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5G & Digital Transformation: Will Telco Operators Seize – or Lose – the Opportunity?

Content

Executive Summary

After years of hype, the 5G era is now underway, and it is becoming clear that nearly all operators are on some path toward 5G or likely to be on that path soon. Meanwhile, telco operators are embracing digital transformation – both internally to revamp internal operations and improve network operating efficiencies, while externally to help improve customer relationships and grow revenue from digital services.

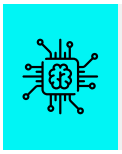
As 5G continues to evolve and mature, it is becoming a more central element of the digital transformation imperative, for example, by providing new tools such as network slicing that can drive new sources of revenue. However, it also ushers in a fundamental change in network architecture that, while vital to the future of telco operators' ability to thrive, requires significant internal change and makes network operations significantly more complex. In an environment in which most telco operators are seeing flat or declining revenue from traditional voice and data services, digital transformation is no longer optional.

In this paper we:

Examine the current status of 5G, including technology standards and early cases;

Assess the role of 5G as the key enabler of telco operators becoming digital service providers;

Identify new capabilities and new challenges created by the 5G network architecture, notably network slicing;



Analyze the vital role of small cells in emerging 5G networks and the associated deployment and operational challenges small cells create for telco operators;

Explore emerging approaches to manage the complexity associated with 5G network operations;

Call out the vital role of partners in managing 5G complexity for telco operators and in helping bring transformative 5G use cases to consumers and enterprises.

Global 5G Deployment Update

The 5G era has now begun in earnest. With a number of launches, demonstrations, trials, and commitments from telco operators, network vendors, and device manufacturers globally, 5G has become a reality after several years of hype. Ooredoo Qatar took the lead by becoming the first telco in the world to offer 5G services in June 2018, a month after it launched the network. The momentum continued as a number of operators in the Middle East, Europe, the U.S., and South Korea launched their services later that year.

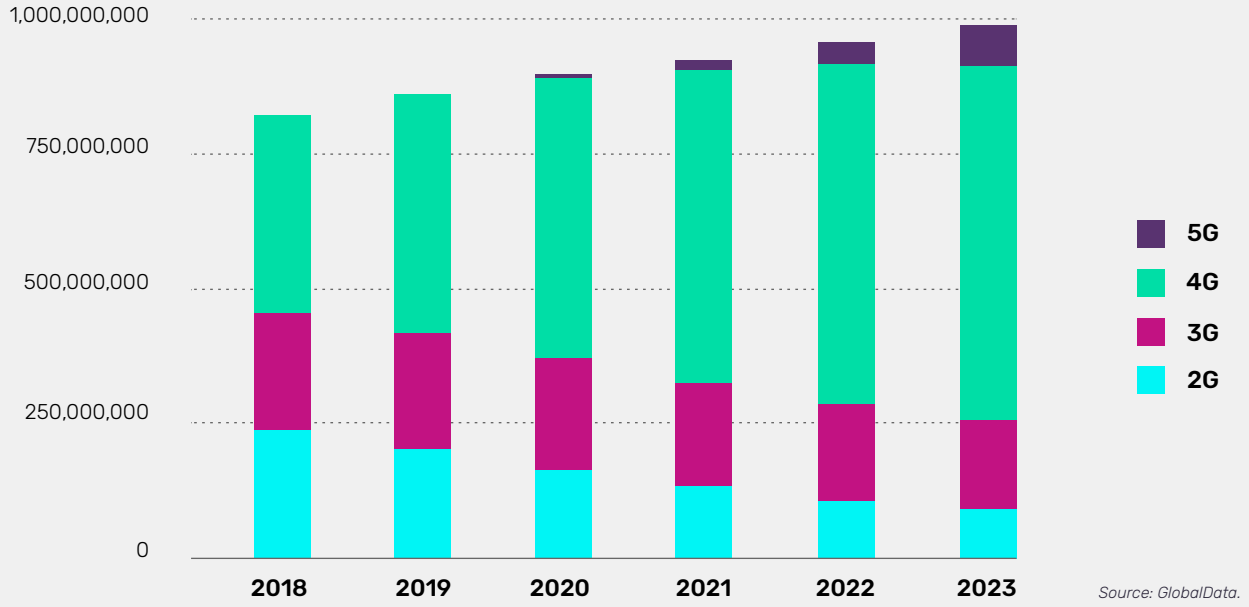
While pre-5G, pre-standards deployments have defined the 5G era thus far, significant standards related to both radio and core innovations are now hardened. After completing the first 5G standard in December 2017 for 'non-standalone' 5G New Radio (NR), the 3GPP, which defines the standards governing cellular technologies, approved the standalone version in June 2018. The non-standalone version enables 5G NR to be deployed on top of an existing LTE core; however, the standalone version enables operators to build greenfield all-5G networks.

There was one minor setback on the 5G timeline, however, as the completion of 3GPP release 16 standards was pushed back from the end of 2019 to March 2020. While this delay is relatively minor, it does raise concerns about the timeline for future standards.

Meanwhile, operators continue to refine the 5G core based on the service-based architecture (SBA). Building a 5G core will be crucial to enabling 5G-related features such as network slicing, but SBA represents a radical change in network design. The reference architecture for SBA is well defined, but the transition will be rocky. As a result, vendors are working with operators to enable a smooth transition to SBA-based 5G core.

