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5G: IS PLATFORM THE KILLER USE CASE?

JUNE 2017

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Published by:
TM Forum
4 Century Drive,
Parsippany,
NJ 07054
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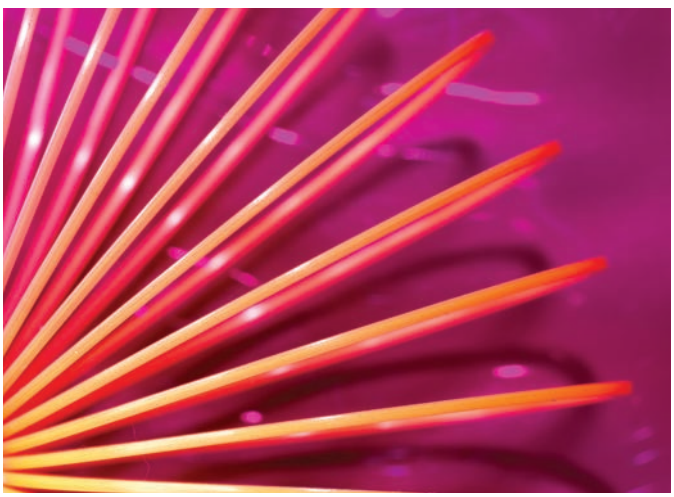
www.tmforum.org
Phone: +1 973-944-5100
Fax: +1 973-944-5110

ISBN: 978-1-945220-24-1



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THE BIG PICTURE

Welcome to our first ever report on platforms and 5G, looking at the relationship between platform business models, the internet of everything (IoE) and 5G. Through our research, which included an online survey of 61 telecom professionals from 52 companies, we've discovered that 5G will be important, but not necessarily critical, to the success of platform business models. But on the flipside, platforms combined with IoE will be essential to 5G – and could be a killer use case.

WHAT IS A PLATFORM?

In short, a platform strategy can have two key elements: a platform business model that sets up digital ecosystems or marketplaces connecting consumers with producers of goods and/or services (like Amazon Marketplace); and a platform-based IT architecture, which supports electronic marketplaces and facilitates the digital business model (like Amazon Web Services – we'll discuss this in detail in Section 1).

"A platform approach is mandatory," says the head of transformation at a large Asian CSP. "We believe that defining 5G as just another air interface is too narrow. For us it's not so much about the air interface; it's about the complete transformation of the architecture into something that is highly agile, highly scalable and highly automated."

Most of the CSPs and suppliers we interviewed for this report echoed these comments, saying that 5G, network functions virtualization, software-defined networking and cloud-based platform business models are all inextricably linked and represent the best (perhaps only) way forward for CSPs.

SEIZE THE OPPORTUNITY

By combining platforms and 5G, CSPs have an opportunity to move beyond providing just connectivity to become ecosystem curators and enablers of many different verticals from smart cities to connected cars, the industrial internet of things (IoT) and more. By some estimates, this market will be worth close to a trillion dollars within the next decade.

"5G has become one of the biggest catalysts for change in our industry," Nik Willetts noted in his keynote at TM Forum Live! in May. "In the 5G world we are going to co-design what our customers need with the customer. And if we're going to really capitalize on the opportunity, we're going to need to transform our business as well as our technology."

That's where platforms come in. Operators need the flexibility of multi-tenant platforms to manage and monetize services with very different network requirements. Some applications, like IoT sensor networks, require relatively little bandwidth – they need to transmit small amounts of data sporadically but frequently. Other applications, like remote surgery, need huge amounts of bandwidth, extremely low latency and guarantees of availability and reliability.

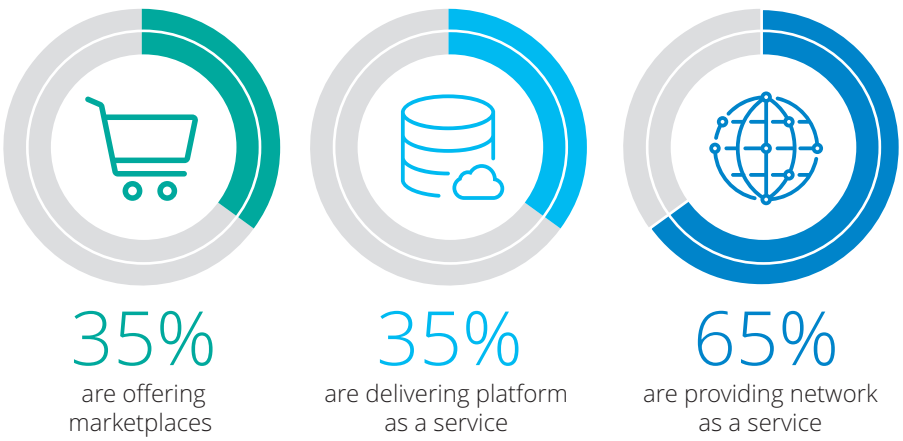
Delivering these and other types of traffic using shared resources is not easy. CSPs believe they can meet the demands by turning the network into a platform and creating network slices that are orchestrated and assured end to end through automated closed control loops using intent-based management, analytics and policy.

"We need to stop thinking about networks as providing connectivity and think of them as platforms on which we can build real-world applications," says Dr. Lester Thomas, Chief Systems Architect, Vodafone Group.

THE TRANSFORMATION BEGINS

Operators have begun their transformations into digital service providers and platform providers (see infographic). It's still very early days for 5G, however. While about 40 percent of survey respondents are participating in trials or proofs of concept, nearly a third said they are content to monitor developments and 12 percent will wait for standards. Initial air interface standards are not expected before the end of this year, and it will be much longer before next-generation core standards are in place. Today, for example, there are many more questions than answers about how to handle 5G network slicing.

CSPs EMBRACE PLATFORMS



Source: TM Forum, 2017

Throughout this report, we explore what operators and their suppliers think about platforms and 5G, what keeps them up at night and ways to address the challenges. Read it to understand:

- How operators and suppliers define 'platform'
- The kinds of platform services that are possible and how many service providers are offering them
- Which technologies are important to platforms
- Which services are best suited to a platform business model
- What's difficult about implementing a platform strategy
- Why open APIs are essential
- How NFV & SDN are related to platform and 5G
- Why standards are important
- Why operators want to implement 5G
- Where CSPs and suppliers are with their 5G strategies, and how in synch they are
- What the main obstacles are to 5G
- Why network slicing is so important – and so difficult
- How TM Forum Catalyst projects are addressing business and management challenges

SECTION 1

WHAT IS A PLATFORM STRATEGY?

This report explores the relationship between platforms, the internet of everything (IoE) and 5G, but before we can do that, it's important to explain what we mean by 'platforms'.

A platform strategy can have two key elements:

- a platform business model – rather than playing a direct role in the supply chain, companies build digital ecosystems or marketplaces connecting consumers with producers of goods and/or services, making it easy for them to do business (think, Airbnb, Amazon Marketplace, eBay and Uber)
- a platform-based IT architecture, which supports electronic marketplaces and facilitates the digital business model (think, Amazon Web Services or Microsoft Azure)

Many platform businesses began with a platform business model in mind, so they purposely built their infrastructure to support such a model from the outset. Others, including most communications service providers (CSPs), must evolve their business models to take advantage of existing infrastructure. And if examples are needed that this evolution is possible and can be outstandingly successful, note that Apple, the world's most valuable company, was originally a hardware vendor and that Amazon started out selling books online.

"And if examples are needed that this evolution is possible and can be outstandingly successful, note that Apple, the world's most valuable company, was originally a hardware vendor and that Amazon started out selling books online."

HOW DO YOU DEFINE A PLATFORM BUSINESS?

We wanted to know whether CSPs and their suppliers share this view of platforms, so in the first question of our survey, we offered the two definitions or allowed people to select 'both' or 'other', with an opportunity to write their own definition. Most CSPs and suppliers said they see platforms as creating digital ecosystems and providing platform-based IT infrastructure (see infographic p8).

Some respondents found both definitions too limiting and offered alternatives. We particularly like this one, courtesy of Dave Duggal, Founder and Managing Director, EnterpriseWeb:

"a set of organizing principles and capabilities for transforming to a digital service provider; as such platforms are for modeling domains and the processes that run across them – a universal application layer for designing and executing highly-dynamic, performant, scalable and resilient services"

Defining platform as a "universal application layer" that can be used broadly to model any domain means CSPs can use this approach to transform all aspects of their businesses, from business

processes to operational and business support systems (OSS/BSS) to the network itself.

It's interesting to note that about 15 percent of operators said digital ecosystems on their own are the true definition of a platform business. This could be the result of their job function – respondents with business responsibility as opposed to a technology focus were more likely to select the marketplace definition. But it could also mean that respondents don't fully understand all the components and potential of a platform strategy.

AMAZON LEADS THE WAY

Amazon is perhaps the best example to illustrate the potential. Back in the early 2000s Amazon was just an online bookstore. Then the company's CEO, Jeff Bezos, mandated that all technology teams within the company expose their data to each other and communicate through specified application program interfaces (APIs). He didn't allow any other form of inter-process communication, and he insisted that these interfaces be exposable to the outside world, which was key.

This gave rise to Amazon Web Services (AWS), whose value today is estimated to be $160 billion. The success of the web services business has enabled Amazon to invest in other parts of its business such as retail, devices, its Marketplace for third-party sellers and producing TV content.

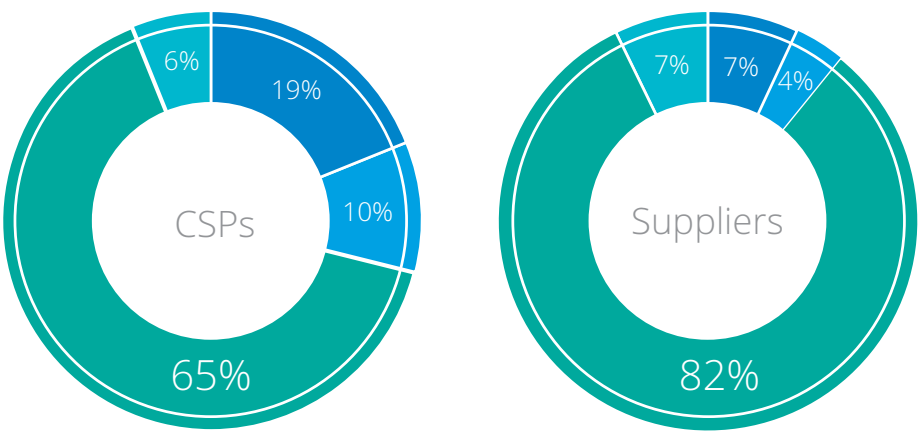
CSPs have a unique opportunity to turn their networks and OSS/BSS inside out the way Amazon did, and our survey results presented in Section 2 indicate that many of them do, indeed, grasp the potential.

BECOMING A CURATOR

Operators have an opportunity to move beyond connectivity to become platform or digital ecosystem curators, enabling many verticals. The World Economic Forum predicts this market could be worth $650 billion during the next 10 years and others suggest it could be even larger. The trick is figuring out how to turn the opportunity into reality.

"I believe it's time for us to change our mindset as an industry," TM Forum's CEO Nik Willetts said during a keynote at TM Forum Live! in May. "The world has changed around us. The industry is having, if you like, a midlife crisis. We're no longer sure what the future holds for us, but we know it's no longer just about dominating linear value chains. It's about embracing ecosystem economics and platform-based business models, where value is created through co-creation and collaboration, leveraging network effects to enable us to grow with phenomenal speed." (For more about leveraging network effects, check out this article on Inform.)

HOW DO YOU DEFINE A PLATFORM BUSINESS?



- Building digital ecosystems or marketplaces connecting customers with producers of goods and/or services, making it easy for them to do business (e.g. Amazon Marketplace)
- Providing an infrastructure platform that supports electronic marketplaces and facilitates a digital business model (for example, by offering PaaS, IaaS, NaaS, SaaS – e.g. Amazon Web Services)
- Both of the above
- Other

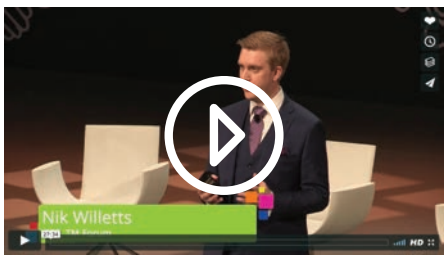
Source: TM Forum, 2017

PARTNERING FOR SUCCESS

Operators must collaborate not only with customers but also other CSPs and digital-native cloud providers like Amazon and Microsoft – in short, telcos must embrace partnerships with companies they traditionally have seen as competitors.

There may not be a big enough market for every CSP to operate its own marketplace or Microsoft Azure-like platform, but there is certainly opportunity to partner with these companies and others to create a network of platforms, on top of which CSPs can offer services such as end-to-end assurance, data analytics capabilities, security, and charging and billing.

WATCH TM FORUM CEO NIK WILLETTS TALK ABOUT THE POTENTIAL FOR PLATFORMS, IoE AND 5G AT TM FORUM LIVE!



WHAT KINDS OF SERVICES ARE POSSIBLE?

CSPs can offer a wide range of services as part of a platform strategy:

Infrastructure as a service (IaaS) – the CSP allows the consumer (usually an enterprise) to deploy applications on cloud infrastructure, with the consumer managing and controlling both infrastructure and applications.

Platform as a service (PaaS) – using APIs the CSP opens its network and IT systems to the consumer (usually a developer), so they can deploy applications on cloud infrastructure. The consumer doesn't manage or control the underlying infrastructure, but has control over the applications.

Software as a service (SaaS) – the network operator provides applications running on cloud infrastructure to the consumer. The consumer doesn't manage or control the underlying infrastructure or the application.

Network as a service (NaaS) – this is a flavor of SaaS where the network operator provides network functionality as a service. This could include hosting virtual firewalls or routers, content delivery, or bandwidth on demand. In some cases, operators host entire networks, as with mobile virtual network operators.

Digital ecosystems/ marketplaces – network operators act as curators, leveraging their status as trusted intermediaries to link producers of goods and/or services with consumers (or to connect other platforms). The key is to provide a seamless user experience and an opportunity for all the ecosystem partners to profit.

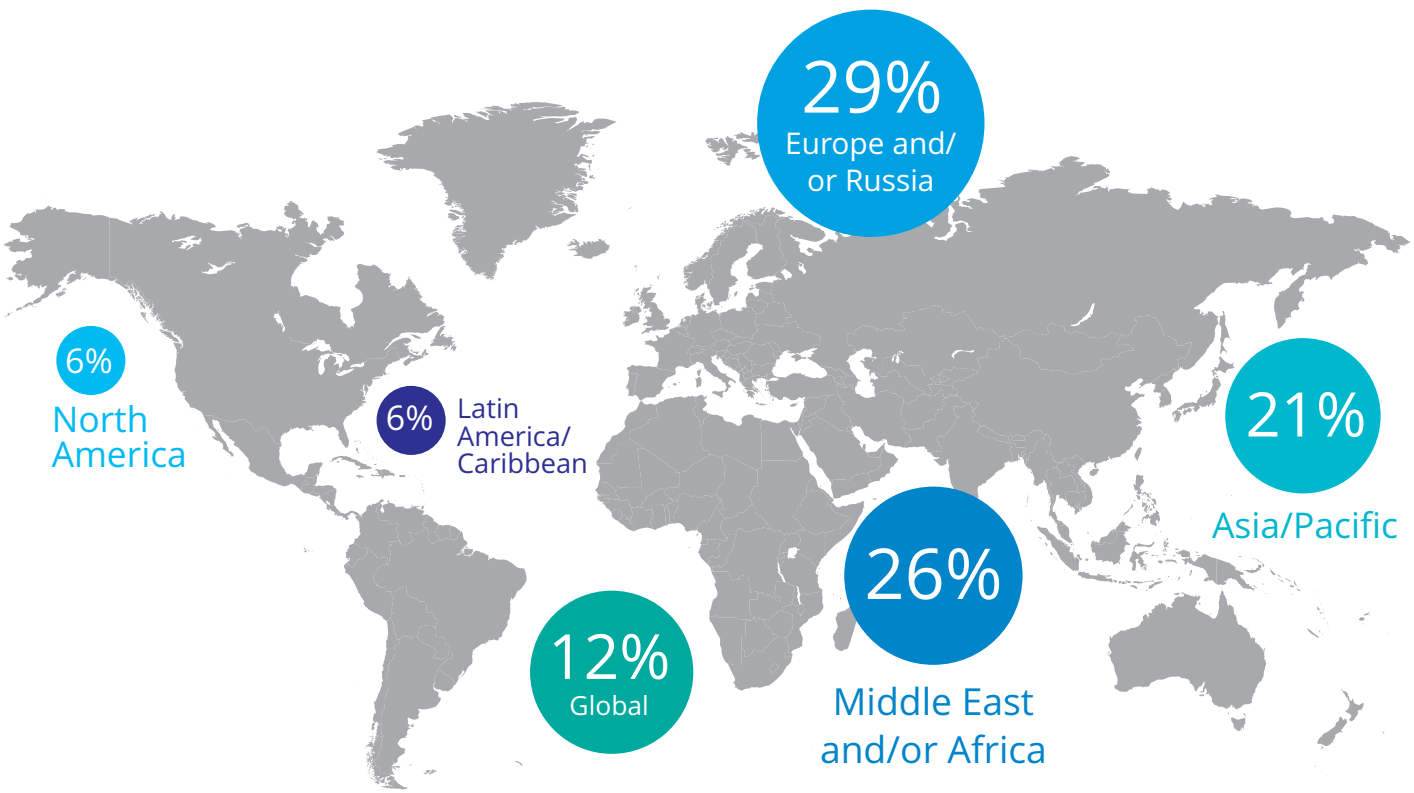
SECTION 2

THE RESPONDENTS SPEAK: THE FUTURE IS PLATFORMS

WHO: 34 CSPs AND 27 SUPPLIERS

Communications service providers (CSPs) survey respondents included chief systems architects; heads of transformation and billing; senior managers and senior directors in internet of things (IoT), engineering, product development and governance; and enterprise architects from 30 unique companies. In terms of job function, CSP respondents were fairly evenly split between the network and IT sides of the business. Supplier respondents included chief marketing officers, chief data scientists, heads of 5G and solution architects from 22 unique companies.

CSPs | WHERE:



HOW: ONLINE SURVEY AND TELEPHONE INTERVIEWS

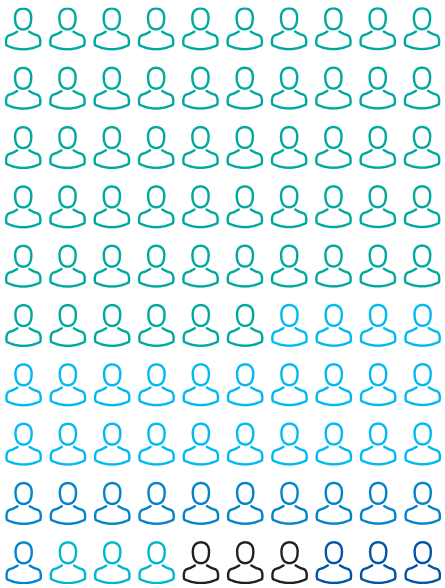
ARE YOU OFFERING MARKETPLACES?

CSPs have begun their transformations into digital service providers and platform providers. Many CSPs respondents indicated they are beginning to offer digital ecosystems connecting producers of goods and/or services with consumers, sometimes through partnerships with other platform providers.

In some cases, these are business to consumer (B2C) marketplaces and in other cases business to business (B2B). More than a third of these respondents said their companies are offering digital ecosystems or marketplace, and another 40 percent intend to do so within the next two years (see infographic on page 13).

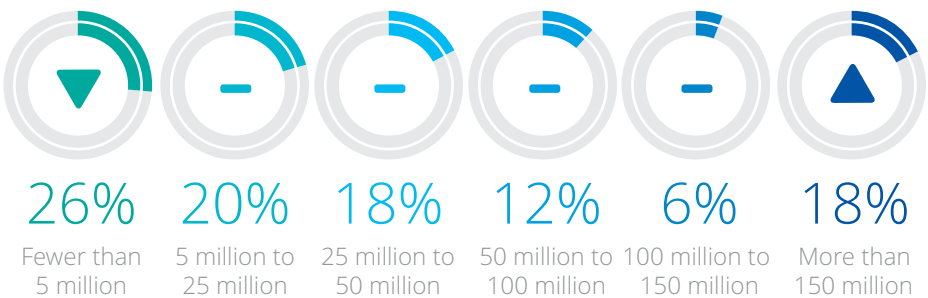
About the same percentage of suppliers said their customers are delivering digital ecosystems, but a larger number (54 percent) believe their customers will offer them within the next two years.

