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5G FUTURE: TARGETING THE ENTERPRISE

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The big picture

Figuring out how to tap the enterprise market will be critical to communications service providers' (CSPs') 5G success, but they must act fast as large companies in many industry verticals are considering whether to deploy their own private 5G networks. To give customers what they want, CSPs must collaborate with third-party providers to deliver automated, ultra-low latency services and customized performance backed by service level guarantees. If they can manage this, mobile operators may find the enterprise market to be a vast multiverse of opportunity with endless demand.

This report assesses the relationship between CSPs and enterprises and highlights the verticals operators believe are most promising. It focuses on three important capabilities enabled by 5G networks that CSPs can use to deliver differentiated services to their customers and help them develop innovative applications:

Co-creation of innovative services – although methodologies may differ, co-creation in telecom is formal collaboration between CSPs and a mix of vendors, enterprise customers, leading innovators across industry verticals and academia, third-party developers, and even competitors to create infrastructure, digital services, applications and business agreements for delivering and monetizing them.

Network slicing – CSPs plan to use network slicing to create differentiated, use case-specific logical networks over shared physical infrastructure made elastic and programmable through network functions virtualization and software-defined networking. Each logical network is created in software based on the specified service level requirements of users.

Multi-access edge computing (MEC) – sometimes called mobile edge computing, MEC shifts centralized compute and storage resources and some applications to distributed cloud locations closer to users who require low latency and other high-performance service characteristics. MEC provides better performance while also lowering network congestion by processing traffic at the edge of the network and not sending it across the network.

Who are the *Future networks* survey respondents?

CSPs

59 respondents from 21 unique companies operating in 24 countries

54% converged operatorsft

29% mobile operatorsft

17% wholesale/managed service providersft

Suppliers

55 respondents from 51 unique companies

18% network functionsft

38% OSS/BSS softwareft

34% consultant or integratorft

10% cloud solutionsft

TM Forum, 2019ft

CSPs surveyed for this report believe these capabilities will be game changers if implemented and managed properly. But they are not pie-eyed about them: They know it will be difficult to meet the needs of vertical markets without partnering.

We analyzed data from two surveys for this report – one conducted over the summer about 5G networks and another shorter poll conducted at Digital Transformation World 2019. Overall, we surveyed 59 CSP and 55 supplier respondents and conducted many follow-up interviews. The CSPs represented are primarily Tier 1 and Tier 2 operators delivering converged services, along with some pure-play wireless providers and managed services providers. CSP respondents included C-level executives and vice presidents with responsibility for product development, along with senior engineers and network architects.

In addition, the report draws on data from a survey about future business models, which was analyzed in-depth in a companion report to this one called *5G future: Business models for monetization*, and another survey conducted as part of TM Forum's annual CXO Summit, which was held in May at Digital Transformation World.

Read these reports to learn more about how CSPs view the future of 5G:

Read this report to understand:

- The complex relationship between CSPs and enterprises
- Which verticals CSPs expect to target with 5G services
- When operators expect to be able to leverage co-creation, network slicing and MEC
- The benefits these capabilities will deliver
- The obstacles to delivering these capabilities
- How CSPs and their suppliers are proving the concepts

Section 1

Assessing the enterprise relationship and opportunity

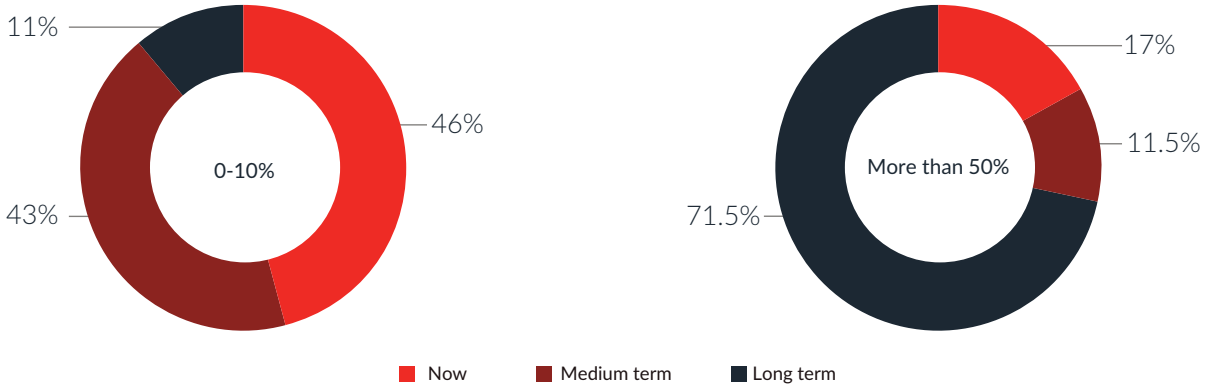
When asked what their companies should aspire to become, about half the communications service providers (CSPs) we survey consistently respond that they should aim to be either platform enablers or platform providers. Indeed, a third of CSP respondents in our recent Future business models survey said they believe their companies should become full digital service providers offering a range of end-to-end services, sometimes in competition with major cloud providers such as Amazon Web Services (AWS) and Microsoft. This is a hugely ambitious goal that requires CSPs to move well beyond the connectivity services upon which they have built their businesses. It requires far greater flexibility, a more innovative spirit and being sufficiently open to collaboration in order to deliver the diversity of services required in enterprise vertical markets.

CSPs must consider, sometimes in individual cases, whether they can accept sharing ownership in partner relationships, can take a back seat or supporting role in others, and whether they have the capacity and desire to manage customer and partner relationships. This responsibility includes service assurance, multi-party compensation, product support and more.

Most CSPs are becoming comfortable partnering with other technology companies. Partnering with customers is less familiar territory, but operators seem confident they can do it. In a poll conducted at Digital Transformation World in May, more than 30% of CSP respondents said they believe they will own the customer relationships of the future. Less than 20% said they won't, while about half said customer ownership will vary by service and industry, which indeed is most likely.

Either way, the opportunity to seize the 5G enterprise market, with its unlimited potential for specialized solutions, is one CSPs cannot afford to miss. Nor do they expect to. Results from a separate TM Forum survey conducted late in 2018 show CSPs' lofty goals for B2B services. Nearly three quarters of respondents said they expect to be generating more than half their revenue from B2B services in the long term.

CSP revenue from B2B services



TM Forum, 2019

Early 5G consumer pricing shifts the spotlight to enterprises

Targeting enterprises with 5G services could become even more important if CSPs are unable to charge a premium for consumer services.

Even though 5G service should command a premium, early consumer pricing appears to indicate that mobile operators may not enjoy the revenue boost that typically results from deployment of next-generation technology. In the UK, for example, early 5G adopters such as BT's EE and others had hoped to sustain a premium for 5G consumer services, but Vodafone threw a wrench into the plan by launching 5G without a premium, forcing others to follow suit. In addition, Vodafone introduced a pricing model that moves consumers away from consumption-based price plans to plans based on speed –in other words, quality of service (QoS).

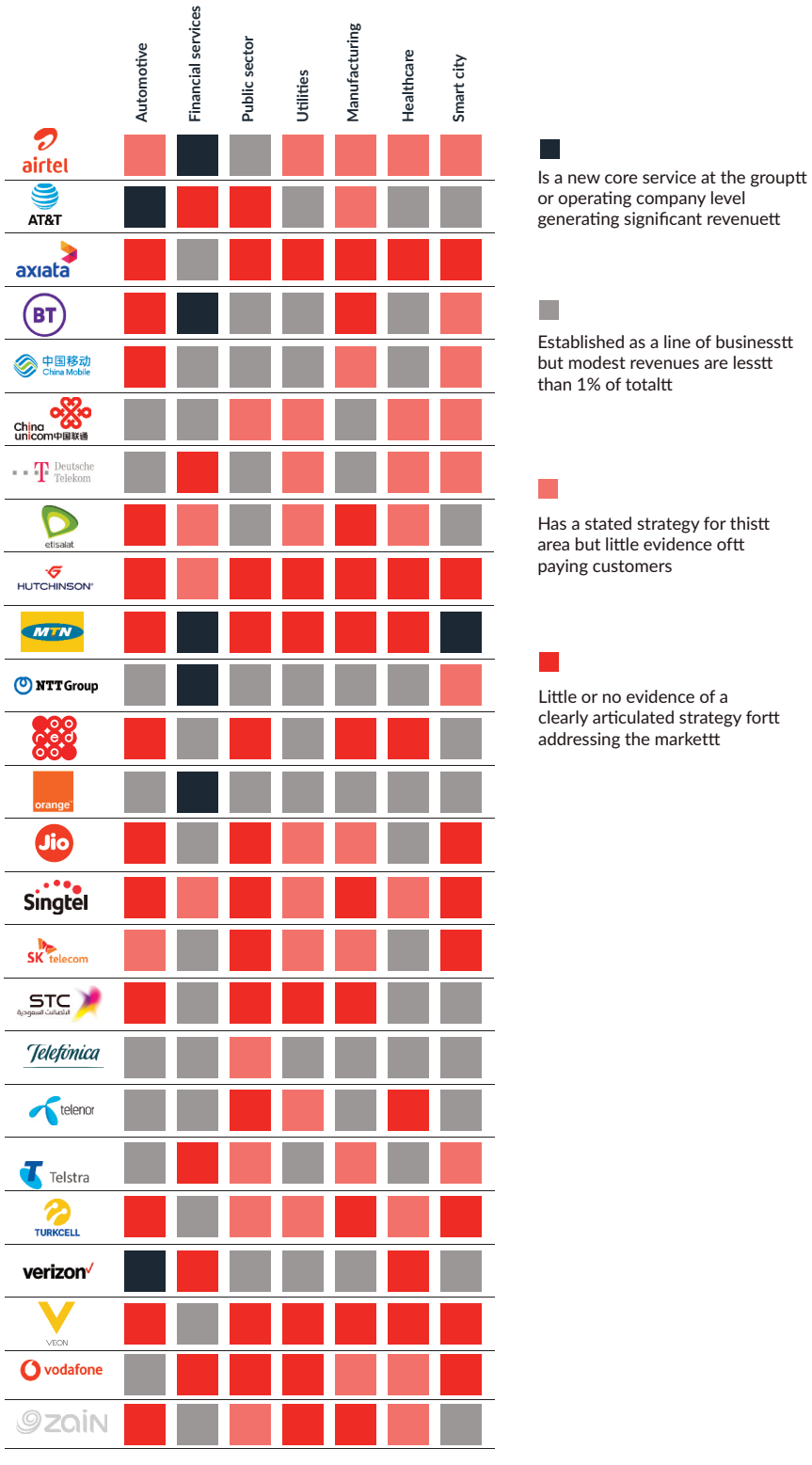
"Foregoing a 5G premium in favor of unlimited plans based on speed is more than a way to nullify first-mover advantage and adversely affect the revenue stream for competitors," TM Forum CEO Nik Willetts noted in a blog about 5G pricing. "Intended or not, if successful, the change may force CSPs to compete in a whole new way in a market that most are not yet ready to serve."