Limited 5G Use Cases So Far

Thus far, 5G services have been limited – "nomadic" 5G hotspot coverage and a handful of fixed wireless markets, with 5G smartphones only now beginning to be introduced. In point of fact, early 5G networks have been launched as much for "bragging rights" than to address any real market needs. That said, many telco operators are trialing 5G with plans to launch services in the next few years as spectrum becomes available, networking equipment matures further, and a critical mass of 5G smartphones emerges. A host of commercial deployments are expected to begin in H2 2019 and kick into high gear in 2020, though initial uptick is likely to remain slow due to a lack of compelling handsets and limited geographic coverage.



Source: GlobalData.

As 5G networks begin to roll out, telco operators of all stripes are eager to build compelling and realistic use cases beyond merely faster broadband. As with any new generation of wireless, the stakes are high, and operators are hoping to offset declining revenue from traditional voice and data services by mining new revenue from advanced services spanning both consumers and business customers.

Some major operators, such as Australia's Optus, are now seeing the value of getting a fixed wireless service into the market before or at the same time as their mobile 5G service introductions in order to begin monetizing the technology right away. Optus and its technology partner Nokia are in the midst of rolling out 5G home broadband service, with 50 live 5G sites by March 2019 and plans to expand to 1,200 sites by March 2020. Optus believes that offering FWA now enables it to begin monetizing 5G early and provides a five-month head start to understand what 5G can do in the field. Similarly, BT's EE announced plans to offer the Huawei 5G CPE Pro device as a home router alongside its mobile broadband service for UK homes. EE is switching on 5G sites in 16 UK cities in 2019.

These carriers are casting a wide net for new 5G subscribers and are able to do so via plug-and-play CPE devices. Longer term, however, the business case will likely vary from market to market, impacted by factors such as the existence of wireline solutions, population, and even city topology. Indeed, these factors are what U.S. operator Verizon is facing. In October 2018, Verizon introduced FWA based on its proprietary 5G technology in four U.S. markets using mmWave spectrum; however, the company has had difficulty clarifying how it will reach its previously stated goal of 30 million households. Perhaps the most vocal advocate of 5G FWA, Verizon has built out just four U.S. markets thus far.

Next Phase of 5G May Focus on Consumer Market

Beyond fixed wireless, common 5G "themes" involve AR, VR, device-to-device/vehicle-to-vehicle internetworking, support of massive capacity demand due to growth of IoT, network slicing-enabled service tiers, and greatly enhanced mobile broadband that may finally be a peer to fiber and cable. Consumer themes focus on AR/VR-enabled gaming, fast and low-latency mobile broadband, and new broadcasting capabilities such as sporting events that allow viewers to see actions from multiple perspectives. The reason why these cases may be earliest to emerge is that they are the ones with the least complex technical challenges and the easiest path to revenue when compared to many of the enterprise-oriented use cases.

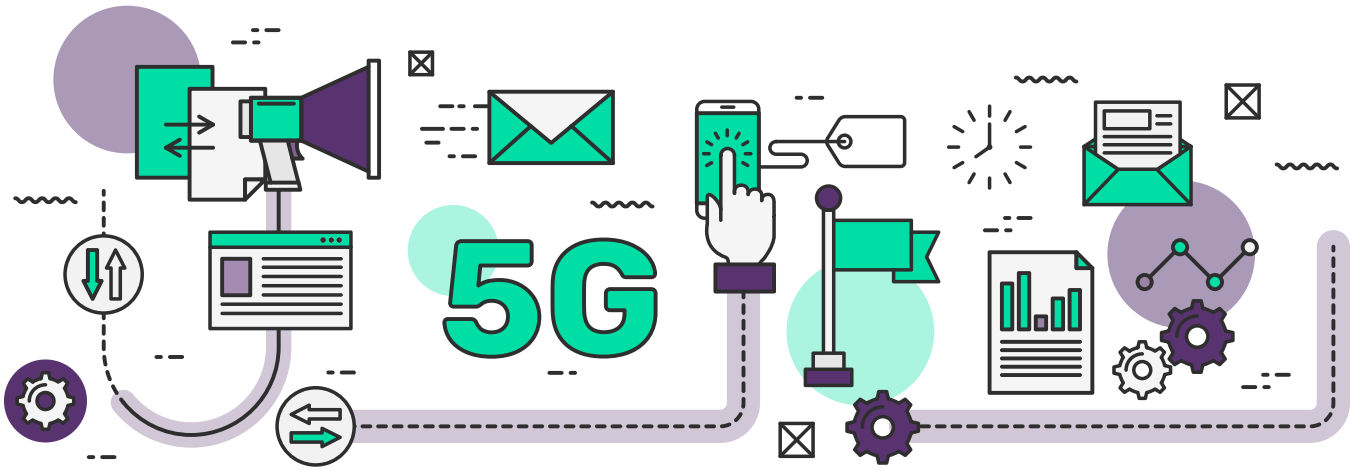
B2B Cases Will Take Longer

Telco operators have devoted much of their 5G rationale on building new B2B use cases. However, thus far these operators are struggling to delineate, clarify, and quantify business outcomes associated with 5G. In these early stages of 5G deployment and planning, these operators have differing ideas about the kinds of applications that 5G will empower. Some are trialing particular use cases while others are still in the planning stages. The table below provides a sample of use cases that major mobile operators are actively trialing, either in labs or with actual customers. .