TYPE OF CSP:

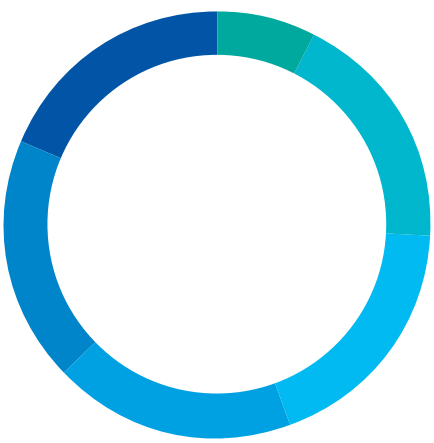


- Converged operator (some combination of mobile, fixed voice and data, cable) **56%**
- Mobile operator **24%**
- Fixed operator **12%**
- Cable operator **3%**
- Digital service provider (for example, smart cities, IoT) **3%**
- Other **3%**

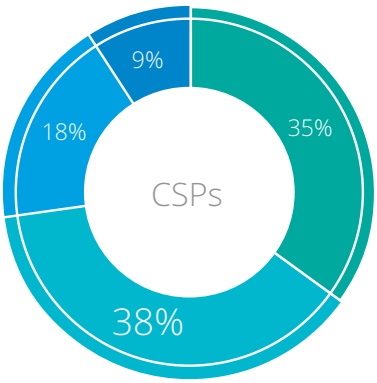
SIZE OF CSP



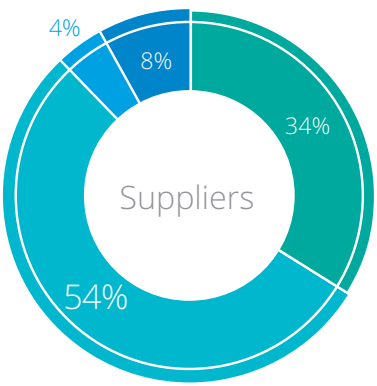
TYPE OF SUPPLIER



ARE YOU OFFERING A MARKETPLACE?



- We are already offering a marketplace
- We have plans to offer a marketplace within 2 years
- We have plans to offer a marketplace within 5 years
- We have no plans to offer a marketplace



- Our CSP customers are already offering a marketplace
- Our CSP customers have plans to offer a marketplace within 2 years
- Our CSP customers have plans to offer a marketplace within 5 years
- Our CSP customers have no plans to offer a marketplace

Source: TM Forum, 2017

CSPs are in the middle of many service chains so they are naturally well placed to become curators. They also have a wealth of knowledge about their customers that they can use in new, innovative ways.

Telefónica UK's O2 Drive insurance offer is a good example. To help customers get better insurance rates, the company combines data about its mobile services' customers – such as how long they've been a customer and their payment history – with information about their insurance policy and how they drive. (This data is collected via a smartphone app, but a service provider could also opt to collect this kind of data through sensors installed in the vehicle).

O2 Drive is offered in partnership with BGL Group, a UK-based insurance broker, but from the customer's perspective, O2 is the insurance provider. The service is sold through a direct website as well as through online insurance aggregator sites in the UK, and O2 partners with Amazon Web Services for the platform infrastructure. For more about O2 Drive, check out this case study on Inform.

OTHER EXAMPLES

Many Tier 1 operators are offering smart home portals and apps that aggregate products and services either for consumers or other businesses. AT&T's Digital Life and SK Telecom's Smart Home Platform, for example, are consumer-facing services, while Deutsche Telekom's White Label Smart Home portfolio is a B2B platform for partners including other telcos, utilities and device manufacturers.

In Switzerland, Swisscom is looking to take on Amazon through a joint venture with retailer Coop. Together the companies offer products from about 130 local, regional and national retailers in a marketplace called Siroop. The marketplace focuses on helping small businesses reach a wider customer base, for example enabling farmers in the Alps to sell their cheeses directly to consumers.

Vodafone also is targeting small businesses with its new Vodafone Digital Marketplace, which offers a suite of applications aimed different sectors from hospitality to construction. Vodafone is partnering with ecommerce platform provider AppDirect to deliver the service in Italy initially and plans to expand to other countries.

Vodafone proved the small business marketplace concept in a TM Forum Catalyst project last year. A new phase of the Catalyst, demonstrated at TM Forum Live! in May, expanded the platform concept, showing how to deliver 'anything as a service' (see panel on page 14).

DRONES DEMONSTRATE THE POWER OF PLATFORMS

If you can use a platform and 5G network slicing to enable drones as a service, you can deliver pretty much anything as a service.

That's how Dr. Lester Thomas, Chief Systems Architect, Vodafone Group, sees it. The company has been championing an ongoing TM Forum Catalyst proof-of-concept project, which has created a digital ecosystem platform to deliver anything as a service.

"We chose drones because it's a crazy application," Thomas says. "If I can demonstrate 5G slicing for drones, I can certainly demonstrate it works for other things like smart meters, smart cities and digital health."

In the first phase of the project, the team, which also includes Centina Systems, Huawei, Infosys and Invercloud, looked at how to onboard small and medium-sized enterprises to a digital ecosystem, how to monetize and assure services for them, and how to orchestrate the network to ensure efficiency.

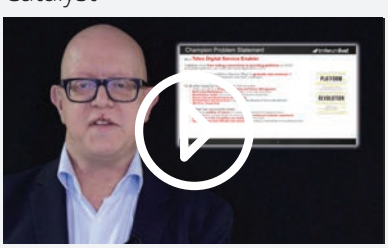
ADDING MOBILITY

The first phase was a fixed network solution but the most recent phase, which was demonstrated at TM Forum Live! in May, added mobility and IoT, in this case offering drones as a service for precision farming. The team used TM Forum's new CurateFX software-as-a-service tool to document user journeys and discover which APIs they would need.

CurateFx, which is built on TM Forum's Frameworx, Partnering Toolkit and Open APIs, is a cloud-based service that provides step-by-step blueprints, information-based decision tools, visualization maps and collaborative capabilities to help companies build digital ecosystems.

Some of the interesting findings of the Catalyst are that businesses want platforms but they don't just want connectivity; they also want the platform operator to provide data analytics that they can use and perhaps monetize. Also, the team discovered that the real opportunity for CSPs likely lies in creating a network of platforms, delivering a connectivity slice across them, assuring the services end to end and offering data analytics along with charging and billing as add-on services.

Watch this video to learn more about the *Anything-as-a-service* Catalyst

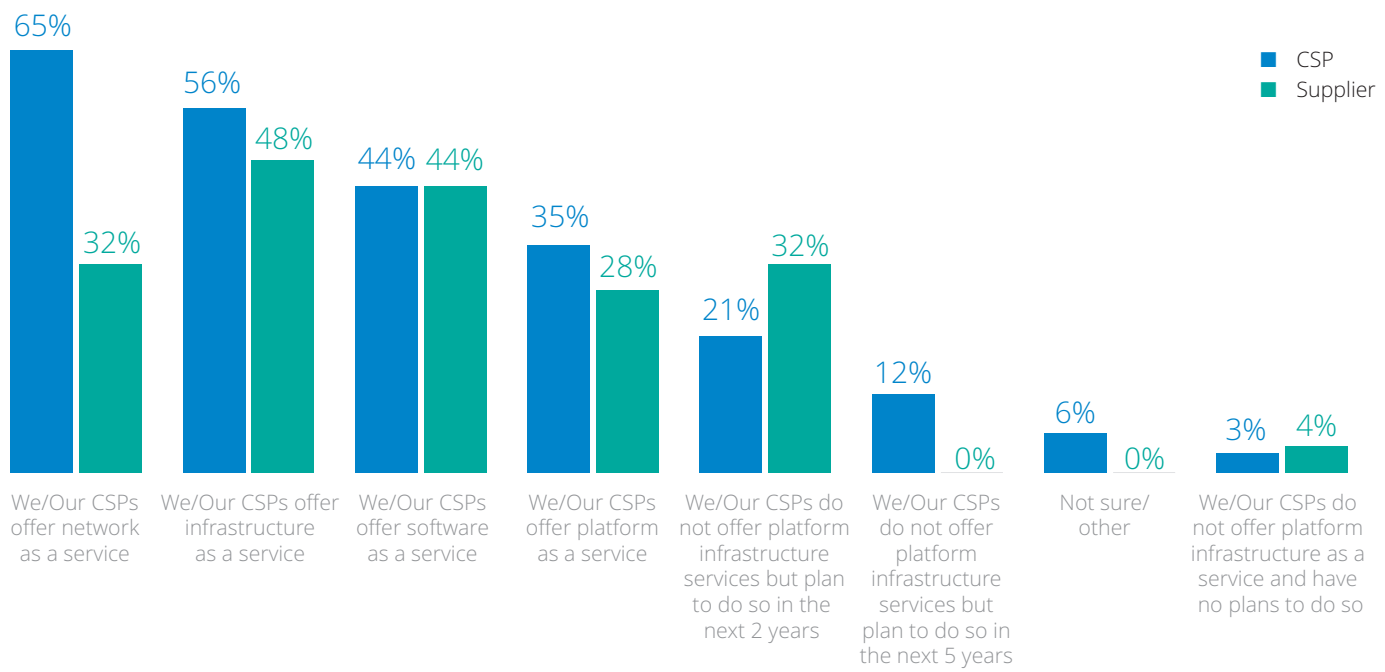


PLATFORM ARCHITECTURE

CSPs also are delivering platform infrastructure services (for a recap of the types of services, see page 9). A full 65 percent of CSP respondents said they are offering network as a service (NaaS – see infographic).

We are a bit surprised that this number is so high, and apparently suppliers are too, since they said that just over 30 percent of their telco customers are offering NaaS. This is encouraging, however, because it indicates that operators are making progress with network functions virtualization (NFV) and digital transformation. We'll talk more about NaaS in Section 4.

DO YOU OFFER PLATFORM INFRASTRUCTURE SERVICES?



PREPARING FOR PAAS

More than a third of CSPs said they are offering platform as a service (PaaS). We expect this number to grow as operators progress with transforming their networks, business processes and OSS/BSS. The next step is dynamically exposing capabilities to partners through application program interfaces (APIs).

Operators can take a couple of approaches when it comes to PaaS: They can build their own platforms and open them to developers, or they can partner with other platform providers. China Unicom, one of 10 CSPs that have committed to adopting TM Forum's Open APIs for digital service management, is taking the first approach.

Shen Ke, Vice President, China Unicom, Shanghai Branch, spoke about his company's digital transformation and opening up to developers during the Huawei Connect 2016 conference. *Telco Transformation* published a transcript of his keynote. He explained how Shanghai Unicom's digital transformation includes bridging the large gap between "front-end" customer-facing platforms and "back-end" OSS/BSS.

"By gap, I mean the many siloed services and products and a lot of manual labor needed at both the front-end and the back-end," Shen Ke says. "This gap is what distances us from customers, making it difficult to respond to B2B customers' requirements. So, we thought maybe we could build an intermediate platform to connect the front-end and the back-end. And that's exactly what we did – we built an open capability system."

Shanghai Unicom has connected 22 internal systems through the open capability platform and integrated 200 capabilities into APIs that were eventually pared down to 83 scenario-based capabilities. More than 30 partners have registered on the platform and, according to Shen Ke, the company's APIs are invoked 40 million times a month, a number that is growing by 20 percent a month.

Shanghai Unicom has used its open capability platform to create a new digital ecosystem with two major portals: Smart WO e-commerce, a B2B portal, and WOchuang Space, a developer portal. Through the portals, the company has launched a WOoffice app for enterprises and has co-branded credit cards with the Bank of Shanghai. The company has also rolled out smart parking services.

PAAS PARTNERS

Through its Geeny connected partner ecosystem, Telefónica NEXT offers a platform for IoT developers targeting consumers, but otherwise Telefónica prefers to partner with platform providers to deliver PaaS capabilities on top of connectivity for its enterprise IoT customers, says Andrés Padilla Fuentes, Director of New IoT Solutions, Telefónica Global.

"We have tried to offer platforms for developers to create their ecosystems in the past, not in IoT but in other areas, and we haven't been very successful," he says. Instead, the company is integrating with multiple platform providers that are already supporting IoT ecosystems, such as Amazon Web Services, IBM Bluemix and Microsoft Azure.

"Because the platform-as-a-service market is so fragmented, we need to be ready to operate with at least a few of them," he says.

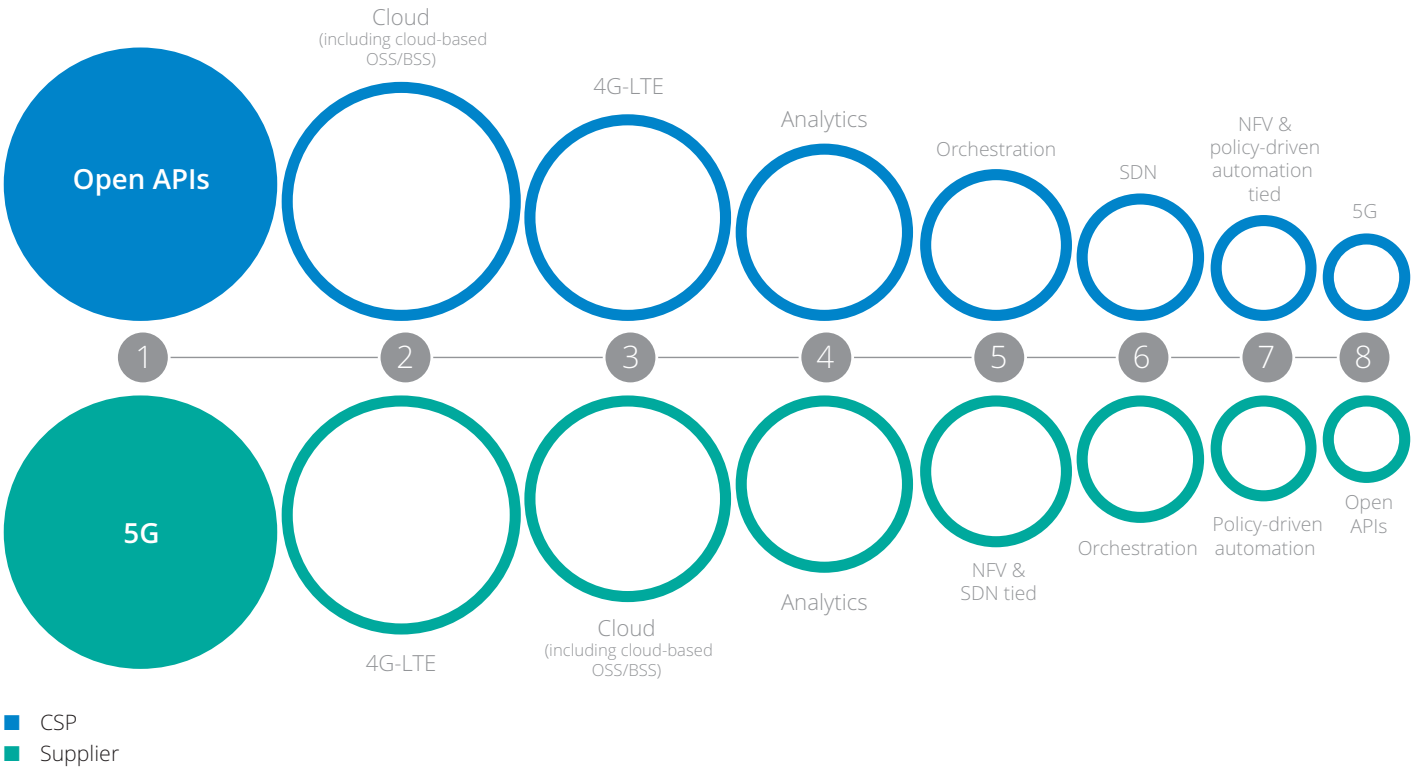
For more about how other TM Forum members are opening their networks to partners, see our report *Orchestration: Get ready for the platform revolution* and our ebook *Platforms: How to join the revolution*. For more about the Forum's Open APIs, see our ebook *Open APIs: Turning business strategy into reality*

With the release of Frameworx 17 in July, TM Forum will publish an information guide outlining the Digital Platform Reference Architecture. The document will explain in detail the potential roles for CSPs in the platform economy and how TM Forum assets can help. For more about Frameworx, see page 58.

WHAT'S MOST IMPORTANT?

We asked survey respondents to rate the importance of several technologies to operators' platform strategies, where 1 was very important and 5 was not important at all. Respondents rated all the technologies as important, but some were viewed as slightly more so than others. We've ranked them below based on their average rating. Tellingly, the most important technology to CSPs (APIs) is the least important to suppliers (5G) – and vice versa.

WHICH TECHNOLOGIES ARE IMPORTANT TO PLATFORM?



Source: TM Forum, 2017

OPEN APIs ARE CRITICAL

It's not surprising that open APIs came out on top with CSPs. The exposure of platform capabilities happens through APIs, and they must be standardized so that ecosystem partners can collaborate easily to deliver services. This is why so many of the world's leading telcos have committed to using the Forum's Open APIs and are requiring their suppliers to do the same. In addition to the ten CSPs that have agreed to adopt the Open APIs, 18 suppliers have pledged to support them.

The discrepancy between CSPs' and suppliers' answers when it comes to APIs and 5G is interesting. Again, it's important to note that everyone rated all the technologies as important, but the operators we surveyed seem to put less emphasis on 5G when it comes to platforms, while some suppliers may not be concerned enough about APIs. We will discuss 5G in much greater detail in the next section, but suffice it to say that operators seem to be looking past the 5G marketing hype and see platforms as promising with or without 5G.

SOFTWARE IS KING

The other technologies – cloud, NFV, SDN, policy-driven automation and analytics – were clustered together, with operators and suppliers, rating them very or moderately important. Key here is that these technologies are about virtualization and automation, which are becoming increasingly important.

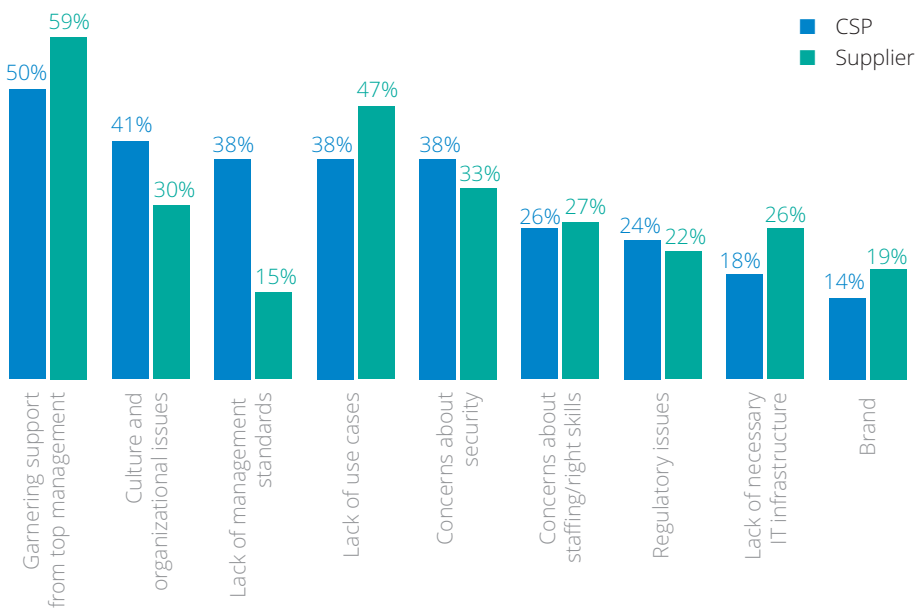
As the internet of everything takes shape, network and service management must be zero-touch, because it simply isn't feasible to manually support the volume and velocity of changes that must happen in software-defined networks made up of billions of nodes running millions of applications. This requires closed-loop automation, combined with policy and analytics. We'll discuss this more in Section 4 where we look at network slicing.

WHAT ARE THE BIGGEST CHALLENGES?

We asked respondents to rank the challenges operators face in implementing a platform strategy. The infographic below shows the percentage of respondents who ranked each challenge in their top three concerns.

Half of CSPs and almost 60 percent of suppliers put support from top management in their top three challenges, which reinforces the findings in our recent report *Digital transformation: Navigating the way to success*. In that survey, operators picked management support and culture as the most important challenges and critical success factors.

RANKING THE PLATFORM CHALLENGES



Source: TM Forum, 2017

CHANGE IS GOOD

Adopting a platform strategy is a radically different approach for telcos, one that requires collaborating with customers to develop services, encouraging experimentation and learning from failure. This takes courageous leadership.

