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VIAVI Solutions

THE 5G BUSINESS CASE PUZZLE

PUTTING IT ALL TOGETHER

Produced by:

LightReading

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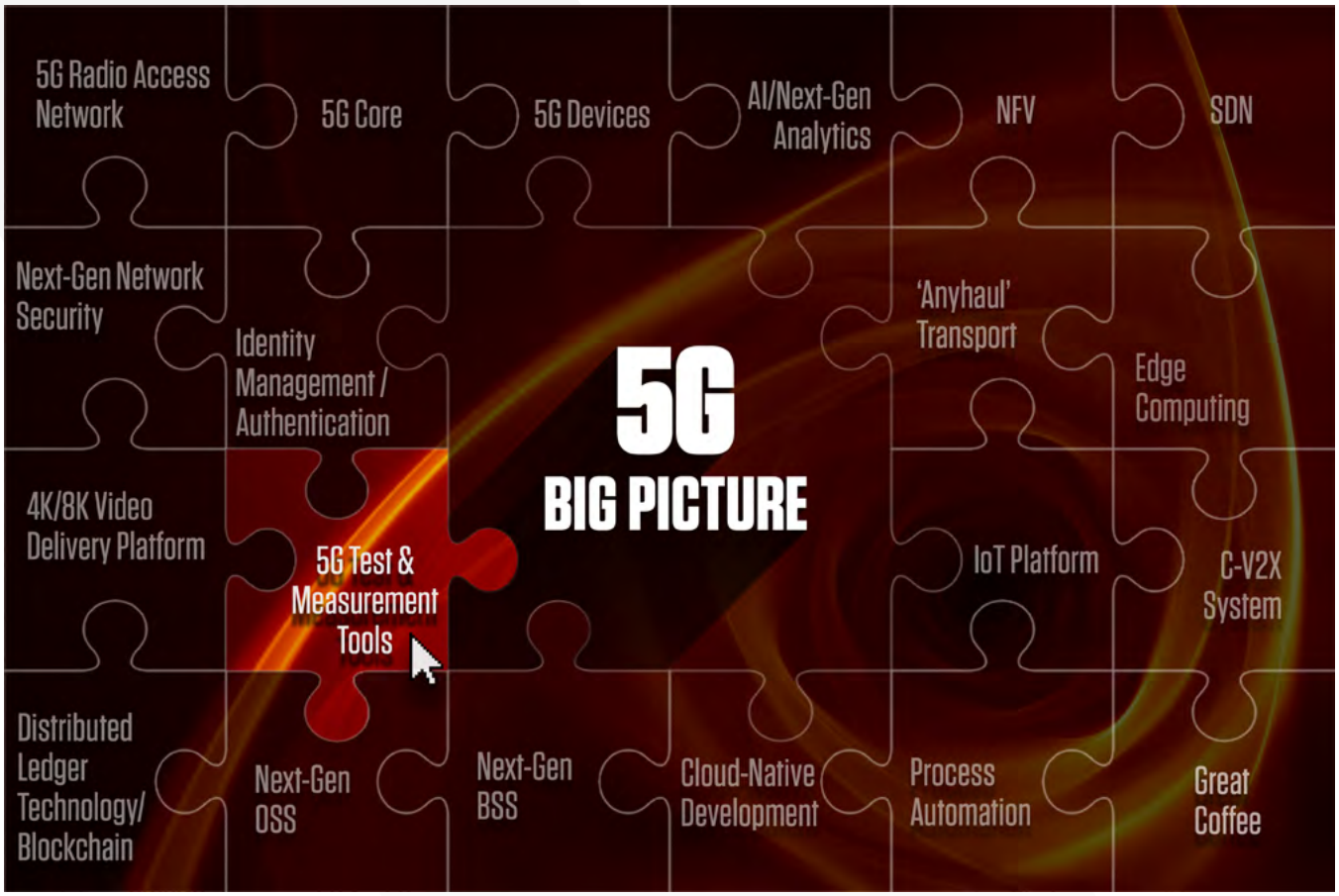
Introduction

As 5G deployments ramp up, new business challenges abound including dilemmas behind how service providers and vendors should price 5G services and devices.



The telecom industry is, once again, at the dawn of a new era. The fifth generation of mobile technology has started to be deployed, slightly ahead of the implied schedule of its formal name – International Mobile Telecommunications-2020. While existing mobile technologies such as 4G-LTE (IMT-Advanced) and even 3G (IMT-2000) are expected to coexist with 5G for many years, the next generation should enable new levels of data throughput and latency, untapping new opportunities for business productivity and consumer leisure.

The new capabilities, that 5G promises, carry stricter technical requirements for the network in areas such as reliability, energy efficiency, and connection density (e.g., for massive IoT). This drives the need for increased testing of components, elements and the end-to-end network itself as well as ongoing performance monitoring and service assurance. Testing begins in the lab where new 5G features and interfaces such as eCPRI are evaluated. It then progresses to functional and load testing of network elements (e.g. next generation node Bs) in production environments. The radio air interface, as well as the fiber network that connects the radio access network to core must be tested.

INTRODUCTION...CONT'D

5G brings new challenges, in particular the much higher frequencies that are being used in comparison with prior generations. While some low frequency bands around 3-4 GHz are being used for 5G the bands above 20 GHz are those that have the greatest available spectrum and hence bandwidth potential. However, these higher frequencies suffer from greater attenuation with distance from the transmitter and are more impacted by atmospheric conditions such as rain. On the other hand, these higher frequencies have shorter wavelengths. As such the antenna size required to transmit these signals is smaller than for longer wavelength carriers. This enables much larger arrays of antennae to be mounted in a given volume which enables massive MIMO (multiple input, multiple output antenna arrays). With massive MIMO, the multiple antennae can control the direction of a wave-front by appropriately weighting the magnitude and phase of individual antenna signals in the array. However, operators must dynamically optimize the weights of antenna elements to improve the coverage in a multi-cell scenario considering the inter-site interference between multiple 5G massive MIMO cell sites. Testing and optimizing massive MIMO introduces a whole new set of challenges for operators.

