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ANATOMY OF AN OPERATOR: RAKUTEN /// COUNTRY PROFILE: INDONESIA /// NETWORKED WORLD

ISSUE #26

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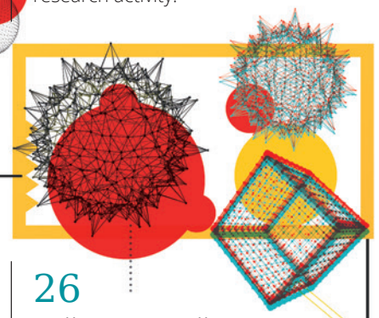
5G MARKET UPDATE

FACT FINDING: AN UPDATE ON 5G, FROM OPERATORS, VENDORS AND STANDARDS BODIES.



REGULARS

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EDITOR

Hi!

As we head into the middle of 2020, it's worth remembering that this is the year that was always planned to be 5G's year. There were a number of reasons for this.

Working on a rule of thumb that each mobile network standard has tended to hit the market in about 10 year waves, 2020 looked to be about the right distance from LTE's introduction. 2020 also looked to be about the first year that operators could launch on viable technology. The standards and specification bodies could not really move much quicker to deliver useable specifications that would in turn be converted into commercial product and then deployed on the ground. And as we have seen, meeting this deadline has been very challenging in itself. Finally, there was the issue of spectrum. Governments also needed to agree on which bands would be used for 5G, and then make them available. Other regulatory aspects to consider included use of unlicensed bands and whether to allow spectrum sharing and planning permissions for site upgrades and new sites.

But even with all that to overcome, it was in fact in 2019 that we started to see the first launches in different continents. These tend to be limited in scale, and often involve just one operator in a certain country. And these launches also relied on a "Phase 1" version of the technology that reworked the radio, but left the core network alone, and did not reach the true, promised potential of 5G.

Now, if you look throughout this issue, you can see just how many operators have launched, where vendors are developing new product, and how the standards continue to develop - even unto 6G. And you can see where challenges remain and where new areas of research are popping up to meet those challenges. So even though the industry can be pleased with the progress made to date, even beating its original 2020 target, it's clear there is still a lot more to do to truly unlock the business value of 5G.

Keith Dyer
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Right Place. **Right** Time. **Right** Result?

Rakuten

CEO HIROSHI "MICKEY" MIKITANI:
Charismatic billionaire owner and founder has stated he wants to disrupt Japan's mobile operator incumbents.

70 +
services

From a network perspective, Rakuten's key message is that it is building a cloud native network from scratch to enable new forms of service delivery. That's because it doesn't want to be a traditional mobile operator, with the structures and business models that that entails. It is already a successful provider of online and other services, from financial services to content and gaming, and even Rakuten Automotive. In fact it says that there are more than 70 services that make up the Rakuten Group.

So it sees its role in mobile to disrupt the status quo and by so doing to use its mobile network as a platform to drive new business opportunities, not merely to carve out a 15-20% chunk of that existing MNO market.

The core of that methodology has been to build its network in a very different way compared to its competitors.

Rakuten decided in mid-2018 to go for an all virtual network, including the RAN. It is basing its vRAN on Intel-based hardware and did not want to do that via any traditional RAN supplier. Instead it is putting the first virtual Distributed Units into 4,000 edge sites, with all the vRAN software from Altiostar. To back that up, it has taken a strategic investment in Altiostar, making it doubly in its interest that Altiostar's technology is a success.

Nokia supplied the first generation of remote radio units, bolting these on via a specially designed coupling to antennas from Korean antenna supplier KMW Communications.

Cisco is the cloud core and NFVi provider. The hardware, which comes in just four server variants, is all from Taiwanese provider Quanta Cloud Technology.

Red Hat is providing the Open Stack based cloud operations and automation control. Intel seems to have worked its tail off to make sure it can support the workloads Rakuten is placing in its processors' hands.

CTO TAREQ AMIN:
Conference-friendly and in-demand Amin has shrewdly leveraged the desire of his vendor partners for good publicity to position Rakuten Mobile as the cloud native exemplar.

Although the company is not explicitly building its RAN to formal TIP or O-RAN specifications, its insistence is that any software must be deployable in its cloud environment, and manageable by its cloud management and automation software. Here we see Red Hat and Tech Mahindra involved in integration, and Netcracker in operational software.

Rakuten has gained prominence as a technical exemplar because it seems that there is a genuine desire on behalf of Rakuten's vendor partners to push the industry to consider the disaggregated, open hardware and software approach at scale and for real - not as lip service and not as a science project. Saudi Arabian telco Etisalat has recently announced it is deploying a cloud RAN project, with many of the same group of vendors involved.

Rakuten's proposed "Phase Two" rollout will use integrated a new antenna-radiohead design that does not include Nokia. The operator is working directly with KMW and with Flex (formerly Flextronics) to make the integrated radio-antenna units.

The operator has talked about a $5-6 billion range to build a network with the same size infrastructure as Sprint in the US. But it has also claimed that its upgrade to 5G will be 60% cheaper because of this architecture.