"[Digital natives] have a laser-focused strategy that's built from a very deep understanding of customers' needs...and they focus on agility and the ability to outpace their competitors, because they know if they get there first they will dominate the market for many years," says Nik Willetts, CEO, TM Forum. "They also have a different approach to technology; they're not treating it as some kind of cost center or a kind of internal supplier, but as the heart of the business."

The CSPs we interviewed agree. "Telcos are used to having this integrated model where we try to do everything on our own and fight the OTT players," says the head of strategy at a large Asian CSP. "We need to change that mindset because they are here to stay; they will not disappear. We need to position ourselves in someone else's value chain – instead of always being at the front, we as telcos will become more of an enabler, which is a different way of thinking."

Milind Bhagwat, Enterprise Architect, BT, echoes the comment about mindset and adds, "The way projects are funded today in a telco is based on short-term benefits, but platforms are a long-term investment, which means that the way business cases are created and approved has to change."

THE IMPORTANCE OF STANDARDS

For CSPs, lack of standards for and consensus about how to handle management is a real concern when it comes to delivering platform services. Not only did almost 40 percent of operators put it in their top three challenges, but overall when all the rankings were averaged, it was their No. 1 concern. By contrast, only 15 percent of suppliers ranked this as a top concern.

CSPs see end-to-end orchestration as a key component of their strategies to become platform providers: Multiple orchestrators in multiple software platforms must communicate with each other through APIs and with other network and infrastructure components to deliver and assure services. In many cases, these components will be in someone else's domain – another CSP's, a supplier's, a platform partner's or an enterprise customer's.

CSPs must agree to use the same information and data models along with standard APIs so that orchestrators and other components in different domains can communicate. This, combined with intent-based management, is how service providers will automate service provisioning and management end to end – the intent-based management abstracts the complexity of the network at a high level, then uses a customer's intent along with assurance, analytics and policy to manage it.

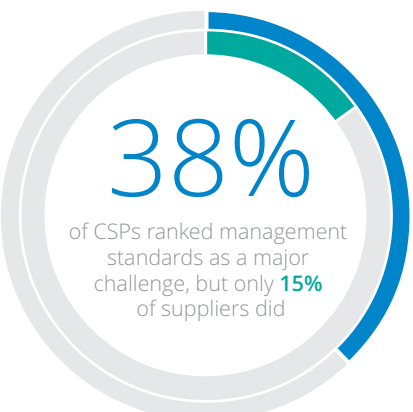
It's challenging to get agreement on common information models that allow for zero-touch, end-to-end service operation across partners and technologies, while still allowing for innovation in API data models. TM Forum's approach is to use an information model to provide a skeleton framework, which can then be augmented with patterns and best practices to support automated generation of API data models.

WHAT GIVES?

According to our survey results, suppliers are much less concerned about management standards, which is a bit surprising given that many suppliers talk publicly about their commitment to standards and open source. But if standards really are a lower priority for them, it could signal their preference to continue selling proprietary solutions to CSPs.

This is an unrealistic expectation, however. Operators have made it clear that they want to eliminate vendor lock-in. Ultimately, successful ecosystems must deliver value to all participants. The challenge for 5G is to define standards for management in a way that avoids lock-in, while at the same time providing an agreed framework for suppliers to add value.

DISAGREEMENT ABOUT PLATFORM MANAGEMENT STANDARDS

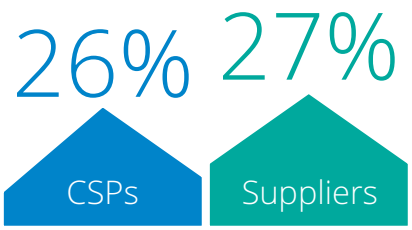


Source: TM Forum, 2017

LACK OF SKILLS

Overall, there is a shortage of software skills, and when you add familiarity with telco networks as a requirement, it's even more difficult to find talent. The CSPs we interviewed said they are trying to reskill employees but it's not easy, especially when so many new skills are required.

"We as operators just have too much on our plates, from SDN and NFV transformation to DevOps to IoT platform," says one respondent. "The whole business is changing – and this is too much at once."



cite availability of skills as a top platform challenge

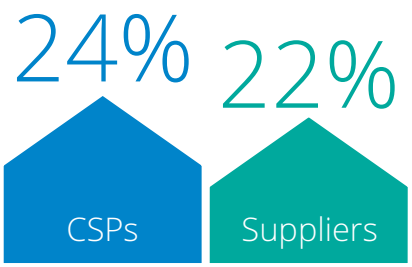
Source: TM Forum, 2017

REGULATION IMPLICATIONS

Regulation is also a concern because CSPs are operating in a highly-regulated environment, whereas their competitors, the digital natives, are not. Most telco regulation is based on a set of well-defined services but it's unclear how regulation might affect platform-based services.

"We have strict rules about what we can offer and even what price we can ask in many cases," explains Diego Lopez, Head of Technology Exploration and Standards, Telefónica. "The definition of platform services would be complicated under current regulatory rules. I'm concerned that this could translate into trying to regulate things that can't be regulated or that can be very difficult to verify."

We'll cover lack of use cases and security, both of which ranked highly as concerns, in Section 4 because they are also 5G challenges.



say regulation is a main challenge in implementing a platform strategy

Source: TM Forum, 2017

SECTION 3

THE RESPONDENTS SPEAK: GETTING READY FOR 5G

The head of ecosystem development at a Tier 1 European CSP said he sees the promise of 5G as twofold: "One is a massive mobile broadband buildout – that's coming from the growth of traffic and is a normal way of doing business in the telecom space. The other is about IoT and broadening the applicability. We can broaden it not just on the technology side, but also on the platform or supporting services side."

WHAT'S SO GREAT ABOUT 5G?

5G is exciting because it promises to enable communications service providers (CSPs) to deliver a wide range of new services, from connecting autonomous vehicles to remote surgery, tactile internet and internet of things (IoT) sensor networks. Below are some of the expected changes that will come with 5G, and the infographic on page 23 shows the kinds of use cases operators and suppliers envision, many of which will be delivered using platforms.

Improved coverage and capacity – requirements are for 5G to support up to a million connections per square kilometer; millimeter wave, small cell and massive MIMO (multiple-input, multiple-output) technologies will help 5G support billions of connected devices

Increased speed/throughput – 5G promises data rates of at least 10Mbps almost everywhere and up to 10Gbps in dense environments

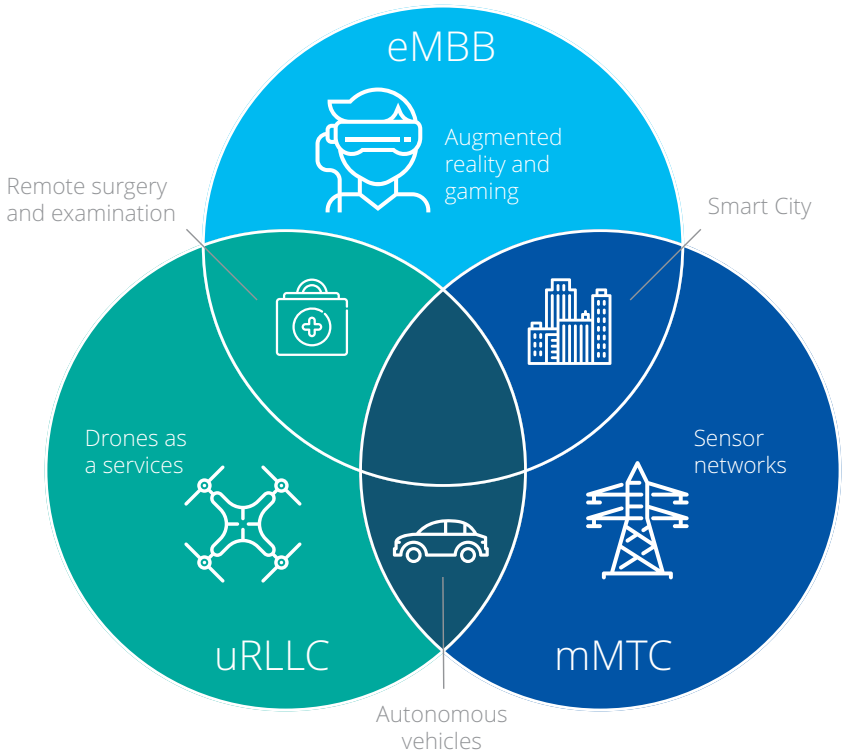
Reduced latency – end-to-end latency on a 4G network typically is about 50-100 milliseconds but on a 5G network it will be 1 millisecond or less

Ultra-high reliability and availability – 99.9999 percent availability is anticipated in 5G networks

Improved efficiency – Sharing mobile and fixed infrastructure increases efficiency and improves utilization. And base station energy efficiency is expected to increase 30-60%

> *"The difference between 4G at a 100-millisecond delay and 5G at 1 millisecond is in the order of half a car length. Half a car length can mean the difference between life and death."*
>
> Dr. Kenneth C. Budka, Senior Partner, Bell Labs Consulting, speaking at the Brooklyn 5G Summit in April.

5G's GOT POTENTIAL



Source: Based on Ericsson graphic, TM Forum, 2017

eMBB

(enhanced mobile broadband) – use cases require high bandwidth, low latency and in some cases ultra-high reliability; examples include 4K and 8K video, immersive augmented reality and gaming, and tactile internet applications such as remote surgery

uRLLC

(ultra-reliable, low-latency communications) – sometimes called cMTC or critical machine-type communications, these use cases demand reliability and millisecond latency, but not necessarily high bandwidth; examples are autonomous vehicles or even drones as a service

mMTC

(massive machine-type communications) – use cases are concerned with connecting millions or billions of low-power sensors with low data rates; examples include sensor networks for smart grids and smart cities

Use cases agreed by 3GPP, June 2016

"What makes 5G interesting is the fact that many use cases will need to be delivered on the same network with very different impacts on the way network resources will be consumed," says Laurent Leboucher, Vice President, Architecture, Enablers and Security, Orange. "From heavy throughput 4k video streamed to mobile users to real-time, low-latency information exchanged by autonomous vehicles, the cost per bit will be very different. This differentiation will need to be managed from an end-to-end perspective."

WHY PLATFORMS?

Operators need the flexibility of multi-tenant platforms to manage and monetize these very different services, and with 5G this is expected to happen through network slicing. In today's mobile networks, operators deliver a fixed set of services with service chains that essentially are defined by a specific standard (4G LTE, for example). These service chains are static and don't require end-to-end orchestration. But in 5G they will not be static and they must be automated because we're no longer talking about human communications but rather machine connectivity of billions of devices.

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.

"We're dealing with several dimensions of QoS [quality of service]," Leboucher explains. If you wanted to provide the highest QoS for every application, you would need to size the network capacity for the improbable worst case and the cost of the network would be enormous – it wouldn't make any economic sense. So, there is an absolute need to manage the network – not only the resources but also the revenue – so that we can find the right balance between revenue and cost."

We'll talk more about network slicing in the next section.

VERY EARLY DAYS

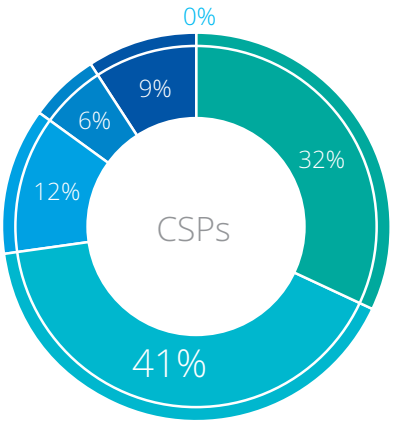
There is no shortage of 5G marketing hype – it was hard to find a supplier's press announcement at Mobile World Congress (MWC) this year that didn't trumpet 5G. And some operators already have bold deployment plans.

In the US, for example, AT&T and Verizon have said they will deploy pre-standard 5G technology for fixed wireless access this year, and in May T-Mobile announced plans for "real nationwide mobile 5G" using its newly awarded 600Mhz spectrum. Not to be outdone, Sprint announced shortly thereafter that it plans to offer 5G devices and services by late 2019. Across the globe in Asia, operators are pushing hard for the completion of 5G standards in time the 2018 Winter Olympics in South Korea and the 2020 Summer Olympics in Japan.

Our survey and interviews indicate that many CSPs are more cautious. While 41 percent of survey respondents are participating in trials or proofs of concept, nearly a third said they are content to monitor developments and 12 percent said they will wait for standards (see infographic). Despite the MWC hype, suppliers' responses were similar.

Our survey results are comparable to several other recent 5G surveys: An Ericsson survey of 29 CSPs found 34 percent of operators monitoring developments and 32 percent conducting trials; a Telecommunications Industry Association survey of 31 CSPs found 32 percent conducting trials in 2016 and 26 percent planning trials for this year and next; and a Telecom TV survey of operators and suppliers found 42 percent watching developments and 19 percent participating in trials.

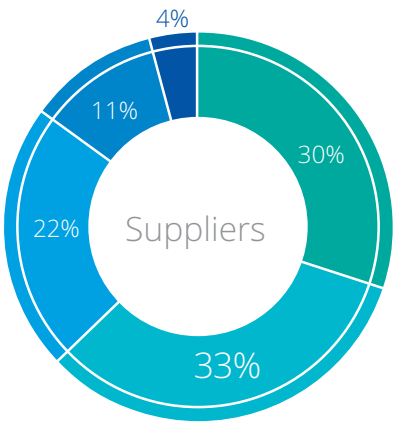
WHERE ARE OPERATORS WITH THEIR 5G STRATEGIES?



- Monitoring developments
- Participating in 5G trials/proofs of concept
- Will wait until standards are agreed to deploy 5G technology
- Mobile operator with no plans to deploy 5G
- Not a mobile operator so 5G is not applicable
- Deploying non-standard 5G technology today

Source: TM Forum, 2017

WHERE ARE SUPPLIERS WITH THEIR 5G STRATEGIES?



- Monitoring developments
- Participating in 5G trials/proofs of concept
- Will wait until standards are agreed to deliver 5G technology
- Not applicable
- Delivering non-standard 5G technology today

Source: TM Forum, 2017

5G STANDARDS

The International Telecommunication Union (ITU) will standardize 5G as part of its IMT [International Mobile Telecommunication system] for 2020 and beyond initiative, with specifications from 3GPP and contributions from other standards bodies like ETSI and NGMN. Specifically, 5G standards are being developed for new radio (NR) interfaces and a next-generation (NG) mobile core. These will be delivered in two phases, the first focusing on specs for enhanced mobile broadband and the second adding capabilities for advanced services like uRLLC and mMTC.

3GPP recently agreed to speed up work on non-stand-alone NR (this allows 5G radio to be deployed with LTE access and core). Hosting the Olympic Games is a big motivator to introduce 5G services, so the push is to complete initial non-stand-alone specs by December and finalize them by March 2018. Initial stand-alone NR and NG core specs are due out in June 2018.

And many mobile operators are already virtualizing mobile core networks. "It is logical that this virtualized EPC [evolved packet core] would be cloud-native and, where possible, designed to be '5G-ready'," Gabriel Brown, Principal Analyst, Heavy Reading, notes in a white paper authored for Nokia. "Even though 5G will specify new interfaces and functional elements, experience with cloud-native 4G core networks gives operators a very good insight into the platform environment and operational processes needed for NG Core in 5G. Moreover, it is anticipated that 5G will interwork very closely with 4G radio and core and that, over time, the new NG Core will become the common core for 4G and 5G services."

THE ROLE FOR NFV AND SDN

With this in mind, we asked operators about the importance of network functions virtualization (NFV) and software-defined networking (SDN) to 5G, and almost 60 percent of operators and suppliers surveyed said they believe both will be very important to 5G (see infographic).

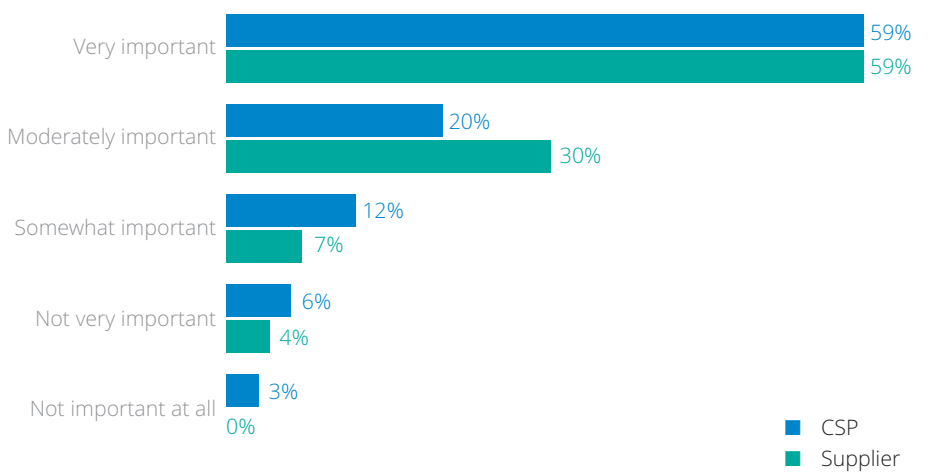
We expected this result and are surprised that even a small handful of operators would say the technologies are not important to 5G. All the CSPs we interviewed stressed their importance.

"We've started virtualization of our core mobile network and transforming our backbone transport network, which is often forgotten when you are talking about 5G," says the head of strategy at a large Asian CSP. "The packet backbone and front-haul networks need to be transformed into something highly scalable and very agile."

Indeed, 24 operators participating in the ETSI NFV Industry Specification Group recently published a white paper addressing priorities for 5G, and they assert that NFV is a key enabler.

"While what '5G' exactly means is still to be defined, the evolved 5G network will be characterized by agile resilient converged fixed/mobile networks based on NFV and SDN technologies... This requires integration with existing network systems, efficiently extending the network and backhaul support and implementing end-to-end service management."

HOW IMPORTANT ARE NFV AND SDN TO 5G?



Source: TM Forum, 2017

The paper goes on to explain that meeting the demands for the wide-ranging use cases envisioned for 5G will require network slicing, edge computing, security, reliability and scalability. We'll talk more about this in Section 4.

EVOLUTION, NOT REVOLUTION

Most CSPs see 5G as evolution, not revolution. "5G is not going to become any kind of radical change in the network in the sense that many of the technologies or business models that we foresee for 5G would be applicable in the current network, and may in many cases be successful in the network before we call it 5G," says Diego Lopez, Head of Technology Exploration and Standards, Telefónica.

Dr. Lester Thomas, Chief Systems Architect, Vodafone Group, agrees. "From a technical perspective, there is no 5G. The technology term is LTE – long-term evolution," he says. "LTE was effectively meant to be the last G. It's a bit like Windows 10 – there's not going to be a Windows 11 because 10 will evolve incrementally. "With 5G, there will be a marketing event, probably with the Tokyo Olympics," he adds. "But in our plans, we're doing things which you could claim are 5G and we're doing them now – we don't intend to wait." (See page 14 for a discussion of Vodafone's *Anything-as-a-service* Catalyst project).

MOST PROMISING SERVICES

We gave operators and suppliers a list of potential 5G services and asked them to rank them from most promising to least. The infographic below shows the percentage of operators and suppliers who ranked each service in their top three choices.

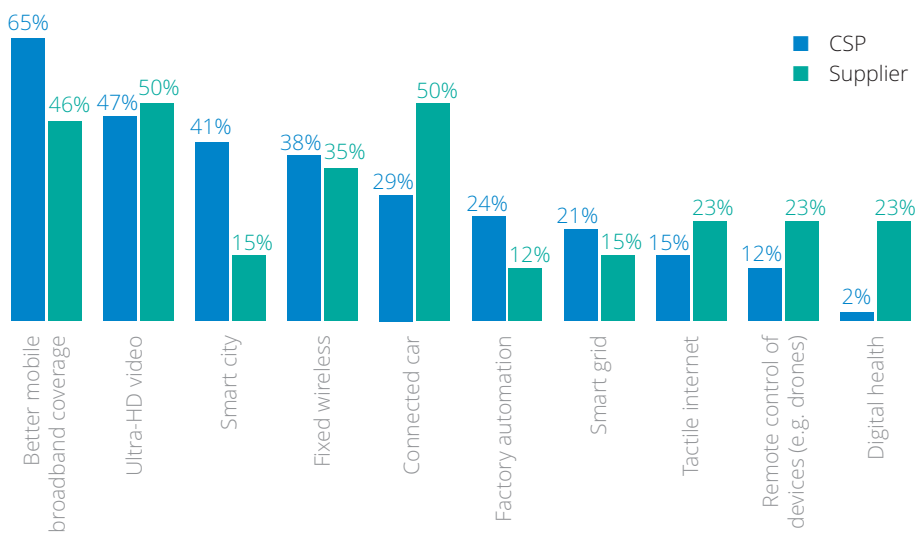
CSPs' top priorities for 5G are improved mobile broadband coverage (such as at events or on public transportation) and ultra-high-definition video. This isn't surprising given that a main reason for deploying 5G technology is to accommodate the ever-increasing number of mobile users and devices, and their always-on demand for data including video.

