Staking a claim in the 5G era

White Paper

13 September 2019

Stéphane Téral

Executive Director – Research and Analysis, Mobile Infrastructure & Carrier Economics

IHS Markit Technology | **White Paper**

Contents

Executive summary

There is no doubt that 2019 will be remembered as the year of first commercial 5G network rollouts and services. Yet, despite unabated trials and massive commercial deployments, the number of challenges associated with 5G continues to rise. For example, complex network architecture choices, limited availability of user devices, and investment needed to build 5G networks are just a few of those challenges. However, the long-term life changing opportunities of 5G outweigh the challenges. These opportunities lie in the new technologies and features that allow service providers to make the most out of their infrastructure. Features like massive MIMO, network slicing, Multi-access Edge Computing (MEC) and public cloud, as well as innovation in transport networks are the most notable. Finally, although service providers are facing a number of strategic considerations for deploying 5G network, many have already begun to solve them with the help of leading 5G suppliers, including Ericsson, Huawei, Nokia, and ZTE.

The State of the 5G Market: China is already on board

As of June 30, 2019, 33 operators that have commercially launched 5G networks and service in 20 countries, which is more than twice the number of commercial 5G networks counted in 1Q19. And for the first time in the history of the mobile industry, China is among the early adopters. Current worldwide 5G activities point to the following early adopters:

- Like 4G LTE, the earliest of all adopters is South Korea. In early April 2019, pushed by the government, the country's three operators, SK Telecom, KT and LG Uplus, launched their live 5G network to offer the very first enhanced mobile broadband (eMBB) services.
- The US market was marked by sporadic Fixed Wireless Access (FWA) services in 4Q18 and quickly joined South Korea the same first week of April 2019 with eMBB services from AT&T and Verizon. Since, Sprint and T-Mobile US have launched 5G services as well.
- China awarded four 5G licenses in early June 2019 and gave the go ahead to the 3 service providers, China Mobile, China Unicom, and China Telecom, and a new comer, China Broadcasting Network (CBN) to launch 5G services. China's roll out plan will likely place it ahead of other markets based on scale. This scale of deployment will likely accelerate to hundreds of thousands to even one million base stations yearly from 2020. For example, with LTE, China built over 4 million base stations accounting for over half of the world totally, which heavily influenced other markets and the industry supply chain as well.
- The Middle East already had live 5G networks in the summer 2018 and has since expanded the footprint with Saudi Telecom taking the lead.
- In Europe, Elisa in Finland, Hutchison Drei Austria and Sunrise in Switzerland were the first to launch commercial 5G services, along with BT EE in the UK.
- In Australia, Telstra is the first 5G adopter, rolling out its network.

As 5G deployments are heating up and all market players are trying to reserve their 5G market leadership seats, it is important to re-visit market variables. Technology standards, network equipment, users' devices, and spectrum allocation are the major pillars of successful 5G deployment. Some of these pillars, as will be explained in this paper, are at various stages of development with some close enough to commercialization. Others are dependent on external market factors such as components and chips development, economic conditions, and even political agendas.

Technical Challenges and Opportunities

As is the case with any new technology, 5G carries many challenges and opportunities to the market. The challenges are primarily associated with deploying a new network architecture while overcoming financial and operational uncertainties. The opportunities, on the other hand, are brought in by the new features and use cases that the end-to-end service-based architecture 5G promises to deliver. In this section, we review some of the challenges and opportunities that service providers and mobile operators are likely to face, or are currently facing, during their respective 5G deployment journey, including:

- Network architecture
- Single RAN for 4G, SA and NSA
- Handsets and chips
- Massive MIMO technology
- Network slicing
- SDN/NFV, AI, ML
- MEC
- MEC and Public Cloud
- Transport requirements

Network Architecture – SA or NSA?

Since the inception of 5G, standards' developers have set different architectural options for the technology rollout. The fundamental reason is to protect existing investments in previous generations of mobile technology and provide a bridge with 4G LTE to speed up the adoption of 5G. Named non-standalone (NSA), this 5G architecture allows operators to gradually introduce 5G services into their existing network and has become by far the most popular choice among operators as it provides a safe path. In this scenario, the 5G base stations or new radios are anchored into LTE and therefore use the existing LTE EPC to provide core services.

The other option, standalone (SA) architecture, cuts the tie with LTE and allows operators to rollout an independent network that can support all use cases and offer the grade of services that 5G promises. This SA architecture requires a 5G new core and is likely to be the choice of operators in developed and highly mature market.

Most operators started from NSA, they will evolve to SA eventually, the NSA & SA transition and coexistence will definitely be a norm in the industry. Vendors will solve this conundrum and accelerate the 5G adoption.