However, the reality is that most enterprises aren't ready either, and in some cases they have realized that 5G may not even be necessary for the applications they are most interested in. For example, LTE is sufficient for many IoT use cases.

Vertical leap

To identify which verticals CSPs view as most promising, we analyzed the business strategies of the world's top 25 telcos using publicly available financial results and presentations to investors. The graphic below shows whether CSPs have a strategy targeting specific verticals (detailed analysis begins on page 7).

Which verticals are CSPs targeting?



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Automotive

The automotive and fleet sector is primarily a B2B opportunity for CSPs, although operators in some countries have developed a modest business selling in-car connectivity directly to consumers. In the enterprise market, connected vehicles have been an early focus for operators with internet of things (IoT) strategies. Vodafone and AT&T, for example, are offering automotive companies global connectivity through a patchwork of global roaming agreements, while Verizon has taken the approach of acquiring specialty companies to become one of the world's largest telematics service providers. Interestingly, BT recently exited the telematics business, selling BT Fleet Solutions to private equity group Aurelius Equity in August 2019.

While there has been much discussion about the role of 5G in connected and self-driving vehicles, it's not likely that 5G connectivity will be used to 'control' them. Prototypes of autonomous vehicles rely on radar to control speed, and there is no suggestion that this will change with 5G. However, autonomous vehicles will require continuous mapping capability which will rely on connectivity through mobile networks. Furthermore, 5G is emerging as the preferred connectivity technology for vehicle-to-vehicle communications.

Financial services

Banking services are one of the most promising opportunities for CSPs to diversify, but this is primarily a consumer-focused market opportunity to deliver mobile payments, mobile wallets and digital commerce, which includes carrier billing. Safaricom and Orange have been particularly successful at delivering payment services in Africa, while Japan's DoCoMo and South Korea's SK Telecom are leaders in carrier billing. BT has expanded into the B2B banking and financial services sector with a dedicated subsidiary called BT Radianz, which operates a neutral platform for financial trading applications. (For more about this vertical, see the companion report *5G future: Business models for monetization.*)

Public sector

This vertical targeting governmental organizations covers a broad range of applications and use cases, and there is overlap with transportation, utilities and smart cities. Many of the operator groups we have assessed include former state-owned telcos that have a strong record in delivering telecoms services to the public sector. It has been less of a focus for challengers. Looking specifically at 5G, while there is a strong drive to digitize government, there has not been much focus on connectivity so far.

Utilities

Utility metering is a big driver globally for IoT. Many CSPs have large regional or national contracts for deploying smart meters, principally for electricity consumption. When it comes to 5G, the future evolution of the energy grid and its requirement for bi-directional energy flows presents huge opportunities for CSPs.

In a recent blog, Verizon Wireless notes there is "a much greater need to be able to manage the flow of electricity from distributed generation sources like rooftop solar panels and distributed storage sources like electric vehicles." The company makes the case for "near-instantaneous speed across millions of sensor points, greater connectivity and ultra-low latency…throughout the system."

Manufacturing

Mobile communications has played a limited role in manufacturing so far, but manufacturing processes often require guaranteed quality of service and millisecond latency, so there is much excitement around 5G. One of the key discussions now centers around whether large industrial groups will build their own 5G networks with unlicensed spectrum or buy network services from operators.

According to a recent report by Capgemini, which surveyed more than 800 executives from asset-intensive companies in 12 countries and 150 executives from 80 telecom companies operating in those countries, a third of manufacturers are considering applying for a 5G local license.

Report author Pierre Fortier, Principal Consultant, Capgemini Invent, notes that this is an opportunity for telcos:

> "The study found that manufacturers are willing to pay a premium charge for enhanced 5G connectivity. For example, 71% of industry companies will pay more for ten or a hundred times faster wireless connectivity. But when you ask the telco operators, only 55% of them think that there is appetite for this. This is an example of an opportunity for telcos to consider how to build a highly profitable 5G business model."

Healthcare

CSPs have long aspired to deliver digital and mobile health services, but the opportunity is more complex than it is with other verticals. From a B2B perspective operators can target huge government-owned health organizations, individual healthcare facilities, medical device manufacturers and individual practitioners. On the B2C side, the segment includes healthcare information and alerting services, devices and remote monitoring.

Our analysis shows a lot of activity in healthcare, but it is worth pointing out that the lines of business are many and varied. For example, Telstra Health and Orange Health provide a range of ICT solutions to healthcare providers, while other operators (particularly mobile-centric CSPs in emerging markets) are providing healthcare alerting and information services to consumers.

5G is forecast to have a big impact on connected healthcare, from remote surgery to connected devices and services that require high bandwidth, low latency and support for augmented and virtual reality.

Watch this video to learn about a TM Forum Catalyst proof of concept that is using network slicing to connect hospitals:

Smart city

In many respects the smart city vertical represents the amalgamation and integration of all the services provided to different verticals. It consistently ranks as the most attractive opportunity for CSPs in 5G, but the municipal budget available for smart city services is often modest.

CSPs are excited by the potential of smart cities because it offers the prospect of a massive increase in connectivity – principally for IoT. But deployments so far have been extremely limited. Connected streetlights and 'smart-bin' waste management solutions are use cases that have resulted in commercial deployments but neither generate a significant volume of traffic.

Indeed, it's possible that CSPs need smart cities more than smart cities need them. Unless CSPs can find a cheaper, quicker way of building out small cells, 5G deployments that significantly add capacity and indoor coverage will be limited. There is a case to be made for 5G operators working with municipal authorities to help lower the cost of passive urban infrastructure. Perhaps in return the CSPs can factor coverage requirements for city authorities into the roll out.

Vertical or vertigo?

Most CSPs are excited about the potential to target verticals with 5G services, but there is a dizzying array of challenges to address. For example, the CSP's role in a value chain for vertical market use cases remains unclear, and while use cases may be easy to identify, making the business case for them can be difficult.

As noted, 5G isn't necessary for most IoT use cases, at least in the short term, even though the linkage between IoT and 5G initially sparked the interest in vertical markets. Perhaps most importantly, there is uncertainty about how quickly CSPs will be able to take advantage of software-defined networking to facilitate the development of services for vertical markets. We'll look more closely at the challenges and how to address them in the next sections.

Section 2

What do enterprises want from 5G?

Communications service providers' (CSPs') success in co-creating innovative 5G services with enterprise customers and capitalizing on network slicing and multi-access edge computing (MEC) depends largely on what enterprises want to accomplish and whether they see CSPs as necessary to helping them achieve their goals.

The promised speed and reliability of 5G make it an attractive option for private mobile networks. Mobile operators hope that enterprises will turn to them not only to upgrade land mobile radio systems, but also 5G-based IoT networks. But some enterprises are exploring the possibility of building their own private 5G networks, which in theory would give them ownership of the core and radio network elements, although the spectrum would likely either be unlicensed or leased from an operator.

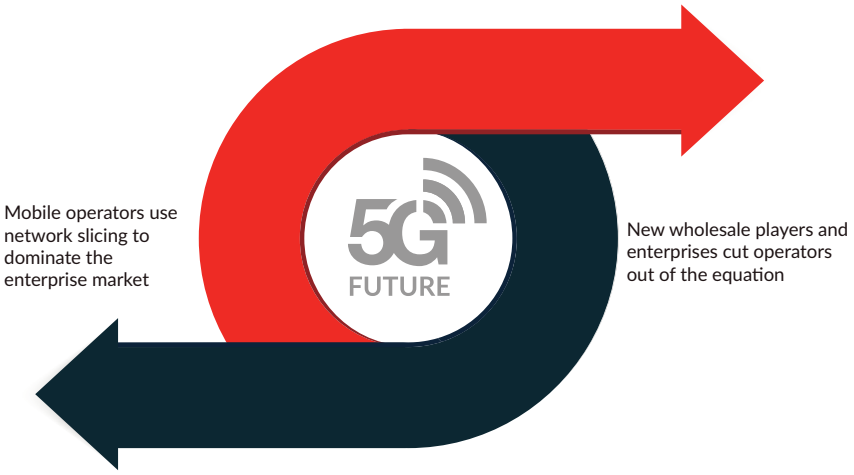
Private 5G

Private LTE networks exist today, but they are not common. Organizations that build such networks value the benefits of LTE over Wi-Fi in terms of security, configurability, upgradeability and compatibility. (This does not include enterprises that use a 'neutral host' model to improve indoor coverage, in which case the mobile network fully interconnects with the public network – see page 10 for more about neutral hosts).

The surge in interest in private 5G networks is coming from:

- Large enterprises that are attracted to the possibility of cutting out the middle man (the mobile operator) by buying directly from a technology vendor. In some cases, large network vendors are luring enterprises with attractive finance options. IoT is central to most of these use cases.
- CSPs that see private networks as an attractive opportunity to grow revenues. Network slicing is key to realizing this opportunity (see Section 4).

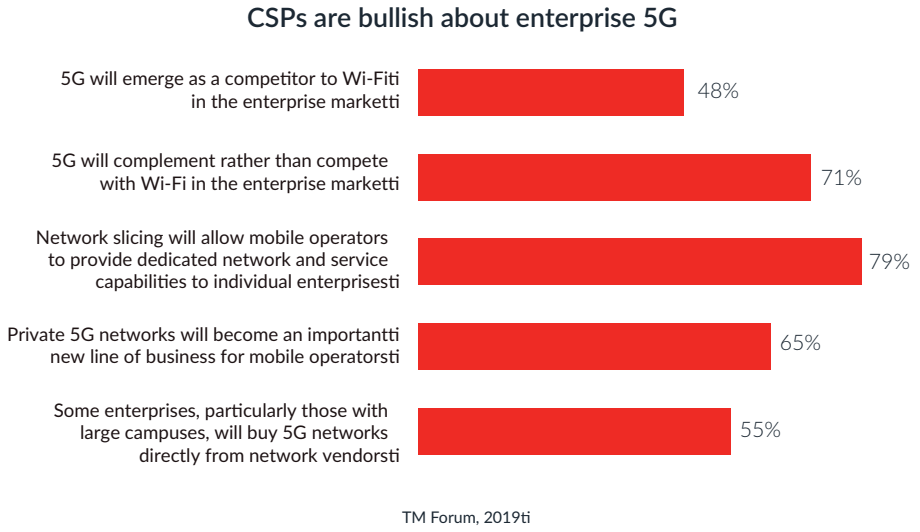
Which path to 5G for enterprises?



TM Forum, 2019

Any approach that bypasses the CSP is clearly a negative for the operator's business. However, it is not clear how many enterprises will want to undertake the management and operation of private 5G networks. Many will prefer to partner with operators.

For their part, CSPs are optimistic about the potential to deliver 5G private network services, particularly using network slicing capabilities. The graphic opposite reveals the percentage of CSP respondents from our recent *Future business models* survey who agreed with the statements shown.