Enabling massive MIMO in turn enables beamforming whereby many parameters (reference signal power, distance, channel quality indicator, etc.) are altered to determine the optimum trade-off between the probability of users finding a good beam and system resource consumption. Finding this optimal trade off will require complex measurements and analysis.

5G also brings new challenges with the move to virtualization. The baseband processing part of the RAN has been virtualized which means that resources can be scaled up or down dynamically to meet changing demand patterns. Centralizing this processing in an edge data centre makes sense economically but introduces new challenges around latency and suitability of standard server technology (x86-based) for signal processing. Testing how these virtual RAN resources will perform as 5G traffic loads increase will be key.

In the near term 5G RAN is being deployed to work with existing core networks (the so-called non-standalone arrangement). Testing the interoperability between the new radio network and the existing core is paramount. As operators start to deploy the new 5G core (moving to the standalone 5G mode) this should facilitate new capabilities such as network slicing. However, the end-to-end testing of network slices will be complex as each slice will have its own performance requirements. Mapping the optimal slice configurations across the RAN, transport and core will be a major challenge for service providers.

To live up to its promise network slicing will need robust prototyping, testing and continuous assurance.

In addition, Location Intelligence (LI) supporting Assurance and Monetization will play a key part. LI will become beam-aware and slice-aware providing granular insight on what is happening and where on a highly densified 5G network

Given all the complexities of 5G and the new testing and assurance requirements it brings, automation will be key to its success. Automation will enable faster root-cause analysis and real-time service impact assessment. Connecting the service assurance system with the orchestration platform or ticketing systems can enable operators to close the loop with remediation measures being automatically initiated. Ultimately the aim is to reach completely automated service orchestration over the entire lifecycle from customer request to service provisioning and ongoing monitoring, leading to Predictive Analytics.

For 5G to live up to expectations the industry needs to incorporate new test and measurement solutions that span pre-deployment lab testing, networking planning, deployment, site verification, service turn up, and ongoing optimization. Operators will need new tools that let them manage, assure and maximize the monetization potential of their networks whether that be through the enablement of new services (e.g. industrial IoT) or by gaining greater insight from customer analytics.

INTRODUCTION...CONT'D

This is why '5G Test & Measurement Tools' is one of the key puzzle parts in Light Reading's 5G Big Picture. In our view, a successful 5G strategy will require network operators to address, in some way, a very broad range of technologies and processes, all of which will play a critical role in enabling them to capitalize on the full potential that a 5G deployment will offer. All of these are pieces in the 5G Big Picture jigsaw puzzle: Miss, or dismiss, any of the 20 elements, many of which are interdependent, and the picture will be incomplete and opportunities lost. Deploy them together and the chance of success is greatly enhanced.

With 5G, the mobile industry is poised for a new lease of life. As always, the challenge will be to efficiently operationalize the new technology to enable low cost, high quality services.

This report highlights some of the early advances made by participants in the 5G ecosystem and the opportunities and challenges that 5G is bringing to the telecoms industry.

James Crawshaw
Senior Analyst
Heavy Reading

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Making the Case for 5G

5G business models are emerging – including some pleasant surprises – even though the technology is still in its infancy.

5G is in its early days and facing an increasing barrage of criticism, but it's rolling out fast and much sought-after business models are emerging -- including a few pleasant surprises.

Eight operators had rolled out more than 1,120 5G radio access network site deployments as of late October 2019, noted Gabriel Brown, Heavy Reading principal analyst, during a recent breakfast briefing in Los Angeles. Brown attributed those numbers to Ookla, which provides a popular speed test tool for consumers and which has built a 5G map of where operators have built out 5G sites.

"For an industry that often describes itself as slow moving, this is phenomenal," Brown said.

In the US, Sprint is early to market with 5G, and the provider is already seeing early use cases and trends, Bryan Fries, Sprint VP 5G strategy and global services, said. But even though 5G is new, Fries said he's been living with 5G a long time.

"I've spent nearly every moment of my life thinking about 5G for the past few years," he said.

Kicking off his talk about business potential for 5G, Fries said, "I'm not going to spend a lot of time talking about remote surgery."

Remote surgery is front-and-center in telco and vendor marketing presentations about the future of 5G, along with mass-market virtual reality and self-driving cars. What these use cases have in common is they don't exist -- they're entirely speculative.

Meanwhile, in the real world, media delivery is emerging as a 5G use case. Media traffic comprises some 70% or more of network traffic, and 5G lets users access media in a fraction of the time it takes using 4G/LTE, Fries noted.

"When you make things better and easier for people, they'll use more of it," Fries said. And, indeed, Sprint is already seeing higher levels of engagement with data services over 5G, though Fries acknowledged that at least part of that would be due to today's 5G early adopters being likely to use more bandwidth anyway, simply by virtue of being "power users."

Sprint partnered with streaming mobile gaming platform Hatch in a recent 5G project. Gaming is a big opportunity for 5G; more than half of the US population plays a mobile game at least once per month, providing an early opportunity to highlight 5G opportunities, Fries said.

THE GAMEPLAY WAS AWESOME

Soon after lighting up 5G in Los Angeles, Sprint hosted the first amateur esports tournament over 5G in a full night of gameplay. For example, four people competed on Hatch on a beach buggy racing game, followed by a bout of Fortnite, all done using high-end gaming PCs hooked up to 5G connections, Fries said.

"The gameplay was awesome. The energy was high. People had a fantastic night," Fries said, noting this wasn't a telecom industry event -- the people involved were part of the gaming community.

The event was held in partnership with Hatch, Nokia (Sprint's radio access network provider) and Super League Gaming. Partnership is key to delivering 5G benefits, Fries said -- operators won't be able to do it alone.