To accommodate billions of connected devices, 5G is expected to use millimeter waves broadcast at higher frequencies in new high-spectrum bands. These signals won't travel as far and can't easily pass through obstacles, so lots of new small cells will be required. In urban areas, for example, radio access equipment will be deployed on street furniture and atop buildings.

The result will be increased coverage and capacity. 5G also promises significantly higher data rates – at least 10Mbps in sparsely populated areas and up to 10Gbps is dense areas.

Fixed wireless access is related to improved coverage, and CSPs ranked it as a likely first 5G service. This is a very popular application in the US. AT&T and Verizon are already installing non-standard 5G equipment for fixed wireless access, which they intend to roll out this year in the 28GHz spectrum, but in other regions there hasn't been quite as much interest.

WHICH 5G SERVICES WILL BE DEPLOYED FIRST?



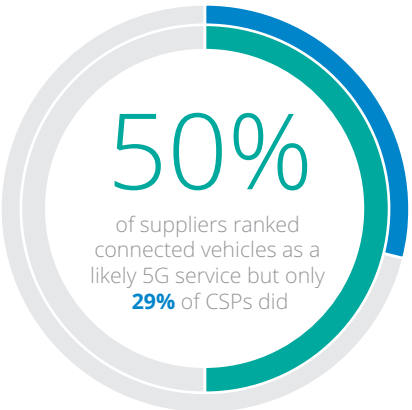
Source: TM Forum, 2017

CONNECTED VEHICLE DISCONNECT?

Our survey finds discrepancy between CSPs and suppliers when it comes to connected vehicles, with suppliers more bullish about it as an early 5G service (see graphic right). There is an even bigger disconnect between CSPs and suppliers when asked which of the potential 5G services are best suited to a platform model – 65 percent of suppliers put connected vehicles in their top three, whereas only 27 percent of operators did (see infographic below).

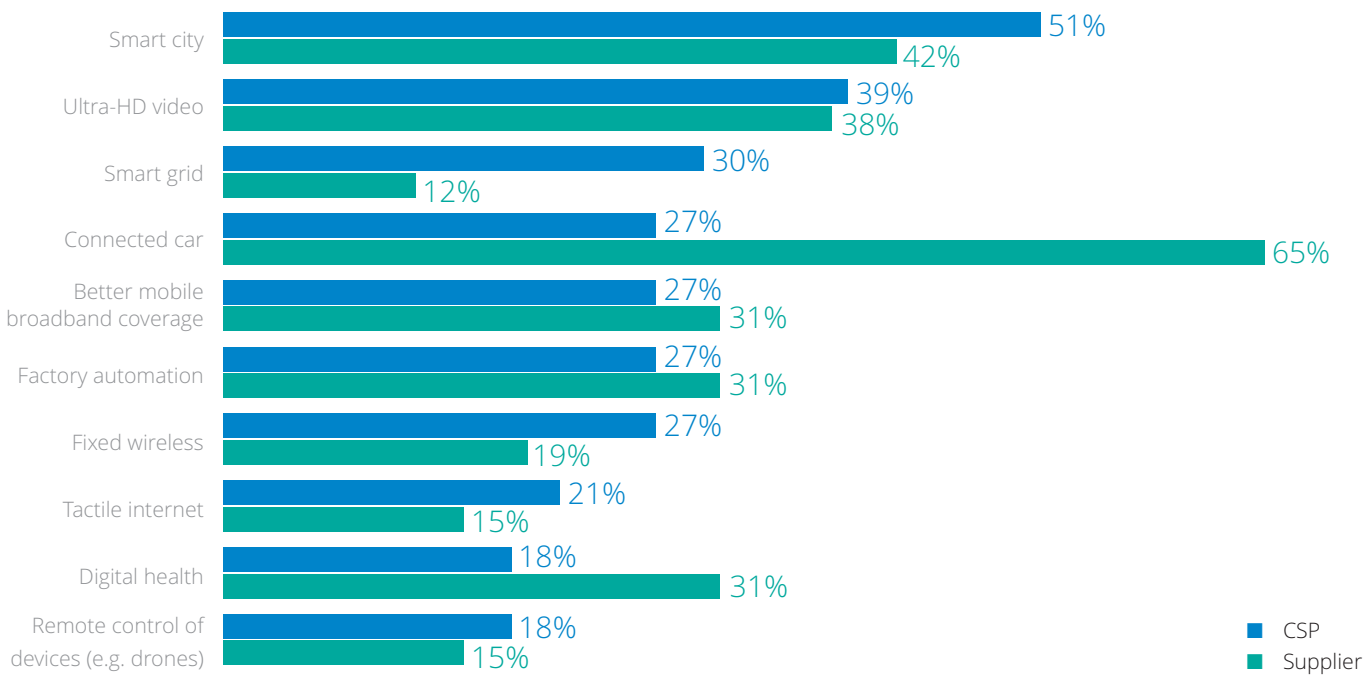
It's easy to understand why suppliers ranked connected vehicles so highly. Of all the potential 5G services, it's certainly the one that has received the most attention, particularly with the development of autonomous vehicles.

Most of the CSPs we interviewed are optimistic about the platform potential for connected vehicles, but it's possible that other operators are hearing from the large automakers that they want to run their own platforms or that they are already partnering with large platform providers like Apple and Microsoft to develop ecosystems.



Source: TM Forum, 2017

5G SERVICES BEST SUITED FOR A PLATFORM MODEL



Source: TM Forum, 2017

THE PROMISE OF SMART CITIES

We're not surprised that a majority of CSPs believe smart cities are promising for platform services. An ongoing TM Forum Catalyst in Milton Keynes in the UK has demonstrated that they are, indeed, an excellent opportunity for CSPs to play a platform curator role, with or without 5G.

As part of the project, BT has developed the MK Data Hub, which brings the entire smart city ecosystem onto one platform including end users, energy and water companies, government agencies, sensor network providers, data providers and developers. The team has looked at how to use analytics to monetize a smart city ecosystem and has tested commercial viability and trust by adding service level agreements and security.

In the most recent phase of the Catalyst, demonstrated at TM Forum Live! in May, participants including BT, BearingPoint/Infonova, Cloudsoft and EXFO brought application logic closer to the edge, where the data is collected naturally in the city.

MONETIZING THE PLATFORM

There are multiple ways for a network operator to monetize a smart city data hub. The most lucrative, perhaps, would be to host it and charge transaction fees for processing and analyzing data, but operators could also choose to play a more limited role, allowing the city or other partners to take the lead.

Today the MK Data Hub is an innovation project within BT's R&D group, but the company has established a new IoT business unit which could use the hub as a blueprint for developing commercial platform services.

Watch this video to learn more about the Smart city on the edge Catalyst

WHAT ABOUT DIGITAL HEALTH?

CSPs also appear to be a bit less certain than suppliers about the viability of platform services for digital health, and they're much less confident about its deployment as a 5G service. Digital health should be a natural platform fit for CSPs because it demands reliability and availability, and is a market full of small startups with exciting technology but limited funds for ecosystem development.

TM Forum members have been participating in an ongoing Catalyst project looking at platform challenges related to digital health. The latest phase of the project called Hyperscale IoT Management – Healthcare Catalyst, demonstrated a digital health ecosystem for managing a large number of devices throughout their lifecycle, from onboarding to decommissioning. This included automated resolution of problems with devices and using blockchain technology for identity management of devices.

Watch this video to learn more about the Hyperscale IoT Management – Healthcare Catalyst

CSPs ARE UNCERTAIN ABOUT DIGITAL HEALTH

31%
of suppliers ranked digital health as a top platform service

18%
of CSPs did

2%
of CSPs ranked it as a top 5G priority

Source: TM Forum, 2017

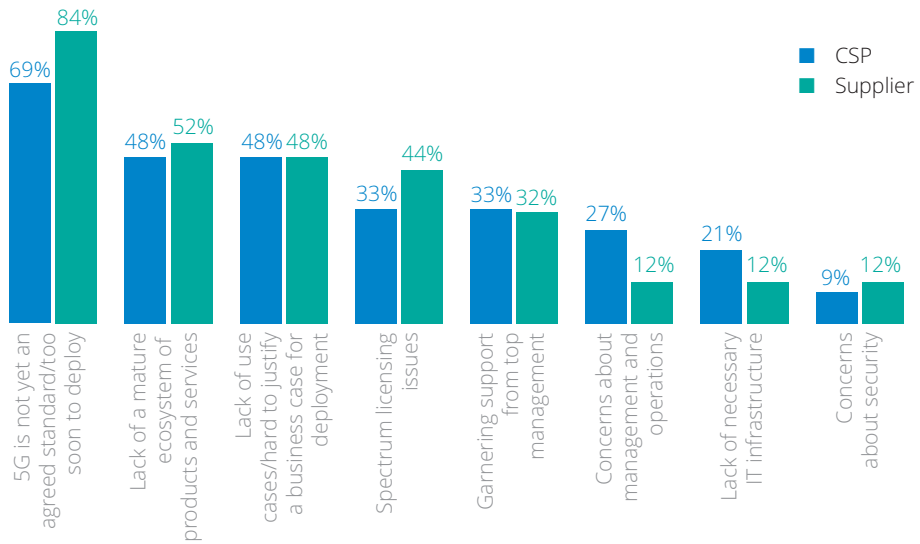
SECTION 4

ADDRESSING THE 5G CHALLENGES – IN PARTICULAR NETWORK SLICING

Communications service providers (CSPs) and their suppliers face many challenges in deploying 5G, and network slicing is a particularly difficult one, especially since there is no agreement yet on exactly how to do it.

The biggest overall 5G challenge is that standards have not been agreed. Almost 70 percent of operators and 84 percent of suppliers ranked this in their top three challenges (see infographic), and 50 percent and 44 percent respectively ranked it as No. 1. It's not surprising then that the No. 2 challenge is lack of a mature ecosystem of products and services because maturity depends on standards.

RANKING THE 5G CHALLENGES



Source: TM Forum, 2017

As we noted in the previous section, an initial non-stand-alone (NSA) 5G radio interface standard is expected before the end of this year with an initial stand-alone (SA) interface and next-generation (NG) core standards due in 2018. It's completely understandable why some companies are pushing for an early NSA standard – to deliver 5G fixed wireless and mobile service for the Olympics, an NSA standard is needed as soon as possible.

But some CSPs question why there is such a hurry to deliver SA and NG standards in 2018. Speaking at the Brooklyn 5G Summit in April, Deutsche Telekom's Franz Seiser, Vice President, Core Network and Services, said he doesn't understand the rush: "[3GPP] Release 15 core network for 5G does not have one single advantage over EPC [evolved packet core]... There is nothing it can do better, so why deploy it?"

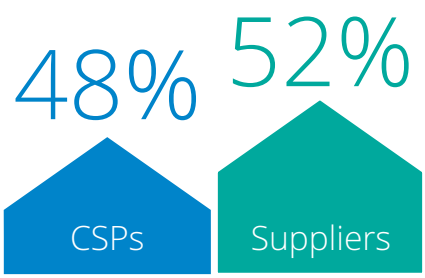
> *"There is a kind of wall between the hype we create in the industry and the reality that's happening today in standards."*
>
> Franz Seiser,
> Deutsche Telekom

He added, "There is a kind of wall between the hype we create in the industry and the reality that's happening today in standards. I believe what we get currently out of 3GPP is 4G++ – full stop. It's still very close to LTE."

Seiser believes that agreeing on how to handle network slicing is critical to advancing 5G and making it more than LTE on steroids, and he would like to see this happen in 3GPP Release 16.

Watch Sesier discuss 5G network slicing

LACK OF USE CASES



think lack of 5G use cases is a significant challenge

Source: TM Forum, 2017

About half of operators and suppliers that responded to our survey cited lack of 5G use cases as a significant obstacle. The 3GPP 5G white paper famously laid out the potential 5G use cases (see graphic on page 23) – enhanced mobile broadband, ultra-reliable, low-latency communications and massive machine-type communications – but it didn't really address the business case for these services. Who's willing to pay for them and how much are they willing to pay?

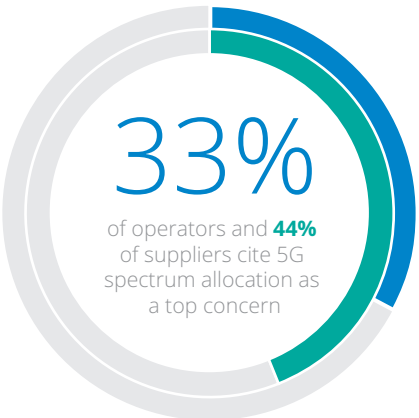
Lack of use cases also ranked highly as a challenge for platforms (see page 18). In both cases, the industry is facing a classic chicken-and-egg dilemma: To justify widespread deployment of 5G or platform technology, management and stakeholders want to see proven (monetizable) business cases, but many of the real killer apps won't be developed unless the infrastructure is in place. After all, the internet wasn't built with Netflix or Uber in mind.

ULTIMATELY, 5G WILL BE IMPORTANT BUT NOT NECESSARILY CRITICAL TO A SUCCESSFUL PLATFORM STRATEGY, BUT WHAT ABOUT THE REVERSE? IS PLATFORM ESSENTIAL FOR 5G?

"That's the multi-million-dollar question," says the head of ecosystem development at a Tier 1 European CSP. "Personally, I don't think we are able to monetize 5G only as it's discussed today. I think we are only able to properly monetize it in a more platform-oriented business model. The value lies in combining higher bandwidth with network slicing."

Another respondent agrees: "As part of our 5G readiness strategy, we've asked, 'What is 5G'? You have some well-known use cases – then you realize there are so many use cases out there. The only way to support them is by setting the network up as a platform."

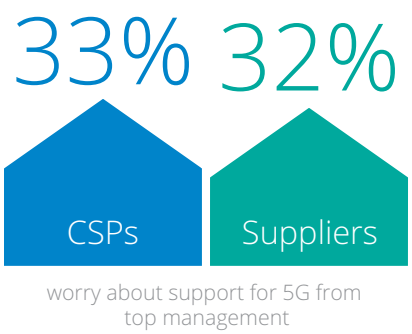
CONCERNS ABOUT SPECTRUM



Source: TM Forum, 2017

Availability of spectrum is another concern for operators and suppliers. Generally, CSPs and suppliers are targeting three key frequency ranges for 5G: below 1GHz, 1-6GHz, and above 6GHz. Each range has characteristics that make it suitable for certain applications. In some countries new spectrum has been allocated for 5G trials but there has not been harmonization of spectrum, which could lead to fragmentation rather than economies of scale.

MANAGEMENT SUPPORT



Source: TM Forum, 2017

About a third of CSPs and suppliers again cited support from top management as a challenge. Many CSPs want to be first to market with 5G, so there is commitment from management to invest in it, but it's less clear whether operators will be able to succeed in delivering more than just broader, faster mobile coverage.

"The question is: Do we have all the capabilities required to launch successful 5G?" says Milind Bhagwat, Enterprise Architect, BT. "You don't want it to be just a faster mobile broadband service; you want it to to deliver a step change in performance and economics of the entire network in order to transform industries. For transformation to happen, certain capabilities are required like orchestration, automation and service assurance. That is the biggest challenge: Is there enough time for us to obtain those capabilities and be good at managing such a complex beast?"

OTHER CHALLENGES

Some CSPs we interviewed also cited the cost of chipsets for devices as a general 5G challenge. "For IoT to be massive and present in almost every object, the return on investment is critical for our customers," says Andrés Padilla Fuentes, Director of New IoT Solutions, Telefónica Global. "Margins, of course, are very tight, so to have chipset in device that is very, very cheap is critical to enable mass deployment to happen."

Padilla Fuentes says chipsets probably need to be in the $2 range and this means that radically simplified technology is needed. "One of most massive use cases we have today is connecting water or gas meters," he says. "There are millions of those, but to make it profitable for our customers, the cost of the device has to be around $20 and we are not there yet."

> *"The question is: Do we have all the capabilities required to launch successful 5G?"*
>
> Milind Bhagwat,
> BT

THE PROMISE (AND HEADACHES) OF SLICING

Everyone agrees that network slicing is going to be important for 5G, but there is no industry consensus yet about how to implement it. Deutsche Telekom's Seiser sees this as a problem for operators looking to sell enterprise customers on the benefits.

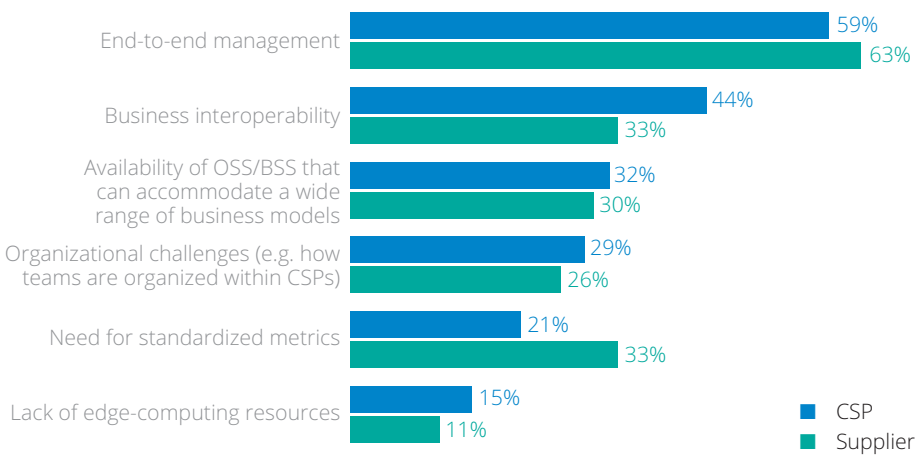
"We need a common story as an industry to approach the verticals – the basic thing they get with slicing is always the same," he says, adding that GSMA is beginning work on this. "The idea is to come to a much better story and come to one story as a telecommunications industry so that we have good lever to get that business on board," he says.

TM Forum, NGMN and MEF also are addressing these issues. NGMN has published two white papers, one on 5G definition and design and a more recent paper detailing the management requirements for 5G, which focuses mostly on low-level resource and technology requirements. MEF and TM Forum are focusing above on resource-, service- and business-level integration required to support 5G use cases. For more about how standards bodies are working together on 5G, see this article on Inform.

WHAT ARE THE SLICING CHALLENGES?

CSPs and suppliers are largely in agreement when it comes to the management challenges associated with network slicing. The infographic below shows the percentage of respondents who ranked each in their top two challenges. End-to-end management is solidly No. 1, with 59 percent of CSPs and 63 percent of suppliers choosing it as a top concern, and the No. 2 concern, business interoperability, is closely related.