Indoor 5G

Delivering 5G coverage inside large buildings – particularly modern buildings made with thick glass – will be challenging for outdoor 5G networks, particularly in the upper range of 5G radio spectrum. As such, both CSPs and enterprises must step up their efforts to install radio equipment inside buildings.

An extension of indoor coverage could happen through a few different business models:

A single mobile operator takes responsibility for the installation of indoor coverage as part of a contract to deliver mobile services to a company's workforce.

The enterprise manages and operates the indoor network, which it connects with one or more mobile networks, in which case mobile operator(s) may or may not contribute to its cost.

A third party, or neutral host, builds and operates the network for the enterprise and receives payment from both the enterprise and network operators.

There is considerable interest in extending the neutral-host model and potentially using it as an approach to deliver enterprise networks more broadly. A variation on this is a wholesale operator. This is likely to be a large enterprise or public body that already has an extensive fiber network and valuable real estate that can be used as a location for radio infrastructure. Motorways and railways are strong candidates.

Upgrading LMR

Ericsson's Mobility Report from June 2019 shows how various industry verticals are evolving their strategies for using private LTE and 5G networks and where they might be most useful. One primary difference among verticals as they evaluate the potential is how critical it is for them to upgrade from their land mobile radio (LMR) systems (person-to-person voice communication systems, such as those used by police or taxi services). LMR does not support broadband, and much of the infrastructure is nearing its end of life.

There are two primary drivers for considering private LTE and 5G networks:

- Replacing aging LMR infrastructure
- New use cases resulting from Industry 4.0 initiatives in search of productivity improvements and/or operational efficiencies (for example, in logistics/supply and manufacturing verticals).

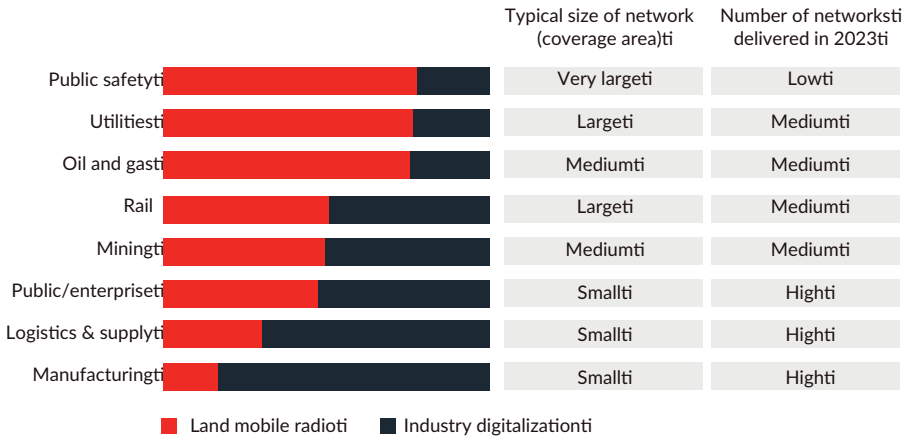
The graphic opposite shows the drivers for private mobile networks among various verticals and how their requirements differ. For example, networks for public safety and utility environments are generally large, covering expansive geographic areas. The requirements for these verticals are for very large networks but a low number of them, whereas manufacturing and logistics companies tend to require smaller coverage areas but a potentially high number of local networks.

5G deployment

Before CSPs can capture the immense 5G enterprise opportunity, they must make progress on their own digital transformations. This includes not only deploying 5G technology in the radio access network (RAN) and core networks, but also virtualizing network functions, adopting software-defined networking and upgrading operational and business support systems.

Many 5G trials have already been completed, and 5G deployment is now underway worldwide. But the speed of deployment is likely to depend on demand for new capabilities. As Jason Inskeep, Director of Business

Verticals evaluating private LTE/5G networks



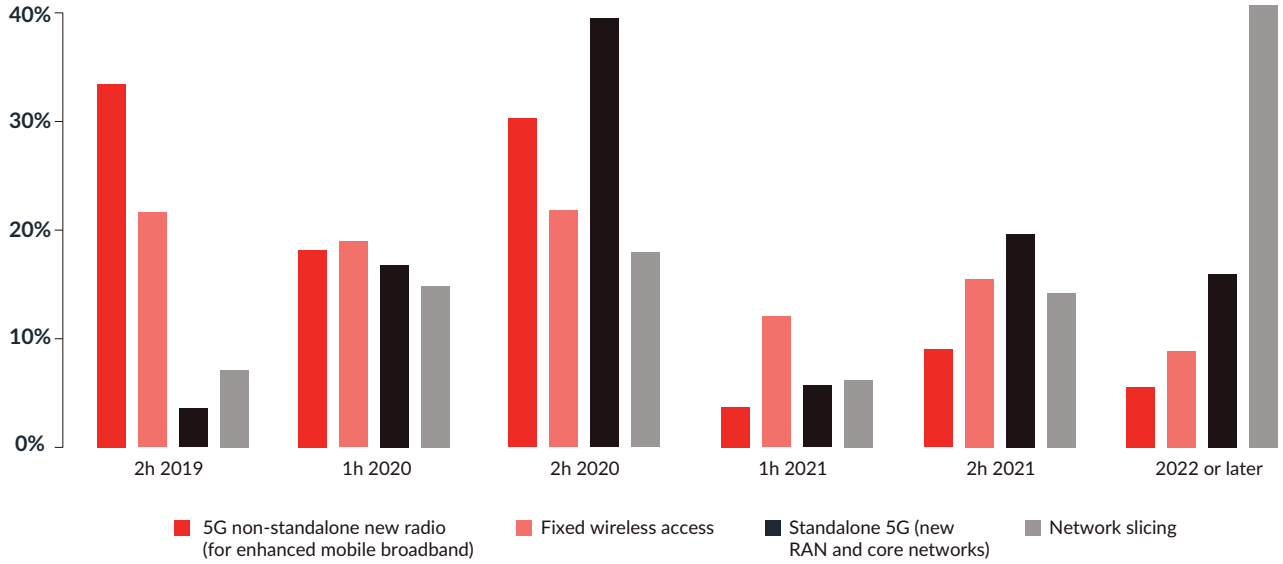
TM Forum, 2019 (source for data: Ericsson Mobility Report)ti

Development for 5G/Multi-access Edge Computing at AT&T notes:

> “The macro network is going to build how it’s going to build. It gets here when it gets here. It all depends on what you want to do with it.”

In other words, rollout will be prioritized depending on what enterprise customers want to accomplish and how lucrative enabling the use case will be for CSPs. It will be determined on a use-case by use-case basis, taking into account the potential business case for each use case. The graphic below shows when the CSP respondents to our surveys expect their companies to deploy 5G capabilities.

Time frame for deploying phases of 5G



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A third of CSPs globally have begun to deploy 5G New Radio or will be doing so later this year, and close to half will have begun by the second half of 2020. These early deployments are mostly consumer-focused, but operators will begin rolling out fixed wireless access (FWA) for businesses later this year.

FWA is becoming a viable alternative to terrestrial broadband in building-to-building local area networks. Indeed, one research firm predicts that FWA revenue will reach $1 billion worldwide by the end of this year.

Delay for slicing

The expected timeline for network slicing sticks out in the chart. Often described as one of the most important characteristics of 5G because it will help CSPs achieve the long-sought ability to differentiate and monetize services based on quality, large-scale network slicing implementations aren't expected until 2022 or later. This conservative projection is due in part to the need for slices to operate end to end in the prescribed manner, which requires standalone 5G.

Standalone 5G is the grand prize of the next-generation network, and its capabilities are what really matter to enterprises. With new core and radio access networks, be they centralized or virtual RANs, Standalone 5G will support and drive the triumvirate of differentiating capabilities – co-creation, network slicing and edge computing. However, the big push for Standalone 5G is not expected until the latter half of 2020 after standards are in place. (See Section 4 for more on slicing and Section 5 for more on edge computing.)

For a more extensive analysis of 5G deployment and standards, see this report:

In the next section we'll look at the potential for CSPs and enterprises to collaborate on 5G innovation.

Section 3

Co-creating innovative services

Business consultant and Forbes *contributor Christine Crandell defines 'co-creation' as "the purposeful action of partnering with strategic customers, partners or employees to ideate, problem solve, improve performance, or create a new product, service or business." It's not a new concept, and it's not dependent on 5G. However, 5G has given co-creation new life and a sense of urgency, driven by the complexity and vast potential for innovation that next-generation networks offer.*

Many technologies over the last 30 years have enabled major, evolutionary steps in telecom networks:

- Analog to digital
- Circuit-switching to internet protocol
- Wireline networks to wireless and converged networks
- Low-speed to high-speed
- Point-to-point connectivity to internet connectivity
- Physical infrastructure to virtual and software-defined networks

Architecturally, the evolution to 5G may not be as dramatic as some of the other transformations, but when it comes to opportunity, 5G promises to be revolutionary if communications service providers (CSPs), suppliers, application developers and enterprises can figure out how to co-create, manage and participate in digital ecosystems. The graphic opposite shows the benefits and challenges of co-creation in 5G environments.

Benefits and challenges of co-creation

Benefits	Challenges
Going it alone is untenable	Culture (not every cross-industry team gels)
Shared skills, assets & technology	Ill-defined roles & expectations
Development based on use cases	No guarantee of success
Shared R&D costs	Potential for too many individual projects
Building new ecosystems & relationships	IP ownership for development & output
Results in more useful apps	Complex monetization

TM Forum, 2019

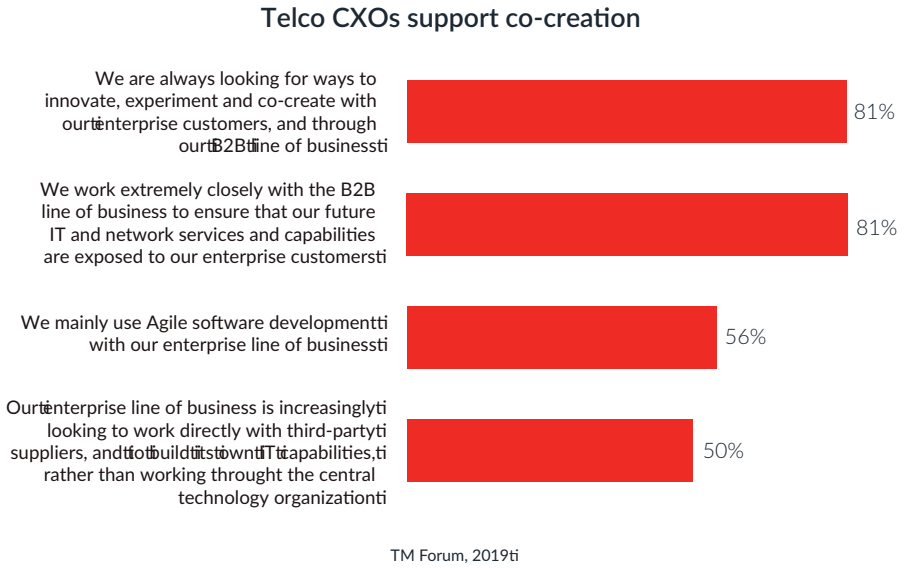
It takes patience

Overcoming the challenges of co-creation takes considerable patience, according to research firm Innovation Leader, which published a study earlier this year on best practices for co-creation and ecosystem development. The companies most often mentioned as good role models are Amazon, Apple, Microsoft, Google, Cisco and GE.