SA and NSA

As more 5G network are being deployed, the long-term coexistence and integrated development of 4G/5G is already becoming a practical problem that operators pay close attention to, so do vendors. The major highlights of this RAN platform include support for both 5G NSA and SA architecture, high-bandwidth and high-power multi-mode active antenna unit (AAU), multi-mode large-capacity baseband unit (BBU), and 4G/5G dynamic spectrum sharing. It protects the operator's investment and meet the long-term evolution requirements of the operator's 5G commercial network, greatly reducing the complexity of construction and maintenance, and reducing the pressure of the operator's investment and deployment.

It is also notable that Chinese vendors Huawei and ZTE have engaged in designing their own chipsets for baseband and radio processing for more than a decade. After several generations, some of their chipsets are based on 7nm process with high performance. These efforts have translated into competitive RAN products, especially in Massive MIMO and BBU capacity. For example, Huawei's BBU 5900 and ZTE's BBU V9200 are industry's leading BBUs with very large capacity and high throughput.

Handset and Chips

Users' equipment is a huge challenge to the adoption of 5G. As a major part of the mobile eco-system, commercial handsets and chips are the bottleneck in the path of any commercial network.

Handset makers are planning to launch 5G Smartphone aggressively. There were seven or eight 5G smartphone models already in commercial use in the first half of 2019 and more models were scheduled for the second half.

In addition, declining average selling prices are expected to spur demand toward more than 100 million 5G smart phone shipments in 2020.

Massive MIMO Technology

Invented in 2008, Massive MIMO (multiple-input multiple-output) is a major element of many enhancements that 5G features. It greatly improves channels throughput and spectral efficiency.

Delivering multiple data layers, Massive MIMO allows users under the same cell to experience optimum data rate regardless of their distance. Unlike older continuous signals broadcasts, Massive MIMO with beamforming transmits focuses beams to the receiving devices and delivers strong signals with minimal interference. Most 5G base stations, likely over 90%, will be based on Massive MIMO that includes space-division multiple-access (SDMA), beamforming, dynamic resource allocation, and interference elimination. In various scenarios, different technologies have their specific effects, making Massive MIMO "critical" to application scenarios, which tests manufacturers' research and experience in this field. It's worth mentioning that ZTE is the first to adopt Massive MIMO technology in the 4G era since 2014. ZTE and Huawei continue to be advanced in this technology.

Massive MIMO is ideal for all deployment scenarios, and especially suited for congested areas. Trials and commercial pilots have shown great improvement to the end user experience. Whether it is a dense urban area or a stadium with thousands of fans, Massive MIMO delivered substantial improvement in cell throughput by at least a factor of 3, and also 6 to 10 times data rate improvement for cell edge users.

In addition, Massive MIMO trials showed significant coverage improvement, which in turn may diminish the need for small cells and remove the need for more sites This means that 5G NR can be effectively co-sited with current LTE eNodeB (eNB) without the need to increase the number of 5G NR sites.

Convergent Core

With the introduction of 5G and the long-term coexistence of 2G/3G/4G, operators are facing the challenge of diverse network architectures and rising costs. In the early stage of 5G network construction, hot spot coverage is the main focus. Therefore, the existing 4G evolved packet core (EPC) needs to cooperate with the upcoming 5G core (5GC) to support 2G/3G/4G/5G services. In the maturity period of 5G network, 4G and 5G will still coexist for a long time. EPC equipment will gradually exit the network, while the converged 5GC will support multiple access modes.

- Having said that, the SA architecture is well suited to enable eMBB, mMTC and URLLC. For example, China is adopting a SA network approach, while in Europe, Orange was the first to conduct SA trial in Valencia Spain in 2018. These developments require a 5G Convergent Core. The components of the core include: The convergent core needs to support 2G/3G/4G/5G mobile and fixed services based on a 5G-oriented 3GPP cloud native service-based architecture (SBA).
- The convergent core needs to meet the diversified requirements of operators for NSA and SA networking deployment.

Network Slicing

Based on NFV and SDN, network slicing allows multiple logical networks to run on top of a shared physical infrastructure and will allow service providers to allocate network resources dynamically to accommodate different seasonality and peak times.

Network slicing is set to improve operators' revenue streams. It optimizes the utilization of operators' infrastructure by enabling them to serve different use cases using the same set of network equipment. Each network slice would have its own quality of service criteria that enable each slice to be tailored to different verticals. And the capability of end-to-end network slicing including core network, mobile network as well as transport network can make it possible for operators to coordinate different network resources in highly efficient way to meet diverse requirements.

