Building on belief

Building futuristic wireless networks: creating a unified platform for all RAN design services

Abstract

The rapid rise of 5G technology is unlike that of any other technology in the preceding generations. The massive scale of global 5G deployments requires a commensurate change in telecom infrastructure, starting with the way network devices are designed. Digital transformation of RAN design services (radio access networks) is indispensable to run futuristic wireless networks.

From monolithic hardware base stations, RAN is fast transforming into open, flexible, interoperable, cloud-native, and software-defined systems. Traditional RAN designs happen in isolation using various technologies across diverse platforms. Hence, they need to be unified under the digital RAN design assurance model, which will serve as a single pane of glass for all network components, irrespective of the manufacturer, technology or service. This paper delves into the optimal digitizing process for RAN design including digital coverage design, digital capacity design and digital quality assurance.

Digitalizing the RAN design process

The unprecedented pace of 5G rollouts is expected to provide coverage for about 40% of the global population by 2025[1] . Communications service providers (CSPs) are striving to deploy 5G services through 5G New Radio (5G NR), the global standard for unified, superior wireless air interfaces. 5G NR not only provides superior connectivity as an eMBB technology (extreme mobile broadband), but also enables new-age applications using connected devices (Massive Internet of Things) with variable latency rates.

Digital transformation of RAN design is critical to meet 5G standards. The process needs to address the three foundational blocks of RAN design, namely coverage, capacity and quality, leveraging digital technologies such as extreme automation, agile and lean ways of operation (Figure 1). Moreover, 5G, 5G-Advanced and 6G networks bring in newer dimensions to device densities, service reliabilities, virtualization, cloud computing, and microservices, enabling further adoption of digital technologies. The RAN digital journey encompasses closed-loop self-organizing network (SON) automation, artificial intelligence (AI) and machine learning-driven (ML) capacity pooling, software-driven power-saving mode, self-healing and zero touch configurations.

[1] *GSMA, The 5G Guide – A Reference for Operators (April 2019), accessed August 9, 2021, https://www.gsma.com/wp-content/uploads/2019/04/The-5G-Guide_GSMA_2019_04_29_compressed.pdf*