While most companies claim to have some experience in co-creation, most do not consider themselves experts. According to Innovation Leader, among organizations actively pursuing co-creation efforts, 61% did so most often with existing suppliers, distributors, partners and franchisees, while 58% reported collaborating with customers.

Among telecom companies, Innovation Leader highlights Ericsson as a company with co-creation experience. The telecom supplier worked with Reuters beginning in 2014 to build a mobile banking solution for small businesses and farmers in Africa, and this year the company is opening a new co-creation center at its Silicon Valley facility. The center, called D-Fifteen, will be an incubator for new ideas to push the boundaries of what mobile technology can do as the Industry 4.0 becomes a reality.

TM Forum's recent survey of CXOs finds that a large majority of CSPs are looking for ways to innovate, experiment and co-create with their customers and suppliers. The graphic above reveals the percentage of CXOs who agreed with the statements shown.



Innovation at AT&T

Earlier this year, AT&T launched its 5G Innovation Program to co-create new service capabilities and drive innovation for 5G. Program participants include Cisco, Ericsson, Infosys, Intel, Magic Leap, Microsoft, Nokia, Samsung and Warner Media. The partners will collaborate in live networks and at AT&T Labs, AT&T Foundry and 5G Innovation Zone locations.

In a statement about the program, Andre Fuetsch, President of AT&T Labs and CTO of AT&T Communications, noted that it is designed to create the right conditions for 5G innovation to flourish. Data analytics, machine learning, open source software and vendor interoperability will drive the innovation.

AT&T co-creates with enterprise customers at its Foundry locations, particularly in Plano, Texas, where teams demonstrate how applications and services will work in a 5G environment. In the telecom industry, there is intense focus on rolling out Standalone 5G to serve enterprise customers, but many customers don't care about Standalone, according to Jason Inskeep, AT&T's Director of Business Development for 5G/Multi-access Edge Computing (MEC). They are only interested in how CSPs can help them solve their business challenges faster. He adds:

> "You can get there faster by working together than by working in two different closets."

At the Plano Foundry, AT&T aims to shorten the lifecycle of product development. Enterprises work throughout the software, hardware, networking and content pipeline to develop edge-native applications. Some of this work is beginning to extend beyond the Foundries and into partners' labs and innovation centers. For example, AT&T put a new 5G radio into Ericsson's 5G testbed in Santa Clara, Calif.

AT&T is also collaborating inside its enterprise customers' labs. Examples include:

magic leap – AT&T plans to launch a 5G Innovation Zone on the Magic Leap campus in Plantation, Florida, for developers and creators to test devices and applications on a 5G network.

RUSH – AT&T is installing an MEC network at the edge for Rush that will enable the hospital system to manage cellular traffic over its local area network in Chicago and its wide area network. This will improve network communications and application processing as well as enhance use cases across the Rush system.

WARNERMEDIA – The media company's Content Innovation Lab will explore AT&T's 5G infrastructure offerings to develop, deliver and deploy new immersive consumer content experiences such as augmented reality, virtual reality and mixed reality gaming.

SAMSUNG – AT&T and Samsung are creating a manufacturing-focused 5G "Innovation Zone" in Austin, Texas. The goal of the testbed is to explore different use cases over 5G to provide a real-world understanding of how the technology can impact manufacturing and to provide insight into the future of a smart factory (see panel opposite for more about 5G and manufacturing).

AT&T hopes to manufacture 5G success with MxD

Manufacturing is one of the most promising verticals for demonstrating return on investment in 5G. To explore the potential, AT&T recently joined MxD (Manufacturing times Digital), a US-based association for manufacturers formerly known as the Digital Manufacturing and Design Innovation Institute. AT&T plans to install 5G mmWave and edge computing technology at the MxD facility in Chicago in order to collaborate with manufacturing companies and demonstrate capabilities.

MxD is a non-profit innovation center that facilitates collaboration between public and private companies, academia and governmental institutions, including the US Department of Defense. The organization focuses on digital manufacturing and accelerating the adoption of Industry 4.0.

"[Industry 4.0] opens a whole new set of use cases and solutions that were simply not possible in 3.0," says Tony Del Sesto, Vice President of Projects and Engineering, MxD. He adds that it builds on Industry 3.0's introduction of continuous improvement, Six Sigma, and lean operations concepts to address emerging challenges such as cybersecurity, near real-time communication and data analytics.

While AT&T has its own Foundries, working with MxD gives the telco an opportunity to collaborate with and learn from more than 300 manufacturing and technology companies and academic institutions. MxD offers access to 22,000 square feet of dedicated factory floor space to showcase the art of the possible in manufacturing. Says Del Sesto:

"We are excited to bring 5G to manufacturers as a non-profit, neutral sandbox. That gives AT&T credibility within manufacturing and in the playground and ecosystem of partners to explore what it can do."

MxD's manufacturing company members are excited about getting to see how 5G technology really works in their environments. Says Tony Papke, Director of Business Development for the organization, "If you look at some of these legacy factories, they are not going to rip up their factories to put in a bunch of Ethernet cable, so having a high-bandwidth, low-latency system – especially with network slicing which can be customized for different use cases – says there is a lot of good potential here."

MxD is hosting a workshop in September with 5G as a big topic of discussion, including potential use cases. The organization has invested about $90 million in more than 60 applied research and development projects in areas such as design, product development, systems engineering, future factories, Agile, resilient supply chains and cybersecurity.

Telenor teams up

Although Norway's Telenor Group does not yet have a formal co-creation environment for 5G, the company is taking an aggressive approach to serving enterprise verticals and engaging collaboratively in several regions. As the telco enters new markets, it determines ahead of time what role it wants to play, says Terje Jensen, Head of the Network Architecture Team. Sometimes that means taking the lead, while other times it means being a contributor.

"It all depends on the level of maturity in the market," he explains. "There will be differences from market to market."

Telenor is collaborating with enterprises in B2B and B2B2C scenarios. The CSP is also collaborating with local governments on emergency network solutions. It is even working directly with consumer groups to identify potential services. In Norway, Thailand and Malaysia, the company has several multi-party trials underway on solutions for private networks, autonomous buses and supporting ambulance services with virtual reality-based application. Says Jensen:

> "If an operator really wants to approach verticals with a full offering, they need to team up with someone else."

Telenor operates as Digi Telecommunications in Malaysia and dtac in Thailand. The company was seeking to merge with Axiata, which serves 150 million subscribers in Asia and has a strong track record in ecosystem-based innovation. However, the two companies ended talks of a deal in September, with Telenor citing "complexities" that could not be resolved.

5G demonstrations

Telenor's Digi partnered with ZTE in April 2019 to demonstrate 5G use cases in emergency services, distance learning and e-sports (virtual reality gaming.) For emergency services, the demonstration included enhanced mobile broadband (eMBB) with ultra-low latency connected to a command center that dispatches a drone equipped with high-definition cameras that delivered live video feeds at emergency sites. At the same time the drone monitors road and traffic conditions and transmits real-time data to the command center, ambulances en route and the hospital.

The distance learning demo also used eMBB to deliver augmented reality-based applications for distance learning that can be used globally at the same time. Telenor has also conducted 5G pilots for autonomous ships, boats and fish farms, and the company is seeking partners for new trials at its test bed in Putrajaya, Malaysia.

Telenor also heads up the 5G Verticals INNovation Infrastructure (5G-VINNI) project, which was launched in January 2018 with €20 million in funding and test facilities in Norway, the UK, Spain, Greece, Germany and Portugal. Telenor will work with 23 member companies – among them BT, Telefónica Spain, SES, Cisco, Ericsson, Huawei and Samsung – to accelerate 5G uptake in Europe. Some of the group's early work focuses on network slicing (see page 20).

In the next section we'll look at how CSPs envision using network slicing to deliver enterprise use cases for 5G.

Collaborating to create digital ecosystems

In order to co-create using 5G technology, CSPs, their suppliers, customers and third-party partners must develop digital ecosystems where they can collaborate without a lot of complex integration. TM Forum's Digital Ecosystems Program aims to help companies address the business challenges associated with partnering.

> "The ecosystem is not a legal entity; it doesn't have a brain, no legal obligation as a single unit," says Joann O'Brien, Vice President of Ecosystems & Labs, TM Forum. "It is the business that has all these things. So you have to come at [the ecosystem concept] from that business perspective."

Through open collaboration among members, which include CSPs, suppliers, integrators, developers and enterprises, TM Forum provides how-to guidance for rapidly designing, implementing, operating and monetizing digital services with partners. The Forum's Digital Ecosystem Program has three primary components:

- The Business Architecture & Capability Model generates the critical elements of a business architecture, both from the CSP and digital service provider (DSP) perspectives. The model includes assets such as Vison & Mission, Concepts & Principles, Capability Model, Value Fabric Map. These assets can be used to plot a company's digital transformation strategy and enable more cohesive co-operation between business and technical partners.
- The Ecosystem Business Architecture initiative gathers market and business requirements and capabilities; builds practical tools to help organizations evaluate use cases and business opportunities; gauges risk, reward and sustainability; and better manages their ecosystem business strategy and operations.
- The Business Assurance Project subsumes several work streams and addresses fraud management, revenue assurance, and billing, charging and settlement in the context of digital business and the inherent ecosystem of partners involved.

The project is working to evaluate and gain greater insight into how traditional areas of business need to adapt to cope with the changing needs of organizations, driven by the digital ecosystem revolution, 5G and emerging technologies as well as AI and Blockchain.

> "The whole idea of the ecosystem program is built around co-innovation," O'Brien says.

Zero-touch partnering

Many TM Forum Catalyst proofs of concept have demonstrated solutions to partnering challenges. One award-winning project called *Zero-touch partnering*, which was championed by BitX, BT and Vodafone Group, shows how CSPs can simplify and automate onboarding of platform partners without any IT development work by using TM Forum Open APIs.

The idea is for operators to be able to give enterprise customers the speed, convenience and innovation they demand by partnering with innovative companies and startups to create mix-and-match products, services, offers and bundles almost instantly, with all complexity hidden. The impact on cost and time of integration between platforms and innovators has been a huge barrier to achieving this.

Watch this video to learn more about the project:

Section 4

More questions than answers about network slicing

As communications service providers (CSPs) deploy 5G in their access networks and software-defined networking (SDN) in the core, network slicing will become an important capability for targeting enterprises. Primarily, it gives mobile operators a way to monetize dynamic service levels, a long-held goal. But many questions remain about how to implement the capability, and how to charge and bill for it.