By January 2019, 26 projects reported the deployment of network slicing. Many operators have already been in trials to test the feature. And with the positive business outlook of network slicing, a fast and high adoption rate is expected in the near future.

MEC

Multi-access Edge Computing is purely being used by operators to improve 4G network performance and at least maintain a stable customer experience with no appealing business case that can generate more revenue so far. Meanwhile, the MEC implementation requires substantial investment in infrastructure and comes with the chief challenge of location acquisition that involves heavy negotiations with real estate owners. Some recommendations to the MEC stakeholders include:

1. MEC needs to adopt lightweight cloud technologies, such as container technology, to support third-party application deployment.
2. Faced with the limitation of space and power, MEC needs to use hardware accelerators such as field programmable gate arrays (FPGA) and graphics processing units (GPU) to improve the efficiency of specific services.
3. An open source MEC platform is needed to motivate third-party applications to deploy to the edge.

With the emergence of latency-sensitive vertical applications such as critical communications, remote healthcare, virtual reality, and self-driving cars, MEC is quickly becoming an essential part of the next generation network. And finally, to meet the ultra-low latency demand, the vertical applications are moved to the MEC, and the computing capability is converted at the MEC.

SDN/NFV, AI, ML

5G networks will be cloud-based and use SDN/NFV technology, increasing the scale and the complexity that in turn will lead to network operation and service level agreement (SLA) maintenance challenges. The implementation of Artificial Intelligence (AI) and Machine Learning (ML) will address these challenges and will also improve the performance of network slicing by adding smarter optimization.

Comprehensive application of AI and ML throughout the network can help boost quality of service (QoS) in real time. Closed-loop Automation (CLA) and NFV Management and Network Orchestration (MANO) can measure end-to-end QoS, dynamically adjusting end-to-end key performance indicators (KPIs) and accurately locating faults for KPI degradation to achieve self-healing and self-optimization.

To support this, the BBU in the radio system have extra computation power that can be used for AI or other applications, such as AI-based network load balancing, reducing the traffic of a high-load carrier.

Transport Requirements

The transport infrastructure play a major role in the delivery of the end-to-end 5G experience. The diversity of use cases and applications 5G enables will require a sound transport infrastructure. The key transport requirements include support for ultra-large bandwidth, ultra-low latency, ubiquitous connection, high-precise synchronization and network slicing. Transport network should have flexible slicing ability including hard slicing and soft slicing to meet diverse requirements of 5G services and rental services from individuals and enterprises.

To meet those 5G transport requirements, many vendors have developed a unified ‘x-haul’ approach that offers fully integrated transport environment handling all macro/small cell backhaul traffic as well as fronthaul traffic (between remote radio heads and baseband units in a centralized RAN architecture) and mid-haul traffic (between a distributed unit and a centralized unit in a 5G RAN architecture).

Investment Challenges

Unlike other mobile technologies, 5G has a lot to offer to operators’ top and bottom line.

Going way beyond eMBB, the long-term 5G business case is very promising as it brings diversity to the operators’ portfolio with a plethora of use cases to come from industry verticals. With China jumping in the 5G early adopter bandwagon, Chinese operators announced ambitious and fast-moving evolution of 5G plans that are strongly supported by the government. Moving forward, with massive 5G rollouts already taking place, China has the potential to drive the global 5G ecosystem, technology innovation and speed up the commercial uptake of 5G services.

Operators expect to reverse the declining MBB ARPU trend and harness many other areas such as enterprises, industrial automation, and next gen applications including connected cars, AR/VR, and smart cities, to name a few. However, moving from a single MBB service portfolio to multiple various services creates the challenge of rightly scaling the 5G network with a tactical investment that delivers the right return on investment (ROI).

Network Scale

Network scale is a major concern for operators. Due to the higher spectrum bands being used for 5G, it is expected that more sites and consequently more investment will be needed to achieve proper coverage. By contrast, LTE is using spectrum bands with better propagation properties, which translate into lower numbers of BTSs needed to achieve continuous coverage.

Looking at the world’s extreme case, China’s LTE eNBs account for 50% of all globally deployed eNBs. Achieving comparable coverage for 5G using higher spectrum bands will be tough. However, vendors have been working on this issue.

The biggest player China Mobile has 160MHz on 2.6GHz and they will deploy both LTE and 5G on this spectrum, making DSS (dynamic spectrum sharing) between LTE and 5G a must. Huawei, Ericsson and ZTE have advocated this technology, and DSS trials have been underway since mid-2019. All vendors are on track to commercially deploy PRB/TTI based DSS—in LTE scheduling, PRB is physical resource allocation and TTI traffic time interval.

