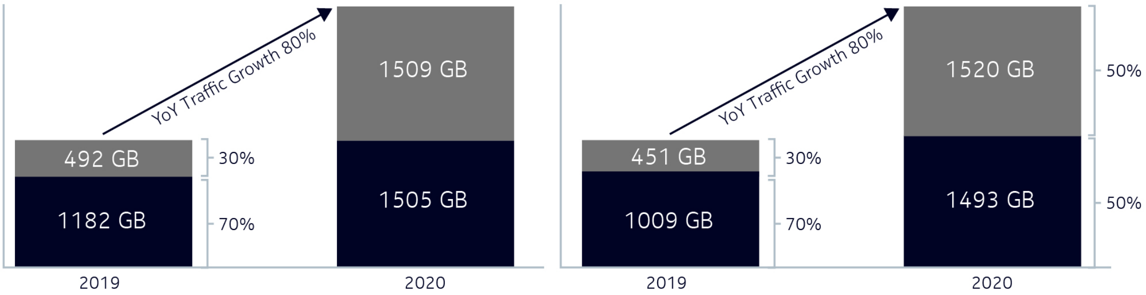


Figure 7: Unserved Traffic Estimation for a Current 4G network

The roadmap of 5G analytics use cases follows the evolution of 5G, its architecture and when it will meet the requirements listed above. It implies when data will be available to execution engines and analytics / ML platforms. This evolution is addressed below.

*Many operators based on PRB Utilization Threshold RRC Connected user Threshold

6.5 3D Radio Planning

Once the 3D traffic map, unserved demand estimate and use-case based estimation of demand is completed, the 3D representation of the 5G demand is generated. The 3D analysis is performed at various heights representative of the target coverage area. Due to the nature of high bands and mMIMO beamsets, the coverage difference between floors is very high. Using a 3D analysis of coverage and throughput is also important in reducing the overall site count for 5G. For example, the building in the bottom right hand corner of the picture below has very poor coverage on the lower floor but good coverage on the upper floors. If we assume that all the traffic is on the lower level, it will drive a larger site count than necessary. The converse is also true when the coverage on the lower level exceeds that on the upper floors due to shorter street sites.

Also, in the first sprint, many operators are planning to build their 5G network with NSA architecture, which means the LTE layer will be the anchor layer and must be taken to account in the planning stage.

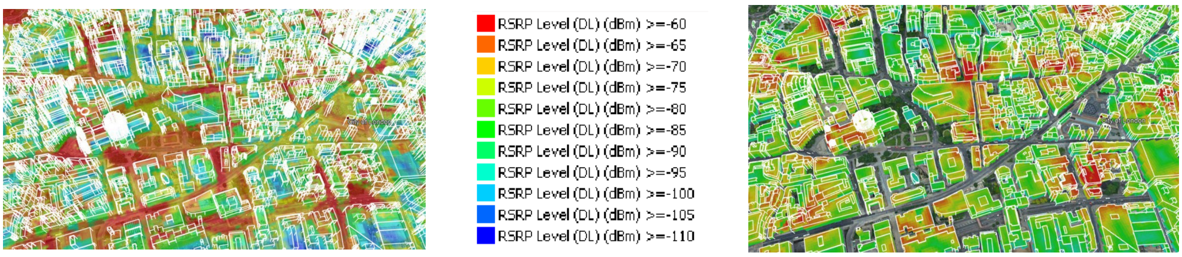


Figure 8: 3D coverage analysis of lower floor (level) and upper floors (right)

This type of analysis is used to select the optimum beamset for each sector, improving the coverage, throughput for each user and overall cell throughput.

6.6 ROI and TCO Analysis using patent pending SCORE algorithm

One of the most important aims of a wireless operator is to get positive ROI for their 5G deployment, which is best achieved when the cost of building and operating the site is less than the revenue minus the operating expenses.

This offers operators a step-by-step approach for the year-by-year investment, which can have a positive effect on the operator’s cash-flow.

Rather than directly estimate future traffic on a site, which is prone to error, SCORE considers factors such as traffic carried, coverage and spectral efficiency as positives and the total TCO as a negative. SCORE ranks all the candidate sites for 5G, and chooses the ones with the highest SCORE, which can carry about 80 percent of the total traffic. Such an analysis provides the best ROI, while also ensuring adequate average cell and cell edge throughputs to avoid customer complaints and churns.

Figure 8 shows the performance of different design approaches, including Digital Design with SCORE. The first technique, which is very common, uses ACP to meet the defined coverage and targets. This gives the best cell edge and average throughput performance but extracts a compromise on ROI. The second option only deploys at traffic hotspots, while the third option looks at the traffic and individual ROIs at each cell.