BIGGEST MANAGEMENT CHALLENGES FOR 5G NETWORK SLICING

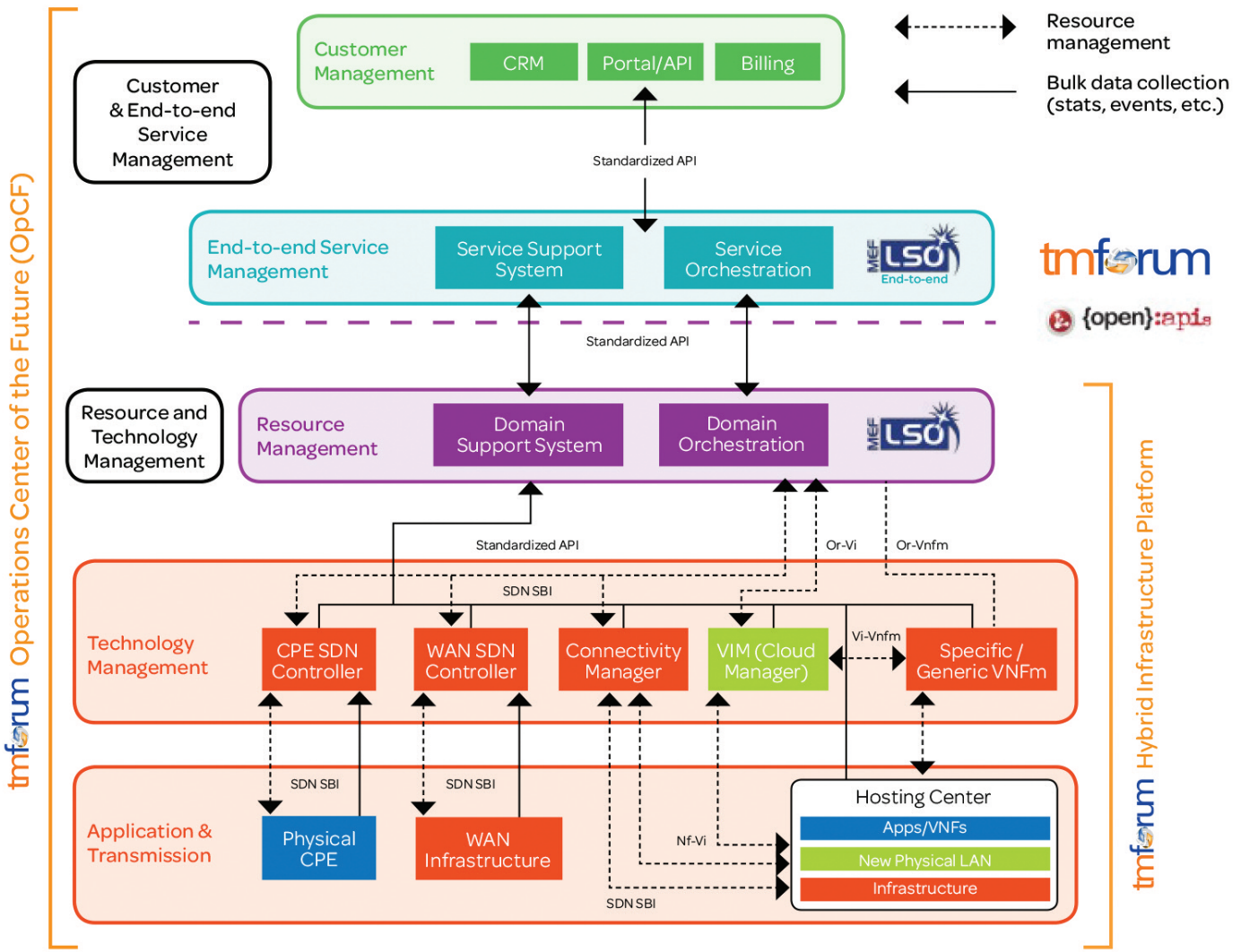


Source: TM Forum, 2017

ORCHESTRATING THE LAYERS

As we have explained, common language, definitions, information models and APIs are needed to help service providers automate ordering, provisioning, management and assurance of and billing for services end to end. Management and orchestration are necessary at multiple levels, from the physical and logical resources in a CSP's network to service chains of technical components to the commercial relationship with the customer (see graphic).

MANAGEMENT HAPPENS EVERYWHERE



Source: TM Forum, 2017

TM Forum's Catalyst and Collaboration programs are crowdsourcing prototypes and investigating operational and business models for 5G, virtualization and platforms

TM Forum's Zero-touch Orchestration, Operations and Management (ZOOM) team is working on a document, to be published in July as part of Frameworx Release 17, that will address business scenarios and expected value creation from slicing. This follows a significant body of work looking at end-to-end management and business collaboration among partners, including several Catalyst proof-of-concept projects.

The *Anything-as-a-service* Catalyst (see page 14) and the *Smart city on the edge* Catalyst (see page 28) both have looked at how to deliver platform-based services at the upper layers of the diagram. Another award-winning project, *Enabling digital marketplaces*, has investigated enabling digital ecosystems at the resource level. The team is hoping to drive industry-wide adoption of a metamodel and standardized metadata that will enable same-day onboarding of virtualized functions. They are aiming to automate the entire lifecycle of a virtual function from procurement and onboarding to testing and validation, deployment, configuration and assurance.

A recent project called *5G service operations – real-time service assurance*, which was championed by AT&T, BT, Orange, Telecom Italia, Telenor and Vodafone and included MYCOM OSI, Netcracker and TEOCO as participants, focused specifically on how to manage a 5G environment at the service-management level using network slicing and assurance.

The project looked at the efficiency or utilization of the infrastructure as one business driver and at two IoT use cases:

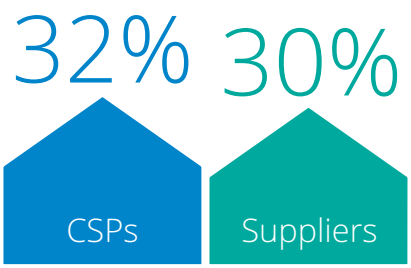
- an ultra-reliable low-latency communications (uRLLC) smart factory of the future application using robots, sensors, actuators and high-definition cameras connected via a 5G network; and
- a massive machine-type communications (mMTC) connected vehicle example with a car sending IoT data feeds via a 5G network to an automobile manufacturer to indicate performance.

The idea was to create different types of network slices with completely different characteristics, but using a common infrastructure, and then optimize usage of the resources. For example, if there was no demand, the slices wouldn't consume resources, or if the uRLLC application needed additional resources to meet its service level agreements (SLAs), then capacity could be increased on the fly, perhaps by 'stealing' resources from the mMTC application.

The project highlighted some areas for future exploration including operations' responsibility within a CSP organization, necessary updates to the Forum's Open APIs, whether network slices may need to be broken down into separate radio access network and core slices, and how this might work in a platform marketplace.

Watch this video to learn more about the 5G service operations project

OSS/BSS OF THE FUTURE



say availability of OSS/BSS that can accommodate a wide range of innovative business models with multiple parties, using a variety of pricing strategies is a top concern

Source: TM Forum, 2017

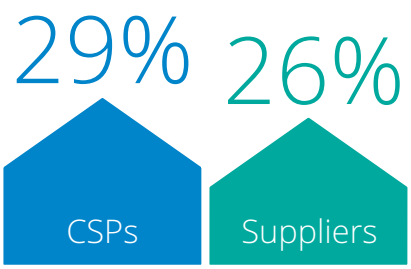
To accommodate platform business models and network slicing, CSPs need radically different support systems. Traditionally, OSS/BSS have been tightly integrated applications developed for specific functions like ordering, provisioning, assurance and billing. The problem is the extraordinary amount of time it takes to make changes to services or develop new ones using these systems. It's not uncommon for a CSP to spend 18 months or more developing a new service.

Systems must be rearchitected for the cloud so that new services can be created almost instantaneously. OSS, for example, need to be based on a modular microservices architecture that follows the principles below. These principles have been identified by TM Forum's Zero-touch Orchestration, Operations and Management (ZOOM) project (and are explained in greater detail in this white paper):

- loose coupling of components so that changes to one don't affect another;
- exposure of capabilities through standard APIs;
- policy-driven autonomic support with zero-touch orchestration, network self-healing and self-organization; and
- metadata-driven and catalog-based with self-declared and well-described components

For more about microservices, see our *Quick Insights* report *Microservices: Piecing together a strategy*

HOW TO ORGANIZE TEAMS



are worried about organizational issues when it comes to network slicing

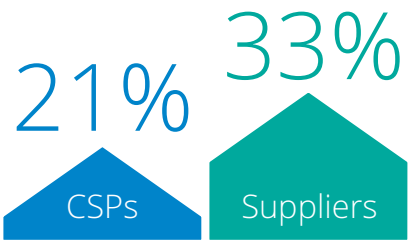
Source: TM Forum, 2017

Today telco operations teams typically are arranged vertically around specific product groups, but this likely will not work for platform-based models that use network slicing. This was highlighted as an issue in the 5G Catalyst, and more than a quarter of respondents share the concern.

"I think where were headed is that you'll have an operations responsibility within the service provider's organization where one group is responsible for service types and another is responsible for efficient use of the infrastructure," says Dave Milham, Chief Architect, TM Forum. This means CSPs likely will have to organize themselves more horizontally, the way cloud operators do.

STANDARDIZED METRICS

How to measure?



have concerns about standardizing metrics for slicing

Source: TM Forum, 2017

While suppliers did not seem to be overly concerned about platform management standards (see page 18), they are a little more concerned than CSPs about standardized metrics for slicing. To automate the lifecycles of network components, services and customers, CSPs, their suppliers and other partners must agree on how to measure everything including:

- the maturity of virtual functions;
- how well services are performing;
- whether customers are satisfied; and
- if charges have been billed and paid.

That's not easy when organizations from various industries use different terms to explain similar concepts.

Standards bodies have been very prescriptive in the past. Now the goal is to create an efficient marketplace, automatically onboard virtual functions and use them to automatically provision, license, manage, assure and bill for services, end to end across partners' networks. This means the communications industry will have to adopt metadata-driven metrics to seamlessly enable assessment of each step of the cycle.

EDGE-COMPUTING RESOURCES

Source: TM Forum, 2017

Computing power at the edge of the network did not rate highly as a concern among CSPs or suppliers, but it is an issue to consider. As AT&T's Kathy Meier-Hellstern, Assistant Vice President of Inventive Science, AT&T Labs, notes in our *Quick Insights* report *Data Analytics & AI: Key to end-to-end management*, there is not enough computing power at the edge today to analyze network usage patterns and ensure quality of service.

"One of the challenges with 5G is that we've got these very dense access networks with thousands or tens of thousands of locations, as opposed to before where you maybe had hundreds," she says. "It will be essential to have real-time analytics to support some of our new services like augmented or virtual reality and tactile internet, because they do rely on having analytics at the edge with fairly decent processing and very low latency."

Milham agrees that solving challenges at the edge is crucial. "In fixed networks, the core has so much capacity it's hardly worth worrying about it," he says. "Where the problems arise is in the access network. You may have one cell running both types of communications where uRLL is on the verge of breaking the SLA agreement. We need to figure out what to do when that happens. The finite resource is the bandwidth in the cell."

ADDRESSING SECURITY

In hindsight, we should have highlighted security as a slicing challenge as opposed to a general 5G challenge. Security scored low as a general challenge – only 9 percent of CSPs and 12 percent of suppliers put it in their top three picks. Had we asked about security as a slicing challenge, however, we believe the numbers would have been much higher.

With network slicing, it's critical to be able to isolate tenants and applications. This is not only a performance issue but also one of safety – imagine if a slice supporting remote surgery were somehow compromised. Data privacy is also a concern.

"Our goal is to create a chain of trust going from the device end point, be it a sensor, smartphone, car or whatever, through to the cloud of the service provider who is analyzing and making decisions on that data," says Paul Bradley, Head of 5G Strategy and Partnerships, Gemalto, a digital security solutions provider. "It's very important that as we build this chain of trust we only allow the functions that are on the same slice to be able to talk to each other so that there's trust established at all levels."

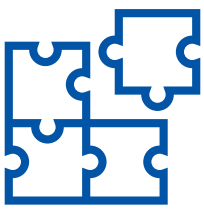
How this is going to be solved isn't exactly clear, but it's something standards bodies are looking into. Proposals to address the isolation of network slices are under discussion by 3GPP and the ETSI Network Functions Virtualization Industry Specification Group, for example.

TM Forum's ZOOM team is addressing security in a new technical report due out in July as part of Frameworx 17. It will provide implementation guidelines for common integration challenges when using platform, service-oriented architecture and open API concepts, specifically addressing the challenge of securing software that is being orchestrated and composed dynamically.

SECTION 5

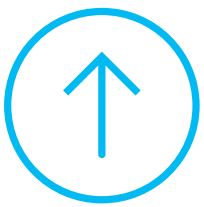
MAKE IT HAPPEN – STRATEGIES FOR ADOPTING PLATFORMS AND 5G

5G, network functions virtualization, software-defined networking and cloud-based platform business models are inextricably linked and represent the best (perhaps only) way forward for communications service providers (CSPs). By combining platforms, the internet of everything (IoE) and 5G, CSPs have an opportunity to move beyond providing just connectivity to become ecosystem curators and enablers of many different verticals from smart cities to connected cars, the industrial internet of things and more. Following are key steps to take to make it happen.



Understand the benefits of platforms

A platform strategy can have two key elements: a platform business model that sets up digital ecosystems or marketplaces connecting consumers with producers of goods and/or services; and a platform-based IT architecture, which supports an electronic marketplace and facilitates the digital business model. Going a step beyond this to define platform as a kind of "universal application layer" that can be used broadly to model any domain means CSPs can use the platform approach to transform all aspects of their businesses, from business processes to operational and business support systems (OSS/BSS) to the network itself.



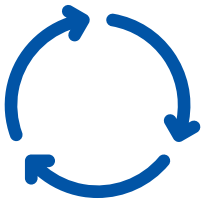
Start at the top

Adopting a platform strategy is a radically different approach for telcos, one that requires collaborating with customers and partners to develop services, encouraging experimentation and learning from failure. This takes courageous leadership.

As the head of strategy at a large Asian CSP, notes: "Telcos are used to having this integrated model where we try to do everything on our own and fight the OTT players. We need to change that mindset because they are here to stay; they will not disappear. We need to position ourselves in someone else's value chain – instead of always being at the front, we as telcos will become more of an enabler, which is a different way of thinking."

Commit to using Open APIs

As operators progress with transforming their networks, business processes and OSS/BSS, the next step is dynamically exposing capabilities to partners through open application program interfaces (APIs). CSPs that have not done so should consider adopting TM Forum's Open APIs for digital service management. By aligning around a common set of APIs, CSPs will be able to connect with each other and partners to deliver and assure platform-based services end to end.



Adopt intent-based management

Intent-based management abstracts the complexity of the network at a high level and then uses customer intent, analytics and policy to manage it. By combining intent-based management with adoption of common information and data models and standard APIs, CSPs will be able to automate service provisioning, configuration and assurance end to end across partners' boundaries.

Partner with other providers

The real opportunity for CSPs lies in creating a network of platforms, delivering a connectivity slice across them, assuring the services end to end and offering data analytics along with charging and billing as add-on services. Operators should seek out multiple ecosystem partners who can help them expand their digital footprint and deliver new revenue-generating services.

Experiment with 5G

For mobile operators, 5G offers the exciting promise of being able to slice the network to accommodate a wide range of applications with very different reliability and throughput requirements. There are many challenges including how to manage mixed workloads, how to increase computing power at the edge of the network to handle the necessary analytics and how to get standards bodies and open source groups to work together on standardizing end-to-end management for 5G. CSPs should get started with 5G trials and work with collaboration groups to solve the challenges.

Address security from the outset

Service providers need to build a security framework that includes internal and external security functions and policies that can be applied right from the start. Orchestration will be key here, particularly for remote device configuration and upgrades. Service providers also need to consider how they will implement end-to-end security lifecycle management and how data analytics can be used to identify unusual patterns of behavior in both people and machines. TM Forum's new technical report due out in July will help with this.

Get involved!

TM Forum's Collaboration Community and Catalyst Program are addressing many of the challenges related to platforms, IoE monetization and 5G network slicing. TM Forum Catalysts act as an accelerator to complement the R&D efforts of the companies involved by bringing them together to address specific business and technology challenges. The companies work closely on projects lasting from three to six months, culminating in live demonstrations at TM Forum's events. To find out more or to get involved in collaboration, contact Barry Graham.

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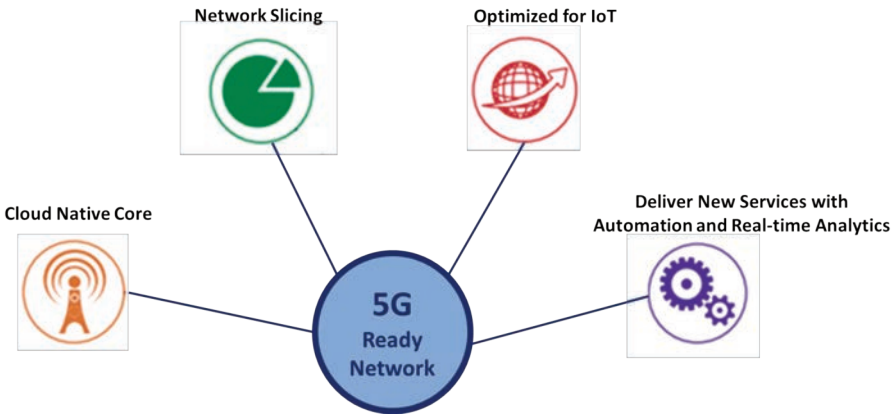
5G IS COMING. ARE YOU READY?

SAY "YES" TO THE FUTURE WITH AFFIRMED'S 5G-READY SOLUTIONS

AFFIRMED NETWORKS 5G-READY NETWORK

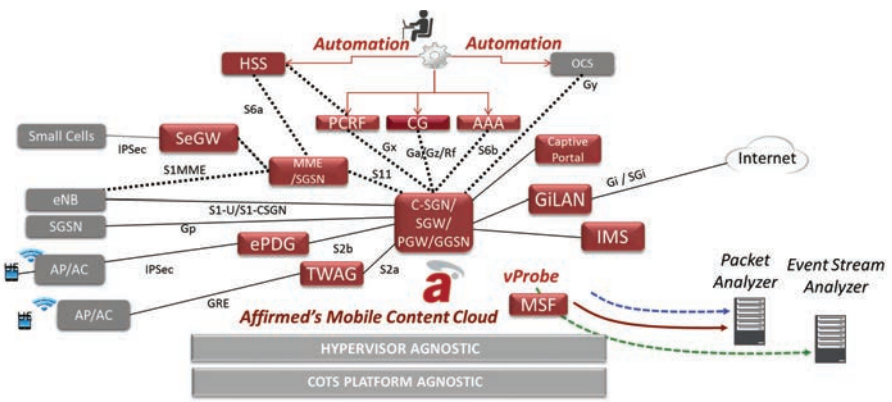
Although 5G won't officially arrive for a couple years, we know the network will need to be more flexible, more scalable, more intelligent, and less expensive to operate. At Affirmed Networks, we built our solutions with the future in mind—enabling operators to build a 5G-Ready Network now.



AFFIRMED MOBILE CONTENT CLOUD vEPC

It is a Cloud Native Core.

The core architecture is natively decomposed, separating the user and control planes so virtual network functions (VNFs) can be scaled independently.



- Orchestration – Resources are more loosely coupled and service providers gain the ability to create clusters of resources, perform load balancing across their entire network, and connect functions more effectively to deliver new services.
- Decoupled Applications and State Store – The data store and session state are separated from the network element itself, allowing VNFs to become transaction processing engines that can deliver higher levels of performance, while increasing resiliency and simplify operational processes.
- External Load Balancing – VNFs run as independent, small instances.
- Containers – Functions and services are placed into containers, enabling mobile operators to orchestrate, create, and deploy applications with more agility and speed.

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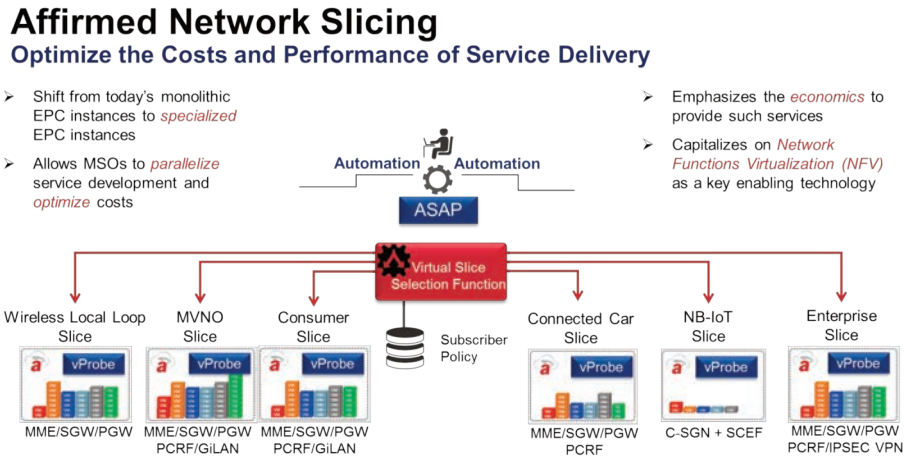
AFFIRMED NETWORK SLICING

It Supports Network Slicing.

While network slicing has become more visible with the arrival of 5G, mobile operators can benefit from slicing today. Affirmed supports existing slicing capabilities APN, MOCN, and DECOR and also offers an advanced slicing function called the Virtual Slice Selection Function (vSSF).