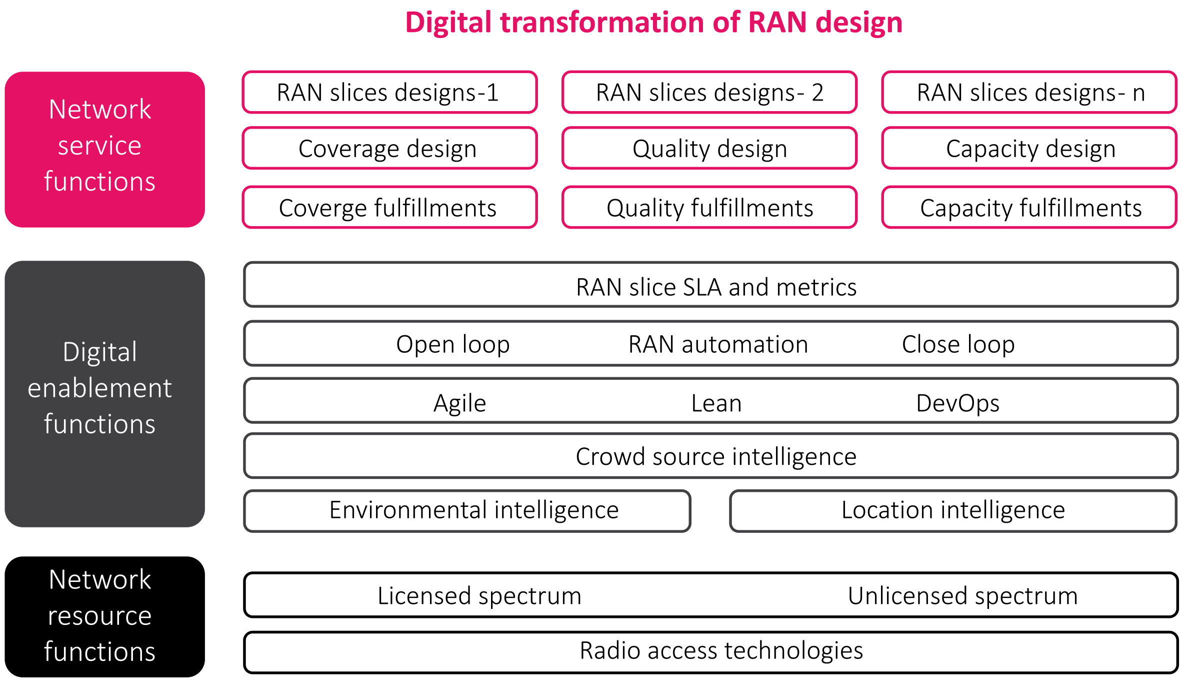

Figure 1 : Fundamental blocks of the digital RAN design process

Next-generation RAN (NGRAN) is diversified into licensed and unlicensed spectrum. Each aspect of the spectrum layer serves a specific use case. Licensed spectrum is usually cellular-grade and has a high reserved price. It is governed by the regulatory bodies in respective countries. The scarcity of 900 MHz and 1800 MHz spectrum layers led to auctioning of the bands including 2100 MHz, 2600 MHz and beyond. Higher layers of spectrum help meet 5G requirements. The B5G (beyond 5G) and 6G networks are moving into the terahertz range, far above that of high-band spectrum. So, the type of spectrum, its layering and technology combinations such as time-division duplex or frequency-division duplex are critical inputs for the design process.

Digital Coverage Design: The First Pillar of RAN Design

It is important to incorporate coverage as a major digital design criterion to provide seamless coverage connectivity irrespective of subscribers' locations such as outdoor, indoor, static, or mobile conditions. The digital coverage design ensures that the best servers amongst 2G, 3G, 4G or 5G prevail as per the spatial conditions. The indoor densification is usually catered through digital DAS (Distributed Antenna System). The other feasible and low-cost solutions are designing of hotspots using Wi-Fi solutions using unlicensed spectrum. The coverage digitization ensures the best out of the available options irrespective of whether it is licensed or unlicensed spectrum (see Figure 2).

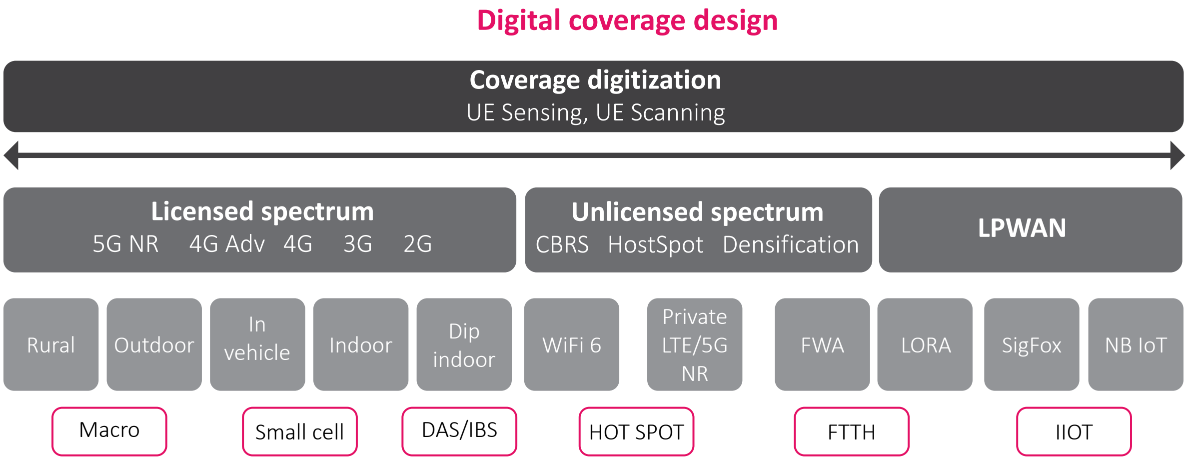

Figure 2 : Coverage digitization process

Coverage assurance solutions are designed differently for diverse needs. Deep-indoor coverage requires distributed antennae systems, in-building solutions (DAS-IBS) antenna. Signal boosters and repeaters increase the coverage density, but proper design and deployment methodologies need to be adopted during the densification drive.

However, irrespective of frequency bands, geography and topography play a major role in ensuring optimum coverage. Path losses differ according to location types including high-rise buildings, forests and water bodies. Overlay umbrella cells and underlay small cells are traditional designs interwoven into networks to provide seamless mobility to vehicles and pedestrians simultaneously. Some of the tested methods to provide coverage include using leaky feeders and radio frequency (RF) chaining with smart antennas.

Coverage densification ensures that there are minimum black spots in target areas and densification usually takes multiple iterations. The regular coverage assurance process details out random coverage gaps in real time as much as possible. Coverage predominately depends on the path loss during the transit of signal to and from the base station and user equipment.

