VIEW POINT

NAVIGATING THE INTRICACIES OF 5G NETWORK PLANNING

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Introduction

5G is undoubtedly one of the most talked-about technologies these days with an impact much beyond connecting people over the wider digitalization of the world economy. In aggregate, the adoption of 5G is expected to add US$ 1.3 Trillion to the global GDP by 2030 [1]. 5G investments are happening across the globe with 163 operators already having launched commercial 5G network in 64 countries with early movers like the USA, South Korea, and China already having hundreds of millions of 5G subscribers till Dec '2020 and many other global markets are in the process of spectrum auctions and moving towards 5G rollouts. By 2026, over 3.5 Billion 5G subscribers accounting for 54% of the total mobile traffic are expected [2]. There are several activities ongoing on the chipset and device space as well with over 703 5G devices announced including various form factors like smartphones, FWA CPEs, drones, TVs, cameras, etc., and even a vending machine [3].

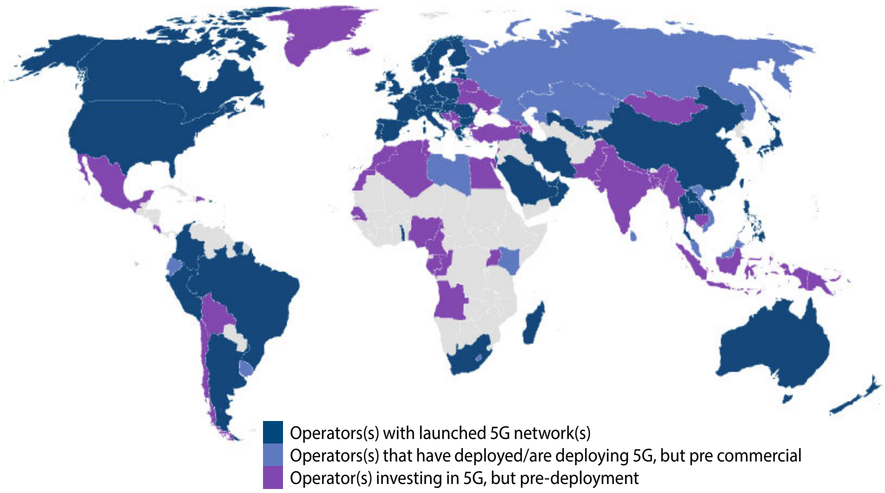

Figure 1 Global 5G Deployments, Source : GSA 2020

> We have been assessing use cases for 5G mmWave in the Australian market. Infosys has been a great partner with rich domain expertise for 5G and proactively adding value to our due diligence!