Gambling is another promising use case for 5G, Boingo Wireless CEO Mike Finley said. More precisely, "micro-betting." Using the low-latency capabilities of 5G networks, consumers will be able to make almost instantaneous bets on individual events in games, such as whether a basketball player makes a particular shot.

Shifting to a focus on enterprise opportunities, Alejandro Holcman, Qualcomm SVP corporate engineering, said the company is bullish on the

MAKING THE CASE FOR 5G...CONT'D

possibilities of millimeter wave 5G, which works well indoors, in locations such as warehouses, factories and other commercial buildings with a need for the kind of wireless networking 5G can provide.

Enterprise applications are often cited as the first, best use case for 5G, but those will be challenging to implement, Ericsson CTO Erik Ekudden said. The technology is there, but it requires enterprises to make big changes, finding engagement for deployments that will play out over multiple years.

Nonetheless, enterprises have strong interest in 5G as a network platform. They want the guaranteed, predictable performance in a wireless network that 5G promises, Ekudden said.

Different industries and regions are finding their own unique needs for 5G, Qualcomm's Holcman noted. 5G looks set to replace WiFi in some industries, while regulators in countries such as Germany have set aside 5G spectrum fro allocation to enterprises that want to build their own 5G networks.

THE PLATFORM AS A PLATFORM

Ekudden made the case for Ericsson as a 5G technology provider to telcos and enterprises. Openness, he said, is important, but it requires a guiding architecture. Organizations are "caught in a web of system integration work that costs them more and more," he said. And that's why organizations are coming to Ericsson. They want to consume "the platform as a platform, and not as bespoke pieces," the Ericsson man said.

On the consumer side, 5G is going very well, Ekudden said. If you interview random consumers, many are not just expecting 5G, they're "expecting it to be a step change," he said. About two thirds are willing to pay more for performance, he suggested: "They are longing for that higher bitrate and low latency they have been promised," Ekudden said.

Where is 5G most prevalent? An early start in North America paved the way for aggressive buildout plans, Ekudden said. Northeast Asia, particularly South Korea, saw massive buildout at the same time, with 3 million customers and nearly universal coverage, albeit in a smaller country. That penetration will pave the way for new user experiences such as AR/VR. Japan and China are strong on planned buildouts, the Ericsson CTO said.

Worldwide, 1.9 billion subscribers are expected to be using 5G services within five years, and penetration is already underway in every part of the world, including pockets of development in the Middle East and parts of Africa, Ekudden said.

With 5G in its infancy, some early services have attracted criticism for poor performance, but according to Ekudden, reality exceeds expectations. "One of the things that surprises people is that it works so well," he said. Using tools such as midband spectrum, dynamic spectrum sharing and carrier aggregation, operators can solve for noticeable problems. "You start with the current grid and upgrade it and deploy more densities when you need it," the Ericsson executive said.

DIFFERENT STROKES

Heavy Reading analyst Steve Bell expressed concern that consumers might experience different speeds and performance on different networks, giving them a bad impression of 5G.

But Boingo's Finley disagreed. He said consumers initially had different experiences on different networks when both 3G and 4G rolled out, and that might happen again with 5G at first, but operators will move quickly to resolve it, as they did with 3G and 4G.

Finley said the best applications for 5G have yet to come; apps like Uber, Airbnb and the current iteration of Netflix only came out after 4G had been deployed.

Fast connections alone will be a valuable use case for 5G, Finley said. He cited the example of someone at an airport rushing to board a plane; in that situation, the difference between a one-minute download on 5G versus eight to ten minutes on an LTE network can be a big deal.

Mitch Wagner
Executive Editor
Light Reading

Verizon's Indoor 5G Goes the Distance in NFL Stadium Test

A new test of Verizon's 5G network in U.S. Bank Stadium in Minneapolis showed plenty of horsepower, but more importantly it also showed impressive coverage.

Verizon has been telling football fans that 5G will enable them to download an episode of sports-based reality show Hard Knocks faster than former Minnesota Viking Randy Moss can run a 40-yard dash. Now data on the actual performance of its stadium 5G network is trickling in, thanks to analysis from wireless consulting and testing firm Signals Research Group.

The firm's analysts walked the entire U.S. Bank Stadium in Minneapolis, performing downlink and latency tests of the Verizon 5G network using Samsung Galaxy S10 smartphones. The venue is one of 13 NFL stadiums getting 5G through a Verizon partnership with the NFL. At U.S. Bank Stadium, the tests showed that download speeds topped out just under 1.9Gbit/s. That's clearly speedy, but the stadium was mostly empty and not many people have 5G phones anyway, so the figure mostly matches expectations.

More importantly though, 5G coverage in the stadium was widespread.

"Although we can't definitively state that every single seat in the 66,655-seat stadium has 5G coverage, we are confident that virtually all seats have good, if not great, 5G RF connectivity," the analysts concluded in their report. Even in the concourse behind the seats, the analysts found that throughput was typically more than 1Gbit/s.

"The RF energy from the 5G radios was able to radiate through the narrow gaps in the stadium seats and find its way into the concourse," the team wrote. "These results are impressive because the network wasn't designed to provide coverage in this area." Moreover, the analysts said signal strength in the stadium was consistently better than the signal strength they have seen in outdoor 5G tests.

CAVEATS AND DETAILS

There are at least two important differences between what the analysts observed in their test and the ways actual fans could experience 5G on game days. First, the network is heavily congested on game days, which of course is one big reason the NFL sees the value in 5G. But all those people could slow things down.

Second, most cellphone use occurs while fans are in their seats watching the game, not walking the aisles. If a fan happens to be seated in a place the signal does not reach, he or she might have to be on LTE or WiFi throughout the game instead of 5G. Most people would be fine with this as long as their phone worked, but it does present a problem if the stadium wants to use 5G to offer promotions or apps to the fan base. And clearly this is what the NFL has in mind. "Having this cutting-edge technology in our stadiums will greatly enhance the game-day experience and bring a multitude of benefits to our fans and Clubs in a number of different ways," NFL Commissioner Roger Goodell said when the league announced its deal with Verizon earlier this year.