Digital Quality Assurance: The Second Pillar of RAN Design

5G trials and deployments worldwide have started in non-standalone mode as 5G NRs do not offer blanket coverage. Call or data connections make use of 4G core networks and hence sessions can swiftly move from 4G to 5G. So, designing of intersystem handover is essential. The main factors affecting quality are interferences, golden parameter settings, and special feature audits, as illustrated in the diagram below. Spectrum harmonization is critical before starting tests and trials.

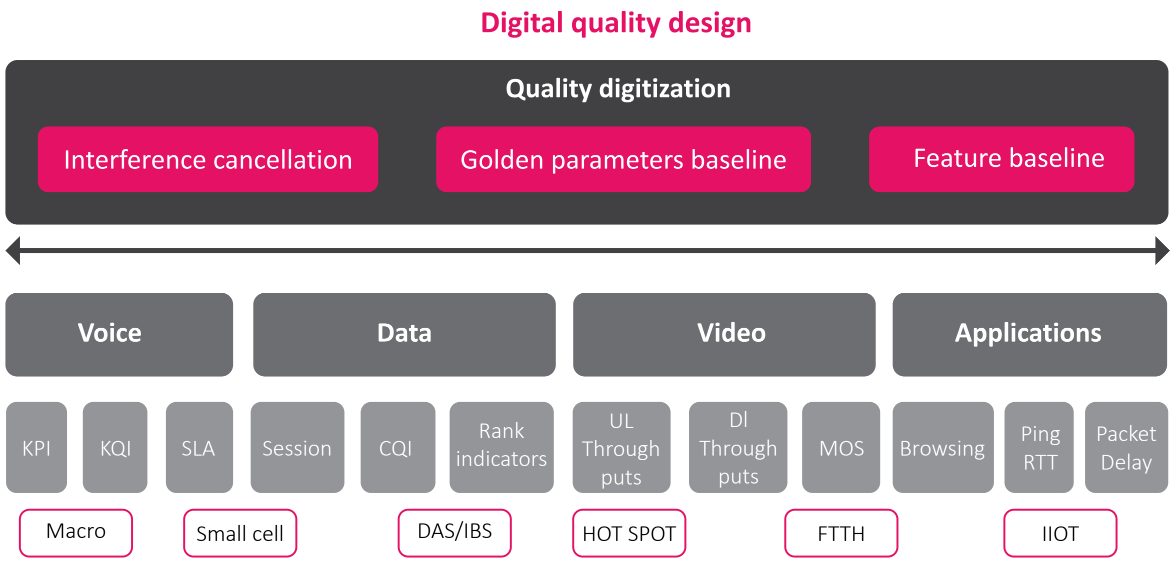

Figure 3 : Quality digitization process

Interferences: The primary reason for quality degradation in RAN is due to interferences. Subscribers get distorted, often a cracking voice and intermittent reconnection to video sessions, causing poor customer experiences. There is a high chance that the cell edge produces a lot of interference due to the high-transmit power in both uplink and downlink. While a multi-layer strategy is important, there is also a trade-off in terms of reduced accessibility, mobility and retainability. Automated spectrum scanning and reporting are essential in 5G because of the numerous frequency layers.

There are multiple instances of in-band interferences both in downlink and uplink, while incorporating newer frequencies across the spectrum. Spectrum harmonization is of utmost importance before starting 5G NR trials. In addition to the new spectrum, the existing 4G layers need to be effectively managed for spectral efficiency.

Golden parameters: Golden parameters bring synchronization to the multi-vendor RAN, multiple technologies and multi-services. Parameter discrepancies and anomalies get audited and corrected. The introduction of 5G has brought a significant number of parameters on eMBB, URLLC, mIoT (massive Internet of Things) and connected vehicle to everything. The real-time data produced from these services needs to be automatically validated and fixed.

Feature audits: 5G RAN deployments involve a lot of new features on dynamic spectrum share and energy efficiencies, which come at a premium price. There is a strong need to keep records of the feature activation states to safeguard the guaranteed quality of service.

Digital Capacity Design: The Third and Final Pillar of RAN Design

Capacity design is the fine art of balancing resource allocation with satisfying network service level requirements. It is directly related to the diverse service offerings of CSPs. Capacity digitization services prioritize various network level services, guaranteed quality of service, as well as dynamic resource allocation, and utilization.

Embracing the Agile approach

The RAN design process involves three aspects of agile adoption, namely continuous planning and continuous design (CP-CD), cross functionality and autonomy. Embracing CP-CD principles enable coverage design and capacity augmentation in real-time with continuous network feedback systems (see Figure 4). This way, the system is more customer-centric, granular and robust.

On the other hand, cross functionality helps the network to seamlessly integrate with the larger digital ecosystem unifying the various business functions.