Use Case ROI – Network Slicing

Network slicing is basically a huge key enabler of a large variety of use cases over a single 5G network. That’s the reason why this feature is of absolute importance to all operators. In determining network slicing ROI, it is useful to compare it to other technologies such as fiber access and LTE private networks. When compared to these technologies, 5G network slicing for discrete use cases—taking into consideration that part of the existing infrastructure can be upgraded and re-used--has the least total cost of ownership (TCO). The reason for the lower TCO is the shareability characteristics of network slicing. The fact that operators can serve many use cases using the same infrastructure makes it very cost effective when looking at individual use case. Deploying 40-50 network slices for different use cases would enable operators to breakeven in 2-3 years. Operators can also prioritize use cases that pay off faster to achieve faster ROI. Moreover, innovation in addressing the business needs of each vertical will allow operators to develop competitive advantage and unique value proposition.

Deployment Strategies

When it comes to 5G deployment, it is important to have a clear strategy that defines the path to full 5G SA network. This is the ultimate network setup through which operators can offer end-to-end 5G services. This path should define how to evolve the network from initial selective deployment to nationwide continuous coverage, and from NSA 5G network to a fully independent SA 5G network. The company that can provide the NSA & SA dual mode 5G system will ultimately make the NSA to SA transition easier.

The plan should take into consideration many factors such as interoperation with LTE and legacy networks, availability and users' adoption of 5G-capable UEs, infrastructure readiness, availability of spectrum, and timing.

The latter is especially important because it defines the mature options available in the market. Most operators who are planning early 5G release, are doing so based on NSA architecture. And there are obvious reasons for that choice. First, 5G-enabled UEs are limited and second, most operators want to make the most use of their LTE network.

On the other hand, operators who do not plan to release 5G services before 2020 are more likely to head for the SA deployment option directly. This is because the year 2020 is expected to witness a huge wave of 5G releases, including commercial networks and 5G-capable UEs. In addition, late movers will want to get some market share offering SA 5G exclusive services.

5G SA Architecture Deployment Strategy

The 5G SA architecture works better with sub-6GHz spectrum band. Whether operators will start with selective coverage or continuous nationwide coverage, sub-6GHz spectrum band is the best choice to achieve that desired coverage.

When it comes to 5G NR, co-site strategy is recommended because 5G NR can achieve equivalent coverage as LTE for most of the urban scenarios. Using multi-band, multi-port antennas and ultra-broadband, multi-mode AAU/RRUs to consolidate the RF equipment on a tower and empty space for 5G AAU, operators can sharply lower cost and maximize the utilization of LTE infrastructure.

Selective 5G NR coverage would help operators introduce 5G services to early adopters first and then, to those more likely to buy an early version of a 5G-capable UE. At the same time, this strategy would give operators the time to optimize network performance and get ready for wide-scale deployment. Moreover, operators can still leverage their LTE network by using its infrastructure for service continuity.

The network should then transition to nationwide continuous 5G coverage. The continuous coverage would enable operators to offer other services that depend on end-to-end 5G architecture.

5G NSA Architecture Deployment Strategy

This strategy aims at providing 5G services by leveraging the existing LTE network. The deployment strategy involves two major deployment/upgrade steps:

1. Upgrade both access and core network infrastructure of the LTE network. The upgrade enables the LTE network to interwork with 5G NR.
2. Deploy 5G NR selectively in areas where high demand for data services is expected

The 5G NR acts as a secondary access node controlled by an upgraded eNB as a master access node. This setup allows operators to offer eMBB services to end users. As it requires close interoperation between 4G and 5G networks, it introduces some complexities into network operations and service optimization. In addition, operators may need to upgrade the EPC capacity.

As the transition from NSA to SA is inevitable, it makes the NSA & SA dual-mode 5G system a necessity. The operators can benefit greatly from deploying NSA & SA dual-mode system at the beginning of 5G. However, they can boldly deploy NSA at hot spots and high value areas, marketing their 5G footprint with the ability to support SA terminal and new application on the same hardware, blurring the boundary of NSA and SA.

Introducing the 5G new core into the network and increasing the 5G NR coverage area represents the transition toward a SA 5G network. In this case, the 5G network becomes less dependent on the LTE infrastructure but the LTE network can still be used for service continuity.

EPC and 5G new core will coexist for a long time and operators do not need to replace their EPC with 5GC right away unless they know that 5G adoption among their subscribers is 100%. The deployment of 5G new core and the ability to perform end-to-end network slicing will allow operators to serve new verticals.