Operator	5G Trial
Drive productivity	Video streaming/video conferencing with upload/download speeds ~1 Gbps
China Mobile	VR broadcasting on a 5G network slice, with real-time color tuning, rendering optimization, and compression encoding to achieve 4K broadcasting with ultra-low latency
Deutsche Telekom (Germany)	Trialing 5G at the port of Hamburg, Germany for use cases of traffic control data, traffic light steering, and environmental monitoring
KDDI (Japan)	Field experiment using 5G to remotely control construction machinery, combining 5G with an existing remote control system
Orange (France)	Test of Samsung's Connectivity Node installed on a streetlamp with temperature and humidity sensors and security cameras, connected wirelessly between node and the core network via 5G
Verizon (U.S.)	Cloud gaming with ultra-low latency for auto racing game streamed on a 5G Android phone and to a TV display using a 5G network

Source: GlobalData.

5G as the Key Enabler of Operators Becoming Digital Service Providers



From the above list, it is apparent that operators expect 5G to deliver higher quality, faster speeds, wider coverage (indoors and out), and lower latency (down by 10x). This translates into better support for a host of transformative consumer and enterprise applications. For consumers, streaming video and interactive gaming will be earliest to emerge. 5G will also support the growing market for applications that use augmented and virtual reality (AR/VR) technologies.

In the enterprise, massive communications traffic is expected from sensors embedded in roads, railways, and vehicles. These devices are not only sending information to the cloud or to edge processing devices for analysis; they are sending data to each other. This capability for device-to-device (including vehicle-to-vehicle and vehicle-to-roadway) communications is key for many applications, including autonomous driving. 5G providers also aim to leverage speed, reliability, and low latency to control critical services and infrastructure for public safety, healthcare, government organizations, and utilities. Real-time video streaming, support for diverse IoT applications such as autonomous vehicles and advanced robotics in manufacturing are other anticipated use cases in the future.

The trials and demos provide a future view of digital applications that may provide telco operators and their solution partners with meaningful differentiation. From AR and VR-enhanced educational and healthcare tools, to smart city data and video collection and streaming, to ultra-HD broadcasting – 5G use cases really are different from those of the past and present.

However, in order to enable transformative new use cases, operators must embrace a fundamental re-architecture of cellular networks. The adoption of 5G is the key to operators' internal digital transformation required to provide advanced services to consumers and enterprises.

5G: Linchpin of Telco Operator Digital Transformation

CAPABILITIES	4G (IMT-Advanced)	5G (IMT-2020)I	MPROVEMENT
User Experienced data rate	10 MBit/second	100 MBit/second	10x
Peak data rate	10 GB/second	20 GB/second	20x
Spectrum efficiency	Measured in bit/second/HZ	Three times higher than 4G	3x
Mobility	350 kilometers/hour	500 kilometers/hour	1.4x
Latency	310 milliseconds	1 millisecond	10x
Connection density	100,000 devices per square kilometer	100,000,000 devices per square kilometer	10x
Network energy efficiency	Measure in bit/joule	100 times higher than 4G	100x
Area traffic capacity	0.1 Mbit/second/square meter	10 Mbit/second/square meter	100x

Source: GlobalData 5G Thematic Research (July 2018).

Despite the various performance and capacity improvements promised above, the most basic answer to the question "why 5G" so far has had very little to do with transformative new digital services enabled by 5G, and much more to do with delivering mobile broadband, at faster data speeds and lower cost per bit. This is the main driver for the current flavor of deployments in Korea in midband 3.5 GHz spectrum, and will be the primary reason for widescale deployments by U.S. operators such as AT&T and T-Mobile in the low bands (700 MHz and 600 MHz bands respectively).

This approach necessarily limits the functionality of 5G and relegates it to "LTE on steroids" – offering operators the ability to keep pace more effectively with steadily increasing demand, especially for streaming video traffic. However, these initial deployments, while casting a broad 5G net in some markets, does not bring the capabilities required to drive meaningful digital transformation to operators or their customers.

The key features that will drive true 5G innovation include ultra-low latency and ultra-high reliability. Low latency is crucial for many transformative 5G use cases: industrial automation and the use of 5G-powered robotics will require near-instantaneous communications; ditto for mission-critical applications such as remote surgery and autonomous driving. Low latency will also be required for many consumer use cases such as mobile gaming.

Some use cases within mobile broadband and IoT services require high reliability, such as emergency communications (e.g., first-responder communications) or sensitive IoT applications (e.g., remote surgery). Operators look to 5G not only to provide this enhanced reliability, but to do so while leveraging, as much as possible, the same network they use to provide consumer mobile broadband and other services. This multi-purposing of network resources poses the potential to grow revenue using shared network resources – thus growing operator profits.

New Technology, New Challenges

While 5G carries great potential for operators, the latency and reliability required to support these new use cases require the adoption of a host of new concepts that are currently unfamiliar to operators:

Network Slicing

Network slicing is the process of creating and managing virtual network slices which reside on the physical network, encompassing radio, core and transport elements. The 5G core access and mobility function (AMF) adds a network slice selection function (NSSF) and all network functions must also have a 'slice identifier.' 5G end-to-end slice orchestration is an extension of ETSI's existing NFV management and network orchestration (MANO) architectural framework.

Although network slicing technology (e.g., the ability to logically divide network resources into sub-networks with different characteristics to meet different service needs) is largely implemented by core platforms, it must also be supported by the radio and transport layers, so that networks can deliver, for example, high speeds and low-latency to the use cases that need it rather than deliver a common set of characteristics to all of them.