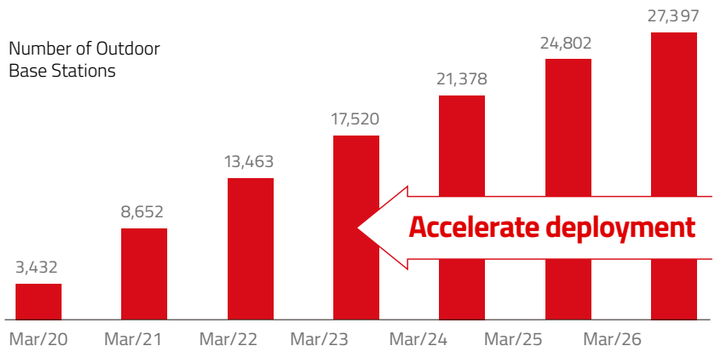
For 5G, the operator has chosen a 3.5GHz antenna-radio unit from NEC and will deploy mmWave small cells from Airspan that are based on the Qualcomm's FSM 100xx SoC design. The vCUs stay on Intel-based hardware. In fact, there may be rather a lot of those 5G mmWave small cells going down, with Amin having said that street poles are easy to get onto in Japan, and that the country might well have the largest mmWave deployment in the world in 2020.

CTO Amin said he knows that much of what he has achieved is about mindset because he has already had to change mindsets, he said, or to find those who aligned with his.

For example, he said that he knew Cisco wasn't technically ready to support and roll out a totally virtualised core network on NFVi across two large core datacentres and 4,000 distributed sites, but he went with the vendor because he knew it would adopt the correct mindset. As far back as MWC Barcelona, 2019, he said, "In RAN, if I went to the traditional large OEMs they would say, 'You are crazy. You cannot run a vCU on x86 - it will not work'.

Outdoor Base Station Development Roadmap

Accelerating base station deployment (Commitment to MIC: 27,397 sites by March 2026)



"So we said we would think differently and partnered and took a big position in Altiostar, believing they have the right software mindset. And we built the world first vDU - so the actual site is down to very little. There's no cabinet or big equipment or baseband. The site is a very simplified antenna and the Radio Unit, with dark fibre connecting it to the edge. It works and it works remarkably well.

"The capex impact is huge, but the operational efficiency is even more impactful. Everything is automated. From taking eight hours to activate one traditional NodeB, when the RAN is virtualised it takes the activation of a VM to 15 minutes."

Originally Targeted for October 2019, Rakuten launched full commercial services in April 2020.

The company's own network service area will cover the 23 wards of Tokyo, Nagoya City, Osaka City and parts of Hyogo prefecture. Elsewhere in the country, as it builds out, Rakuten will offer LTE services until March 2026 via national roaming agreements with KDDI Corporation and Okinawa Cellular.

Rakuten has denied that its delay was caused by problems with its virtual network buildout, and reports from Japan said that progress has been slowed by trouble connecting base stations to existing fiber-optic and other networks.

> "To back that up, it has taken a strategic investment in Altiostar, making it doubly in its interest that Altiostar's technology is a success."

ALTIOSTAR

Unusually, Rakuten actually holds a substantial equity position in one of its key suppliers - radio software vendor Altiostar. But how much of the company does it own?

Altiostar closed a C Round that included Rakuten, Qualcomm Ventures and Tech Mahindra. Tech Mahindra invested $15 million, and said that it took a 17.5% equity position as a result. With the C Round closing at $114 million, it seems likely that Rakuten would have invested substantially more than Tech Mahindra (bear in mind though, that we don't know Qualcomm's contribution). Telefonica joined in as a strategic investor after the round closed, but its investment is not thought to be substantial.

It certainly looks like Rakuten has accessed Altiostar as a substantial owner - and it has two of its execs on the Altiostar board as part of the deal. As an owner of the company, it is therefore doubly invested in the success of its high profile all-vRAN strategy.

Seven things I know about...

ENABLING NEW 5G BUSINESS MODELS TO SUCCEED

Richard Piasentin, Chief Strategy and Marketing Officer, Accedian, on the role that automation and analytics will play in making 5G pay.

1 5G IS A GAME CHANGER FOR MOBILE OPERATOR REVENUE STREAMS

5G is the first wide area wireless network technology that can operate at the latency, speed and capacity of human senses. A sliceable RAN and core network, allied to cloud compute that is sited as close as possible to users and enterprises, changes the nature of the user experiences that can be delivered.

It will be a foundational technology on top of which enterprises can build use cases and applications to create new services for their end customers – all with Quality of Service (QoS) performance guarantees. This will create new partnerships between network operators and industry verticals, and with that comes a shift in as well brand new, business models.

2 MOBILE BROADBAND AND FIXED WIRELESS WILL COME FIRST, BUT THE FIRST "VERTICAL" APPLICATIONS WILL CHANGE THE GAME

Most operators are starting with existing services of enhanced mobile broadband and fixed wireless broadband. There is notable activity as well in cloud-based gaming and low latency gaming, with companies like Hatch present at 5G launches.