According to Signals Research Group, Verizon has a total of 13 5G radios inside U.S. Bank Stadium. The carrier has never claimed that this deployment would guarantee a 5G experience for every Vikings fan with a 5G smartphone. When it announced its plans to bring 5G to the 13 stadiums, the company said the service would be "concentrated in parts of the seating areas." But Signals Research Group found that almost every seat now has "good 5G RF connectivity," which suggests that the indoor network is performing at least as well as expected, if not better.

VERIZON'S INDOOR 5G...CONT'D

Still, 13 radios may not ultimately be sufficient for the 1.75 million square foot U.S. Bank Stadium. According to Qualcomm, 10 co-sited 5G NR mmWave small cells can provide median throughput of ~4.2 Gbit/s to a 160,000 square foot airport concourse. The U.S. Bank Stadium is more than ten times that large.

Right now it's difficult to know exactly how many 5G radios each carrier will need in premiere venues like football stadiums. Even if a carrier wanted to blanket a venue with 5G radios, it could be tricky given that stadiums need to also accommodate LTE and WiFi access points as well.

MORE AND MORE WIFI

Despite the promises of 5G, stadiums are expected to remain heavily committed to WiFi for the foreseeable future. For example, Cisco recently signed a deal to deploy 2,500 WiFi 6 access points in Los Angeles's new SoFi Stadium, which will be the world's largest NFL stadium when it is completed. WiFi is carrier neutral and is the go-to solution for mobile ticket downloads, which are increasingly important to sports arenas. Ticket issuers often update barcodes every 15 seconds to avoid theft, so a screenshot of a mobile ticket is almost certain to be rejected at the gate. Fans need to be able to download their tickets in real-time at the gate, regardless of which mobile carrier they use.

U.S. Bank Stadium says its free public WiFi network is supported by 550 miles of fiber optics and 6,200 miles of copper wiring. That same infrastructure supports a 1,200-antenna neutral host distributed antenna system for 4G and 3G cellular connectivity.

The stadium might like to use a neutral host or shared infrastructure model for 5G, so that it wouldn't have to support equipment for each carrier. One model for 5G infrastructure sharing is the multi-operator core network approach, which means that operators share the radio access network and maintain their own core networks. But that is most likely to work in situations where the operators use the same spectrum bands for 5G.

Verizon is using the 28GHz millimeter wave band for 5G, and according to chip vendor Qualcomm, that bodes well for 5G performance indoors. "The fact that mmWave does not propagate well from the outside to inside is beneficial for deploying mmWave indoors as well, since the same mmWave spectrum can be reused indoors with limited coordination with the outdoor deployment," Qualcomm wrote in recent blog post. "This benefit opens new possibilities for mobile operators to offer private indoor mmWave networks, in addition to expanding mmWave indoors as part of their public networks."

Expansion of the public network indoors is clearly the goal for Verizon with its stadium initiatives. AT&T is moving in the same direction, having recently announced plans to deploy 5G at AT&T Stadium in Arlington, Texas. And although no carrier has publicly announced plans to bring 5G to Tampa's Raymond James Stadium, vendors expect it to be 5G-ready by the time it hosts the Super Bowl in 2021.

Martha DeGrasse
Contributing Writer
Special to Light Reading

Question & Answer

James Crawshaw, Senior Analyst at Heavy Reading conducts an interview with VIAVI's:

Paul Gowans
Director, Solutions Marketing
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+

Kashif Hussain
Director, Solutions Marketing,
Network Enablement

Q: How does 5G differ from previous mobile technologies from a Test & Assurance perspective? Are there any particularly new challenges in assuring the network across RAN and core?

With previous generations of mobile technology, the management was very cell centric. With 5G the approach is more beam-centric. On top of that we have new capabilities such as enhanced mobile broadband, massive machine type communication and ultra-reliable low latency communication – you need to be able to test and guarantee these new service types. You've also got a more virtualized network which means the points of data capture in the network will change. Similarly, with the move to mobile edge computing and control and user-plane separation (CUPS) there will be new points of network measurement. At the same time networks are going to become denser with 3 or 4 times the number of cell sites required for mm wave to have the same coverage as lower frequency bands. The whole scale and density and complexity of 5G adds an order of magnitude to the test and assurance requirements of the network. Test solutions need to become more automated and fool proof as operators cannot afford to send engineers back multiple times to check a site after installation.

Q: What are the challenges of testing and assuring massive MIMO & Beamforming and how does this differ from MIMO that exists today with 4G?

MIMO has been around for a while but one of the key factors has been when you are in the lower frequency ranges the form factor of the antenna cannot accommodate many antennae. We saw 2x2 and 4x4 but given the size of the wavelength at typical 4G frequencies this was the limit. With the higher frequencies of 5G such as 28 GHz the wavelength is much smaller and hence smaller antennae are possible and much larger MIMO arrays can be constructed. That in turn is enabling beamforming to be implemented in these high frequency FR2 [24 GHz to 52 GHz] ranges. The question is – how do you test it? How do I validate the way I am configuring my MIMO antennas? Am I seeing the correct physical cell identities (PCIs) and Synchronization Signal Blocks? These are the challenges that VIAVI is addressing for its service provider customers.

QUESTION & ANSWER...CONT'D

Q: On the transport side the synchronization requirements of 5G are stricter than with prior generations and there is a need for very precise timing. Is the 5G network infrastructure meeting these requirements?

With 4G we had Common Public Radio Interface (CPRI) – a synchronous transport mechanism for fronthaul. Now we have eCPRI which is packet based. The challenge is to ensure that the radios are all in synch otherwise end devices will have trouble demodulating the signals, they will suffer interference and will have more dropped connections. On some small cells it won't be cost effective to deploy GPS to get the precise timing needed for synchronization. The standards have identified certain requirements in order to achieve this timing and synchronization and it is important to test for these otherwise operators will not be able to reap the benefits of massive MIMO and beamforming.