The ACP approach will provide high quality with high investment. By contrast, hotspots based on OSS KPIs and Return of Investment only strategies will create customer dissatisfaction and may cause customer complaints and churns.

These approaches fall short of performance goals for 5G. Finally, the SCORE approach provides a very good ROI, while preserving the cell edge performance, so called balanced Return of Investment (ROI) and (QoS Quality of Service)

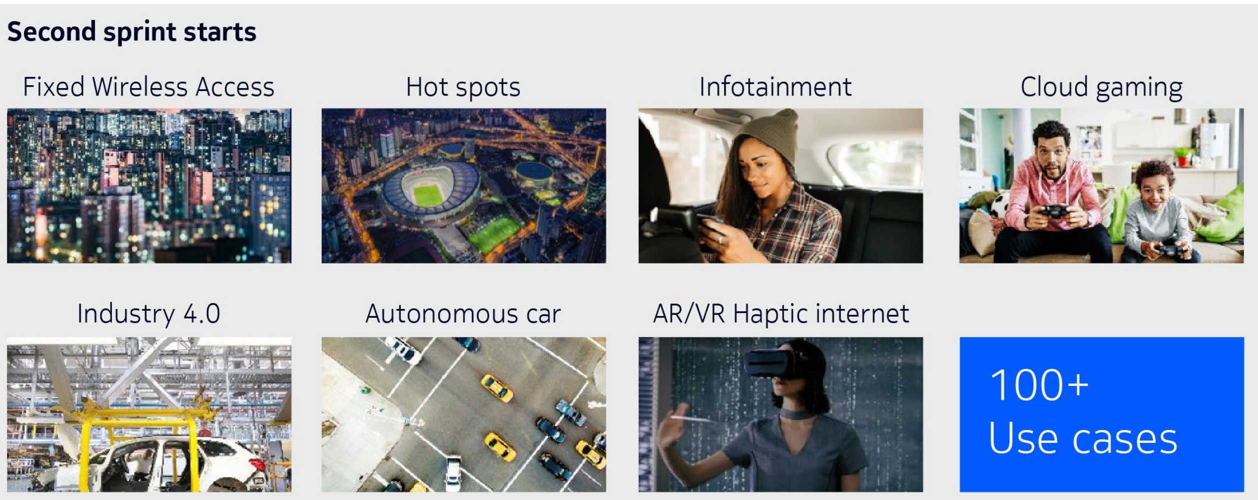


Figure 9: Next wave of 5G use case deployments

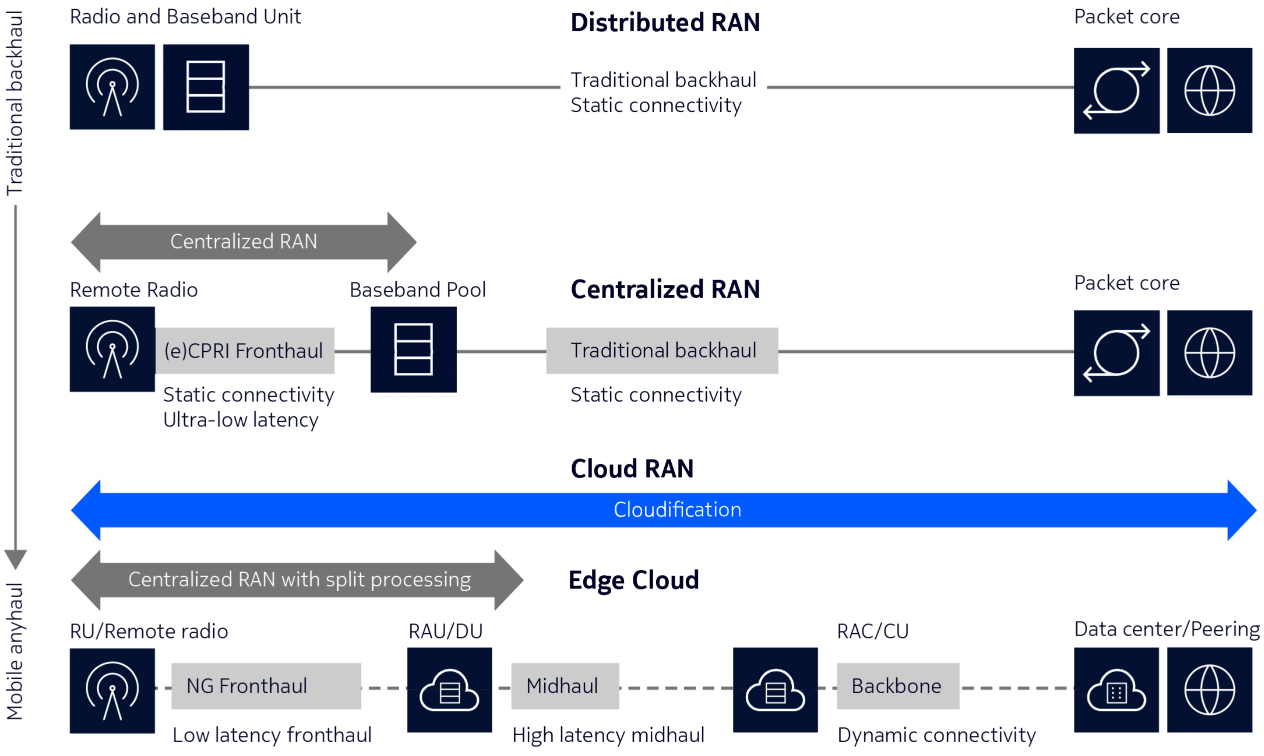


Figure 10: Any-haul topology design for Ultra-Reliable Low-Latency Communication (URLLC)

6.7 Any-haul topology design for latency

5G use cases are much more sensitive to latency than 4G use cases, making it vital to design for latency from the start to ensure success. In the second sprint there will be latency dependent use cases.

Solutioning and rollout decisions are likely to be taken at the level of micromarkets, based on their individual economics and on use case requirements such as throughput, ultra-low latency and high reliability.

A number of tools can accommodate various 5G deployment scenarios, which include combinations of fronthaul, midhaul and backhaul.

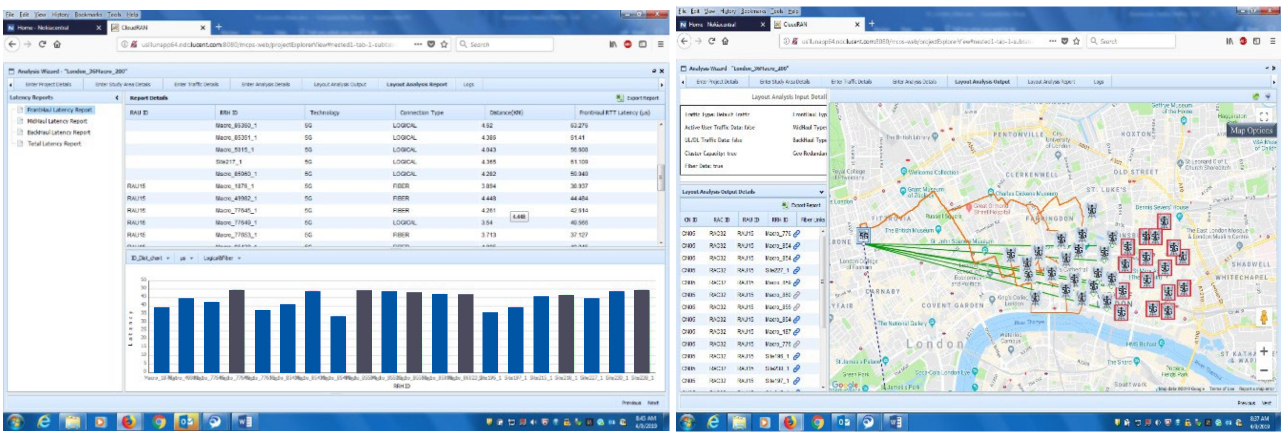


Figure 11: Sample output of Any-Haul Latency Predictor

7 Conclusion: The digital transformation of network design

Realizing 5G promise and its revenues requires a good recognition of the business case and immaculate planning to achieve a high ROI. 5G digital design offers a multifaceted solution to the technical and business challenges faced during the design of a wireless network to support future 5G use cases. The approach builds on digital modelling, intuitive design and agile techniques.

The 5G digital design process is more inclusive, involving all stakeholders in the creation of the use case and ensuring that as the network design is optimized, the needs of the use case are met. This will help to meet the business needs of stakeholders and prioritize investments for the first sprint, while also achieving a faster time to market.

Digital design uses its own use case library and advanced tools and analytics to develop 5G use case trials for the second sprint.

About Nokia

At Nokia, we create technology that helps the world act together.

As a B2B technology innovation leader, we are pioneering networks that sense, think and act by leveraging our work across mobile, fixed and cloud networks. In addition, we create value with intellectual property and long-term research, led by the award-winning Nokia Bell Labs, which is celebrating 100 years of innovation.

With truly open architectures that seamlessly integrate into any ecosystem, our high-performance networks create new opportunities for monetization and scale. Service providers, enterprises and partners worldwide trust Nokia to deliver secure, reliable and sustainable networks today – and work with us to create the digital services and applications of the future.

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