Simultaneousnesly, operators are preparing their operations and infrastructure for more advanced enterprise services based on network slicing. The 5G architecture enables automation and efficiency, and will have the biggest impacts on use cases and verticals with a mobility element to their business, for example logistics, farming, transport, automated and connected vehicles, as well as industrial automation.

An example is transport safety and the monitoring of bridge or road infrastructure, where a combination of drones, high quality video, and other 5G capabilities can reduce the costs of manual inspection significantly. Looking ahead to the future, autonomous vehicles could require remote driver or intervention services. This will be an area of significant revenue.

3 FLEXIBLE IT AND PERFORMANCE ASSURANCE WILL UNDERPIN THESE NEW BUSINESS MODELS

There will be a wide range of different go-to-market partners and business models - selling with and selling through partners in wholesale models.

This broadens the market opportunity for operators but it also means that flexibility and robustness in IT (OSS/BSS) and network management systems will be essential. For example charging systems must be capable of charging customers in many different ways - by QoS, by slice, by usage - and all in real time.

The same goes for network performance management systems and KPIs. These have to be more flexible, granular, precise, dynamic and transparent to customers, with real-time reporting and analytics, especially in enterprise services involving multiple partners. These systems have to be deployed as part of the service chain automatically.

Performance requirements for many of these business-critical enterprise 5G use cases are so tight that the underlying infrastructure has to be looked at in a level of detail and granularity that was never needed before.

4 MANAGING THIS ENVIRONMENT IS ALL ABOUT AUTOMATION AND SPEED

With 5G service assurance and performance management for business-critical enterprise services, it's all about automation and quickly interpreting data using analytics and AI to help make the 'right' decisions' at the 'right time'.

That's why getting data collection and AI algorithms finely tuned is so important. You can't afford AI bias in automated processes when timescales to launch services are really tight or where the services are mission critical. In these circumstances assurance is vital.

With the commitment to mission critical services, new performance management needs are created. Streaming video doesn't really need advanced performance management currently, but slow performance when a remote driver is helping a stranded client isn't going to fly.

5 OPERATORS BADLY NEED NEW ANALYTICS-BASED MONITORING SOFTWARE

With the move to software-defined networks and cloud-native network functions, there is a pressing need for new analytics-based monitoring software that can provide multilayer insight on service availability and performance—in real time and in context.

A key challenge is having control and visibility of service performance, in real time, in order to inform policy changes as networks scale out and back based on application and traffic demands. Machine learning and AI analyse events across all network layers up to the application layers and provide insight on key events to the orchestration layer, which can take action for self-healing and closed loop automation.

6 BEYOND THE CLOUD, NETWORKING IS ITS OWN CHALLENGE

People often think that the hyper scale providers set the bar for performance and complexity. But the software that manages the wavelengths and bits of high performance networks are several orders of magnitude more complex and high performance than many web services. The companies that understand the service efficiency of cloud native applications and at the same time think for example in terms of an optical network ring switch time, or a 300 kph handover are the companies that will succeed.

A performance management system that can monitor KPIs at the service and Quality of Experience level rather than just network health monitoring will be essential, and it must be flexible enough to do this at the network slice level as well as monitoring the service experience for each customer.

7 IT'S HAPPENING NOW – AND YOU CAN BE PART OF IT

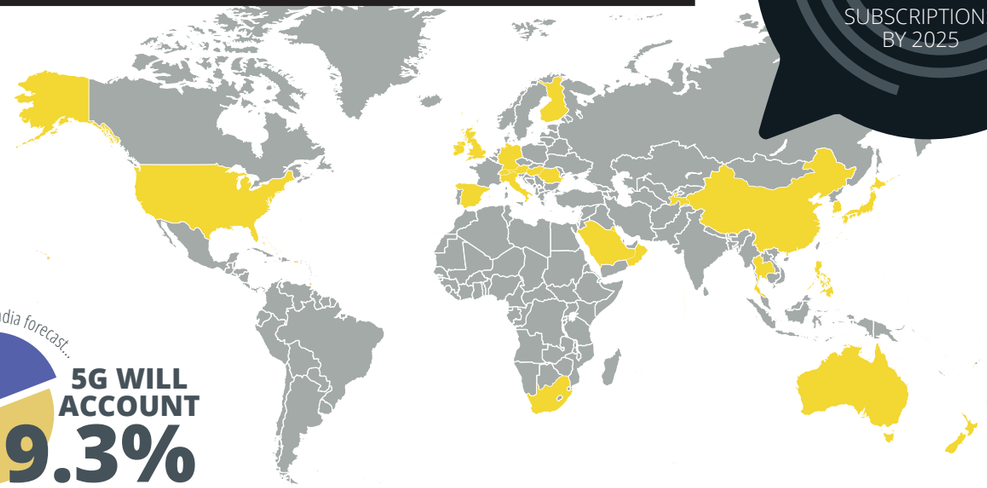
Accedian's Skylight solution is part of the new wave of intelligent performance monitoring tools that look at data in every layer to get the full picture of service performance and customer experience, as well as supporting real-time IT and network operations. Skylight control agents are micro services that reside within network slices, adapt to the use case and monitor the quality and KPIs. These network and service intelligence feeds back into Orchestrators and IT systems