Multi-Access Edge Computing

To address low-latency 5G use cases, operators must distribute functionality to the edge of the network, reducing the span between it and end users. Most network gear vendors and many telco operators are eyeing multi-access edge computing (previously labeled mobile edge computing, and still called MEC) for distributed processing of real-time applications that can shift dynamically among locations as needed. For VR/AR in particular, MEC can theoretically help address insufficient processing power on devices and battery life by shifting the computational work needed to deliver virtual experiences to the network edge. However, operator uncertainties around MEC deployment strategies have hampered its progress thus far.

Service-based Architecture

The 5G core network (5GC) supports 5G access networks with session management, mobility, authentication, and security. 3GPP has specified that the new 5GC architecture must evolve from the traditional point-to-point architecture to a 'services-based' architecture offering more flexibility and thus 'service agility.' Meanwhile, the 5GC architecture must also support existing core network functions and interfaces through what will likely be a long period of simultaneous legacy and 5G core support.

The SBA includes numerous evolutions of existing core network functionality, including the access and mobility management function (AMF), session management function (SMF), policy control function (PCF), and unified data management (UDM). A new NF repository function (NRF) maintains profiles of all existing network functions and services to facilitate new network function 'discovery.' This is a key 5GC SBA flexibility point enabling functions to be added without the overhead of point-to-point architecture design and specification.

However, telco operators are struggling with optimal strategies for moving to an SBA-based 5G core while simultaneously supporting legacy networking technologies.

Control-user Plane Separation (CUPS)

CUPS splits the core network's control and user planes to enable clear functional separation and independent resource scaling. The new SBA decouples the core from access networks. It also enables core network functionality nearer the network edge to meet stringent 5G latency requirements.

CUPS is already being introduced into 4G enhanced packet core (EPC) networks, providing the basis of a smooth migration path from 4G to 5G core networks.

Open Source and Cloud-native

While not a direct consequence of 5G requirements, the service agility targeted by the 5G core demands a new breed of open source, 'cloud-native' virtual network functions (VNFs). At a minimum, cloud-native VNFs provide clear separation between application logic and application data, are microservices-based, provide smaller functional and reusable logic components, and are capable of easy onboarding and orchestration within the 5G core.

5G Brings New Complexity and Management Headaches

As shown above, 5G introduces a host of new innovations designed to drive digital transformation goals. However, it also brings a host of new challenges. A few of the key challenges are outlined below:

Undefined Use Cases and Business Models for Network Slicing

As a concept for running diverse logical networks over a common physical infrastructure, network slicing has been linked closely to 5G network transformation objectives as well as 5G's aspirations of servicing the needs of consumers alongside a myriad of industries. As it gets put into practice, however, a number of questions around slicing remain unresolved:

Granularity. How specific will slices be in meeting the demands of many different audiences? Will a small set of templates be offered up, or will slices be built on a custom basis as requested by customers?

Network Diversity. End-to-end slicing includes many different networks and service components including RAN, transport, core, and diverse radio network elements. Will true 'end-to-end' slicing work in commercial deployments?

Openness. The larger slicing vision includes the ability for enterprises to order slices and have them provisioned, potentially transparently to the service provider. What should the best role of the telco operator be?

SLA Support. Can telco operators truly guarantee service levels with the degree of confidence required to offer SLAs to enterprise customers? If so, how can these operators ensure they are charging for the value of the slice provide within the context of the use case and not be relegated to the dreaded "dumb pipe" role?

Any telco operator looking to execute on the promise of network slicing will not only need to build out the requisite network capabilities, but also a new set of business relationships and policies around "service-by-the-slice."

Small Cell Deployment Velocity

Small cells are commonly deployed to meet ongoing needs to increase network capacity and coverage in a more precise and less costly way than traditional base stations (i.e., macrocells) can. Densification will become even more important to deliver faster, more diverse 5G services – both outdoors and indoors.

The Small Cell Forum predicts 5G small cell deployments will exceed 4G small cells in 2024.
As shown in the table below, small cells will also be crucial to enabling a variety of digital use cases requiring low latency and robust indoor coverage.

Industry Vertical	Applications	Latency Requirements
Industrial Automation	Motion Control Industrial Ethernet Control-to-Control Communication Process Automation	Sub-1 ms one way delay in control applications
Healthcare	Remote Diagnosis Emergency Response Remote Surgery	10 ms maximum round trip delay to support haptic feedback
Entertainment	Immersive Entertainment Online Gaming	7 ms round trip delay to support VR/AR
Transport	Driver Assistance Applications Enhanced Safety Autonomous Driving Traffic Management	10 ms one way delay for cooperative driving applications
Energy	Smart Energy Smart Grid	As low as 5ms for high voltage electricity distribution

Sources: GlobalData; "New Services & Applications With 5G Ultra-Reliable Low Latency Communications," 5G Americas (November 2018); "Business Case and Technology Analysis for 5G Low Latency Applications," IEEE Xplore (April 2017).

Operators are likely to look to use small cells to support both communication and IoT services in 5G networks, and small cell deployments will be required to enable many network slicing scenarios, particularly in indoor settings. The Small Cell Forum identifies six areas where small cells will be vital in 5G:

>6GHz spectrum, where propagation limits cell sizes;

Radios using shared and license-exempt spectrum, which generally mandates lower power;

Areas of hyperdense traffic demand in cities, stadiums, transport hubs etc.;

Scalable, low-cost deployment using unskilled third parties or end users;

Small/medium enterprises requiring self-deployed indoor coverage; and

Coverage extension in rural, remote, moving, and temporary deployments.