JEFFREY OWEN,
Head of RAN Strategy
TPG Telecom Australia

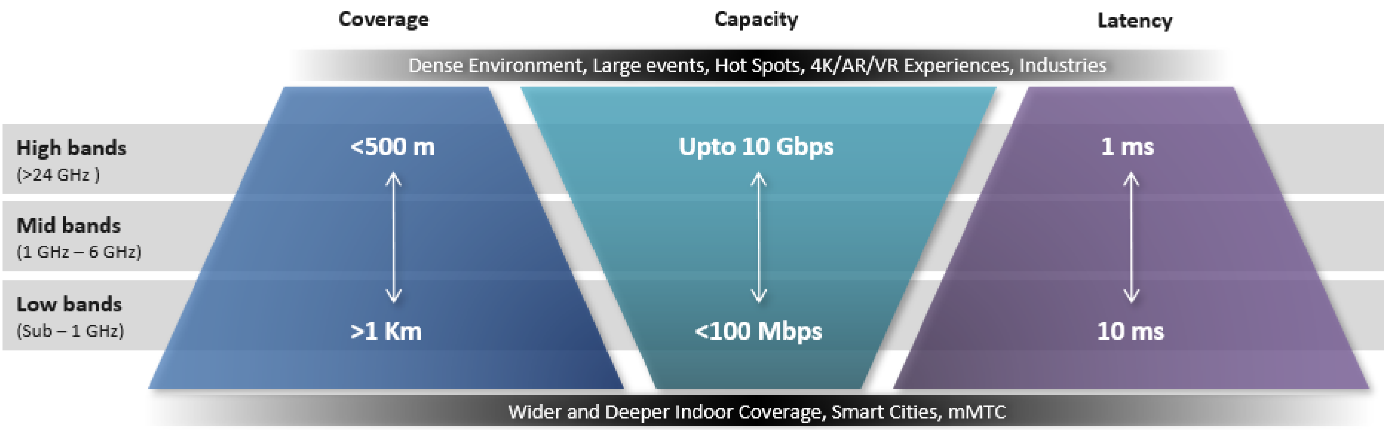

Figure 2 5G Spectrum Options and their implications

As operators are on their journey of deploying 5G, one of the most important assets being looked at globally is the wireless spectrum including a drive to achieve global harmonization of spectrum usage to facilitate affordable services and devices. Different available 5G spectrum options have different implications in terms of coverage, capacity, and latency and thus making a well-thought spectrum strategy an inevitable component of any operator's 5G roadmap to provide the most affordable and market-leading propositions across retail, home broadband, and enterprise segments.

5G spectrum comprises a roadmap for evolution for existing frequency bands used for 4G, as well as new bands. 3GPP has defined the 5G bands into two ranges, FR1 below 7.125 GHz and FR2 above 24.250 GHz for 5G. The FR1 bands are more suitable for wider coverage, specifically indoors, and are also enabling the Dynamic Spectrum Sharing capabilities with 4G but may be limited on the high throughputs due to smaller chunks of available spectrum. The FR2 bands referred to as mmWave bands will be instrumental in addressing the 10x high throughputs and low latency requirements particularly driven by a large amount of available spectrum and subcarrier spacing options for low latency. The mid-band, i.e. 3.5GHz band is globally being perceived as a suitable band for 5G offering a good balance of coverage and capacity, but in many regions, these bands are being used for other purposes such as Satellites.

The chipset and device market is also evolving with the various 5G band options. By January 2021, 29 commercially available 5G mobile processors/platforms and 11 commercially available discrete 5G modems from Hi-Silicon (Huawei), MediaTek, Qualcomm, Samsung, and Tsinghua Unigroup (UNISOC, and formerly Spreadtrum) [4]. Chipset vendors are also taking actions to drive the costs lower to enhance affordable devices, like Qualcomm® Snapdragon™ 480 5G Mobile Platform to drive the proliferation of 5G and allowing users to access 5G with devices at affordable prices [5]. 80% of the announced 5G devices are identified as supporting sub-6 GHz spectrum bands and only 20 handsets supporting mmWave bands. New devices such as the Apple iPhone 12 support all ranges of the 5G spectrum subject to market variations and Dynamic Spectrum Sharing.

Since there are various implications of the 5G spectrum, the pricing also needs to be different from the long-term vision for deliverable affordable services and motivate operators to invest. Government and regulators have been instrumental in driving spectrum pricing aligned to capabilities offered, thus we observe a clear difference between pricing for various bands. In USA, low range spectrum cost around 0.1 $/MHz/pop, mid-band (CBRS) cost around 0.2 $/MHz/pop while the high band (24,37 and 39 GHz) costs around 0.0091 $/MHz/pop. 47 GHz band cost only 0.001$/MHz/pop [6].

Planning a 5G Network

The different type of 5G spectrum options and their varying characteristics, 5G SA or NSA deployments and need to offer rich customer experience and address plethora of 5G use cases for industries, pose a tough challenge for the operators to identify the correct 5G strategy to plan their network. Conventionally, the planning was all about providing coverage and ensuring the people get a signal on their handsets, but things have become more complicated now to meet the needs of different use cases, a hot spot for high capacity, or even 5G enabled Fixed Wireless Access. The 5G mmWave bands are very sensitive, an interesting case is shown below where a group of trees blocks the signal.