Bouygues Telecom, a mobile operator with over 20 million customers, deployed Skylight analytics to gain a deep, real-time understanding of network, application and service behavior. Now Bouygues is preparing to automate performance management in order to meet more stringent SLAs for new 5G business-critical services. ●

ACCEDIAN

FOR MORE:
WWW.ACCEDIAN.COM/AUTOMATION

5G GLOBAL LAUNCHES



5G WILL ACCOUNT FOR AS MANY AS **1.2 billion** SUBSCRIPTIONS BY 2025

GSA and Omdia forecast...

5G WILL ACCOUNT 19.3%

WORLDWIDE MARKET BY END OF 2024

The GSA reports that there were...

17.73M

5G SUBSCRIBERS GLOBALLY BY THE END OF 2019

THE MAJOR VENDOR SCORECARD

5G RAN DEALS:

ERICSSON
- 86 commercial deals,
- 29 live 5G networks

HUAWEI
- 91 commercial deals,
- [number of live networks unknown]

NOKIA
- 69 commercial deals,
- 21 commercial live networks

SAMSUNG
- Not announced but around 10, includes early movers in South Korea, Japan and USA

ZTE
- 46 commercial deals

(Note: these are self-declarations by the vendors)

THE GLOBAL ROLLOUT OF 5G // COMMERCIAL LAUNCHES SO FAR

AUSTRIA
A1 // Magenta (Deutsche Telecom) // Three

AUSTRALIA
Optus // Telstra

BAHRAIN
Batelco // Viva

CHINA
China Mobile // China Telecom // China Unicom

FINLAND
DNA // Elisa // Telia

GERMANY
Deutsche Telekom, Vodafone

HUNGARY
Vodafone

IRELAND
EIR // Vodafone

ITALY
TIM // Vodafone

JAPAN
KDDI, NTT DoCoMo, SoftBank

KUWAIT
Ooredoo, Viva, Zain

LAOS
AWN

NEW ZEALAND
Spark // Vodafone

NORWAY
Telenor (2020)

OMAN
Omantel

QATAR
Ooredoo, Vodafone

PHILIPPINES
Globe

ROMANIA
Digi Mobile, Orange, Vodafone

SAUDI ARABIA:
STC, Zain

SPAIN
Vodafone

SOUTH KOREA:
KT, LGU+, SKT

SWITZERLAND
Sunrise, Swisscom

TAJIKISTAN:
Megafon

UAE
Du, Etisalat

UNITED KINGDOM
EE, Telefonica (O2), Three, Vodafone

USA
AT&T, Sprint, T-Mobile (to be merged), Verizon (all 2019)

REFERENCE: https://www.gsma.com/futurenetworks/technology/understanding-5g/5g-innovation/

5G 2020 UPDATE

5G THE FACTS

OPERATOR LAUNCHES, VENDOR MOVES & RESEARCH DIRECTIONS

NON TRADITIONAL VENDORS MAKE MOVES IN 5G - A MOVE TO OPEN RAN?

In early 2020, Telefonica announced an ecosystem agreement that it says will progress the testing and industrialisation of Open RAN across its footprint this year. The operator agreed a collaboration with Altiostar, Gigatera Communications, Intel, Supermicro and Xilinx for the development of Open RAN technologies in 4G and 5G. The operator said it will launch 4G and 5G Open RAN trials in UK, Germany, Spain and Brazil this year.

WHO IS DOING WHAT?

Telefonica said it will be developing Distributed Units based on Intel's FlexRAN reference platform which includes Intel XEON-based servers. Remote Radio Units (RRUs) would be connected to Distributed Units (DUs) using the O-RAN Aliance's fronthaul interface specification.

The ecosystem appears to combine SuperMicro's Intel-based servers with Altiostar's virtual baseband technology for the DUs. Gigatera Communications is the company that owns KMW, the antenna and RF component manufacturer that designs Remote Radio Heads. Xilinx is an RF System on Chip provider and said it would be providing Telefónica with a "unique and flexible platform for radio, fronthaul, and acceleration for 4G and 5G networks."

Elements of this ecosystem echo parts, but not all, of Rakuten's high profile vRAN deployment. That aligned KMW at the RRU end, with Altiostar vRAN software in the DU and Central Unit (CU), and Intel in the guts of the servers processing the vRAN workloads.

Telefonica's statement said that it wants to define the necessary hardware and software components for an Open RAN deployment, including testing the complete solution in the lab and in the field and integrating the open RAN model as part of its overall virtualisation programme known as UNICA Next.

The statement said that the motivation for introducing Open RAN is a more flexible operational environment where it can upgrade elements of the radio network individually, and deliver updates in a faster and more targeted fashion. It can also take advantage of a radically simplified hardware platform in the distributed or centralised elements of the RAN. Finally, the distributed architecture, combined with the virtualised and open nature of Open RAN means the operator feels it can expose RAN capabilities in an easier fashion to aid MEC rollouts, when the time comes.