Small cell vendors are promoting 5G upgrades to distributed enterprise solutions and are increasing their roster of multi-operator solutions that will help ease enterprise concerns about having to install individual radios for each operator in the market.

That said, telco operators face numerous regulatory challenges as they look to massively scale up their investments in small cells posted on the sides of city buildings, as well as on "street furniture" such as utility poles, street lights, bus stops, etc. While in some markets such as China, regulatory issues are fairly easily dispensed with, but in many markets, notably in North America and Western Europe, telco operators must obtain a dizzying number of approvals related to site acquisitions, RF and environmental compliance, power supply, and zoning.

In addition to the regulatory challenges, telco operators must determine the optimal pipe for reaching these sites. All things being equal, fiber is generally the best solution if it is available, but that is a big "if" in many small cell scenarios. As microwave technology continues to evolve, it becomes increasingly feasible to deliver the capacity and latency required for 5G services without requiring the expense of extending fiber.

Given the significant civil and technical challenges, and the massive scale of small cell buildouts to support 5G services, operators currently lack a "programmatic" approach to small cell buildouts that can address common complexities across a roster of small cells rather than having to deal with these challenges on a "one-by-one" approach that has characterized traditional macrocell buildouts.

5G Energy Consumption Concerns

One of 5G's original justifications was its ability to deliver mobile broadband more efficiently than previous generations on an apples-to-apples basis. However, while that may be true, it only tells part of the story. As the rubber is finally beginning to meet the road on 5G after several years of hype, telco operators are increasingly concerned that 5G networks may actually require significantly more power than previous technology iterations. That's due to a number of factors, including:

Two to three times more base stations required compared to 4G/LTE due to deployments in relatively short-range mmWave spectrum

Massive increases in processing power requirements per cell site

An exponential increase in number of antennas with massive MIMO

Telco equipment vendors are addressing the power challenge through a number of routes, including a new focus on improving efficiency of their new 5G radio portfolios; looking to identify alternative energy sources such as solar to power some 5G equipment; and implementing "energy-as-a-service" solutions that can help operators identify and implement systemic changes that can help ensure that 5G deployments can scale in a cost-effective way.

Still, those solutions remain largely nascent, and until 5G deployments begin to really scale, the actual effects on energy consumption will remain a primary concern for operators.

5G Network Operations: No Owner's Manual

The introduction of 5G ushers in a new level of complexity for telco operators in terms of how to manage and optimize their network operations. In the emerging "zero touch" environment, services will need to be activated and orchestrated automatically through robust network slicing management and dynamic service orchestration. Advanced policy management and proactive assurance services will need to be brought to bear. Robust billing and active API management will need to be applied to allow third-party developers to take advantage of new network slicing capabilities. Closed-loop automation will be required in order to continuously assess network quality and make appropriate adjustments to ensure that capacity and performance requirements are being met and that network security is locked down.

In addition to the continuous monitoring, network operators will require robust network design and optimization solutions to minimize operating expenses in a dramatically more environment than ever before:

As noted earlier, power consumption requirements are likely to increase compared to LTE for a number of reasons. Network optimization will need to account for a far greater number of network parameters and design factors.

With previous network generations, network design has focused primarily on optimizing radio resources. By contrast, with 5G, networks will need to be designed to ensure sufficient data capacity throughout various radio, core, and transport elements.

Rather than focus to ensure sufficient bandwidth capacity, 5G networks must be designed and optimized for resilience; i.e., to be able to accommodate multiple network slices, dynamically, as efficiently as possible.

Traditional network KPIs that have historically defined network quality will still be relevant in 5G. However, operators will also need to ensure adherence to specific SLAs as defined by use cases and customer agreements, many of which will be mission-critical. As a result, networks must be designed and optimized in a way that ties directly into exacting customer requirements, with greater repercussions in the event of a network failure or outage.

Increasing Webscale Competition

Finally, the emerging 5G era is likely to shift the competitive landscape significantly as webscale, cloud-native operators increasingly compete against operators for an increasing slice of the value chain. That's because the move to cloud-native architectures plays directly into the hands of the "big 3" public cloud providers -- Amazon, Microsoft, and Google. These companes and a handful of other webscales are already competing to claim a greater share of the IoT value chain, and are also sharpening their value proposition at the network edge.

In order to continue to thrive, telco operators will need to make intelligent strategic and tactical decisions on 1) how to prepare internally to better compete with the webscales; and 2) when and how to partner smartly with webscales in order to ensure that telcos can continue to monetize their investments in 5G infrastructure.

Recommendations for Telco Operators

5G and Digital Transformation Are Not Optional

Regardless of type, size, or region, telco operators are all embarked on the digital transformation journey. While some operators are moving more quickly than others, all realize that their ability to thrive depends on moving to software-defined, and eventually, fully cloud-native environments characterized by open platforms, agility, and flexibility. Today operators are boosting investment and accelerating adoption of DevOps-enabled agile software development, automation, and advanced analytics to accelerate their digital transformation plans. This enables end-to-end orchestration and control over hybrid physical and virtual network environments, including cloud, SDN/NFV, and microservices capabilities. Internal digital transformation augments the overall operator push to achieve agility in both their business processes and network operations, but ultimately 5G networks will be a crucial piece of the puzzle to enable a host of new services externally in both the consumer and enterprise markets.