Q: How is the fronthaul architecture changing with the roll out of 5G and O-RAN and what testing is required?

Fronthaul has evolved over the years. Originally, we just had a coax cable going from the basestation at the foot of the tower to the antenna on top. Then we started to deploy radios on top of the tower so we needed a fronthaul link between the radio and the digital baseband unit at the base of the tower. Now with the increased data throughput of 5G operators need to make a significant increase in capacity of this front haul link. This has been partly mitigated by moving some of the functionality of the baseband into a centralized unit in the core of the network and the rest into a distributed unit at the cell site. But this disaggregation creates its own latency challenges which might require a move to faster optical networking technologies such as NG-PON2. So front haul architecture is constantly evolving and with it the test and assurance requirements are evolving too.

The interesting thing about O-RAN is that it breaks the vendor lock in around the baseband unit (BBU) components so in theory you can now match a distributed component of a BBU from one vendor with a centralized component from another vendor. That is simply not possible with the CPRI interface. With O-RAN the market can become more competitive and operators can have more choice of supplier. On the other hand, mixing and matching suppliers will increase the amount of testing required to ensure different systems work well together and avoid suppliers blaming each other when problems arise.

Q: There is a big push to make networking more automated. What opportunities does VIAVI see to make test and assurance more automated especially things like network optimization? Can ML and GEO Location help here?

The increased complexity of 5G demands automated processes and procedures for test and assurance because the number of parameters involved is so great. Automation has to work throughout the lifecycle from lab test to cell site turn up right the way through to service assurance and optimization so you can do things like predictive analytics. Network optimization is already a complex task in a 4G environment. But when you move to 5G it is not just about optimizing each individual cell site, now it is about optimizing a cluster of cell-sites which contain a variety of radio access technologies. VIAVI has been heavily involved in leveraging machine learning and geolocation capabilities to support 5G optimization. This enables operators to get more granular, real-time information which is beam-aware, slice-aware and even application-aware. Those are the kind of insights which operators will need to deliver on the promise of 5G.

5G Industrial Automation Isn't Right Around the Corner

With manufacturers like Audi and Bosch testing 5G in an industrial setting, the 5G Alliance for Connected Industries and Automation (5G-ACIA) is hoping to supercharge the space. But some are cautioning patience.

Operators will invest up to $1 trillion in 5G networks between 2018 and 2025, according to the GSM Association (GSMA). The return on that investment isn't expected to come from charging consumers more for smartphone services, although that will almost certainly be part of the plan. The biggest returns for operators could well come from new network efficiencies and new enterprise use cases, especially industrial use cases, according to those in the industry.

Already heavy industry has heard a lot about 5G, and so far companies like what they're hearing. The most prominent early adopters in this space are in Germany, home to many of the world's leading industrial automation companies.

For example, Audi is preparing to test 5G-connected robots at a production lab in Gaimersheim, Germany. "A powerful network architecture that can respond in real time is of decisive importance for us," said Audi CIO Frank Loydl in a press release. The company has partnered with Ericsson to implement 5G in a simulated production environment.

Audi is one of the first companies to experiment with industrial 5G.

Elsewhere in Germany, Deutsche Telekom and Nokia partnered with the Port of Hamburg to test 5G in three separate use cases over a single network. One was a 5G-connected traffic light, which enabled the port to add traffic control without the expense of running fiber or cable. Another was connected sensors on ships to monitor motion and environmental data. The third was an augmented reality application that fed relevant information to maintenance and operations crews wearing 3D glasses. The port ran the tests for six months and said it would like to implement even more complex use cases in the future.

One of Germany's biggest manufacturing companies is Bosch, which owns and operates 280 factories around the world as well as an industrial automation equipment supplier called Rexroth. Bosch is trialing 5G at several factories and is a founding member of 5G-ACIA, the 5G Alliance for Connected Industries and Automation.

TEAMING ON 5G

"It is not enough if just industrial automation companies get together and discuss this because we are not necessarily the 5G experts," said Bosch's Andreas Mueller, who serves as chairman of 5G-ACIA, in explaining the purpose of the association. "It's hard to say what the infrastructure will be capable of. It's hard to say what the network operators will do. So that's why... we have to reach out to all these other stakeholders as well."

The group counts almost 60 members spanning manufacturers, network operators, radio equipment vendors, chipmakers, module makers and test equipment vendors. "We are very much interested in attracting more companies," said Mueller. "We want to attract end users."

5G INDUSTRIAL AUTOMATION...CONT'D

End users of 5G industrial automation solutions are the big prize for the companies that are investing in and testing these new technologies. But so far, none of them have launched live production lines using 5G. Even at Bosch's own factories, the 5G trials run parallel to the live production lines, but are not responsible for actual manufactured deliverables.

Bosch is a leader in factory automation.

In the future, Mueller hopes to see Bosch and many other companies using 5G to connect mobile control panels that can instantaneously start and stop factory machines. He said WiFi isn't reliable enough for this application, but 5G will be ideal.

Clearly, 5G will enable factory workers to be more mobile, but that isn't a change that can happen overnight, according to analyst Chris Nicoll of ACG Research. "It really touches the business strategy as well," he said. "How agile is the business in... redesigning the manufacturing floor?"

Nicoll doesn't see 5G industrial automation as a tool to help factory workers do the same work faster; he sees it as a revolutionary technology. "5G really, in order to take full advantage, has to impact literally the entire company: organization, strategy, philosophy, production, ecosystem -- the whole nine yards," Nicoll said.

MARKETING CHALLENGES

5G connectivity solutions for factories are just starting to hit the market, according to 5G-ACIA's Mueller. For now, network operators may find it hard to sell companies on the value of 5G connectivity because there are very few components that can leverage the technology in a factory setting.