It said, ***"Edge-computing applications running in the Telco cloud can benefit from the strong capillarity of the access network, hence tailoring the service behavior to the instantaneous user conditions as well as the status of the live network."***

OPEN RAN DRIVERS AND MOMENTUM

Stephen Douglas, Head of 5G, Spirent, said that the start of 2020 had seen many operators asking for validation of Open RAN interfaces and architectures. In fact, Douglas said demand had "gone crazy" over that time period.

Douglas said that in particular operators want to prove out that things work as they should across the fronthaul interface. That's mainly to assess interoperability and how truly flexible and multi vendor deployments could be.

Douglas thinks that operators are assessing Open RAN as a potential boost to supply chain diversity, rather than as a result of recent US-China trade battles. That said, he thinks that campus and enterprise deployments are the most likely starting points for Open RAN.

Pardeep Kohli, CEO of vRAN provider Mavenir, agreed that supply chain diversity is key to adoption of Open RAN. But he also highlighted another possible market entry point for the technology.

Kohli said that markets have seen the downside of relying on a limited number of closed RAN vendors. For example, in Europe, operators tied to Huawei 4G RANs have said that banning Huawei from 5G would be very costly and delay 5G, as they would have to rip and replace their 4G networks. In the USA the government is financing regional operators with billions of dollars to replace Huawei radio networks. Kohli said that would not have been so expensive if operators had been able to replace parts of the network independently. He said that operators can take advantage of Open RAN to give themselves peace of mind that they can avoid such lock-in in the future.

A second area Kohli has identified is for operators who, like its partner Vodafone Idea in India, can use Open RAN in unused TDD spectrum to create an overlay network over their existing RAN, as a capacity boost.

A third potential market entry for Open RAN is in rural networks. A recent example of this is in Ghana, where Parallel Wireless has been contracted to build out 2,000 rural sites in 1,000 locations, to bring mobile coverage to areas that are currently without it.

Parallel Wireless is providing a solution comprising its DU/CU software with radio units from its partners, along with Parallel's Radio Controller. In ultra rural locations deployments will use satellite backhaul, and Parallel's virtual BSC (Base Station Controller) on the OpenRAN controller node will be turning off RF and satellite links in low usage times to preserve energy and backhaul.

Initially the programme will provide 2/3G, with migration to 4G when phones become available to local populations.

A CHIP FOR EVERYTHING

Intel has said that it will be a year early to its goal to win 40% of the 5G mobile base station processor market. The company recently launched its RAN-focussed Atom P5900 Processor - the product name for the SnowRidge SoC it announced at CES a year ago. At that time, the company said it wanted to win 40% of the mobile base station chip market by 2022. But David Fraser, Technical Sales Director, Communications Service Providers, EMEA, said, "Based on the ramp that we are seeing, driven by 5G, we will be a year early. So by 2021 we will have 40% market share in the base station category of product."

The chip giant said in 2019 that it already had design wins with major network equipment manufacturers Ericsson, Nokia and ZTE. It looks as though pick-up within those vendors to add beef to their own custom designs has gone quicker than even Intel anticipated.

Fraser said, "We estimated last year that we would hope to be at 40% market share in this segment with this CPU by 2022, and based on the ramp that we are seeing, driven by 5G, will be a year early. By 2021 40% market share in BTS category of product."

The 10nm System on Chip is designed as an integrated solution that includes compute, connectivity and acceleration into the same package. Fraser said that design wins were being driven by the operator need to push compute further to the edge of the network, and by enabling the virtualisation of RAN functions. It says the P5900 can get 3.4x throughput compared to software-based designs.

Fraser said, "Within the 5900 is an acceleration engine that enables the key functions that happen at that base station node in the network to accelerate natively, and to partner with structured eASICs [where required]."

One example Fraser gave of this need for enhanced processing is within RAN nodes based on architecture splits at L1/2/3 - eg between centralised and distributed radio units. Here the acceleration can help do some of the conversion between xHaul connectivity standards and enable that partitioning at the base station, Fraser said.

Enabling fast processing for specific RAN and edge compute related use cases is one key to achieving a virtualised RAN, where software running on COTS hardware would not get the job done.

Ericsson and nVidia announced in late 2019 that they are exploring a GPU-based approach - using Nvidia's GPUs for RAN workloads. At that point, Per Navinger, Head of Product Area, Networks, Ericsson, told TMN that the company is in the earlier stages of exploring the virtualisation of the lower RAN layers.

"It's quite an interesting point in time right now, the discussion on how we can virtualise the RAN. Of course we at Ericsson deliver on purpose-built hardware and typically purpose-built is more effective and efficient. But we continuously explore and evaluate other alternatives as to how networks can be built in the future. Everyone agrees you cannot build on pure x86 server solutions – you need something that is accelerating protocol stacks, and then we see different ways of handling this acceleration. In the Nvidia discussion we are looking at how you can use GPUs with x86 and a PCI express (PCI-e) interface to build a fully virtual RAN."