As explained in the companion report to this one, *5G future: Business models for monetization*, 5G and SDN give CSPs the opportunity to provide new networking capabilities dynamically, on demand and at lower cost through network slicing and IT capabilities that enable customer self-service. Today's networks have been built to manage traffic at peak times, but if it were possible to give customers the ability to scale network resources up and down as needed based on many variables, theoretically the cost of delivering the service would be lower and customer experience would improve.

Using network slicing and network as a service (NaaS), CSPs are hoping to develop new business models for delivering varying levels of service to different groups of customers. Services could be based on many parameters such as quality of service (QoS), throughput, latency, capacity, time of day, location or security level. Mobile operators can already create network slices in a virtualized 4G mobile core, but 5G adds the capability in the radio access portion of the network. This makes it possible to create a slice at the edge for a low-power application where sensors have limited battery power or for a very low-latency, high-bandwidth application like augmented reality.

What is slicing?

From an implementation standpoint, CSPs and their suppliers often talk loosely about network slicing and confuse slices, which are a network resource-level concept, with the intelligent connectivity services that slicing enables. This is not unusual for a technology on the hype curve. Earlier work in slicing attempted to thwart the problem and avoid market confusion by using the term 'assured quality services', but alas, here we are, still talking about slicing.

Network slicing is currently being defined with slight variations by industry groups such as the 3GPP, the International Telecommunication Union (ITU) and the Next Generation Mobile Networks Alliance (NGMN). But these groups are primarily focusing on how to spin up slices in data centers and chain them together. There has been much less discussion about subscriber provisioning, assuring dynamic service levels and monetizing slices.

TM Forum is focusing on these challenges and defines network slicing as a logical network serving a defined business purpose or customer, consisting of all required network resources configured together. Slices are created, changed and removed through CSPs' management and orchestration systems, and their characteristics include:

- **End to end within a provider's environment** – CSPs cannot always define shared network assets or service quality beyond their own networks.
- **Viewed as an enabler, not a service** – as noted above, a slice is not a service; CSPs and their suppliers should think of slicing as an enabler of services.
- **Can be mobile or fixed** – network slicing can work in either or both environments.
- **Resources may be physical or virtual, dedicated or shared** – the network resources used to create a slice can be physical or virtual. Generally, they are shared but do not have to be. However, dedicating resources somewhat defeats the purpose, which is to re-use assets.

Why the excitement?

As noted in Section 2, most CSPs do not anticipate implementing network slicing capabilities until after 2022 (see page 11). The graphic opposite highlights several reasons network slicing is highly anticipated, along with the potential challenges.

The market for network slicing is expected to grow at a compound annual growth rate of about 20% though 2024. However, CSPs are not looking at network slicing as a market unto itself. It is a means to an end: creating differentiated service levels they can monetize.

TM Forum's *Future business models* survey shows that 82% of CSP respondents are counting on network slicing to provide dedicated network and service capabilities to individual enterprises, and nearly the same percentage said they believe that private networks for the B2B market, enabled by network slicing, will have both short- and long-term impact on their business.

How many slices?

That's where the consensus ends, however. Our *Future networks* survey shows that CSP respondents disagree about the number of network slices they expect to support, and interestingly they seem to be at one extreme or the other. Nearly 40% said they expect standalone 5G networks to deliver all the differentiated service levels they need with 10 or fewer slices, while about 30% said they are confident they will be able to support an infinite number of slices and cater to enterprise customers' unique needs. In other words, if they can charge for a slice and assure it, they will build it.

Benefits and challenges of network slicing

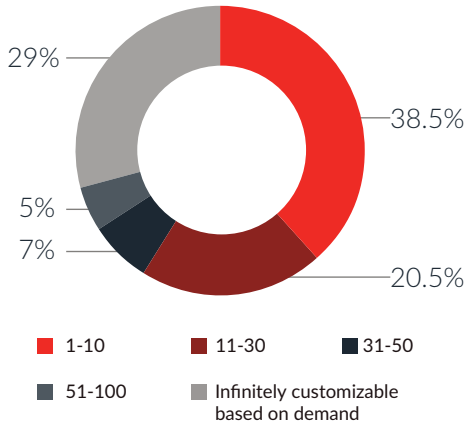
Benefits	Challenges
Leverages virtualization for faster time to market	Needs automated orchestration to turn up and tear down slices
Differentiated, use case specific logical networks	Requires close attention to internal resource allocation
Service characteristics can be dynamic & based on policy	Lack of standards for QoS KPIs and metrics
Customized enterprise solutions	Interference/contention of resources
Monetizes performance-based services	Difficult to charge for services with dynamic QoS based on policy
Helps all parties execute SLAs	Complexity of end-to-end service assurance
Eliminates long-standing regulatory hurdles to prioritization	Questions about how to slice virtual RANs

TM Forum, 2019

The wide discrepancy can be explained if some CSPs are considering what's possible while others are focusing on what's practical. Theoretically, an infinite number of slices might be possible from a programmability or design perspective, but from a resource perspective, there are limits.

In the end it comes down to which service level requirements can be monetized and which can be managed and assured affordably. In other words, if it makes good business sense to define and offer a slice, and it can be managed properly through automation, then a CSP is likely to create it.

Number of slices CSPs expect to support



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Slicing variables

In our *Future networks* survey, we asked CSPs to rate several potential performance requirements that slices may need to support. The graphic below shows the ones CSPs believe are an 'essential' or 'very strong' requirement. The top requirement is neither speed nor latency as expected, but rather security, which three quarters of respondents rated as a very strong or essential requirement.

Network slices are logical networks that require the same level of security as any other virtual or physical network. From a security standpoint they must be treated as an additional point of vulnerability. Security rules and parameters must be applied to the slice and the network assets it uses. Functionally, security must operate like a service orchestration platform, making sure access and egress points have been securely locked down after slices dynamically go in and out of service. This can be done with a separate security orchestration stack or by integrating security with existing network and service orchestration platforms.

On the bright side, slicing can be used to enhance security as well. CSPs can use slicing to segment the network into discreet areas where access restrictions could be applied. Securing IoT devices and networks would be an example.

Privacy follows closely behind security, with 72% of CSP respondents saying it is an important requirement. Privacy in slicing centers on concerns over protecting data on shared network assets. CSPs ranked coverage fairly low on the list, likely because it will be assumed, especially when 5G is fully deployed with indoor and outdoor radios, and because users of network slicing are often working from a known, fixed location or locations.

Learn more about security imperatives for CSPs in this report:

Testing the concept

Most CSPs are only experimenting with network slicing. Telenor and Telefónica, for example, demonstrated the capability with Open Source MANO in February at Mobile World Congress. As part of ongoing collaboration, the companies showed how slices with different characteristics can be created on demand across different domains, including the core, transport and radio networks, then centrally managed. Says Terje Jensen, Head of the Network Architecture Team at Telenor:

"The industry is moving forward. It's not clear if we are on a peak or a hype curve, but we will be meeting reality quite soon."

As noted in Section 3, Telenor is leading the 5G Verticals INNovation Infrastructure (5G-VINNI) project, a pan-European research and innovation project created to drive adoption of 5G in Europe through interconnected 5G test facilities. Its initial goals are to demonstrate the practical implementation of infrastructure to support key 5G key performance indicators (KPIs) useful for network slicing. Next it will allow vertical industries to test and validate specific applications that are dependent upon those KPIs. 5G-VINNI intends to work with public safety, healthcare, shipping, transportation, media and entertainment, and automotive verticals looking to leverage network slicing and co-create solutions for 5G.

5G-VINNI participants hope to:

- Design an advanced and accessible 5G end-to-end facility and build several interworking sites
- Provide user-friendly, zero-touch orchestration, operations and management systems for the 5G-VINNI facility
- Validate 5G KPIs and support the execution of end-to-end trials of vertical use cases to prove the 5G-VINNI capabilities

This 5G-VINNI approach employs network functions virtualization (NFV), network slicing and automated testing to validate 5G KPIs using various technologies and network loads. The 5G-VINNI facilities include seven infrastructure instances in nationally supported 5G nodes across Europe, and this number may be expanded as projects come online.

Jensen notes that this is important research designed from the enterprise customers' point of view. In addition to the work on KPIs, other work will include ensuring the isolation of traffic so it cannot interfere with other network slices, and prioritization so services can be tailored to users of emergency services users.

Anticipated slicing characteristics

TM Forum, 2019tt

Learning from Catalysts

TM Forum members are exploring how to manage network slicing in several Catalyst proofs of concept. In a recent project called *Riders on the storm*, BT, KDDI, Orange, Telecom Austria, Telecom Italia and Telenor collaborated with a group of suppliers (Accenture, Huawei, Netcracker and TEOCO) to explore using slices to ensure public safety, demonstrating that even in catastrophic storm conditions some level of communication can still be delivered for high-priority services essential to managing emergency response.

The learnings from this Catalyst are being contributed back to the TM Forum Open Digital Architecture project (see panel below) as a new report that will be published later this year. According to the report, mobile operators believe that the market success of slicing will depend greatly on how simple it is to order and use a slice, including the ability for users or groups of users to self-select service levels. The process must be as frictionless as possible. Standardized slice templates, which provide a list of attributes that can characterize a type of network slice and make design and orchestration quicker, and open APIs for slice management are key to making it happen.

Watch this video to learn more about the *Riders on the storm* Catalyst:

Optimizing capacity

BT and Verizon teamed up in another Catalyst project called *5G optimized capacity & E2E experience* to show how network slicing can be managed through planning, testing, implementation, assurance and monetization phases to marshal the resources necessary to deliver closed-loop service orchestration for dynamic, on-demand network slices.

Guaranteeing assured service quality across multiple services, with peak usage conditions, requires intelligent, strategic planning and tactical, real-time orchestration to optimize resource allocation, especially when delivering services through customized network slices. The Catalyst team, which included Amdocs, ARRIS, CanGo Networks, MYCOM OSI, Nokia and Wipro as participants, demonstrated automated planning and closed-loop service orchestration to set up and decommission network slices on demand.

Artificial intelligence and machine learning were used to deliver service assurance, and the team also demonstrated the use of immutable blockchain for automated settlements of complex inter-CSP agreements. These are the fundamentals that must be in place to ensure that network slicing works equitably for both the user and the provider. Fred Feisullin, NFV, SDN & 5G Architect, Verizon, explains:

> “[The demonstration] is about showing how we make 5G profitable – how we automate not just the tactical aspect of optimization and orchestration, but how we actually close the loop with the automation of the planning aspects for making these services deployed, optimized and profitable.”

Watch this video to learn more about the Catalyst project:

In the next section, we’ll look at how CSPs expect to use multi-access edge computing to address the enterprise 5G opportunity.

Helping CSPs manage network slicing

Delivering intelligent connectivity services using network slicing requires understanding the full lifecycle of the services from ordering to billing. The Open Digital Architecture (ODA), which is part of the TM Forum Open Digital Framework (see page 34), provides a functional architecture that CSPs can use for end-to-end management and orchestration of 5G and other digital services.