"What we have in general is a chicken-egg problem," Mueller explained. "Unless many factories have 5G connectivity available, the incentive for an industrial automation company to offer 5G-based products is very low because if there are no customers who are able to use 5G, then there is no market. But it's also the other way around. If there are no 5G-based industrial automation components, the incentive to build up a private 5G network, for example, in a factory... is very low as well."

Mobile network operators and their equipment vendors may not be able to ignite the market on their own. Many manufacturing companies are more comfortable buying technology for their factories from their own vendors, not ones in the mobile space. Research conducted by Nicoll's firm found that most industrial companies do not think mobile network operators understand their businesses. Nicoll expects to see third party integrators step in to bring next-generation networks to factories. And it may not happen right away.

Right now, many companies are interested in 5G, but when it comes to actual deployments they may be fine with LTE for a bit longer, according to Erik Joseffson, who leads Ericsson's global industrial IoT and 5G offering to manufacturing and process industries. "You can reach really, really far with LTE-Advanced," Joseffson said. "From an industrial point of view, they don't really see any difference between LTE-Advanced or 5G Release 15 in the first phase."

Joseffson added that many customers are looking with interest at Release 16, and said his conversations with customers are definitely shifting. "Before it was, 'What is the cool use case or why should I use it?'" he remembers. "Now it is not so much about why; it's more about how. 'How can I get info and how can I get started? How do I get spectrum?' It's more a conversation of the business side."

Joseffson said Ericsson currently has more than 40 references or installations related to industrial 5G, most of them in Europe.

5G INDUSTRIAL AUTOMATION...CONT'D

RETURN ON INVESTMENT

For industrial manufacturers, a private 5G network is not an investment that can be expected to pay for itself within a quarter or two. That may be one reason US firms have lagged behind their European counterparts. "The whole DNA of our US firms is that they have to have a short-term return on investment," said Joseffson. But he said that's starting to change as American firms find more "flexible" ways to calculate projected returns. "It's quite hard to justify a big investment with just one use case," he said. "But it is [easier] when multiple use cases come together ... it will start to blow your mind with the value that it can generate."

ACG's Nicoll thinks 5G networks need to evolve before they will be ready to deliver value at scale for industrial manufacturers. He thinks that once mobile network operators can offer enterprise customers a range of 5G connectivity options, along with network slicing and edge computing, the value proposition will become much more real. "It may be kind of a late 2020 opportunity," he said. "It's probably a 2021, 2022, 2023 opportunity."

Martha DeGrasse
Contributing Writer
Special to Light Reading

Operators Starting to Face Up to 5G Power Cost

The cost of running new 5G networks in parallel with older systems could be huge, according to the latest research.

The cost of the energy needed to power 5G is shaping up to be one of the biggest headaches for operators rolling out the new networks.

Experts believe that a 5G network will consume three and half times as much electricity as 4G, thanks to a combination of massive MIMO antennas, legacy networks in multiple bands and the massive proliferation of small cells.

Jake Saunders, the managing director at ABI Research, says a typical LTE cellsite today might draw about 6 kilowatts (kW) in power, rising to perhaps 8-9kW at peak traffic periods.

In five years, a 3.5GHz site deploying massive MIMO with four transmitters and four receivers (so-called 4T4R) might draw 14kW on average and up to 19kW under peak load, he said.

"In that scenario, the basestation will be also supporting 2G, 3G and 4G as well, in as many as seven different bands from 700MHz up to 3.5GHz. That's where you're seeing the multiplication take place," he said.

Beyond that, another two or three times as many small cells sites will have to be deployed in order to achieve full 5G coverage and throughput.

A Huawei analysis based on operator data draws similar conclusions.

The power consumption of 5G equipment in 3.5GHz, with 64T64R and massive MIMO, will be "300% to 350%" of a 4G basestation, it says.

It says a cellsite today deploying 2G, 3G and 4G in five different bands will on average consume 5.9kW in power, with a peak of 7.3kW.

In three years, with the addition of 5G equipment in 2.6GHz and 3.5GHz bands, this will almost double to an average of 10.4kW, with 13.7kW during peak periods, Huawei predicts.

In five years, following the deployment of mmWave, this will rise to 13.4kW on average and 18.9kW at peak times.

The steep rise in energy consumption is a problem that is vexing Chinese operators, which have already deployed more than 80,000 basestations.

Huawei estimates that by 2026 Chinese operators will have deployed 4.75 million 5G macro basestations and another 9.5 million small cells using mmWave.

Yan Binfeng, director of the technical committee of China Unicom Research Institute, agrees that the 5G power bill would be more than three times that of 4G.

The state cell tower company, China Tower, has forecast that the electricity cost of 5G basestations is about ten times the annual rent, the IT Home website has reported.

Some regional governments keen to see 5G rolled out quickly are now offering electricity subsidies.

Jiangxi province authorities are offering a power subsidy of RMB8,000 ($1,134) this year for every additional basestation built beyond a baseline target, with further subsidies in 2020 and 2021. Shenzhen city and Shanxi province are also subsidizing 5G electricity costs.

Saunders said the 5G power consumption and cost "is a complex one, and I think operators are only just starting to fully digest it."

OPERATORS STARTING TO...CONT'D

He expected some telcos would ditch their legacy 2G and 3G technologies to help manage the power load.

"I think over time the solutions will become more cost-effective, but massive MIMO does require an awful lot of power. It will take a number of generations before we can get substantial energy savings built into the silicon," he said.

But he also notes that in the next few years operators are likely to start deploying mobile edge computing, which could mean extra significant power loads at the edge and a new problem to solve.

Ericsson said in a statement that while massive MIMO consumes more energy as more antennas are deployed, legacy networks "will by far consume the largest share of the energy used."

Despite that, it says that massive MIMO, which extends coverage and capacity and can quickly change between low and heavy loads, is important for efficient energy consumption, along with ultra-lean designs that allow basestations to sleep during off-peak periods.