DIAMOND LIGHT DESIGN

Intel is also launching a structured eASIC that could be suitable for custom logic applications in RAN products, giving manufacturers a half-way house between their FPGA-based solutions and hardened ASICs. Its Diamond MESA eASIC is designed to have the same footprint as its FPGA so that vendors can migrate from the FPGA to eASIC within the product development cycle.

Intel said that Diamond MESA might suit new types of radio being designed by the host of vendors targeting Open RAN and vRAN type solutions. These can benefit from FPGA programmability and flexibility but at the cost and power structures that would come with an ASIC-based design. Currently Intel is offering designers early access to the structured ASIC programme, with product designs expected in 2022.

5G RESEARCH DIRECTIONS

EDGE CLOUD

In January, a group of operators formed a Forum called the 5G Future Forum. The group of operators wanted to set out interoperable standards for the way developers could interact with "5G and mobile-edge computing-enabled solutions."

The Forum's founding members, América Móvil, KT, Rogers, Telstra, Verizon and Vodafone, said it would focus on the "creation of uniform interoperability specifications" to improve speed to market for developers and multinational enterprises working on 5G-enabled solutions. In addition, Forum participants would develop public and private marketplaces to enhance developer and customer access to 5G, and will share global best practices in technology deployment.

Although the Forum doesn't formally carry the word Edge within its title, the edge is very much the target environment for this codification of interoperability. The idea is to make it easier for enterprises and developers to engage with the telco edge, so that applications requiring mobile edge resources or presence could be deployed and behave in a more uniform manner.

Then a month later another group was formed, this one called the Telco Edge Cloud. The Telco Edge Cloud is being formed by another group of operators - China Unicom, Deutsche Telekom, EE, KDDI, Orange, Singtel, SK Telecom, Telefonica and TIM.

These operators say they will develop "develop an interoperable platform to make edge compute capabilities widely and easily available."

Then we saw a further group of operators establisha technology initiative designed to fill in gaps in existing mobile edge standards.

Four operators, Telefonica, KT, China Unico and Telstra, will work with technology company Altran to develop and test software solutions that they will then submit to open source and standards organisations developing mobile edge computing standards.

This third initiative is known as the Multi-Operator Multiaccess Edge Computing (MEC) Experience and is part of the GSMA Operator Platform project, a wider initiative to bring some shape and order to mobile operator edge cloud deployments, finding means to federate them to make it easier for enterprises and developers to do business with operators.

Juan Carlos Garcia, SVP Technology and Architecture Telefonica, said that the operator has been assessing how

to monetise its network capabilities within the new 5G architecture, including how to expose and monetise its edge capabilities. There are currently a number of solutions to expose network capabilities via APIs, but after assessing 30-40 commercial solutions on the market, Telefonica concluded nobody had a mature telco-grade solution and also that many were lacking the basic functionality to meet its needs.

Nor did the standards hold all the answers. Garcia said that the standards had holes in three main areas. First, in the connection of different operator edge platforms. Second, how to handle mobility of a device between different edge locations within the same network, and third, service continuity when a user requiring an edge-enabled application leaves one operator's network and roams onto another operator's network.

The Telco Edge Cloud is also operating as part of the GSMA's Operator Platform Project, and Garcia said that it is focused more on commercial implementation of MEC specs, trialling different tactical approaches such as MobiledgeX's aggregator model. The MEC Experience is focused on delivering those technical requirements that will be missing whatever edge cloud delivery model is chosen.

R&D NEWS

TIM said it had achieved over 2Gbps speed on a 5G live commercial network, using a combined 400Mhz of spectrum in the 26GHz band and at 3.4GHz, in alliance with Ericsson and Qualcomm.

TIM said that the Turin-based mmWave network will be able to use up to 800 MHz during 2020, and afterwards up to 1.000 MHz. It said such big capacities would be a good match for FWA use cases, as well as the creation of "dedicated" indoor coverage.

Qualcomm Technologies and ZTE Corporation said they had achieved a 5G-enabled Voice over New Radio voice call during December. The call was performed over the 2.5 GHz spectrum band (n41) using a ZTE 5G NR base station and a 5G smartphone form factor test device powered by a Qualcomm Snapdragon 5G Modem-RF System.

The ability to complete VoNR calls will allow operators to deliver voice services without having to rely on VoLTE (voice over LTE) or an LTE anchor.

China Mobile is testing network slice performance across backhaul using a new test module from Spirent. The carrier, which has deployed 5G commercial SPN transport to offer SLAs across a variety of 5G applications, is using Spirent's FlexE-100 module to test functional, performance and specification aspects related to its 5G transport Slicing Packet Network (SPN).

SPN has been accepted by the ITU Telecommunication Standardisation Sector (ITU-T) for further work towards the G.mtn (Metro Transport Network) standard series, which provides an end-to-end transport network architecture that supports network slicing. Standards-based testing for SPN validates use cases, technologies and solutions prior to deployment.