Lastly, the digital RAN design process proposes autonomous planning and design systems, which are self-healing, self-organizing and self-learning in nature. It encompasses the closed-loop and zero-touch approaches, leveraging the machine- first approach.

The overall design system is stitched together with the agile, lean and DevOps methodologies. While agile release trains (ARTs) enable agile teams and systems that are organized to release value on demand via a continuous delivery pipeline, the culture, automation, lean flow, measurement, and recovery (CALMR) approach to DevOps guides ARTs toward the goals.

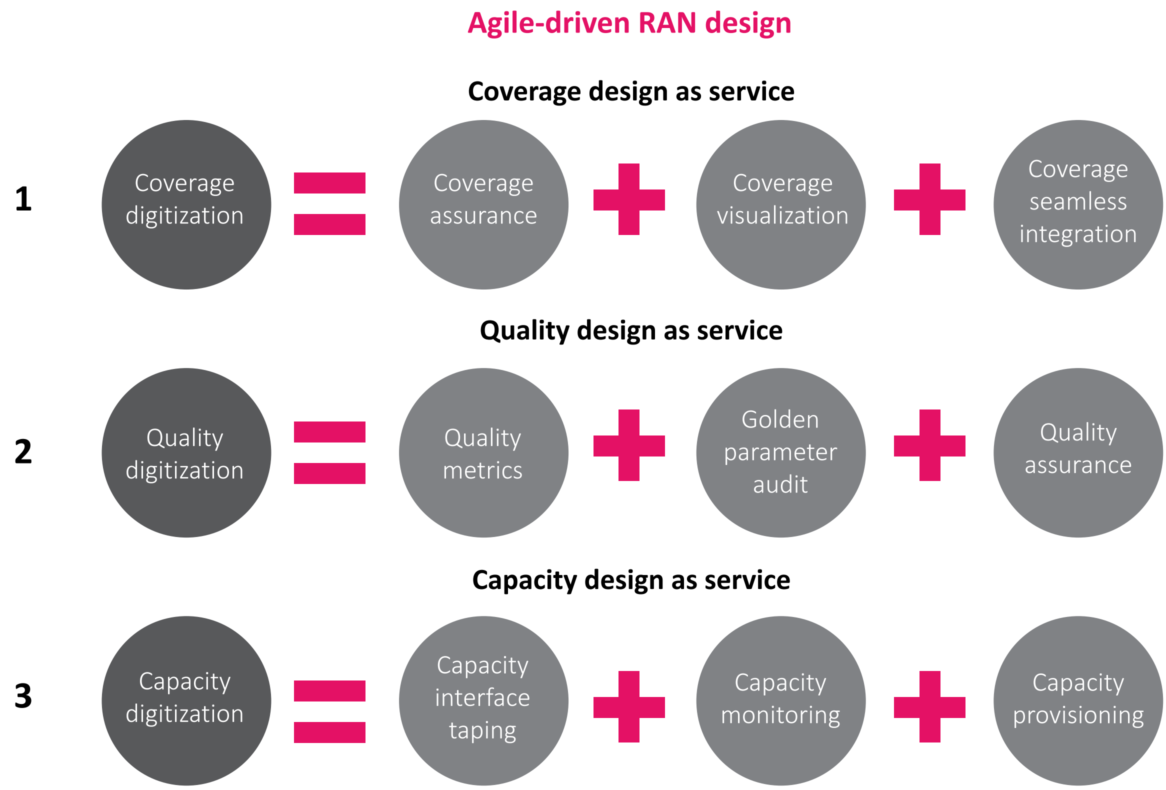

Figure 4 : Agile-Driven RAN design process

Prepping the networks of today for technologies of tomorrow

Digital transformation of the RAN design process is in line with the overall strategy of CSPs to become digital services providers. It leverages the open RAN strategy, and is aligned to other initiatives including RAN slicing, cognitive network operations and service operation centers for closed-loop interaction. It enables telecom operators to offer digital customer experiences that adapt to open source automation, zero-touch operations and digital telecom infrastructures. Digitization of the RAN design process along with the methods and tools support futuristic architectures such as 5G, 5G-Advanced and beyond, ranging from 6G to 10 G radios.

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Samir Kanta Satapathy is a consulting partner and chief architect at the Network Solution Group within the Communications, Media and Information Services business group at TCS. He is an expert in cross-domain network technologies including network services, strategies and architecture. Satapathy has over two decades of experience in mobile communication and wireless technologies. He is a senior member at IEEE and a life member at the Computer Society of India. He has a master’s degree from the Indian Institute of Technology Bombay, and has done a post graduate program in management at the University of California, Los Angeles.

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