Using learnings from several Catalyst projects, the ODA team is developing an implementation framework that can support 5G use cases. This work is detailed in a document called *User guide for network slice management*. The team also is developing best practices for security and governance which can be applied to network slicing.

Section 5

Gaining an edge with MEC

When it comes to multi-access edge computing (MEC), getting close to the customer is not a marketing metaphor for customer engagement. It is a real, physical requirement. Highly anticipated 5G applications like autonomous vehicles and remote surgery require extremely low latency, which means that computing infrastructure must be located as close as possible to the user. Communications service providers (CSPs) also need MEC to reduce the amount of traffic in their core networks.

MEC shifts centralized compute and storage resources and some applications to distributed cloud data centers that are physically closer to end users. Processing data at the edge of the network rather than sending it through the core reduces latency, improves performance and limits network congestion.

However, moving compute, storage, application, analytics and access technologies to the edge can be costly and logistically complex, and edge facilities are difficult to secure. As of now, the role for CSPs in edge computing remains unclear, although most large operators are at least considering deployment (see page 25). As noted in the companion report to this one, *5G future: Business models for monetization*, it is possible that CSPs could play a large role by building their own MEC facilities, but they could also end up taking a backseat to existing cloud providers like Amazon Web Services and Google, or enterprises could opt to deploy their own in-building 5G capabilities. In any case, deployment is likely to be driven by enterprise use cases, mostly internet of things (IoT) use cases.

For optimal deployment, MEC will also require a level of automation that CSPs and their suppliers have not yet achieved. In a 2019 whitepaper, the European Telecommunications Standards Institute (ETSI) noted that one of the key operational requirements for edge computing is the concept of 'zero-touch' provisioning, which applies to all the layers of the edge stack and requires full management automation and service assurance. TM Forum members have been exploring how to automate operations at the edge in TM Forum Catalyst proofs of concept and the Open Digital Architecture project (see panel on page 23).

Proofs of concept test edge-computing principles

Recent, award-winning TM Forum Catalyst projects have demonstrated edge-computing capabilities. The *Blade Runner* Catalyst illustrated a complex and interesting enterprise use case using augmented reality to help a local engineer in a Dubai mine repair earth-moving equipment by receiving instructions from an expert located at an enterprise customer's facility in Germany. The project used ODA to show how orchestrators at different levels of the network must work together to deliver services end to end.

Watch this video to learn more:

Another project called *Smart city on the edge* applied edge and fog computing principles on smart city data hubs to improve efficiency of city operations. The team demonstrated how to decentralize decision-making and push intelligence from a central data hub to a local loop of programmable edge devices such as IoT gateways and sensors. The idea was to help the city efficiently operate the expansion and evolution of their smart infrastructure, improve service level agreements for customers' applications, and improve operations by pro-actively handling incidents as they unfold.

Watch this video to learn more:

Benefits and challenges of edge computing

Benefits	Challenges
Compute & storage close to user to reduce latency	Selection of edge cloud locations
Meets low-latency requirements	Performing analytics when data remains at the edge
Distributed clouds are less vulnerable to major outages	Executing cost-efficient, centralized management and orchestration for distributed clouds
Saves core bandwidth	Dearth of cloud expertise
Caching content reduces core traffic and improves performance, especially for video	Overall infrastructure costs
Supports autonomous cars	Big investment in physical/logical security
Keeps sensitive data at edge	Reaching the necessary level of automation

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Promising technology

Bullish market projections point to MEC's potential. According to a Research & Markets' report released in September, the global edge computing market will grow from $2.8 billion in 2019 to $9 billion by 2024 – a remarkable 26.5% compound annual growth rate. While North America will continue to lead in market share, Asia will be the fastest growing market, due in large part to the manufacturing base, gaming and other industries in the region eager to take advantage of the technology.

Manufacturing will be the biggest vertical market for MEC, reaching $194.4 million in the Asia market alone by 2024. Manufacturing companies will be looking for high number of small private networks which would be ideal for MEC solutions (see Section 2).

Indeed, most CSPs are excited about MEC because they expect it to lead to new revenue. In the *Future business models* survey, a full 85% of CSPs respondents said MEC will enable development of new lines of business providing cloud-based services to enterprises. The graphic opposite shows some of the benefits and challenges associated with edge computing.

Which attributes?

To dig a little deeper, we asked CSPs which MEC attributes will provide the biggest benefits. The graphic opposite shows the capabilities CSPs view as most important for targeting enterprises.

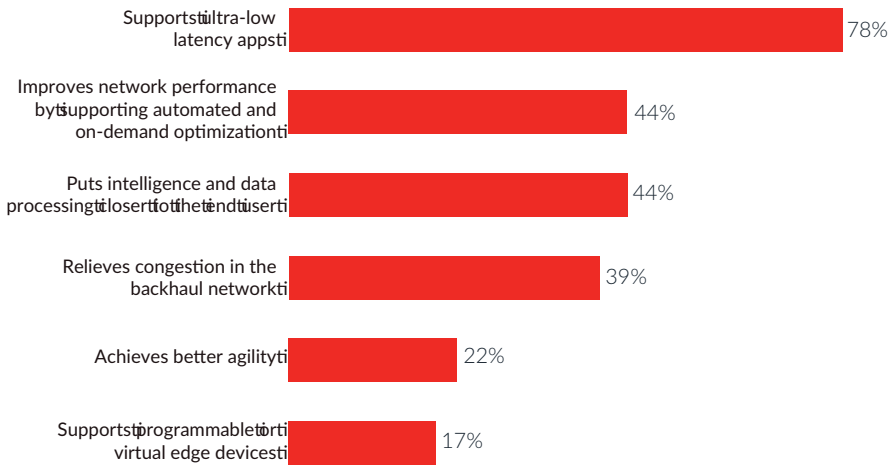
Getting latency below 2 milliseconds is key to enabling many IoT applications, so it's not surprising that nearly 80% of CSP respondents put it in their top three attributes. Improving network performance by supporting automated and on-demand optimization likely would have ranked higher if network automation were already pervasive, but it will increase over time.

Likewise, support for programmable or virtual edge devices will increase as the devices become available. Virtualization at the edge is also expected to help solve the congestion challenges 5G poses to the backhaul network. While virtualization is not required to deploy MEC, our survey shows that 45% of CSP respondents are concerned that a protracted rollout of network functions virtualization (NFV) and software-defined networking (SDN) will negatively impact their timeline for delivering 5G and related technologies.

How to deploy?

MEC facilities are a lot more like data centers than central offices, and rolling them out requires building physical facilities as well as installing cloud computing servers and software. CSPs have several options for how to construct physical facilities:

MEC attributes providing the biggest benefit



TM Forum, 2019

Build and operate their own edge data centers – the cost for doing this is unclear, but it will result in significant capital expenditure

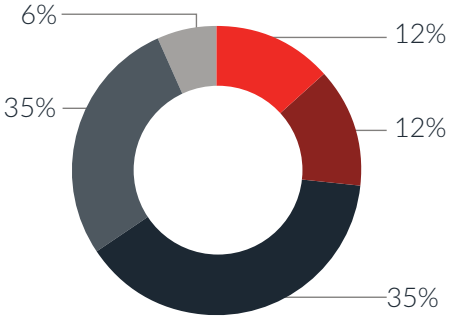
Contract with turnkey colocation and data center providers – this article offers examples of companies providing edge cloud capabilities to CSPs and enterprises.

Partner with content providers, IoT companies and others to build and manage edge data centers – a CSP could partner with a telematics company that operates its own data centers, for example.

Rely on a combination of owned data centers and leased or managed infrastructure – this is likely to be a popular choice because it gives CSPs control over some facilities while keeping construction costs down

The graphic below shows which of these options CSP respondents to our *Future networks* survey intend to use.

How will CSPs support MEC?



TM Forum, 2019

Art of the deal

It is not surprising that more than a third of the operators we surveyed plan to build their own edge data centers, despite the cost. Maintaining control over critical facilities has always been the preferred mode of operation for CSPs. But this approach could become untenable over time as cloud technology proliferates and service providers of all kinds become increasingly dependent upon each other to deliver a quality experience for customers.

Colocation is a well-tested method of sharing the cost of turning up far-flung facilities. CSPs interviewed for an upcoming TM Forum report called *Fusing outside plant data and AI to maximize capex investment*, which will be published in October, said they are open to outsourcing the engineering and operations of outside plant facilities, especially very remote facilities, to third parties. We expect that as the number of edge clouds grow, more CSPs will look for more help from third-party data center providers.

Beyond partnering to build physical MEC facilities, CSPs will need to strike deals with suppliers that have cloud computing experience for what they put into MEC facilities. Companies such as Cisco, HPE, IBM, Microsoft and Oracle are actively positioning themselves to help CSPs succeed at the edge by teaming up to provide end-to-end solutions that support virtual network infrastructure, management and orchestration tools, application hosting, implementation, assurance and charging, analytics, and on-premises systems as well.

While cloud providers like Amazon Web Services, Google and Microsoft could be potential competitors in edge computing, Microsoft has been clear that it does not intend to build MEC facilities. Instead, the company envisions partnering with CSPs, as it is doing with AT&T to deliver edge computing capabilities to enterprises (see page 26).

Testing MEC

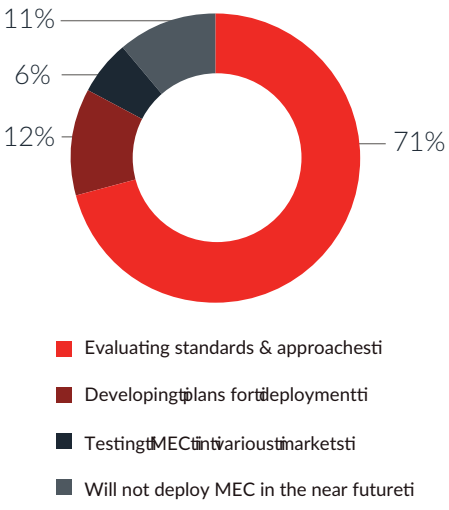
More than 70% of CSP respondents to our survey said they are still in the early stages of MEC deployment, evaluating standards and approaches (see graphic below). Only 6% have deployed the capabilities in technology trials, and these trials are using 4G technology. So far, no operators have announced using MEC in a 5G network. As Guenter Klas, Manager of Internet and Standards, Vodafone Group, noted in a recent blog:

> “MEC has the potential to be transformative. However, as the adoption of vanilla cloud computing has taken a while, the emergence of commercial edge computing applications may take time, as it goes hand in hand with the maturing of other enabling technologies, from machine learning to cognitive computing, from autonomous driving to cyber-physical systems. Even the ongoing evolution of cloud computing itself will have an influence on how developers will design and architect MEC applications.”

Klas added that MEC testbeds, like the one installed by Vodafone in its UK lab and at the Aldenhoven (automotive) Testing Centre in Germany, are part of 5G programs to help co-create the potential next big application. The same applies for internationally funded test facilities like the Open Edge Computing Initiative’s Living Edge Lab.