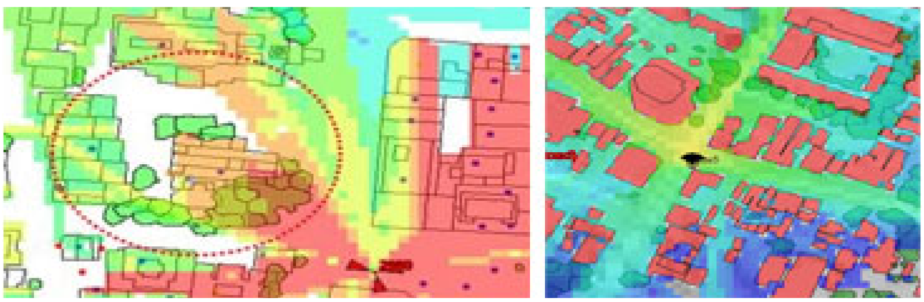

Figure 3 5G mmWave signal impact by foliage in an urban environment

To prepare a robust 5G business case, proper network planning outcomes are essential to understand the most optimum budget requirements and ROI aspects. It is also important to essential to assess the correct placement for equipment in terms of geographical area, building patterns, population density, foliage patterns, tower height, etc. There are various additional features like different MIMO options, beamforming, carrier aggregation, higher output power, Dynamic spectrum sharing, supported channel bandwidth, etc. which can impact the planning process and have implications on the spend for an operator.

Setting the objectives

The very first step for the planning process is to have clarity on the intent and objectives for the activity – What experience, coverage & capacity must be provided? What type of services or use cases will be served? Based on the objectives the planning inputs are prepared.

Leveraging data insights to drive planning

To get near realistic results in a network planning activity, it is important to leverage high quality, latest, sizeable, and accurate data to understand the current state and various trends of the traffic. There may be various internal network sources such as OSS counters or network analytics platforms as well as external sources such as crowd-sourced data. Geolocated sample measurements and other different application-specific crowdsource data give valuable insights.

Geographical, Technology & Propagation Modelling

Conventionally, many planning Geographical modeling inputs were generalized and assumed due to lesser sensitivity of the propagation, but with 5G, particularly 5G mmWave spectrum, accurate Geographical & propagation modeling of the radio operating environments is required. High-resolution 3D building and vegetation maps, GIS inputs, indoor electromagnetic properties must be used for more accurate outcomes. For 5G NR, true 3D multi-path ray-tracing model information is essential to evaluate the performance of massive MIMO. Few widely used propagation models are the Standard propagation model, Aster propagation model, CrossWave propagation model. There are specific models for small cells and mmWave requirements.

Technology options related to different types of numerologies defined as per 3GPP need to be modeled as well. This is related to the different aspects of subcarrier spacing, frame structures, etc. which impact the signal propagation and latency. Wider subcarrier spacing makes the system robust to phase noise and is also suitable to support low latency services. Narrow subcarrier spacing should be used in delay spread intensive environments

These modeling activities perform a complete and detailed cluster-based simulative analysis utilizing radio planning tools to evaluate coverage, QoS, and traffic performance and to validate the candidate site location once and for all, taking into consideration all technological parameters.

Parameter / Numerlogy (u)	0	1	2	3	4
Subcarrier Spacing (Khz)	15	30	60	120	240
OFDM Symbol Duration (us)	66.67	33.33	16.67	8.33	4.17
Cyclic Prefix Duration (us)	4.69	2.34	1.17	0.57	0.29
OFDM Symbol including CP (us)	71.35	35.68	17.84	8.92	4.46

Building Automation in Planning

During the initial days of 2G/3G networks, most of the planning activities were done manually and various tools have been developed over time to cater to automate various activities during planning. With the advent of 5G, the needs from a planning perspective are increasing & more real-time capabilities are expected along with more advanced AI/ML algorithms to identify the right solution for the right areas. Tools are instrumental in evaluating various scenarios for the site placement, spectrum and channel allocation, coverage and capacity assessment, cable routing and are well equipped with capabilities of optimization and maintenance. The tools are highly effective in reducing manual effort and increasing the efficiency & ability to look at more scenarios. In the future, planning tools are being integrated with other systems in the network to provide real-time insights for various teams to make quicker decisions.