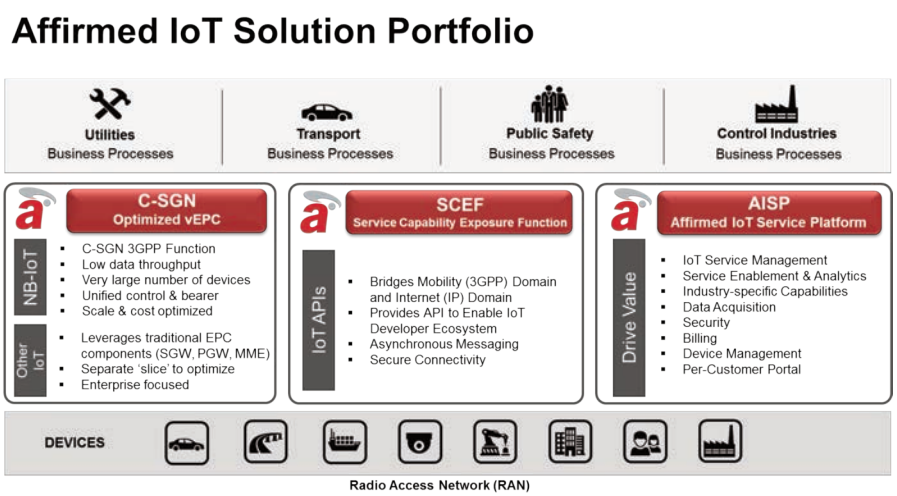
Slicing enables mobile operators to match the capabilities of network to the service it is delivering, dramatically improving the profitability of their services.

The vSSF transparently inserts into an existing network, physical or virtual, and provides fine grained slicing of traffic by a variety of criteria, such as Time of Day, Location of Network, Device Type, Gateway loading, Specific UE (IMSI/MSISDN), UE location, and more. Combining the vSSF with Virtual EPC instances, Automation, and Virtual Probes, enables operators to deliver services faster to market with a guaranteed quality of experience.

AFFIRMED IoT SOLUTION

It is Optimized for Internet of Things (IoT).

IoT will place new demands on mobile networks to handle traffic sessions with widely different characteristics, from low-latency, high-bandwidth traffic to delay-tolerant, low-bandwidth traffic.



Affirmed's IoT offering provides comprehensive support for 2G/3G, LTE, LTE-M, and NB-IoT Services (CSGN). Affirmed provides advanced functions, such as an SCEF and the Affirmed IoT Service Platform (AISP).

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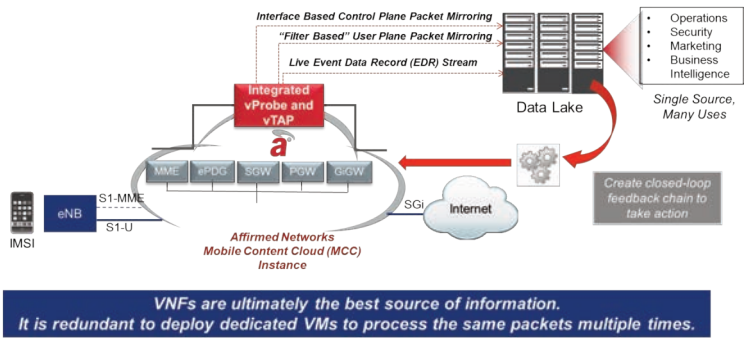
AFFIRMED VIRTUAL PROBE (VPROBE) AND REAL-TIME ANALYTICS

It Simplifies Operations, Improves Network Quality and Helps Identify New Services with Real-Time Analytics.

Affirmed vProbe

Traditional probe functions directly integrated into the VNF



The Affirmed vProbe delivers integrated network probe and monitoring capabilities that is co-located with mobile network functions. This results in several immediate benefits to mobile operators:

- Improves network quality of service
- Reduces network support costs by more than 50%—eliminating the need for a separate probe appliance
- Provides real-time network analytics that allow mobile operators to better target new services and help enforce SLAs across a variety of network slices, from M2M to industry vertical solutions.

AFFIRMED SERVICE AUTOMATION PLATFORM (ASAP)

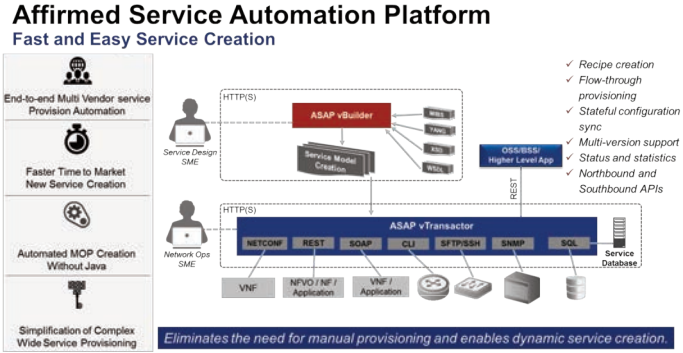
It Helps Operators Create and Launch New Mobile Services Faster with Automation.

The Affirmed Service Automation Platform (ASAP) is a next-generation automated service creation and orchestration platform that revolutionizes the way mobile services are created, tested, and deployed.

ASAP can dramatically accelerate the service creation process, reducing the cost and time required to launch new mobile services by as much as 97%. This is a game-changer that allows mobile operators to increase revenue more quickly and compete more effectively.

Affirmed Service Automation Platform

Fast and Easy Service Creation



- Supports seamless service configuration across multi-vendor legacy and virtual network elements;
- Accelerates and simplifies service creation with GUI-based drag-and-drop screens;
- User of ASAP is freed from the tyranny of custom-built connectors and static service models. (i.e., roll-your-own service models and roll-your-own connectors);
- Provides broad service automation and orchestration across a wide range of standard network element interfaces, including SOAP, REST, NETCONF/YANG and CLI;
- Provides a complete configuration management across multi-vendor virtual and physical network elements and network-wide service instances.

GET THE BENEFITS OF 5G TODAY

You don't need to wait for the 5G revolution to experience the freedom of network virtualization, network orchestration, service automation, seamless mobility and pervasive network intelligence. And you don't need to make short-term network investments that don't align with your long-term plans. You can meet the challenges of today and tomorrow with Affirmed Networks—and enter the 5G future with a competitive advantage (and new revenue momentum).

To learn more about our portfolio of 5G-ready solutions, visit us at affirmednetworks.com

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5G PLATFORMS: ENABLING CONSUMPTION MODELS

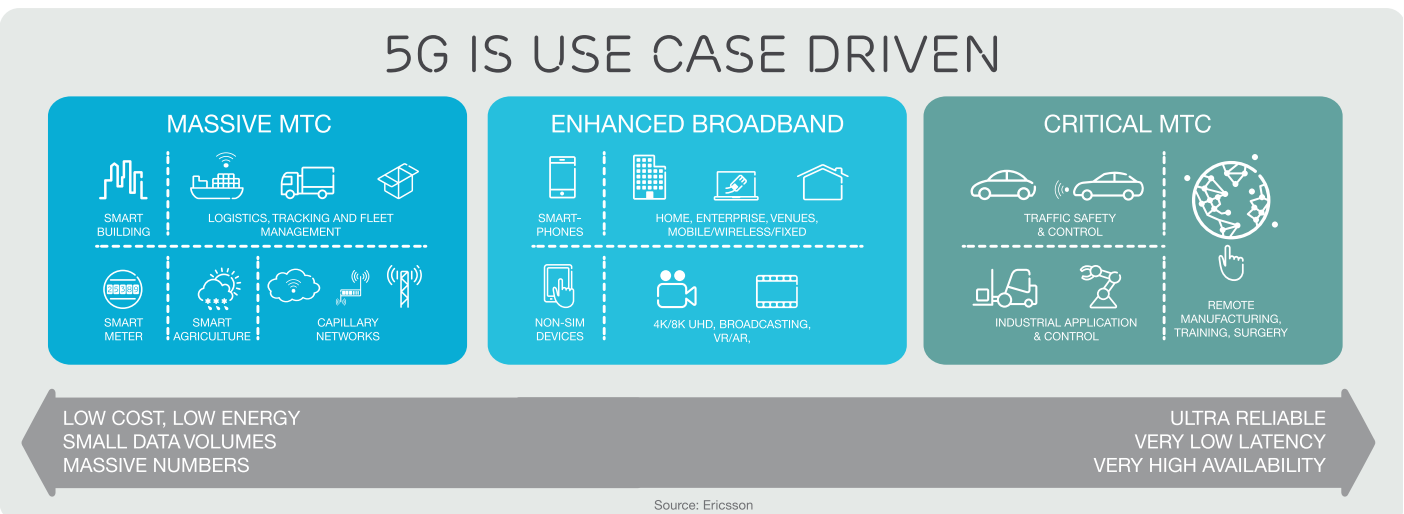
Patrik Regårdh, Head of Strategy for OSS & BSS, Ericsson

5G will be a major technology in growing industrial digitalization, creating and enhancing industry digitalization use cases such as immersive gaming, autonomous driving, remote robotic surgery and augmented reality support in maintenance and repair situations. Operators will look to 5G to add much-needed revenue streams from solving key challenges in digitalization for industries across several use case scenarios (see also The 5G Business Potential):

- Massive machine-type communications (MMTC) require connectivity for millions of devices, typically transmitting a relatively low volume of non-delay-sensitive data (low bandwidth and not latency-critical) via low-cost devices with extended battery life;
- Enhanced mobile broadband for mass mobile connectivity as demand for mobile broadband continues to increase; and
- Critical machine-type communications (CMTC) for ultra-reliable, resilient, instantaneous connectivity, with stringent requirements for capabilities such as throughput, latency and availability.

In the hands of digitally-savvy enterprises, new capabilities such as network slicing, differentiated QoS, boosted bandwidth, and mission-critical low latency will spur a limitless number of 5G use cases, most of which we cannot begin to imagine today. But such a consumerization of connectivity and communications services will not be fully realized if managed under traditional production orchestration models. For the most part, our industry has been very production centric, typically designing offers in the network and pushing them to consumers—eat what we serve, if you will. We have not been as genuinely interested as other consumer products and services sectors in the underlying user needs and what they were doing with what they were buying.

Case in point: allow me to illustrate the current consumer reality with a real-life experience in trying to complete what I hoped was a simple task—connecting remotely to my heating system at my summer camp. I envisioned that only two steps would stand between me and arriving to a warm, cozy cottage on a brisk autumn evening: Step 1, purchase a GSM switch module from the local electronics store; and Step 2, buy a SIM card from my phone dealer. As I was only planning on sending a few SMS's a year (and to save myself a monthly bill of €20), I chose a pre-paid account. I configured the module, and put it into operation. Easy. Easy, except that pre-paid accounts expire if not topped up within 12 months (which I painfully experienced a year after



Source: Ericsson

installation). Easy, except that I had to create an account on the web portal of the operator in order to avoid being left with an inactivated SIM. Easy, except to activate my web account a login code was sent as SMS to my heating module, along with the top-up notifications to avoid expiry of the service.

If what I experienced is representative of our industry, then it seems clear that there is quite a bit of work needed to transform from the current focus on producing connectivity to consumers with phones in their hands, to playing in new markets where enterprises and consumers use network services for digitalization across a broad array of use cases involving all kinds of connections and devices. We cannot anticipate and preproduce all the variations that new technology can create. We need, as an industry, to think and prepare to be a value generating partner in the new ecosystems and business platforms that characterize this new world of 5G.

We need to look at operational models in a different way. 5G platforms allow us to turn the model around—from production driven, to enabling consumption models where the connectivity offering can be defined and packaged at the time of consumption.

In this context, a platform is an enabler from which operators can launch 5G services, encompassing network management, service management, orchestration, analytics, and monetization capabilities. Because of the diverse demands of complex end-to-end use cases, 5G can bring with it a lot of additional complexity, spanning the radio access network, the transport and the core networks, as well as the telco cloud. Operators can provide their users and ecosystem partners a platform to innovate and interact, while abstracting away some of the underlying technical complexities (e.g., sensors, data collection, connectivity).

To that end, operators are in the midst of digital transformation that will guide the modernization and deployment of new information technologies in order to be able to take full advantage of opportunities presented by 5G. Operators need to enable these innovative, fast moving services and expose control of their systems to digital enterprises who would like to play on top of stable, clearly understood platforms. In short, they must deliver value from connectivity in a platform-native way.

In a platform-centric world, the user experience is a result of co-creation at many levels: demands are defined by the configurations made by the consumer themselves. The consumer defines what they can get out of the network and the network can react, whether that comes in the form of a network slice for a remote monitoring system, or a burst of guaranteed connectivity during a natural disaster. The network adapts to the consumer need and the circumstances.

5G will drive new fundamentals from our industry. In a consumption orchestration environment, operators will stop thinking about how to sell the whole network machinery, but rather they will sell whatever is needed by each and every customer on that day at that time. If 5G is to be a great success for the industry, then operators should be interested in delivering anything the customer consumes, in any way they wish to consume it, in real time and over the long term. They must understand and embrace the holistic customer journey, and make their configurations interesting and relevant.

This ship has not yet sailed. Industry critics are quick to point out the success of cloud-native vendors who are running away with the webspeed and webscale platform economy. And yes, telecom consumers have been perpetually confused by a lack of transparency and participation. Production-centric operators may have only been interested in the underlying consumer needs when video gamers or YouTube binge watchers hogged excessive bandwidth.

But a 5G platform has the potential to change that dysfunctional dynamic and reintroduce the operator to the digital-savvy consumer or enterprise on their terms. While not a panacea for legacy restraints, 5G platforms can be the foundation for the true consumerization of telecommunications—out of sheer necessity perhaps. Trying to guess at the boundless configurations that will be of interest to the 5G user is not scalable. Herding marketing teams into conference rooms to monitor Twitter feeds and call center bulletins will no longer suffice.

An outside-in, platform-centric model by its co-creation nature will be more relevant and compelling, rooted in the actual use cases and benefits. I imagine that some day when I try to bring a high-tech feature to my cottage, I will have a virtual network at my fingertips, through a 5G enabled application, supported by end-to-end operator platforms. Easy.

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EXFO

FRONTHAUL TO 5G NEEDS A STRONG OPTICAL NETWORK

FROM C-RAN TO CLOUD-RAN BY YVON ROUAULT, TECHNOLOGY ADVISOR IN CTO OFFICE, EXFO

Accurate predictions for some technologies are difficult, but the ongoing standardization of 5G by 3GPP is providing the industry with precise requirements for future radio access network (RAN) architecture. 5G networks will be based on a radical change like the network functions virtualization (NFV), the new functional split of the 5G-New-Radio (5G-NR) based on an evolution of the centralized RAN (C-RAN) to a Cloud based RAN.

Widespread deployments of 5G are scheduled for 2020. In the meantime, mobile operators can stretch their LTE-A network to address some 5G use cases with accurate performance figures, with a mounting pressure to adopt the C-RAN architecture.

LTE-Advanced Pro (3GPP Release 13), as well as for 5G-NR (release 15), will affect the RAN and fronthaul parts of the network particularly. Hence the optical distribution network will be a key to the C-RAN/Cloud-RAN architecture, as it is hard to reach each cell site and small cells with the appropriate optical network: 5G-PPP has said the lack of access to optical networks will be the biggest obstacle to deployment of 5G.

OPERATORS MUST SPEED TOWARDS 5G

Mobile operators have limited spectrum with which to provide more subscribers with faster connectivity for bandwidth-hungry applications on smart devices. They are also looking for new sources of revenue, such as from the IoT.

5G will address these needs through apparently contradictory features: 10-100 x throughput, 10 x lower latency, and 10-100 x more connected devices. Tier 1 operators are accelerating trials of 5G radio technologies and evaluating new bands, like 3.5 GHz or 28 GHz radio bands with 200 MHz basebands, which are 10 x wider than is used in LTE.

3GPP Release 15 is set to standardize the first phase of 5G requirements by mid-2018, but already 5G is hailed as a game changer. 5G-PPP identified three classes (known as verticals) with specific radio access requirements:

- **Extreme mobile broadband** (eMBB), for example, offers 4K video. Increasing backhaul throughput will raise the bit rate of the fronthaul as well. (for the FWA – fixed wireless access – use case the data rate of the Fronthaul could be 40Gb/s, up to 100Gb/s).
- **Massive machine communication** (MMC), for example, offers connectivity to billions of IoT devices. Some applications will need deep analytics for data from sensors and other devices. More processing will happen in the RAN at the baseband unit (BBU), based on mobile edge computing (MEC) technology.
- **Critical machine communication** (CMC) will feature in many industries, from production (remote robot control) to delivery (piloting drones), which need ultra-low latency (1 ms) and reliability. Fronthaul performance will be critical.

NETWORK SLICING, VIRTUALIZATION AND C-RAN

The 5G network will be based on network slicing, a concept that still needs to be refined. Each slice supports a certain service level (latency, accuracy, data rate, coverage, etc.) for a class of end-users. All slices must run on the NFV infrastructure, including the radio network. Coordinating radio resources in real time is the only way to meet the diverse performance parameters – and this can only be achieved using a centralized RAN architecture– see Figure 1 below.

Also, before mass 5G deployment, mobile operators will improve LTE's performance with new standards. They will use new techniques – like coordinated multipoint (CoMP) – to

reach 1 Gbit/s throughput, but this needs a shorter, faster path between RRHs, which is difficult without centralized RAN architecture.

C-RAN TECHNICAL REQUIREMENTS

C-RAN architecture (see Figure 2) has specific requirements, in addition to the maximum distance between the BBU and the RRHs:

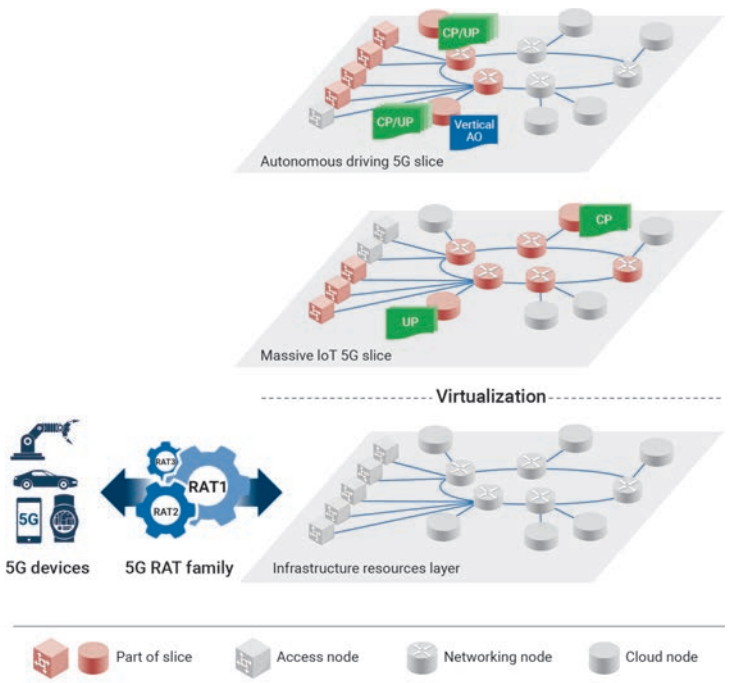
- The round-trip time of the packet handshaking protocol must be less than 3 milliseconds.
- Power budget is important, especially in passive optical networks (typical budget is 15-20 dB) which are affected by wavelength-division multiplexing etc.
- Latency asymmetry – the difference between the speed of the downlink and uplink fronthaul connections.

Virtualization of the mobile network is in progress with virtualized IP multimedia subsystem (vIMS) and virtualized evolved packed core (vEPC) networks. The next phase will be the RAN and virtualizing BBU functions.

NEW DEFINITION OF FRONTHAUL ON THE WAY

With the growing data rate to the end users, the Fronthaul will need a faster bit rate across the common radio public interface (CPRI) as well. Considering that the CPRI rate is 12x to 16x the data rate on the backhaul, bit rates would exceed 25 Gbit/s to support 2 Gbit/s FWA service throughput, for instance. To support higher data rate a new split of the BBU functions is required: a new split between the physical layer and the layers 2&3 would reduce the bit rate on the fronthaul interface significantly. IEEE (c.f. IEEE P.1914) and 3GPP RAN are working several split options. however, at the end, the inevitable increase of the data rates by a full magnitude for eMBB services will require much faster Fronthaul speeds anyway.

FIGURE 1: NEXT GENERATION MOBILE NETWORKS (NGMN) DESCRIPTION OF 5G NETWORK SLICING



C-RAN TESTING CONSIDERATIONS

Fronthaul, with the CPRI transport layer, was designed for short distances between the BBU cabinet and the RRH, on top of a tower or roof. In such a topology, the fronthaul parameters (RTT, jitter, etc.) are easy to meet. Most operators and contractors associate fiber to the antenna (FTTA) in a distributed RAN architecture as plug and play, where the latency of the fiber will never exceed 1 µs and the optical power loss is typically below 3 dB.

This is not so with C-RAN, as the insertion of optical network elements between the BBU hotel and the cell site – and the distance between the two ranging from 15 to 25 km (10 to 16 mi) – make a huge difference. Testing cell sites (RRH) should be separate from the tests at the BBU hotel – they are deployed at different times, by different teams so, in most cases, one of these two points is not active.