AT&T has been particularly aggressive when it comes to MEC trials and testing (see panel). So far, the company is not seeing demand for applications that require extremely low latency, but as such use cases develop, MEC will be able to deliver by eliminating centralized processing of data.

CSPs’ MEC deployment plans



TM Forum, 2019

Partnering is key to AT&T's MEC strategy

AT&T is partnering to advance its MEC strategy, inking deals with Microsoft, IBM and Red Hat, HPE, and others. Earlier this year the company collaborated with Microsoft on a proof of concept to test edge computing using the Azure public cloud platform. AT&T refers to its edge platform as Network Edge Compute (NEC) rather than MEC because the company views MEC as a premises environment, which either AT&T or a partner could manage for the enterprise.

The AT&T/Microsoft Azure project focused on delivering low-latency cloud and IoT solutions for retail, healthcare, public safety, manufacturing and entertainment markets. AT&T is developing other MEC use cases at its Foundry in Plano, Texas where some of the Microsoft collaboration testing was done. In July, the work paid off with the company selecting Microsoft Azure as its preferred cloud provider for non-network applications. The companies entered an extensive, multiyear alliance to jointly apply technologies, for 5G, AI, cloud and edge computing.

This summer, AT&T also forged a multi-year strategic alliance with IBM under which IBM will provide cloud infrastructure support for AT&T Business' applications, including Red Hat's open source platform, to manage workloads and applications. AT&T also is looking to accelerate MEC adoption through a go-to-market program that leverages HPE's Edgeline Converged Edge Systems to create use cases for on-premises edge applications.

Finally, AT&T is partnering directly with enterprise customers. The company is working with Rush University Medical Center in Chicago to install 5G technology in the hospital. AT&T MEC services will enable Rush to manage its cellular traffic over both its local network and its wide area network. The hospital is hoping to use high-speed, low-latency 5G technology to improve access to care, even over long distances.

Understanding demand

Like AT&T, Telenor has indicated that it is open to partnering on MEC. According to Terje Jensen, Head of the Network Architecture Team, the company is considering deals to share the cost of building edge facilities, or it might welcome a partner looking to share a platform for virtual network functions (VNFs). Either way there is a huge benefit in terms of cost, Jensen said.

Other CSPs also have plans to roll out MEC. Verizon, for example, has indicated it will launch an MEC platform before the end of 2019 by installing edge computing functions in its C-RAN hubs around the US.

Telefónica Group is interested in understanding demand. In a white paper issued in February, the company said that while the industry is still evaluating MEC use cases, its strategy is to measure customers' appetite, as well as understand new business models necessary for successful commercial roll out by trialing many use cases, including those for:

- Internal services such as access virtualization and programmable connectivity
- Commercial services such as pay-TV, internet and enterprise cloud storage
- Third-party services such as cloud gaming, content catching, file storage and synchronization, and software-defined wide area networks

The next section provides guidance to CSPs on how to move forward with co-creation, network slicing and mobile edge computing in 5G networks.

Section 6

Make it happen – Strategies for leveraging 5G innovation

The days of communications service providers (CSPs) developing services and then looking for a market are gone, especially as 5G becomes reality. 5G innovation will be driven by enterprise verticals, and CSPs will need to develop services based on use cases. Mobile operators must be prepared to deliver these services in conjunction with partners who understand the specific needs of manufacturing companies, healthcare organizations, automakers and others, and they must decide which verticals make the most sense for their businesses. Following are steps CSPs can take to leverage capabilities like co-creation, network slicing and multi-access edge computing (MEC) to deliver the customized services enterprises want:

Plan partnerships

The process of co-creation begins when CSPs realize they are not in control of the discussion about what 5G can do. What the enterprise wants and needs will drive co-creation, and delivering the capabilities will require CSPs to collaborate not only with enterprises, but also industry vertical organizations (for example, AT&T and MxD – see page 15), suppliers, standards bodies and open source groups.

The cost of collaborating with all these groups can be high, which is why it is important to set goals and expectation for each engagement. To be effective, co-creators need a plan and a specific problem to solve, and they must agree ahead of time how services will be monetized, how all partners will be compensated and who will own intellectual property rights.

While some co-creation is likely to take place in a closed environment at one partner's lab or the other, all partners must be unencumbered by distance and access. Keep pace with or get involved in efforts to develop open systems, open APIs and rules around multi-party collaboration so that all parties work from the same sets of data and have access to the same systems.

Consider culture

CSPs and enterprises often speak about the application of technology differently. CSPs need to be able to understand enterprises when they talk about their business needs. Enterprises often speak more in IT terms than network operations terms. Begin by setting a baseline for common language to describe technology, data models, goals and how to measure success. TM Forum members' work on the Ecosystem Business Architecture and business models can help (see page 17).

Start automating

The biggest challenge for 5G network slicing will be automation on the back end. Dynamic slicing by nature must be orchestrated automatically, from provisioning the slice to adjusting parameters based on policy, to optimization and monetization. The adage that says, 'If you can't measure it, you can't bill for it' applies more than ever to network slicing when the point of it is to monetize custom service levels for various networked applications.

Collaborate on standards

It is difficult to create standard KPIs for service quality when the importance of individual KPIs to one enterprise does not always reflect the importance to another enterprise. CSPs must represent their customers in the effort to standardize KPIs for quality so that enterprises can know what to expect in the real world and have a basis for comparing performance among competing service providers.

Consider 4G slicing

Many CSPs are waiting for Standalone 5G to deploy 5G slicing, believing it is necessary to deliver services end to end – and they are right. However, CSPs that have implemented 4G slicing have learned valuable lessons along the way and feel they can more easily transition to 5G slicing because of their experience. Automating bad processes is not the answer, so working on slicing in a 4G environment can help CSPs improve processes to get ready for 5G network slicing.

Understand assurance

Before deploying network slicing for enterprise customers, CSPs need to have service assurance down pat. They need to be able to prove network slices are delivering as promised. If they can't, they will not be able to monetize them. Worse yet, there is no going back: Once an enterprise is given the capability to customize service characteristics on demand without paying a premium, they are not ever going to pay a premium. Approaching network slicing from a service assurance perspective will help operators determine which attributes and key performance indicators (KPIs) can be guaranteed, adjusted automatically and monetized effectively and reliably.

Focus on vRANs

With CSPs indicating that slicing is at least two years away, they should turn their attention to the radio access network (RAN), in particular the virtual RAN. It is not yet clear that CSPs know how to deliver network slicing across a vRAN or that vRAN makes good business sense. Monetization of slicing could help make the business case.

Weigh MEC options

Most CSPs believe they will need to build their own edge cloud/data center facilities for multi-access edge computing, but it may make more sense to partner to build them. It is too soon to determine whether one approach is better than another. Instead, CSPs should evaluate each MEC opportunity based on use case, geography, cost and available real estate.

Hire cloud talent

CSPs still have a long way to go to be as proficient in cloud operations as they are in network operations. As part of their MEC deployment, they need to hire staff capable of managing internal cloud environments and of monitoring outsourced cloud environments.

Assess security

CSPs will have to rethink their security posture for MEC facilities. New procedures and capabilities will be required to secure remote facilities physically against weather and natural disasters as well as intrusion. In addition, with customers' data stored at the edge, operators will need to consider their cybersecurity posture and how to protect data integrity.

Plan for management

CSPs have been working to centralize management and orchestration of services and infrastructure, but with smart devices and MEC facilities at the edge, operators will need to reconsider their approach to management, monitoring and other support activities, including analytics. CSPs should make end-to-end management and orchestration a key priority and part of the design process as they adopt MEC, not something to be dealt with later.

Additional features and resources

ORACLE Communications

tmforum

Unlock 5G for Enterprise with Co-Creation, Monetization and Digital

For many years consumers have been the bread and butter of communications service providers' business model. Pricing mechanisms, channels and systems of engagement have primarily been oriented around B2C – and with good reason since consumers drive most revenue today.

That paradigm is radically and rapidly shifting as service providers lay the groundwork for 5G. Early consumer-oriented launches are typically charging very little, if anything, for 5G services. The enterprise market represents much of the opportunity to generate returns on the billions of dollars service providers will spend on 5G infrastructure and supporting systems.

The 5G Enterprise Opportunity: A Defining Moment

Service providers can no longer afford to build expensive networks and be relegated to simply providing connectivity. Instead they must move up the value chain and become more central to their customers. Enterprise customers require customizable solutions, agility, speed, automation and scalability. To thrive in this new environment, service providers will increasingly need to adapt their mindset and systems.

Figure 1: Enterprises across industries represent the future of the 5G monetization opportunity.

Keys to Success in Unlocking the Opportunity

What must service providers consider to deliver success in their 5G enterprise strategy?

- Co-creation of services in ecosystems and marketplaces
- Network slicing
- Modern monetization
- Digital experience

Co-Creation in Ecosystems and Digital Marketplaces

The simple days of service providers going it alone are a relic of the past. Enterprises across industries will benefit from 5G-enabled ecosystems that are led by service providers in cooperation with enterprises and other partners. In fact, the World Economic Forum estimates that more than $10 trillion of value depends on such opportunities enabled by the telecom industry.

In order to maximize opportunities for co-creation and value generation, service providers need the tools to collaborate with partners to quickly and seamlessly launch innovative market offerings. Often taking the form of digital marketplaces, these 5G-enabled ecosystems require the ability to rapidly deliver services based on different pricing models, operate across multiple digital channels, and support complex partner relationships including with enterprise customers. Co-creation bears fruit in revenue-generating digital marketplaces.

Oracle participates in a TM Forum catalyst called Zero Touch Partnering that illustrates a paradigm for achieving frictionless collaboration in bringing new services to market. Service providers can leverage TMF Open APIs to rapidly spin up ecosystems and easily on-board offerings from new partners. A simplified user experience enables product managers to assemble timely and innovative offers. Oracle's component of the solution provides comprehensive order orchestration capabilities driven by the TMF Product Order API and in alignment with the Open Digital Architecture principles.

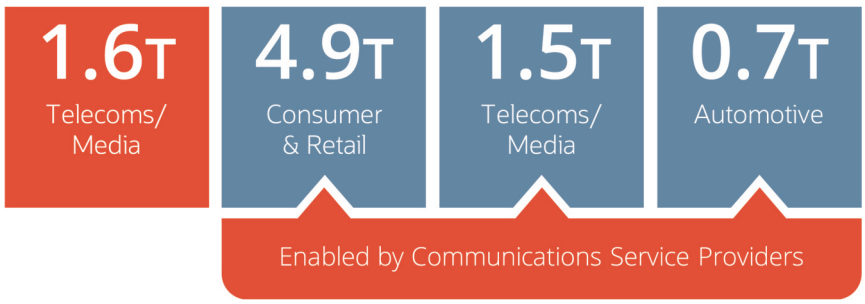


Figure 2: World Economic Forum estimates of value enabled by the telecom industry

Network slicing

Network slicing uses principles of modern cloud architecture to slice a physical network into multiple independent virtual networks that can meet service-specific requirements for latency, data rates, quality of service and other parameters. 5G represents a massive new opportunity for service providers to support many concurrent network slices and deliver vertical-specific capabilities to enterprises. Here are a few examples:

- Smart Car – Specialized slices with appropriate Quality of Service (QoS) parameters will be used for traffic flow information, entertainment, toll passage tracking and eventually autonomous driving.
- Smart Industry – Many industry-watchers expect Industry 4.0 to be the 5G killer app, with slices for IoT digital twinning, robotic process automation, automated sensor-driven crop harvesting and more.
- Smart Health – Healthcare institutions, first responders, medical device manufacturers and service providers are co-creating services such as wearables linked to high reliability, low latency slices.