Success is Not Guaranteed

Recent history shows that telco operator attempts to execute digital transformation only across parts of the organization or in a piecemeal fashion have fared poorly. Without a comprehensive strategy, digital transformation becomes exceedingly difficult if not impossible. Meanwhile, telco operators are grappling with the challenge of overcoming cultural resistance to digital transformation. This includes convincing employees to embrace digital transformation without fearing for their jobs as well as enabling collaboration across existing organizational silos. The executive suite, including CEOs, CFOs, CIOs, CTOs, and CMOs, must develop and coordinate their digital transformation plans to ensure organization-wide acceptance.

5G: Increased Performance Drives Increased Complexity

While 5G offers operators a new set of tools to enable digital services to enterprises, it also introduces a new level of complexity into network operations. This is exacerbated by the fact that most operators will continue to operate 4G/LTE networks alongside 5G. In order to accomplish this, these operators will require robust hybrid operations management, including end-to-end service orchestration across physical and virtual network environments and across multiple access technologies. For lack of a better term, success or failure in the coming 5G "complexity management" will determine which operators thrive and which operators struggle during a prolonged period of hybrid network operations.

Small Cells, Big Challenges

Small cells are an important part of the 5G story. In outdoor settings, small cells will be vital to drive network performance in urban areas, leveraging new >6 GHz spectrum bands. Indoors, small cells will help enable of many of the transformative 5G use cases that will emerge in vertical markets such as healthcare and manufacturing and will be an important factor in the success of 5G IoT. However, the coming exponential increase in small cells will create new challenges in network design, deployment, and management. These challenges can only be addressed by a programmatic approach to deployment that addresses both technical and regulatory challenges, and a comprehensive network management platform that can rely on automation and orchestration to enable 24/7 network monitoring and make dynamic adjustments to ensure network quality and capacity.

Early Network Slicing Wins Pave the Way for Long-term Success

Regardless of the pace, 5G is the ultimate destination for all operators over the next ten years. With that in mind, it is crucial to identify use cases that can take advantage of 5G's new capabilities. Trials and demos thus far have showcased 5G's grand potential in complex future use cases. Those are, of course, important but there are likely less complex cases to take "baby steps" into network slicing. Ironically, for all the focus on network slicing in the enterprise, some of the earliest use cases for network slicing may lie in the consumer segment, including AR/VR in stadiums and mobile gaming applications. To build and monetize more complex, enterprise network slicing, operators may need to focus on building partnerships with vendors with deeper relationships and subject matter expertise in select verticals.

Partners Required

5G is not just a wireless network technology, but a key enabler for various vertical-specific solutions. 5G applications need to be developed and tailored for an industry or even for an enterprise's needs. Professional services play a very important role in ensuring successful implementation of 5G, both internally for telco operators, and in helping those operators tap enterprise opportunities. Business needs and challenges vary across verticals and geographical areas. Service providers need to understand the main concerns and objectives of enterprises as well as the local regulation. As network and IT are converging, integration will be important as well. Service management is equally important, especially in ensuring business outcomes. While the telco operators are the main drivers for 5G today, not all of them are equipped with professional services capabilities. Partnering with 5G providers with a strong consultative approach and service capabilities will mean a better chance for successful deployments.

Overview of Infosys

Enterprises and consumers are demanding usage based service models that are real-time, elastic and with low latency. The future of network innovation powered by 5G is poised to cater to these evolving requirements.

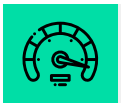
5G will transform network capabilities bringing in significant opportunities for network virtualization, AI, and automation, while lowering associated costs considerably, and enhancing delivery of network based services, IT systems, and applications. Ubiquitous and immersive solutions will be enabled through 5G using technologies such as edge computing and network slicing. More importantly, 5G will enable enterprises – IT and lines of business – to usher in a new era of innovation, create new experiences and services while improving operational efficiency in organizations.

These new use cases / solutions enabled by 5G provides communication service providers an opportunity to tap in to new avenues of monetization of their network infrastructure through innovative services. The network architecture of 5G powered by SDN and NFV provides an opportunity to significantly reduce the operations cost in addition to revenue generation opportunities.

Infosys and its global network of 5G Living Labs, and its rich ecosystem of partners, tech providers, and startups will help organizations learn through rapid experimentation and curating innovation ideas. It brings together Infosys' innovation capabilities across IoT, Healthcare, Utilities, Mining, Media, Immersive Experiences, and Connected Communities, to enable enterprises develop new use cases and solutions.

Positioning & Offerings

Infosys is positioned as a digital ecosystem integrator for bringing-in the various 5G core elements together. Infosys has developed technology tools and accelerators that can fast-track the 5G adoption journey for enterprises and communications service providers (CSP). The service offerings will help enterprises imagine and create new economies with 5G technology, while simultaneously helping communication service providers accelerate and monetize their 5G network deployment:

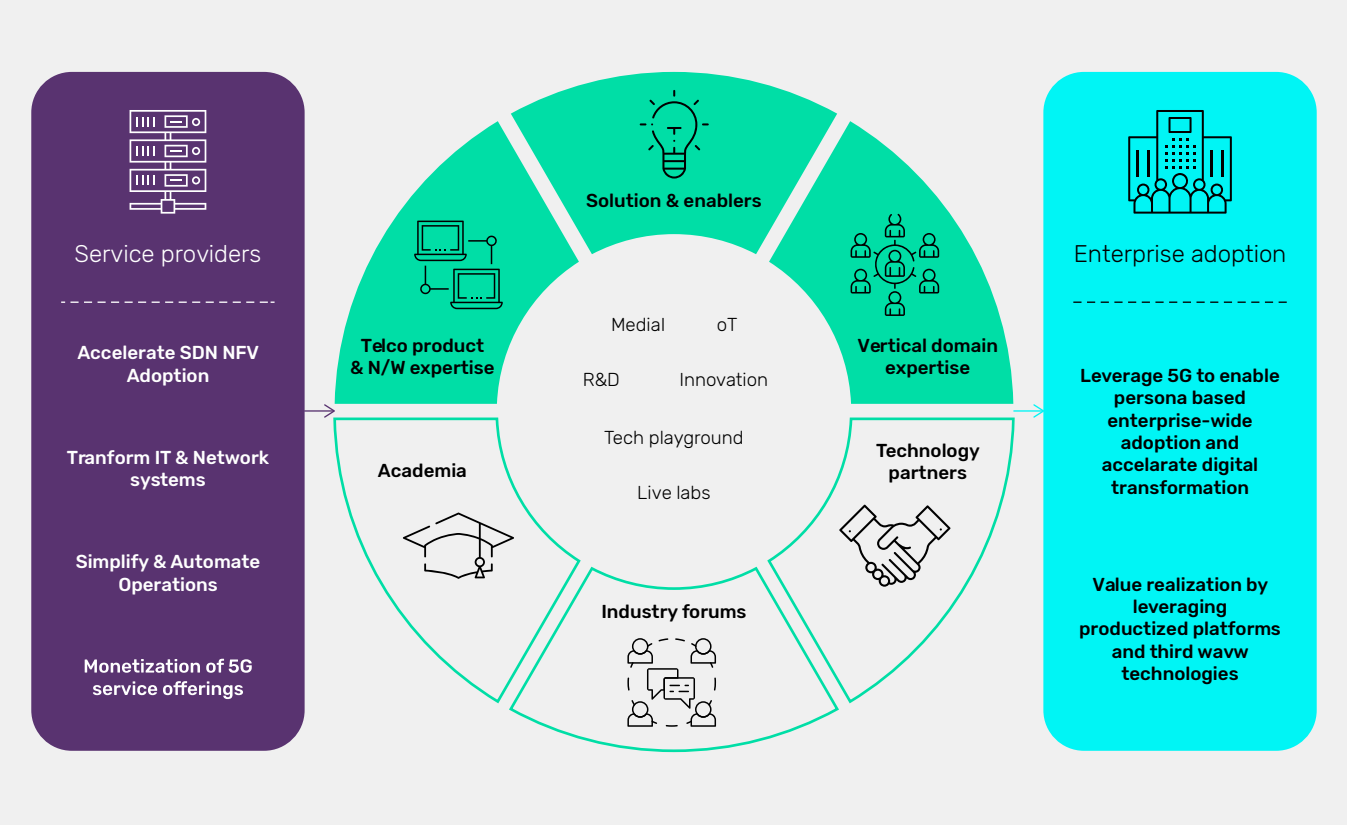


Accelerate 5G adoption

Transform OSS/BSS with service orchestration

Simplify and sutomate operations

Monetization of 5G use cases and capabilities



Differentiation

While 5G technology brings exciting opportunities to the table, it requires heavy CAPEX investments like any other new technology. Accelerated deployments to get the technology generate revenues quickly is essential for justifying such investments. A strong end to end system integrator with expertise across the technology stack along with deep knowledge of the evolution history of the wireless networks along with complementing technologies like SDN/NFV is essential to help service providers for such accelerated deployments. Infosys is well positioned to partner with service providers in the 5G deployment journey by bringing the following differentiation.

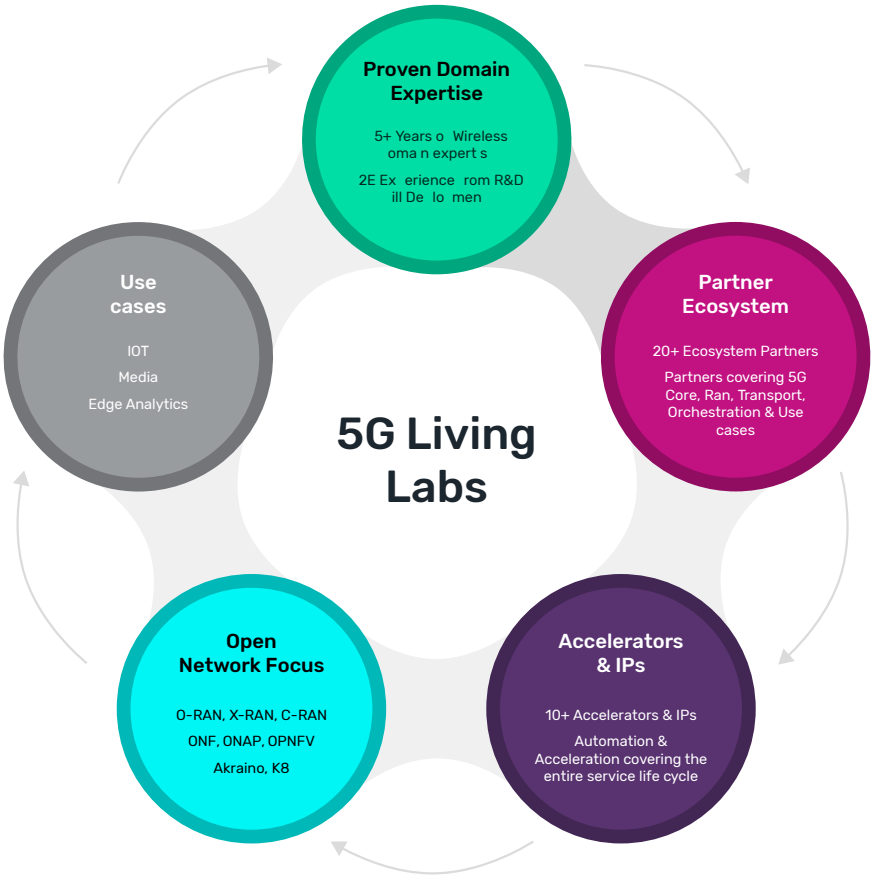
Infosys is helping CSPs by building new business models: Recent advances in 5G cellular relays have resulted in antennas that can be installed closer to customer premises to ensure that transmission of 5G is seamless, which in turn increases the cost of 5G. Telcos might be banking on the coming rollout of 5G, but most won't be able to afford it. Because 5G and complementary technologies will change the DNA of the user experience, internet giants like Google, Amazon, Apple, and Facebook are best positioned to win the race to users' hearts. Unless telcos reinvent themselves beyond their traditional roots as telecommunications carriers, they may not survive the onslaught as 5G is rolled out. In the short term, if 5G is all it's cracked up to be, most telco businesses will survive 5G by radically changing their business models. Infosys, through its partner ecosystem is best placed to help the CSPs in their 5G enablement by building new business models