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RISK OF CD AND PMD DISPERSIONS

In with FTTx optical networks, dispersion issues start when the bandwidth reaches 10Gbaud and the span exceeds 10 km. As C-RAN topologies proliferate, fronthaul optical networks will find themselves in this dangerous zone.

Chromatic dispersion (CD) and polarization mode dispersion (PMD) attenuate the optical signal and increase the bit error rate (BER), especially in unpredictable environmental conditions, such as vibrations, wind and rain. EXFO recommends performing a systematic test of the dispersion above CPRI option 7 (9.83 Gbit/s), with a distance greater than 10 km.

Loss budget varies widely between vendors and network topologies. For example, when comparing SFP+ vendors on the market for a 20-km reach, their power budget will range from 10 dB to 18 dB.

Some disregard this because newer SFP modules have a much better dynamic and are more powerful, making it easier to compensate for a higher signal attenuation end-to-end. This is not an optimal approach, as powerful SFPs are much more expensive for the CWDM and DWDM (colored SFPs). Typically, there will be 12 to 15 SFPs per cell site and the incremental cost per site could exceed $1,000.

EXFO's recommendation is that the most cost-effective SFP/SFP+ modules should be carefully selected, based on the qualification of the power budget between the BBU hotel and the RRHs in each case. Specification sheets usually provide the minimum and maximum transmission power (launch power). Loss budget is calculated as the difference between the minimum launch power and receiver sensitivity.

CONCLUSION

To support the LTE-Advanced Pro evolution, and 5G New Radio, the optical links between the cell sites and the CRAN central offices or Cloud RAN Data Centers (or the virtual BBU data centers) will be a critical component of the new RAN architectures.

Requirements like latency, power loss and CPRI bit error rate, which are not critical for 3G and LTE Release 8, will become major concerns as operators migrate to LTE-Advanced Pro and 5G-NR. Even for the longer-term evolution of fronthaul technology to an Ethernet-based transport layer, the optical infrastructure will remain the same. Today's transformation investments by mobile operators in the RAN will have to support the future evolution of fronthaul technologies.

The transformation starts with FTTA and replacing copper cables with fiber to the RRH on a tower or roof. This is followed by the concentration of the BBUs in a central location, up to 25 km away from the cell sites. The evolution of radio access to C-RAN and Cloud-RAN is driven by the densification of radio access technologies, such as small and indoor cells, the multiplication of frequency bands and their aggregation to form larger basebands.

This growing complexity demands better coordination of the radio resources, requires a better Optical network foundation. Testing the optical distribution network and the CPRI transport protocol today will support network transformation to make 5G feasible and sustainable, and thus protect future investment.

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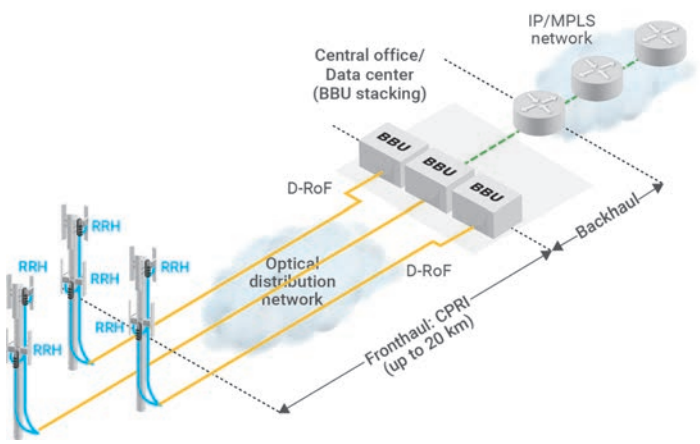
FIGURE 2: C-RAN ARCHITECTURE



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Hewlett Packard Enterprise

intel

INCREASING SERVICE AGILITY WITH 5G-READY TELCO EDGE

Hewlett-Packard Enterprise (HPE) and Intel have collaborated on a proof of concept (POC) that anticipates 5G and combines proven technology from the two powerhouses. The HPE and Intel 5G-Ready Telco Edge POC is about demonstrating a radio-aware application for video optimization in a fully virtualized network.

HPE has more than 20 years' experience as a trusted telco infrastructure provider, and Intel's processors are providing the foundation for HPE's broad portfolio of server solutions.

The coming 5G wireless networking standard promises significant improvements in bandwidth, latency, and data rates. With the new standard, communications service providers (CSPs) will be able to address a stunning range of new vertical markets such as video delivery optimization, fixed wireless communications, autonomous driving, connected homes, smart cities, virtual and augmented reality, drones, and Internet of Things (IoT) applications.

These services will have a dramatic impact, not only on the way people live their lives, but also on how organizations conduct business. Although most 5G services and business models are only in the testing and trial phases, there are many initiatives underway in preparation for the 5G future. Most importantly, we want to maximize service agility in 5G networks so that they can support requirements we've not even thought of yet.

The HPE and Intel 5G-Ready Telco Edge POC is an example of how a CSP can deliver services at the edge of the network. As the connected world moves toward 5G, the wireless industry is standardizing on network virtualization technologies such as SDN and NFV, which are already dynamically reconfiguring networks at the edge and in the core.

This networking evolution gives CSPs the service agility they need to quickly create and deploy new revenue-generating services today. Some services will be spontaneous and temporary, such as a service for a sports event in a stadium, that are put up and taken down on the same day. Such agility and dynamism requires a move away from proprietary appliances to network functions running on general purpose servers.

SLICING THE NETWORK

The POC shows an example of service agility through this "network slicing" is a video application running at the network edge and in the data center. This solution involves the HPE Edgeline EL4000 running video delivery applications and communicating with a centralized EPC built with HPE ProLiant DL380 servers – all powered by Intel architecture.

Video content can now be delivered via a local cloud at the network edge, close to the subscriber. This greatly reduces latency compared with a video appliance in the cloud. The data plane is distributed right to the network edge, and content is delivered by a video application deployed on the edge cloud.

This low-latency network slice supports the service level agreement (SLA) between the subscriber and the operator. For subscribers without an SLA, the same network provides a best-effort network slice. The remote radio head communicates with a Virtual GnodeB, running on the HPE Edgeline 4000 Converged Edge System.

The multi-edge computing platform runs video delivery applications and communicates with a centralized enhanced packet core (EPC), built with HPE Proliant DL380 Servers. HPE servers are built with scalable, high performance Intel Xeon processors, they can satisfy a range of cost/performance needs using the same software throughout the network.

Intel, HPE and our partners like TIM are collaborating to make MEC applications a reality today ahead of 5G deployments.

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TIM – THE OPERATOR'S PERSPECTIVE

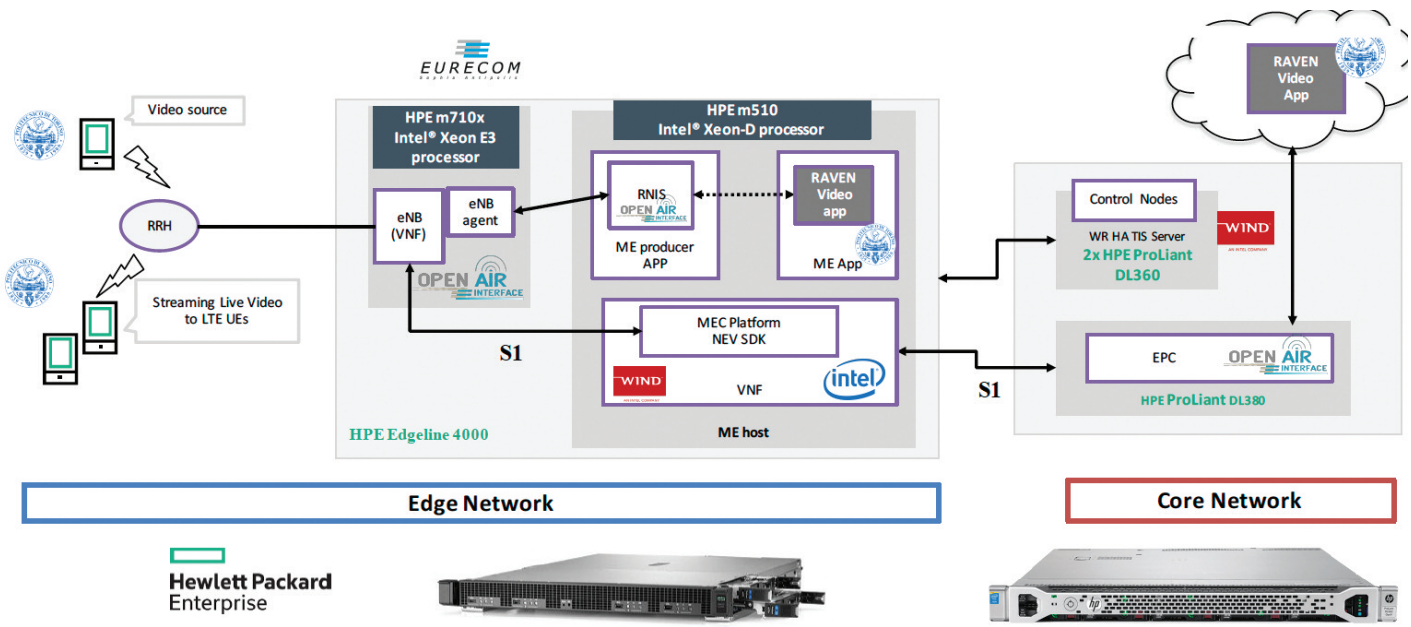
The idea of the POC was to give telcos a look at how to prepare their networks to deliver 5G services and support new business models. More specifically, to let them learn about how to maximize service agility and future proof 5G infrastructure by providing an example of what the future will look like with 5G.

In a recent webinar, Salvatore Scarpina, Project Manager, TIM, gave an operator's perspective on the POC. He explained that POCs could play an important role in proving the benefits of Mobile-Access Edge Computing (MEC is a foundational network architecture concept, designed to help 5G networks live up to their dynamic potential). This is both from a technical point of view, by assessing performance improvements, and from business point of view, by scouting and evaluating the new scenarios enabled by MEC technologies.

TIM is particularly interested in MEC because it could play an important role as an enabler for greater flexibility, to provide the shortest time to market and generate new value thanks to localized computing capabilities.

This environment is characterized by ultralow latency and high bandwidth as well as real-time access to radio network information that can be leveraged by applications and QoE platforms.

Salvatore says MEC can be considered as a technology component for the evolution towards 5G, providing IT service environment and cloud-computing capabilities within the Radio Access Network (RAN), close to mobile



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subscribers. Further, operators could open their RAN edge to authorized third-parties, allowing them to flexibly and rapidly deploy innovative applications and services towards mobile subscribers, enterprises and vertical segments.

Salvatore outlined the following possible use cases for MEC:

- consumer-oriented services include gaming, remote desktop applications, augmented and assisted reality, cognitive assistance, etc.;
- operator and third party services cover innovative services taking advantage of computing and storage at the edge, as active device location tracking, big data, security, safety, enterprise services, etc.; and
- network performance: services improving performance of the network, as content/DNS caching, performance optimization, video optimization, etc.

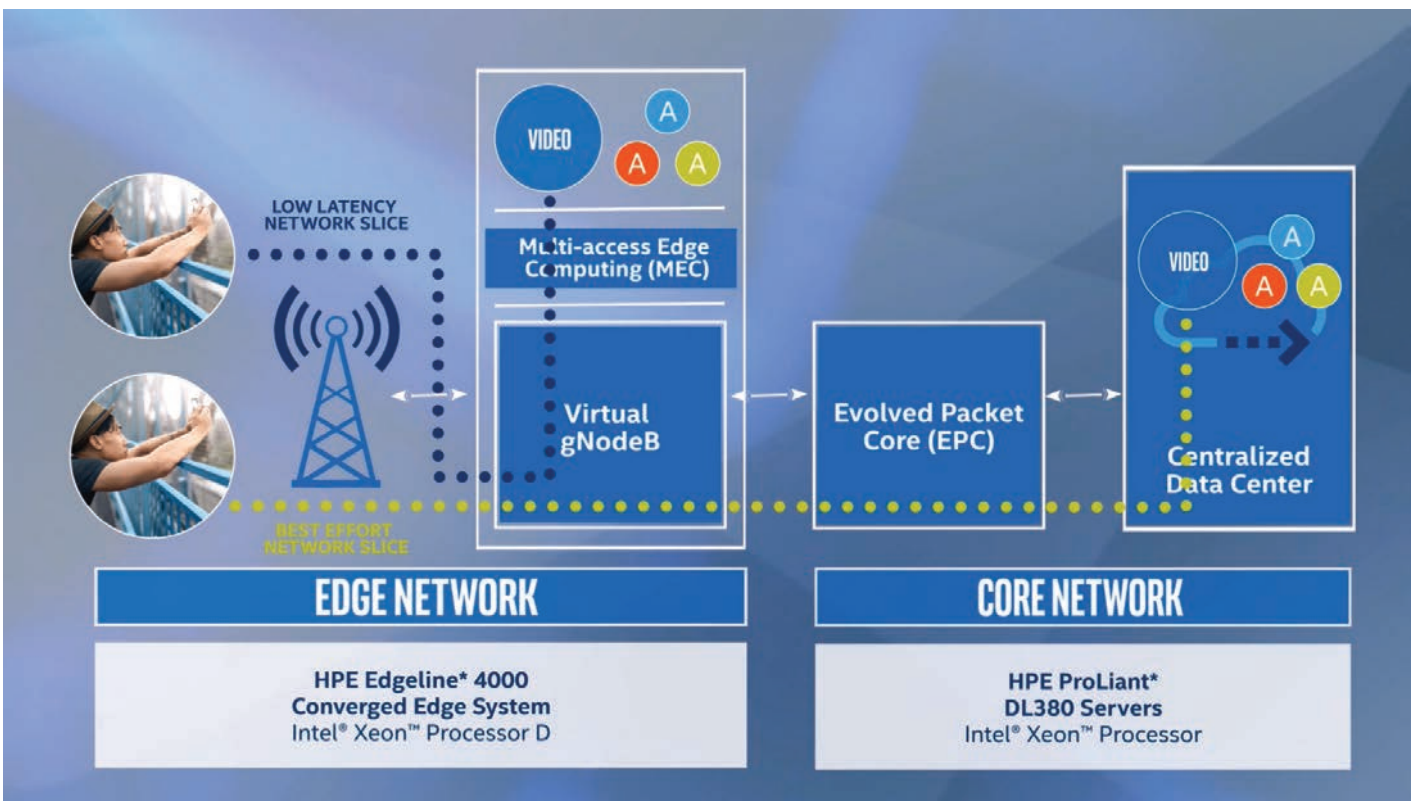
He added that this scenario of video optimization has been chosen for:

- the consolidated importance of video traffic in the present (4G) and in the future (5G); and
- the possibility of scoping out the practical constraints of a realistic application scenario.

HISTORY AND THE FUTURE

Key components of the HPE and Intel 5G-Ready Telco Edge POC were the MEC and the Virtual RAN, which used real-time radio information to modify video in real time, delivered by network slicing and service agility – see the schematic below.

Compute capabilities are changing how networks are built, blurring the boundaries between network and service infrastructure. That means moving from a hierarchical network, where functions are placed along the traffic path to a flattened network where functions are optimally placed and traffic is steered towards the most optimally



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placed. Hence the network edge will be the most dynamic part of the infrastructure because it will be:

- access agnostic
- deal with the exponential rise of connected devices and applications
- the ideal place to introduce applications that influence customer experience
- a perfect sandbox for operators to test new innovative applications.

Or to put it another way, the edge cloud becomes the keystone of the network.

Increasing overall agility for 5G will involve the major strands:

- **Network Agility through Infrastructure Transformation** – creating a flexible and open infrastructure will foster competition and innovation from a broader vendor ecosystem and enable the development and deployment of new revenue generating services.
- **Service Agility through OSS Transformation** – operations support systems (OSS) need to evolve to enable rapid and dynamic service creation, provisioning, activation, and retirement of services. A faster time to market for new services enables the CSP to react faster to market and competitive pressures along with faster time to revenue.
- **Customer Agility through BSS Transformation** – business support systems (BSS) will need to support an end-to-end, customer-centric approach that ensures subscribers get what they want, when they want it, and even before they realize they want it through predictive analytics.

IN CONCLUSION – KEY TAKEAWAYS

It is possible, right now, to deploy an open infrastructure for 5G workloads as shown in the demo described above, running a complete edge compute cloud all on a 1U HPE Edgeline 4000 system powered by Intel Xeon E3 & Xeon-D processors.

Increasing CSPs' overall agility starts with increasing network agility through creating a flexible and open infrastructure. Crucially, it also includes transforming OSS and BSS systems to increase the agility of services and customers respectively.

To be successful with 5G, one of the first requirement is reliability from end-to-end. HPE will continue to deliver high performance server solutions with high availability that are NEBS and ETSI compliant and have extended product lifecycles and more. Future proof your 5G network with HPE servers powered by Intel processors.

Visit https://youtu.be/_IK0BOKkU1A to see the HPE and Intel 5G Telco Edge demo in action.

Watch this video to see the HPE and Intel 5G Telco Edge demo in action. To learn more about HPE and Intel 5G innovations, please visit intel.com/network and hpe.com/dsp/infrastructure

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NTT DATA

5G PLATFORM BUSINESS IS NOT ONLY A TECHNOLOGY CHALLENGE

Laurence Norman, Chief Architect, NTT DATA UK

5G is many things to many people, and is – at the end – a placeholder name for the convergence of a range of technologies, standards and capabilities which will undoubtedly deliver innovative services as well as disrupting entire classes of business.

Our belief is that operators are best suited to deploying these difficult technologies to enable themselves and others to build novel products and services on top of them. One of the main innovations enabled by these technologies will be a new type of platform business.

These business models rely on scale (and scaling up fast). The estimates on the number of connected devices by 2020 vary widely. Latest estimates from Gartner and IDC put the number conservatively in the 10 billion range (plus smart phones) – and with plenty of multi-year growth. This generates a classic network economic effect of its own as well as opportunities for a plentitude of targeted vertically integrated use cases.

The creation of a platform model can be seen as an exciting move into a truly digital business and it can be seen as a terrifying disruption to an existing and successful business model. No one knows how it will shake out. Forward thinking operators such as NTT are already embracing the B2B2X models, and seeing material uptick in revenues. Arthur D Little estimates the B2B2X model could be worth €276Bn by 2020 and CSP are well placed to grab a large proportion of this.

As with all innovations, there are challenges to face. If addressed (even embraced), the opportunities for future profitable revenue growth are enormous.

CHALLENGE 1: HOW ACCOUNTANTS COUNT (AND HOW SHAREHOLDERS BEHAVE)

The international telco industry has been using standard business performance metrics for decades, which has helped define the growth of individual businesses and has been a useful benchmark against which companies are compared.

Metrics such as ARPU and AMPU even made sense for the period of locked in contracts, device subsidies and service contracts; especially for their ability to accurately forecast future revenues. However, it began to stifle innovation fairly early on. The first attempts to separate handset revenue from service revenue stumbled upon the „ARPU" impact. i.e. the key industry performance metric would actually reduce for the first company to adopt this business model innovation, and would be perceived as performing badly against their peers.

In the emerging platform eco-systems, new measures of business performance will be developed which better represent the kind of multi-sided business models which will emerge. ARPU has no relevance when there is no overall 'User'.

Recommendation: Develop new primary business KPIs. These new metrics must be designed to motivate desired outcomes throughout the organisation. For example, encourage rapid creation of new products on the platform, embed an experimental mindset, increase the number of partners and increase areas of automation.

CHALLENGE 2: EMBRACE A NEW CULTURE

CSPs have performed well over the last few decades following their classic pipeline business. That is, they own and control the primary product (connectivity) and they procure and distribute through their own sales channels. Prior to the iPhone, they even had some control of the devices being built.

In essence CSPs are culturally conditioned to control as much of the value chain as possible. From handset subsidies to the attempt at content walled gardens.

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In the platform world, a business can afford to sacrifice margin for scale and enable others to generate value on top of your underlying capabilities. It requires the operator to be brave enough to release control. On the flip side, operators excel at providing end to end integrated service management (i.e. an assured service to the end customer) - and this kind of engineering expertise and deep cultural respect for customer experience is an asset which operators should continue to exploit.

Recommendation: encourage and embed experimentation and rapid governance decision making into the organisation through deployment of new operating models. These are multi-modal in nature with stable and predictable approaches for the classic CSP business, and more fluid approaches for the platform business. As well as enabling 'fail fast' experimentation, the digital CSP must 'scale fast' to take immediate advantage of business opportunities.