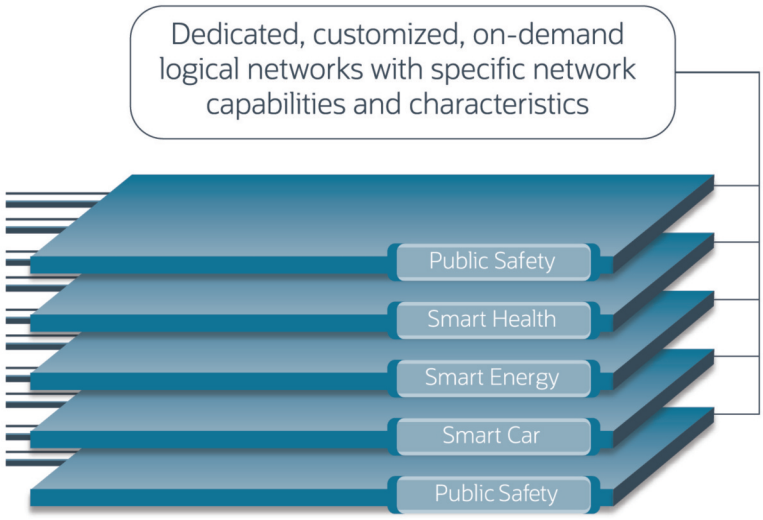


Figure 3: Network slices will enable enterprises to take advantage of customized characteristics.

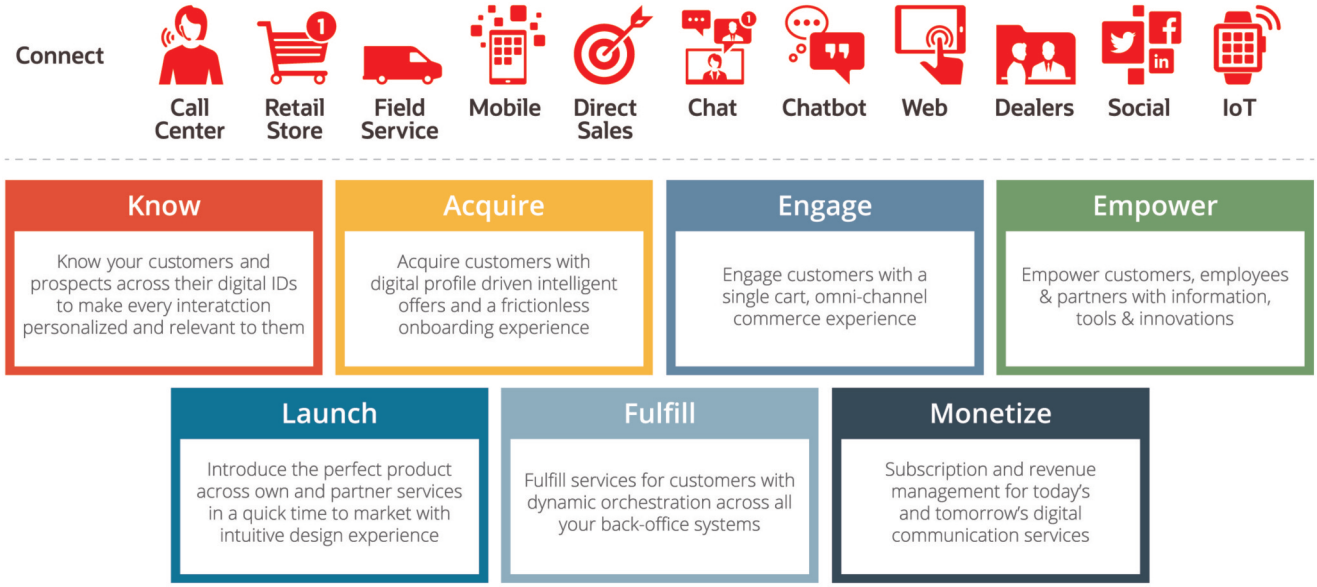


Figure 4: Enterprise customers seek an end-to-end digital experience powered by modern monetization.

Modern Monetization

As the old adage goes, "If you can't bill for it, it's only a hobby." Service providers are rethinking their approach to monetization in light of the many new requirements for 5G enterprise services. These include:

- Massive scalability – In a world with billions of connected people and tens of billions of connected devices, monetization systems must scale to handle massive volumes of data.
- Convergent charging – The 5G charging function supports both online and offline charging. Integrated online charging and policy will be essential for service providers to give customers a real-time experience that places them in control of their services and spending.
- System agility – As new use cases quickly unfold, enterprises need the capability to monetize any type of service and charging model: pay by the click, megabyte, minute, download and more.
- Cloud-native architecture – Containerized microservices in a DevOps environment result in improved security, automation, agility, availability and cost structure.
- Partner management – Ecosystems and digital marketplaces that depend on co-creation require the ability to quickly spin up and spin down partner relationships and efficiently automate commercial settlements.

Digital Experience

Enterprise customers are increasingly seeking B2C-like digital experiences and looking to offer similar experiences to their end users. They expect AI-driven interactions as they progress from offer consideration to purchase to consumption to payment. Many companies approach this in piece parts but Oracle is revolutionizing the industry with a 5G-ready, end to end cloud solution called Digital Experience for Communications. Powered by modern monetization and fulfillment capabilities, enterprise customers now have engaging buying, care, and launch experience – all delivered at substantially reduced cost.

Conclusion

With past "G's", service providers have found themselves in the position of investing heavily in building infrastructure yet losing revenue and margin to disruptors. 5G is a defining moment for service providers to move up the value chain from being connectivity providers to ecosystem providers in cooperation with enterprise customers and partners.

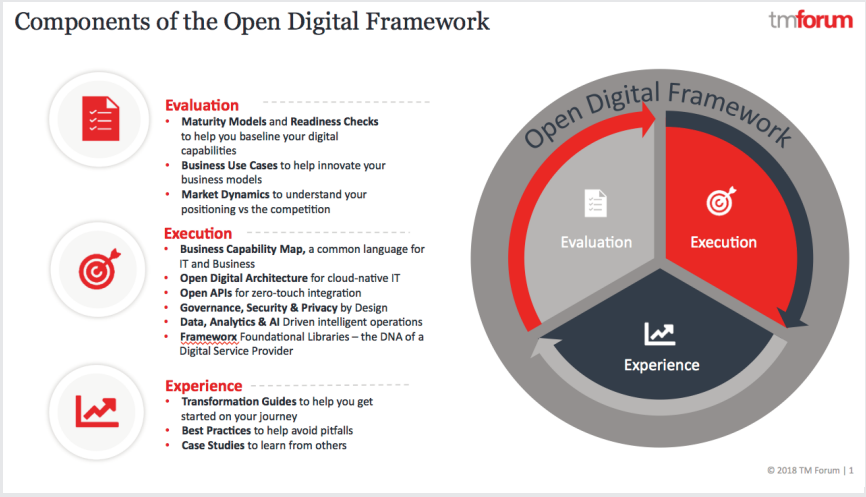
Oracle is uniquely positioned to support service providers as they unlock this opportunity. With 430,000 customers and #1 industry leadership positions in financial service, healthcare, public sector, insurance, communications and more, Oracle has a strong understanding of enterprise customers and dynamics across verticals. This is coupled with Oracle's decades of experience of providing world-class monetization, orchestration and digital experience services and mobile network infrastructure to hundreds of the world's service providers, and the leading-edge capabilities to enable continued innovation and success.

TM Forum Open Digital Framework

Delivering the tools to go from concept to cash in just 18 days

The TM Forum Open Digital Framework is an interactive, continuously evolving collection of tools, knowledge and standards that give communications service providers (CSPs) an end-to-end migration path from legacy systems to modular, cloud-native IT components. Simply put, it is a blueprint for service providers to deliver intelligent operations fit for the 5G era.

A prototype version of the framework is available now for TM Forum members to explore. It is being developed through the TM Forum Collaboration Program and Catalyst Program, and builds on the success of the Forum's established Open APIs and the Frameworx suite of standards. Specifically, it includes:

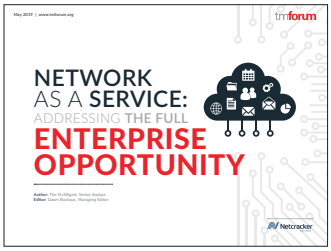


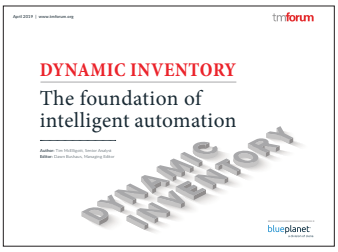
- **Open Digital Architecture (ODA)** – an enterprise architecture blueprint, common language and key design principles for modular, cloud-based, open digital platforms that can be orchestrated using AI
- **Open APIs** – 50+ standardized REST-based APIs to facilitate zero-touch integration and zero-touch partnering
- **Data & AI standards** – an industry-agreed data model, together with standards maximizing the potential of AI to enhance customer experience and increase operational efficiency
- **Reference implementations** – a framework for assembling and validating ODA components in the Forum's Open Digital Lab, fostering the creation of a services marketplace
- **Practical guidance** – guides and videos showing how the Open Digital Framework can be used to transform the core business and enable new business growth
- **Foundational libraries** – normalized models providing a common language for business processes and information that simplifies and de-risks transformation projects

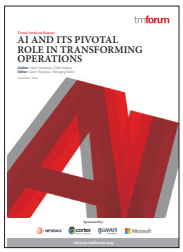
The goal of the Open Digital Framework is to help service providers increase agility and drastically reduce the development cycle for products and services from 18 months to 18 days. Much of the collaborative work that is part of the framework is already available, but it helps to organize it and make it more accessible. The framework is a work in progress and will improve through crowdsourcing.

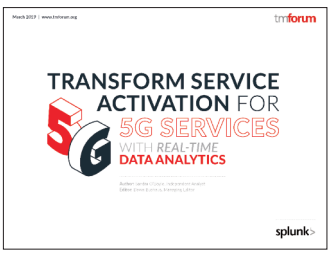
If you would like to learn more about the project or how to get involved in the TM Forum Collaboration Community, please contact Andy Tiller.

TM Forum research reports









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