Robert Clark
Contributing Editor
Special to Light Reading

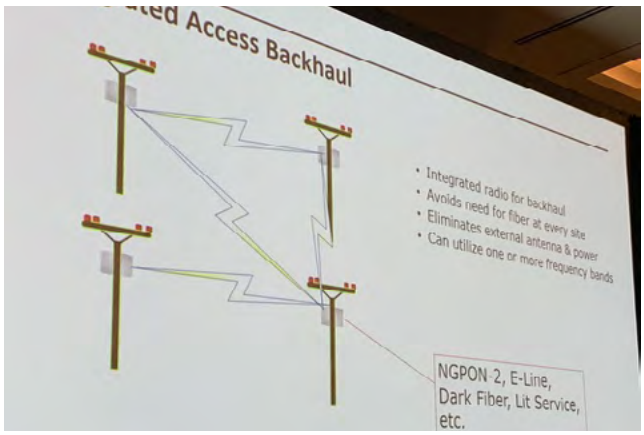
Verizon to Use 'Integrated Access Backhaul' for Fiber-Less 5G

Verizon plans to make use of a new technology that would allow the operator to deploy 5G transmitters into locations where fiber is not available.

Verizon's Glenn Wellbrock said he expects to add "Integrated Access Backhaul" technology to the operator's network-deployment toolkit next year, which would allow Verizon to deploy 5G more easily and cheaply into locations where it can't get fiber.

"It's a really powerful tool," Glenn Wellbrock, director of architecture, design and planning for Verizon's optical transport network, explained during a keynote presentation at Light Reading's recent 5G Transport & the Edge event in New York.

Wellbrock said IAB will be part of the 3GPP's "Release 16" set of 5G specifications, which the standards group expects to finalize early next year. However, Wellbrock said it will likely take equipment vendors some time to implement the technology in actual, physical products. That means 2020 would be the earliest that Verizon could begin deploying the technology, he added.



A slide about IAB presented by Verizon at Light Reading's 5G Transport & the Edge event.

Verizon's embrace of IAB technology is important because the operator so far is overwhelmingly using fiber connections to backhaul traffic from its 5G transmission sites. That's a costly and potentially limiting requirement considering it means Verizon can only install 5G antennas into locations where it can obtain connections to fiber and electricity.

With IAB, Verizon could potentially install 5G transmitters in locations that only have electricity and not fiber because the antennas could backhaul their traffic via a wireless link to a nearby receiver. That receiver would likely need to be connected to a fiber network.

Wellbrock said IAB would allow Verizon to install 5G antennas into locations where routing a fiber cable could be difficult or expensive, such as across a set of train tracks.

However, Wellbrock said that IAB will be but one tool in Verizon's network-deployment toolbox, and that Verizon will continue to use fiber for the bulk of its backhaul needs. Indeed, he pointed out that Verizon is now deploying roughly 1,400 miles of new fiber lines per month in dozens of cities around the country.

He said Verizon could ultimately use IAB in up to 10-20% of its 5G sites, once the technology is widely available. He said that would represent an increase from Verizon's current use of wireless backhaul technologies running in the E-band; he said less than 10% of the operator's sites currently use wireless backhaul. He said IAB is better than current wireless backhaul technologies like those that use the E-band because it won't require a separate antenna for the backhaul link. As indicated by the "integrated" portion of the "integrated access backhaul" moniker, IAB supports wireless connections both for regular 5G users and for backhaul links using the same antenna.

VERIZON TO USE...CONT'D

That Verizon is looking for new backhaul options is not a surprise. The company is in the early stages of building what could ultimately be a massive new 5G wireless network. Further, the operator's 5G network could look much different from its existing 4G network, not only because it will provide faster speeds but also because it will require far more transmission sites. That's because Verizon is deploying 5G in millimeter-wave spectrum in major metro areas in the US, and transmissions in those millimeter-wave spectrum bands can't travel more than a few thousand feet at the most. As a result, Verizon will need to build thousands, and perhaps even millions, of new 5G transmission sites (each with backhaul and electricity options) in order to fully cover large swaths of the US population.

Verizon isn't alone in looking at IAB. AT&T too has hinted it might deploy the technology.

Fiber, IAB and E-band are just a few of the many backhaul options available to wireless network operators. Other options include everything from satellites to drones. Indeed, the cable industry has been pushing the idea that cable operators could offer backhaul connections for 5G through their existing DOCSIS networks, though a number of speakers here at the 5G Transport & the Edge event said DOCSIS could be used for backhaul but not for fronthaul, due to the low-latency requirements in fronthaul. Fronthaul involves connecting distributed antennas to a centralized processing function.

Mike Dano
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Bringing Order to Confusion

5G's time to market and quality will be largely dependent on the rigor of test and measurement before, during and after deployment.

Just as we saw with previous generations, 5G networks will evolve across multiple 3GPP releases. Therefore, it is vital to have a controllable and repeatable test environment that helps implement the latest standards and simplifies the 5G development lifecycle. This will ensure that network equipment deployed in the field is protected and customer experience is not compromised.

Unlike in LTE networks, 5G new radio (NR) will support higher frequency operation from day one. Frequency range one (FR1) overlaps and extends 4G LTE frequencies, operating from 450 MHz to 6 GHz, whereas frequency range two (FR2) operates at a much higher frequency range and will support up to 52.6 GHz

If there is a single theme that defines 5G, it is innovation. Next-generation networking technology is not just an incremental update to existing communication standards. 5G will enable innovative new services made possible through ultra-fast mobile broadband, mission-critical communication, massive device connectivity and ultra-low latency.

5G technology is driving major changes across the entire network — from highly flexible radio access network (RAN) architecture and 3D beamforming active antennas, to software-defined network components — with stringent timing and latency requirements. The combination of new infrastructure features and functions, such as millimeter wave (mmWave) utilization and massive MIMO, provides a pathway to incredible performance enhancements. Yet these expected enhancements will rely on multiple elements performing seamlessly in tandem, introducing much greater complexity than previous generations.