Leading 5G Vendors

Ericsson

Ericsson is one of the world's top 5G NR providers and a key supplier to early adopters in the US and South Korea, and now China. The company has already launched eight 5G networks and publicly announced 21 other contracts for new commercial 5G rollout. Ericsson is also involved with other operators in modernizing existing LTE networks to make them 5G ready. That includes BTS modernization and implementation of high order MIMO (4x4/8x8).

Ericsson was one of the earliest vendors to demonstrate network slicing. In 2017, the company partnered with Japan's NTT DOCOMO and created the world's first 5G network slicing featuring multiple slices on the same device.

In February 2018, Ericsson partnered with BT and Verizon to demonstrate the autonomous control of drones, which was launched from the US by Verizon on a dedicated 5G network slice.

Huawei

Huawei is a leader in 5G NR units shipped. Huawei has 5G commercial networks in Europe, the Middle East and Asia, and many trials demonstrating its 5G abilities as well as 50 contracts already signed and publicly announced.

In collaboration with Deutsche Telekom, Huawei launched the first network slice to be built over shared RAN, core and transport network.

Huawei also advocates network automation. In its report about autonomous driving mobile network, the company forecasted that 80% of mobile network operators would start investing heavily in network automation. The main reasons Huawei addresses that trend to is that all operators are keen to reduce network operation costs and improve user experience. As one of the top UEs manufacturers, Huawei already launched three 5G-enabled CPEs. It has another four models planned to be released 2H19; one of them is the notable Mate X foldable smartphone. The company will also release a 5G-enabled module designed for connected cars during the same period.

Nokia

Nokia is another leading 5G vendor that supplies early adopters in the Middle East, the U.S. and South Korea. The company has also announced 45 5G commercial contracts and stated that around half of those contracts are built on its end-to-end portfolio including Microwave Anyhaul, cloud native RAN and cloud native core. In its contract with SoftBank Mobile, Nokia will be deploying both distributed and centralized RAN using its flagship AirScale BTS.

The company has also been pushing openness and taking a leading role in initiatives like OB-BAA and ONAP, and champion standardization efforts in the BBF and ETSI NFV. Nokia strongly believes open software architectures will renew the focus on true product differentiation and stimulate collaborative development between telecom vendors and service providers

As a strong optical network player, Nokia announced several engagements with different operators. A notable example is achieving a wavelength speed of 550 Gigabits per second in collaboration Telecom Italia. A result that is seen as a huge step forward to anticipate 5G work.

ZTE

ZTE is a leading 5G provider with end-to-end turnkey capability and notable momentum with Telefónica, Orange, Wind Tre, and Hutchison Drei Austria in Europe, and massive 5G rollouts in China. The company has publicly announced 60 partners and more than 25 commercial contracts. As a leader and pioneer of Massive MIMO technology, ZTE's RAN innovation aligns with convergent common core hat supports NSA and SA architecture as well as hybrid cloud deployment configuration.

The company is also a leading supplier of transport equipment. In the mobile backhaul segment for instance, the company features a flagship Flexhaul system that supports ultra-large bandwidth, ultra-low latency, ubiquitous connection, high-precise synchronization and network slicing functions, which in turn, provide operators with the flexibility to support fronthaul, midhaul, and backhaul configurations for various network setups.

And finally, ZTE is also offers consumer devices with a series of diversified 5G terminals including smartphones, routers, Ethernet boxes and modules, each adapted for specific industry 5G use cases.

Conclusion

The race to be first between South Korea and US has shifted to large scale 5G deployment in more countries.. Helped by its massive size, China is uniquely positioned to drive global 5G developments. China has started deploying 5G on a large scale in 2019, and one million annual unit shipments likely in the near term. It is estimated that from 2020, the number of 5G sites in China will account for more than half of the global number of 5G sites. In terms of 5G services and applications, Chinese operators together with typical enterprises and equipment suppliers actively promote 5G applications in vertical industries. In summary, China's commercial scale, product diversity, and innovative technology solutions have great radiative influence on the Asia-Pacific market and have important impacts on Europe and other regions. While there is a high degree of readiness among the suppliers and the whole ecosystem, operators should move carefully despite the pressure to be first. Sound decisions in terms of spectrum, architecture and use cases will be key to achieve a desirable ROI.

This report offers an independent assessment of 5G deployment methods. IHS Markit is exclusively responsible for this report and all the analysis and content contained herein. The analysis and metrics developed during this research represent the independent views of IHS Markit.

Contacts

Stéphane Téral

Executive Director—Research & Analysis, Mobile Infrastructure & Carrier Economics

Technology Fellow, Telecommunications

Stephane.Teral@ihsmarkit.com