CHALLENGE 3: LEARN TO PARTNER NICELY

Operators have a reputation for being hard to partner with. They are organised around large long term deals with big companies. Wholesale arrangements, roaming and interconnect deal take months of negotiations and teams of lawyers to complete. The 5G platform business on the other hand is about enabling hundreds of smaller entrepreneurial companies to create value (or fast moving parts of the operator's new digital business). This needs an entirely different way of working. It needs one click contracts, and simple terms. It needs zero touch processing and rapid, stress free settlement. It also needs a mindset shift to treat partners a new stream of revenue and as important to you as your end customers are now.

Recommendation: As part of the platform business, build systems and processes (and organisations) optimised to identify, onboard and manage a broad range of large, medium and small companies.

CHALLENGE 4: SYSTEMS INTEGRATION

Many of the challenges facing operators in the age of 5G, platform business and digital disruption have become a systems integration problem. The drive towards commodity IT infrastructure, virtualization techniques and software driven functions underpin this statement.

Many network equipment providers are attempting to build consulting and service arms and are struggling to come to terms with their own cultural legacy. Conversely, IT systems integrators are moving cautiously into the network world where scale and high performance requirements are causing their own problems.

Recommendation: Look for systems integrators that partner well and are easy to do work with. Those integrators who work with and contribute to TMFORUM standards Companies that can call on deep network knowledge as a technology supplier as well as knowledge of actually being an operator. Also look for partners who can call on strength in business and cultural change consulting expertise to help navigate through the exciting changes ahead.

In conclusion, the advent of 5G technologies will enable a broad range of new, innovative and disruptive services. Operators are well placed to maximize the value of the investments they made by scaling out into a platform business, but they need to embrace the necessary change. Selecting technology partners with the right combination of business change, technology systems integration and access to deep network knowledge will allow CSPs to accelerate their transformation journey. Oh – and buy a new calculator.

Laurence Norman is the Chief Architect at NTT DATA UK and has more than 20 years in the telco media industry. Working on a wide range of advisory and delivery projects, Laurence is a passionate believer in the power of technology as a vehicle for change.

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5G REVIVES NETWORK-BASED DIFFERENTIATION

LTE LEVELLED THE PLAYING FIELD

The greatest competitive differentiator of any service provider should be its network. Heavy investments in the network should empower the differentiated services that drive price premiums over competitors and drive cost efficiencies through economies of scale and scope. However, since the introduction of LTE technology, mobile network operators have struggled to monetize these advantages.

There are several reasons for this. First, regulations such as net neutrality have limited the extent to which operators can monetize "fast lane" type services on the consumer side, resulting in "one size fits all" service quality. Marketing campaigns have effectively convinced many subscribers that network quality is nearly level across providers, driving the basis of competition to unfavorable dimensions such as price or device subsidy. Additionally, "over the top" competitors on the consumer side enjoy the same network quality as service provider data services in most cases, further eroding any ability for the service provider to distinguish itself technically or commercially.

On the enterprise side, regulatory barriers are less constraining, and many operators support SLA based services with premium pricing. However, here too operators struggle to differentiate as the technologies underlying these services have become more homogenous. This means that most providers are offering similar SLAs and are subject to similar economic realities. In summary, since the introduction of LTE, operators have not enjoyed an opportunity to distance themselves from the pack using their network.

5G CREATES A NEW PLAYING FIELD

5G technologies are especially disruptive as they enable operators to expand their revenues and improve subscriber QoE while simultaneously controlling costs. On the revenue expansion front, 5G enables operators to design and rapidly rollout truly innovative services to unique enterprise verticals in contrast to the "one size fits all" simplistic SLAs of today. An often-touted example of this is remote surgery, where an operator must provide highly reliable, high QoE, real-time video between two potentially distant locations over a secure connection. But there are many other examples as shown in Figure 1, with the ultimate potential limited only by service provider creativity.

On the cost side, several key technologies will allow early adopters to rollout new services faster and with greater efficiency than rivals. First, while the cost saving potential of NFV/SDN is debated in the industry, its ability to make the network more elastic and agile is undeniable. This capability is also a key enabler of the other two efficiency improvements tied to 5G, which are network slicing and automation. With network slicing and NFV/SDN technologies both in place, operators can effectively utilize their network capacity to a greater degree than previously possible. Specifically, virtualized network assets can be reallocated based on priority (e.g. first responder services preempting consumer mobility), seasonal or temporal variations in demand across services and slices, or variations in application requirements (i.e. radio versus signaling intensive services). Finally, automation combines with these capabilities to maximize efficiency by automating previously laborious tasks like service changes, network reconfigurations, and capacity reallocations.

FIGURE 1: EXAMPLES OF INNOVATIVE SERVICES ENABLED BY 5G.

GETTING IT RIGHT THE FIRST TIME

Many operators are sitting on the 5G sidelines, waiting to learn from the experiences of others. This creates an opportunity for bold operators to take calculated risks and disrupt the status quo. However, the key word in the last sentence is calculated, as no operator wants to charge into a new technology with no mechanism to

SPONSORED FEATURE

ensure that it is working at every step in its lifecycle. Complicating this challenge, 5G leverages immature NFV technology and introduces a new layer of complexity with network slicing. Figure 2 provides a sampling of key 5G functionality which must be tested and assured across the lifecycle.

FASTER TIME-TO-MARKET THROUGH DEVOPS

5G must also support radically faster service innovation which means each stage of testing and assurance must take less time and use fewer resources relative to previous generations. That's why leading service providers are adopting DevOps and working to streamline and unify testing across key development and operations workflows such as network validation, service testing and operational assurance. Unfortunately, the migration to DevOps brings significant challenges related to entrenched differences in testing and assurance approaches across development and operations teams.

SPIRENT AS A LIFECYCLE SERVICE ASSURANCE PARTNER

Rapidly rolling out and assuring 5G platform-based services requires two significant changes to the status quo. First, a DevOps approach is required to ensure that development and operations teams leverage a unified set of metrics, methodologies and systems. Spirent is pioneering a new approach to testing and assurance based on DevOps principles called Lifecycle Service Assurance (LSA). With LSA, the same test conditions, agents, scripts and analytics are utilized throughout the lifecycle of the key functions in Figure 2. This speeds time to market and improves quality by ensuring that pre-launch testing and validation mirrors production testing and assurance.

Another key aspect of LSA is the use of sophisticated analytics to monitor, model, analyze and act on the myriad different datasets associated with the functions in Figure 2. Similar analytics are already being applied to 3G and LTE (see Figure 3); however, 5G is driving new needs including consideration of variations in customer quality requirements, support for dynamically changing hybrid physical/virtual networks and closed-loop automation.

Spirent is actively partnering with 5G innovators to apply LSA principles to early deployments and help realize the promise of 5G as a true competitive enabler.

FIGURE 2: CRITICAL 5G FUNCTIONS MUST BE TESTED AND ASSURED ACROSS THE SERVICE LIFECYCLE.

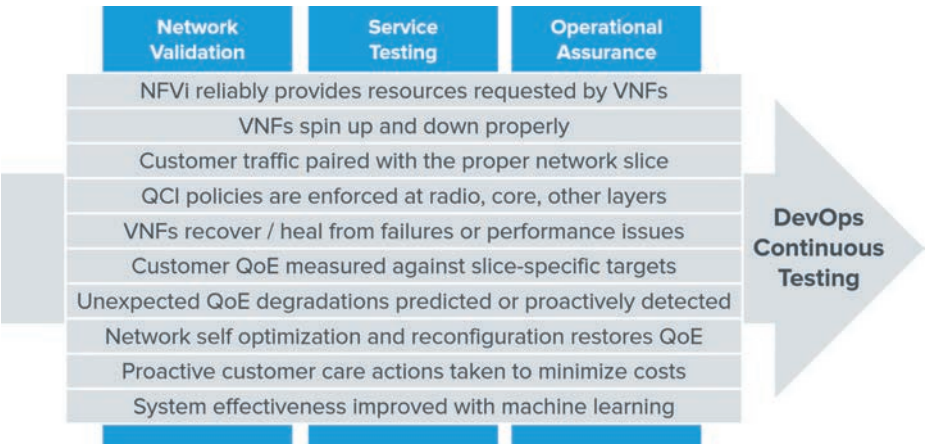
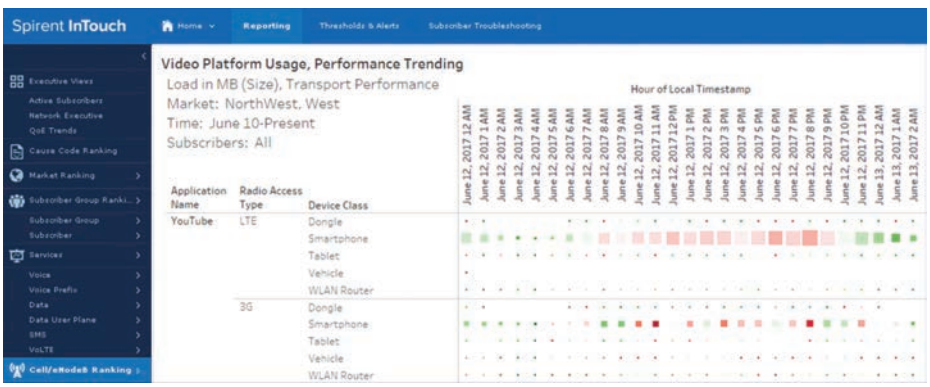
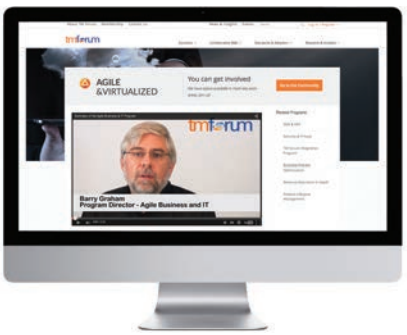


FIGURE 3: SPIRENT INTOUCH DELIVERS THE SOPHISTICATED ANALYTICS REQUIRED BY 5G AND DEVOPS.



TM FORUM TOOLKIT FOR PLATFORMS AND 5G



AGILE & VIRTUALIZED

OSS/BSS Futures Architecture
This exploratory report provides initial steps toward the required architecture for the Future Mode of Operations, which incorporates virtualization and software-defined networking with current networking architectures.

Dynamic Control Architecture for Managing a Virtualized Ecosystem
This information guide presents some practical closed-loop use cases as presented in TM Forum Catalyst proof-of-concept projects.

Business Rationale and Technical Overview for Orchestration and Autonomic Control Loops
This information guide proposes an architecture based on orchestration accomplished through a federation of domains and autonomic control loops.

OPEN & PARTNER EFFECTIVELY

Open APIs
TM Forum offers 18 Open APIs (with more under development) to manage services end to end and throughout their lifecycle in a multi-partner environment.

Digital Services Toolkit
Currently under development, this toolkit will help companies rapidly address business problems using a collection of interlinked assets based on Frameworx.

Online B2B2X Step-by-Step Partnering Guide
This guide explains the five stages required to build a partner relationship. Each stage provides key concepts, strategy and approach, worksheets, examples and exit criteria to enable streamlined and repeatable implementation.

CUSTOMER CENTRICITY

Customer Experience Management Solution Suite
This set of tools consists of six components: a guidebook, hundreds of metrics, a maturity model, a lifecycle model, more than 40 implementation use cases and an ROI model.

Big Data Analytics Solution Suite
This set of tools includes a big data reference model, a guidebook containing 65 use cases and 1700+ pre-defined metrics.

360 Degree View of a Customer
This guidebook offer a 360-degree view of a customer and explains how to put customers at the center of considerations and actions.

RESEARCH & PUBLICATIONS

EBOOKS

- Platforms: How to join the revolution
- Open APIs: Turning business strategy into reality
- Navigating the IoE Roadmap of Challenges

INSIGHTS RESEARCH

- Cloud BSS: The migration begins
- Orchestration: Get ready for the platform revolution
- Delivering end-to-end services in a hyper-connected world

QUICK INSIGHTS

- Microservices: Piecing together a strategy
- Data analytics & AI: Key to end-to-end management
- Digital Transformation: So hard, so necessary – so here's what to do

FRAMEWORX 16.5 ADVANCES DIGITAL TRANSFORMATION THROUGH COLLABORATIVE R&D

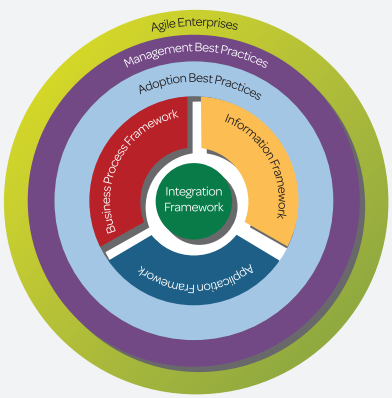
Since May 2016 hundreds of individuals from a diverse range of member companies have worked in TM Forum's unique collaborative environment to deliver new features in TM Forum Frameworx 16.5 The projects were all within the context of the Forum's strategic programs: Open APIs & Digital Platforms, Agile Business & IT, the Internet of Everything and Customer Centricity & Analytics.

OPEN APIs & DIGITAL PLATFORMS

Building on the release of the new API crowdsourcing template in June 2016 and phase two of the Open API Manifesto, which now includes 19 of the world's largest service providers and technology ecosystem partners, this team has delivered:

- an additional 13 API specifications bringing the total number of Open APIs to 31 – new APIs include balance management, loyalty management and change management;
- three conformance profiles and test scripts for the Product Catalog API, Trouble Ticket API and Entity Provisioning API; and
- an Open API governance guidebook, specifically designed to ensure consistency.

Contact Joann O'Brien, Vice President, Open APIs & Ecosystems, TM Forum, for more information or to get involved via jobrien@tmforum.org



AGILE BUSINESS & IT

This program, which includes the Zero-touch Orchestration, Operations and Management (ZOOM) project, helps organizations continuously optimize their IT and business operations.

Additions include:

- the first release of a blueprint for a Hybrid Network Management Platform, providing a guide to creating a management platform – this forms the foundation for major work in 2017 to bring together multiple open-source groups to demonstrate how to implement such a platform;
- an information guide about procuring and onboarding virtual network functions, which draws on work in an important Catalyst proof-of-concept project called Enabling the Digital Services Marketplace with Onboarding Automation;
- continued collaborative work on introducing DevOps methodologies into traditional network operations, including a study on the impacts of working across multiple partners in such an environment;
- a refresh of established Frameworx training courses to ensure they remain fully up-to-date with the latest uses of the Forum's Business Process (eTOM), Information (SID) and Application (TAM) frameworks for digital transformation initiatives.

If you'd like to know more about ZOOM, contact Ken Dilbeck, Vice President, Collaborative R&D, TM Forum via kdilbeck@tmforum.org

THE INTERNET OF EVERYTHING

The goal of this program is to enable an open digital ecosystem where new services can be delivered quickly, easily and securely using a wide range of business models and partners. New additions include:

- the hugely popular recent ebook Navigating the IoE Roadmap of Challenges: Insights and opinions for digital businesses, which provides a reference listing of the top 20 business, technology and market challenges facing all companies in the digital economy;
- an important Catalyst project called Smart life: My home, my city, my planet, which demonstrated the foundation for an agile IoE ecosystem;
- enhancement of the Digital Services Reference Architecture (DSRA) with a new Privacy Management service definition, which for the first time provides privacy management support across the DSRA and introduces the Privacy Management API; and
- extensions of the widely successful TR211 Online B2B2X Partnering Step-by-Step Guide and TR424 B2B2X Business Scenario Template to include new sections on monetization and the platform economy.

Contact Craig Bachmann, Senior Director, Open Digital Program, TM Forum, via cbachmann@tmforum.org if you'd like to find out more or get involved.

CUSTOMER CENTRICITY & ANALYTICS

This program focuses on development of the Forum's extensive library of customer experience management (CEM) assets, metrics and best practices for big data analytics. New features include:

- the Big Data Analytics Guidebook, which provides a new automated toolkit for data analytics maturity to provide a starting point for assessing an organization's current state and identifying opportunities for closing critical analytics gaps;
- evolution of the TM Forum Information Framework to help operational support systems scale with increasing quantities of transactional data;
- enhancements to the Analytics Big Data Repository (ABDR), which address critical domains such as the customer and billing;
- an important Catalyst project called Cognitive Digital Agent, which demonstrated how to create the next generation of customer care services through machine learning and artificial intelligence; and
- a new version of the Guidebook on a 360 Degree view of the Customer, which includes a new method for outside-in scoring of customer experience – this approach helps service providers move beyond the traditional Net Promoter Score (NPS) in measuring customer sentiment.

Contact Robert Walker, Senior Director, Customer Centricity & Analytics Program, TM Forum for more information or if you'd like to get involved via rwalker@tmforum.org

WHAT ARE YOU WAITING FOR?

TM Forum's members can download Frameworx 16.5's assets and deliverables right now.

As Nik Willetts, Deputy CEO, TM Forum, explains, "All TM Forum members can now leverage new toolkits, best practices, maturity models, guides and technical reports to help them tackle the most pressing challenges their businesses are facing.

"Whether you're looking to transform your networks to achieve business and IT agility, drive true customer centricity, or drive growth through new platform business models, TM Forum members are working together to deliver pragmatic, real-world solutions."

And if you're missing out because you're not a member, contact Tim Banham, Managing Director, Member Engagement & Sales, TM Forum via tbanham@tmforum.org.

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AFFIRMED NETWORKS

Affirmed Networks' NFV solution has become the standard for the world's top mobile operators, who are embracing new business models and building new revenue streams by making the transition to virtualized architectures. The company's technology portfolio includes the Affirmed Mobile Content Cloud, the Affirmed Wi-Fi Gateway (serving as a TWAG/TWAP and an ePDG), Affirmed Service Automation Platform (ASAP), and Affirmed Virtual Probe and Analytics Solution. These virtualized solutions have come to represent the present and the future of virtualized mobile networks with extreme scalability, remarkable flexibility, comprehensive network orchestration, and future-proof solutions for a 5G-ready architecture. Please find more information at www.affirmednetworks.com

ERICSSON

Ericsson is a world leader in communications technology and services with headquarters in Stockholm, Sweden. Our organization consists of more than 111,000 experts who provide customers in 180 countries with innovative solutions and services. Together we are building a more connected future where anyone and any industry is empowered to reach their full potential. Net sales in 2016 were SEK 222.6 billion (USD 24.5 billion). The Ericsson stock is listed on Nasdaq Stockholm and on NASDAQ in New York.

Read more on www.ericsson.com

EXFO

EXFO develops smarter network test, monitoring and analytics solutions for the world's leading communications service providers, network equipment manufacturers and webscale companies. Since 1985, we've worked side by side with our customers in the lab, field, data center, boardroom and beyond to pioneer essential technology and methods for each phase of the network lifecycle. Our portfolio of test orchestration and real-time 3D analytics solutions turn complex into simple and deliver business-critical insights from the network, service and subscriber dimensions. Most importantly, we help our customers flourish in a rapidly transforming industry where "good enough" testing, monitoring and analytics just aren't good enough anymore—they never were for us, anyway. For more information, visit EXFO.com and follow us on the EXFO Blog.

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Intel makes possible the most amazing experiences of the future. Harnessing the capability of the cloud, the ubiquity of the Internet of Things, the latest advances in memory and programmable solutions, and the promise of always-on 5G connectivity, Intel is disrupting industries and solving global challenges.

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NTT DATA

NTT DATA is a leading IT services provider and global innovation partner headquartered in Tokyo, with business operations in over 40 countries. We help develop innovative business and IT solutions for some of the most respected organisations in the public and private sectors across areas such as consulting, cloud solutions, business intelligence, analytics, and big data.

Our emphasis is on long-term commitment, combining global reach with local intimacy to provide premier professional services varying from consulting and systems development to outsourcing.

Clients choose NTT DATA because we are easy to work with and technically capable. Many of our clients have been with us for a decade or more and engagements typically start with a small pilot that grows to a strategic partnership arrangement.

SPIRENT COMMUNICATIONS PLC. (LSE: SPT)

Spirent Communications Plc. (LSE: SPT), enables innovations in communications technologies that help connect people. Whether it is service provider, data centers, enterprise IT networks, mobile communications, connected cars vehicles or the Internet of Things, Spirent solutions are working behind the scenes to help the world communicate and collaborate faster, better and more securely. The world's leading innovators rely on Spirent expertise to help them design, develop and deliver best-in-class solutions to their customers.

spirent.com

For more about the Forum's work on platforms and 5G, contact, Barry Graham, Senior Director, Agile Business & IT, via **bagraham@tmforum.org**

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