Mission-critical applications will demand a network which cannot fail. Ensuring network quality will be at the core of deployment to prevent dissatisfied end users, churn and loss of market share.

BREAKING IT DOWN

The added complexity introduced by new 5G functionality poses challenges for network equipment manufacturers (NEMs) and communication services providers (CSPs) alike. Moreover, these complications are compounded further by the adoption of disaggregated architectures where integrated hardware and software are separated and broken down into functional components. As CSPs seek to improve service agility and lower costs, increasingly they are moving away from proprietary network equipment, instead using common off-the-shelf components. This raises the stakes for interoperability and performance because no single vendor is responsible for validating and verifying the entire system.

As such, standards compliance takes on an increasingly crucial role to ensure functionality and interoperability. Moreover, standards are key to developing accurate 5G test models which ultimately will lead to more harmonized test practices and empower faster 5G network development and deployment. Service providers and NEMs alike need to understand and embrace standards-compliant testing methods to ensure the smoothest path forward for 5G innovation.

However, a key roadblock slowing 5G roll-out is the challenge of developing products against changing and maturing 3GPP specifications. Today, the earliest 5G deployments are based on non-stand-alone (NSA) configurations where existing 4G infrastructure is used, although radios will be capable of providing services to 5G-capable devices as they are introduced. In this initial phase of 5G deployment, the focus is on enhanced mobile broadband (eMBB) service to provide increased data bandwidth and connection reliability. Unlike in LTE networks, 5G new radio (NR) will support higher frequency operation from day one. Frequency range one (FR1) overlaps and extends 4G LTE frequencies, operating from 450 MHz to 6 GHz,

BRINGING ORDER TO CONFUSION...CONT'D

whereas frequency range two (FR2) operates at a much higher frequency range and will support up to 52.6 GHz.

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CONFORMING TO NORMS

It's important to recognize the complexity of conformance testing that devices and base stations must undergo before they're released to the marketplace. The rigor of conformance testing develops a baseline of functionality in user equipment (UEs) and base stations, as well as validating transmitter and receiver characteristics and performance. Radio resource management (RMM) and protocol testing are needed for devices, while radio frequency (RF) parameters are used as a baseline to test base stations.

Meanwhile, conformance testing for UEs depends upon radio access, demodulation and signaling tests, as well as validation by certification organizations to ensure they comply to the latest 3GPP specifications. The 3GPP RAN working committee defines the conformance goals, yet these have not been completed for 5G NR.

A number of other standards bodies also are contributing significantly in this area. The International Telecommunications Union (ITU) and the International Mobile Telecommunications (IMT) group created IMT-2020, which has three primary use cases for 5G NR: eMBB; ultra-reliable low latency communications (URLLC); and massive machine-type communications (mMTC).

PERFORMING ABOVE AND BEYOND

Deploying and supporting complex 5G network architecture will not be a trivial exercise. 5G NR introduces flexible spectrum usage with scalable numerology, dynamic TDD, massive MIMO and beamforming — all of which bring greater challenges in the field for RF engineers to validate, test and optimize the 5G network. Time-to-market and network quality will be dependent largely on the rigor of test and measurement before, during and after deployment.

A key factor to consider when testing 5G is how to assure quality of experience (QoE) for the end user. Unlike previous generations, this requires the understanding that in many cases 5G networks end users will be machines, rather than humans. This means that current methodologies for testing and measuring voice, video and data quality to end users needs to be expanded to include mMTC and artificial intelligence (AI).

The three primary use cases identified by IMT-2020 – eMBB, URLLC and mMTC – also drive the need for different ways to measure QoE, especially in the RAN. Expanded test methodologies are needed. These will include new parameters that incorporate higher frequencies and wider bandwidths, accounting for machine-to-machine communications.

As 5G networks grow to support applications such as connected cars, network performance will become absolutely crucial. Delay, jitter and other network issues literally can have disastrous results, so testing of 5G QoE needs to be verifiably traced and transparent to certified international standards bodies, as opposed to proprietary NEM specifications or techniques.

WORK IN PROGRESS

Given the enormous frequency range and high-bandwidth services inherent to 5G technology, standardization of best practices will continue to progress as the technology, tools and applications develop.

Without question, there remains a great deal to be done before standards bodies will finalize their work on 5G, and both service providers and vendors are diligently working with industry organizations to develop strategies for the long-term success of 5G networks. In reality, standards bodies play a vital role in providing a neutral place in the ecosystem—that includes test and measurement vendors—to collaborate and ensure that mission-critical applications on 5G networks are developed, built

BRINGING ORDER TO CONFUSION...CONT'D

and deployed safely and securely for individuals, communities and enterprises.

MAKING HISTORY

While 2019 isn't shaping up to be the transformative year many 5G enthusiasts had hoped for, vital leaps towards mainstream deployment have been made. The first 5G handsets have become available to consumers and operators have installed more basestations and "switched-on" 5G networks. We might not see indoor 5G deployment and VR/AR this side of the new year, but that doesn't lessen the importance of 2019 in 5G's history.

Implementation, testing and certification takes time and it's important to remember that the industry is still in the initial testing and learning phase of 5G. 5G deployments have happened in record time and the position that 5G is in today is extremely impressive, but carriers must be patient and take their time to assess and address issues prior to mainstream deployment. Failure to do that could lead to bigger issues further down the 5G road.

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www.viavisolutions.com/5g-testing.

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UNDERSTANDING 5G

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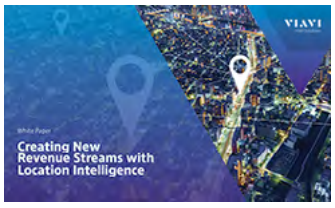
Simplifying 5G deployment complexities with easy-to-use fiber, x-haul and RF solutions

VIAVI 5G FRONTHAUL HANDBOOK

A guide to understanding the impact of 5G on transport networks and key test considerations



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