The network slice testing solution provides protocol emulation and L2-L7 traffic generation over the slicing channel layer to help ensure the diverse bandwidth, latency, security and time synchronisation required by 5G applications.

ETSI has formed a new industry Specification Group to look at developing an alternative networking protocol to TCP/IP for use in 5G networks.

ETSI said that the work of ISG NIN will be applicable initially to private mobile networks and then expanded to public systems, both in the Core network and eventually including the Radio elements.

The group's first output will be a Report detailing the shortcomings of TCP/IP, and how the new alternative system would overcome those shortcomings. ISG NIN will also work on specifying how the technologies initially identified by ISG NGP will form the basis of the new protocols, as well as creating a framework for testing the efficiency and effectiveness of the new protocols, including over radio.

The search for a new set of non-IP base protocols has been ongoing for a while. That's because many think TCP/IP is incompatible with the very efficient use of spectrum that many advanced services will require. In 2015, ETSI formed a group lead by BT's Andy Sutton called the "Next Generation Protocol" Group. Its key output was a list of required deliverables (KPIs) for a new networking protocol.

The Group also concluded that a fundamental change is needed, and that a new Industry Specification Group (ISG) focussing on Non-IP Networking (NIN) should be created. So ISG NIN will also act as responsible body for the maintenance of ISG NGP Deliverables if need arises.

That work has moved forward into the newly established Non-IP Networking Group, which is being chaired by John Grant, BSI. Kevin Smith, a previous Chair of the NGP Group, Vodafone, will serve as the new group's Vice Chair.

The ETSI NIN Group page says, "The TCP/IP protocol suite was designed for an age in which communication was between computers and terminals in fixed locations, and in which the user interface was text rather than dynamic media such as audio and video. Mobile operators have identified a number of problems with its use in core and access networks, and it is unsuitable for some of the new services that are proposed for 5G."

5G IN CHINA VENDORS WINNING & LOSING

As the Chinese mobile operators announce contract awards for Phase 2 of their 5G rollouts, amongst the major NEPS, Huawei is emerging as a clear winner and Nokia as a lower.

Nokia has missed out completely on contracts from China Mobile and from China Unicom and China Telecom, who are sharing parts of their network.

China Mobile had awarded the bulk of its Phase 2 5G base station contracts to Huawei and ZTE, with a smaller share for Ericsson. The FT reported that the overall $5.2bn tender was for 232,143 5G base stations, "the majority of the company's targeted buildout this year". It said that Huawei was awarded 57.2% by number of base stations, ZTE with 28.7% and Ericsson 11.5%. The terms of those shares are unknown, although it is known Ericsson was under severe price pressure to win even that portion of the deal.

That leaves Nokia with nothing. The strike-out in 5G is despite Nokia signing a series of large scale frame agreements - often scoped to a billion Euros - with China Mobile over recent years. The most recent of these, referencing radio access network equipment as part of the frame, was in mid 2018. Later in 2018, the company added two more frame agreements with China Unicom and China Telecom, who were also later to bypass Nokia for Phase 2 5G.

Up until this point, Nokia has been quiet on the 5G tender process in China, but it has told TMN that it will continue to engage with Chinese mobile operators on 5G, despite confirming it came up empty handed this time. It said it still expects to be a "a sizeable player" in China "well into the future".

It also pointed out that the addressable market is about more than 5G base stations, and notably it also referenced the potential to "pursue opportunities" with Enterprise and Webscale players.

Here is its statement: "We are aware that China Mobile has announced its 2020 5G NR CP2 central bidding results. Nokia has been operating in China for 40 years and our commitment to China remains the same. We still expect to be a sizeable player in China well into the future and in addition to supporting the Chinese operators' 5G ambitions, we continue to pursue opportunities with service providers in core, routing, transport, fixed access and our current 4G business, as well as with Enterprise and Webscale customers."

ZTE has said that it gets no special favours from Chinese operators and has to compete in an open competition to win 5G base station contracts in China. It claimed that rival western vendors have fallen behind because they can not meet the exacting technical and logistical requirements demanded by Chinese mobile operators.

By ZTE's calculations, last year Chinese operators awarded contracts totalling about 130,000 base stations. ZTE said in June 2019 that it had "shipped" 50,000 5G base stations.

The vendor said that Chinese operators will ramp up a second phase of deployment in 2020, with contract awards due for around 600,000 base stations. At the time he spoke to TMN, shares of those have not yet been allocated officially. Xiao Ming, President of Global Sales, said that awards would "probably" be public at the end of March 2020, with deployments starting in Q2. Ming said that ZTE expects to

win a similar 5G share to the 35% share it achieved in the country's LTE deployments.

It seems ZTE undershot that at China Mobile, but met that share at China Telecom/Unicom, where it did indeed win a 35% share, the same as Huawei. Ericsson was again the only Western winner, with an 18% share.

But the vendor forcefully denied the suggestion that its market share is due to any Government directive or special dealing by the operators. "No. No way. The process is open, public and fair," said David Dai, Head of Brand for ZTE.

"It's the technical capability which we are seeing gives us a good winning chance because we are more capable than the other vendors," Xiao Ming said.