Analyzing planning tool outcomes

Once all the inputs are used to execute the simulations in an industry-standard planning tool like Atoll, Asset, Mentum, etc. the tool outputs need to be studied in detail. Assessment of various aspects related to coverage (RSRP, etc.), capacity (throughput, modulation samples, etc.), and quality KPI's (SINR, RSRQ, etc.) is required to identify the expected network behavior. It is important to cross-check the objective in terms of the subscriber experience in uplink and downlink are met. Many times various business scenarios may be simulated for comparison and decision-making purposes before approaching the network rollout stages.

Our Experience with 5G

In the past few months, we have studied and collaborated with our clients on 5G network planning activities addressing different types of business scenarios. These are applicable for a variety of 5G use cases for retail customers or enterprise use cases.

eMBB

One of the most basic uses for 5G is for eMBB, addressing the needs of rich data experience and good coverage, including indoors. 5G spectrum options are very diverse in their coverage & capacity characteristics and thus it is a challenging task to define the correct strategy. Mid-band deployment is emerging globally as a mainstream band for 5G leveraging the existing deployed macro grid and increasing the overall capacity of the network. The Low band (700, 850 MHz) deployments help achieve better indoor coverage, whereas the high bands are offering very high throughput and low latency experiences. Operators need to determine the correct mix of spectrum options based on their needs. A reference comparison for a suburban area with different bands and their coverage is shown below.

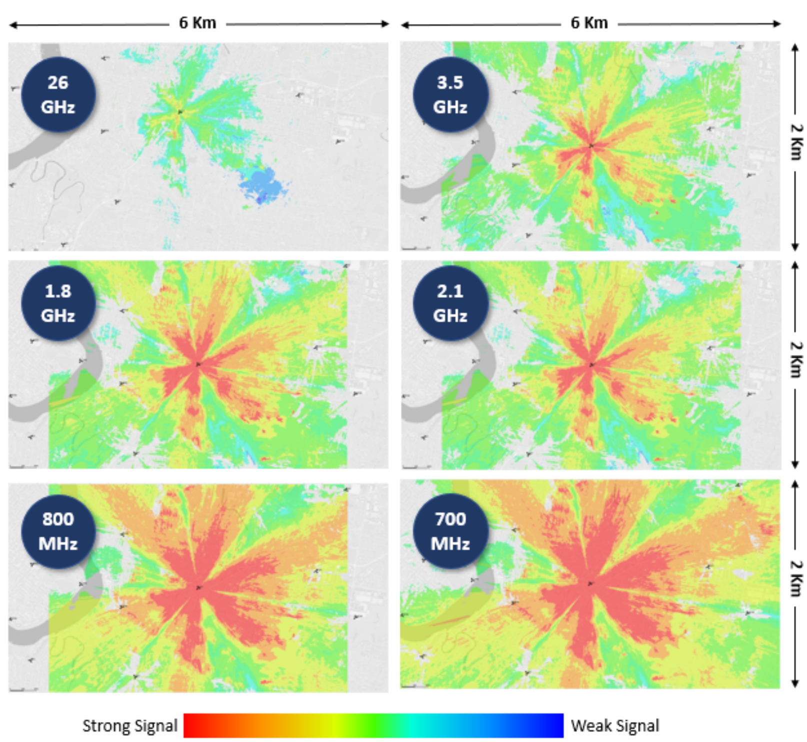

Figure 4 Coverage comparison of 5G spectrum options

Small Cells

Network densification is a major requirement for 5G and thus makes Small cell architecture an integral part of the 5G evolution. Small Cell offers a lower TCO compared to costly macro site solutions, specifically in dense urban areas where site acquisition is a big challenge and upfront leases can be very costly for large infrastructure deployment. Small cell brings the network closer to the subscriber which helps to offload the macrocells and reduce the coverage holes thereby improving customer experience and overall delivering a higher spectral efficiency.