Accelerating 5G Deployment and Operations: Infosys works with partners in developing, planning, and monitoring solutions for 5G RF deployment. Infosys is building solution accelerators to be a significant partner to the CSPs 5G journey:

"Proactive, Predictive, & Automated" Operations: Offer Predictive Operation leveraging Infosys Smart Network Assurance (ISNA) Platform based on AI/ML

"Be the Red Hat" of Open Source: Be a strategic partner for Open Source – e.g., MANO, ONF, ONOS + Solicon & White label hardware partners and accelerate adoption of SDN / NFV platforms

"Partner of Choice" for Accelerated Integration: Use the scaling concepts – "Network Design Factory" and "High Performance Software Engineering" programs



Infosys 5G Living Labs are tech playgrounds where partner products, solutions, Infosys IPs / accelerators, and domain experts come together to provide and ecosystem for service providers and enterprises to incubate and launch new services.

How Infosys Can Help CSPs

Infosys is well positioned to be the system integration partner for accelerated risk free 5G network deployment journey for CSPs. Infosys can help in the following areas.

Areas of Collaboration	Values & Best Practices Infosys Can Bring
5G Core - Building a new 5G core using 5G VNFs and integrating with existing and new RAN	• Expertise in wireless network evolution for 25+ years including virtualized EPC & 5G core VNFs • Strong system integration capabilities and proven experience in executing complex wireless network deployments • Expertise in APIs exposed by the VNFs, expertise in user plane, signalling plane and integrating between multiple vendors, testing of the core, subscriber migration/cutover • Bring OEM partners for different network slices with unique differentiated capabilities
Backhaul & Transport upgrade for supporting 5G	• Very strong credentials on the entire plan, design, & construct and automation based on similar transformation in other service provider engagements
5G RAN – Moving to cloud & New Radio deployments	• Partnership with RF planning vendor • New ways of doing RF design solution • Telco cloud expertise
5G Core Lab Trials	• Lab partner for a large ANZ operator's Mobile Innovation Lab/Automation • Partnering with multiple Tier 2 vendors for potential 5G trials
NFVI, MANO integration & Container as a Service (CaaS) Platform Integration for 5G Core	• Very strong capabilities in vertical NFVI build on products of the likes of Ericson/Huawei • Homegrown on-boarding automation solution • Build & integration of CaaS platforms
5G Slice Management & Closed Loop Assurance	• Infosys solutions built for slice management (demo ready) • IP for AI/ML based closed loop assurance

Early Success Stories

Virtualization of EPC & Transforming to a Cloud Native Solution

Infosys helped a leading OEM in North America to virtualize its evolved packet core (EPC). This project was first of its kind in the industry and demonstrated to the world that virtualization in the wireless core network are is possible. Infosys was involved end to end, right from ideation of the concept to trials with leading service providers to deployment and support of the virtual EPC.

4G Deployment in a Multi-vendor Network

Infosys helped a service provider in ANZ to deploy the 4G core network with complete ownership of the deployment with different vendor equipment. Infosys owned the complete testing of the vendor equipment, interoperability and end to end solution tests before deployment.

Mobile Lab Management and Testing

Infosys is helping a large service provider in managing its mobile lab with network equipment from different vendors. Infosys is responsible for the end to end testing of the lab network and availability of the lab systems. Infosys is currently helping in testing 5G network services in this lab.

Head-end Virtualization for a Service Provider

Infosys helped a leading MSO in virtualizing its cable modem termination system (CMTS). Infosys owned the platform on which the CMTS workloads was executed. The entire solution was built over open source networking components and the new development was upstream contributed.

Immersive Media Entertainment for a Leading Tennis Brand

Infosys built a solution for immersive viewing of sports events from anywhere in the world, a potential use case for 5G eMBB network. This use case was incubated in the Living Labs and piloted in the Grand Slam tennis event in Australia.

5G Lab Trials (work yet to commence):

Infosys along with OEM partners for the core network is under discussion with a large service provider for 5G trials in July 2019. Infosys can bring in experiences of early lab trials with service providers and partners.

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