Both the 5G NSA and SA small cells are available commercially and are gaining traction with the operators globally. FCC commissioner report recently estimated that the US needs 800K small cells to make 5G a reality by 2021[7].

We observed that small cells have the capability to offload 20-50% of existing macro traffic in the simulated areas. In the case of 4G/5G small cells, there are heavy dependencies on the optimization for layer balancing and interference management thus small cells can have a negative impact if not planned properly. The Mid-band 3.5GHz 5G small cells provide a good mix of coverage and capacity whereas 5G SA wave band small cells have been found suitable fit for the hotspot areas with almost 6x more capacity gain as compared to macro. Small-cell units can use existing street furniture such as street lamps and utility poles to provide in-fill coverage and to address the growing capacity demands.

Fixed Wireless Access

Though Fixed Wireless Access is not a new concept and has been existing with previous technologies like WiMAX & LTE, it has been positioned as one of the first commercial use cases for 5G globally. The 5G FWA has been termed as Wireless fiber as an alternative to expensive Fiber networks delivering ultra-high-speed broadband to homes and enterprises specifically fit in geographical areas or localities where fiber deployment was a challenge. 5G FWA CPEs could be roof / window mounted for a direct line of sight to the 5G base station or an indoor unit that can be installed by a user. Over 50 5G FWA CPEs are expected to be available in the market by 2021 [8].

In an assessment for 5G FWA for one of our clients across multiple cities covering 1000+ operator sites with a coverage of over 4.7 million homes, we have observed significant variation in the mmWave coverage from city to city based on different morphologies with an estimated coverage of 30-50% premises. Very evidently the mmWave spectrum is highly sensitive, the dense urban LOS coverage less than 200m and even a group of trees can potentially block a complete sector as shown in Fig.3. The NLOS scenarios due to raytracing, beam bouncing, reflections, and diffractions can provide better coverage as compared to LOS, but the experience is much poorer.

Conclusion

5G has great business potential globally much more than any of the previous connectivity technologies. While 5G has an impact on several areas such as spectrum strategy, network infrastructure, cloud, IT & applications, use cases, devices, security, and sustainability, Network planning is a very important and strategic area for the underlying business decisions. There are various implications for planning for 5G networks and any operator or enterprise must do detailed due diligence before finalizing any business case specifically in terms of the spectrum choices and understanding the experience delivered. Our observation has been that the 5G spectrum, specifically the mmWave is a highly sensitive spectrum and the slightest difference in terrain or geography can lead to a significant difference in the perceived experience.

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Aditya Singla is a Global Radio Access Networks Subject Matter Expert in the Global domain consulting practice for Networks at Infosys Communications, Media, and Technology. He brings in several years of operator experience from one of world's largest operator, Bharti Airtel in the areas of network design, planning and operations for various generations of wireless technologies. He has previously also worked with Ericsson for several years in the capacity of a RF Engineer.

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Glossary

FWA : Fixed Wireless Access
IoT : Internet of Things
FR : Frequency Range
CSP : Communication Service Provider
LTE : Long Term Evolution
RAN : Radio Access Networks
SA : Standalone
NSA : Non-Standalone
NR : New Radio
MIMO : Multiple Input Multiple Output
QoS : Quality of Service
CPE : Customer Premise Equipment
GIS : Geographic Information System
CU : Central Unit
DU : Digital Unit
CBRS : Citizens Broadband Radio Systems
DAS : Distributed antenna system

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