Summer Chen (Chen Zhiping), Director of Wireless Solutions, ZTE, said that from a technical point of view the two western vendors' testing results, roadmap and delivery progress is quite late compared to the Chinese vendors.

Chen said, "The Chinese market requirement is the highest. First the scenario is the most complex. In other countries the requirement is just for macrocell at first, but in China they want all kinds of scenarios, metro, indoor, high speed railway station coverage and so on. Second is the requirement for the specifications, for bandwidth, power consumption and peak and average throughput. Each of the technical requirements is higher than in other areas. And the third is the large scale pressure for delivery and logistics. All these things combined together put huge pressure on the other vendors."

China Unicom and China Telecom are building out a shared 5G network, and have committed to building 250,000 5G base stations by Q3 2020. China Mobile is rolling out its own 5G network and has a target of 300,000 deployed 5G base stations by the end of 2020. China Mobile has 160MHz bandwidth at 2.6GHz while CT and CU have 200MHz in the C-Band, which ZTE's Ming said was a technical challenge for vendors to meet.

China Telecom says it will have access to 300,000 5G base stations by the end of 2020, five times the number it had live at the end of 2019.

The operator, which is taking part in a 5G network share with China Unicom, said that it had deployed 40,000 of its own base stations by the end of 2019, with access to 20,000 of China Unicom's sites. That reflected a RMB9.3 billion investment in 5G networks in 2019.

But it is 2020 that will see the real ramp up. 5G capex is set to expand to RMB45.3 billion as the company deploys or gets access to a further 240,000 5G base stations. For comparison, the company has almost 1.6 million LTE base stations in operation, so there is still considerable headroom for more 5G sites to come in following years.

It will also deploy a 5G Core to support StandAlone mode in 2020, and said it had been investing in R&D into edge computing.

The operator's overall capex in 2019 was RMB77.6 billion, and it is forecast to rise to RMB 85.3 billion in 2020, so although the overall lift is just under 10%, there is a major shift to 5G within the capex mix; 5G is moving from an 11.9% share of capex to 53%. Meanwhile 4G, responsible for 33% of capex in 2019, will amount to just 8.8% in 2020.

China Telecom said that it already had over 10 million 5G "subscribers" by the end of February 2020. It wants to beserving from 60-80 million 5G subscriptions by the end of 2020.

5G AND IOT?

It's still unclear what "5G IoT" will look like. Some mention Massive Machine Type Communications for 5G, connected to a 5G core, as being able to offer increased reliability and reduced latency for mission critical purposes.

But it's worth noting that IoT technologies originally defined as far back as R13 will also continue to be developed and updated in R16 and R17. NB-IoT was defined within 3GPP Release 13 for use over LTE networks. Later, it was decided that NB-IoT's characteristics actually met the ITU's IMT-2020 (5G) requirements, and NB-IoT and LTE-M were both then proposed as 5G candidates for IoT by 3GPP. That meant NB-IoT and LTE-M development continued within the 5G standardisation time frame, with R15 and R16 including enhancements to LTE-M and NB-IoT operation.

But aside from the technology there's a deeper question. Where is the business model for cellular-connected 5G IoT devices? Less than a year after launching its NB-IoT service, Japanese operator NTTDoCoMo said that it will discontinue the service.

The close down seems to have been a business decision. It looks as though it wants to concentrate efforts on selling IoT technology classes that are getting more traction with customers.

Even if NTT DoCoMo is shuttering NB-IoT to wait for a future version of 5G IoT, questions remain. Are we seeing that Japanese enterprise demand for cellular LPWA IoT is not strong enough to justify this carrier continuing operatingNB-IoT. If so, what does that mean for 5G IoT? Do we need a new class of device and network capability beyond NB-IoT - and what must it provide to unlock genuine business demand?

PLANES, TRAINS & AUTOMOBILES...

How the transport sector could benefit from our networked world. From in-journey entertainment and AR experiences to remote operated and driverless vehicles, from 4G to 5G, TMN looks at the world of transport.

RAILWAYS

Possible railway applications include: signalling control, passenger information, AR overlays of routes, live update information.

A new integrated communications architecture is being developed in the framework of the 5G PPP 5G-PICTURE project. This novel architecture will be adopted to build a 5G railway demonstration in the operational rail network of Ferrocarrils de la Generalitat de Catalunya (FGC) in Barcelona, Spain.

FirstGroup and Blu Wireless have announced a project to significantly boost the quality of connectivity on trains by pioneering.

AIRLINES: ON-BOARD CONNECTIVITY

Airbus, Delta Air Lines, OneWeb, Sprint, and Bharti Airtel have teamed up to create the Seamless Air Alliance to provide customers of different airlines with high speed, low latency 5G connectivity via satellite technology.

Nokia spin-off Skyfive markets ground to air mobile cellular technology that works by pointing base station antennas up to the sky, creating large cell sites (150km radius) at high altitudes. On board terminals receive the signals and distribute them as cellular connectivity within the plane cabins.

DRIVERLESS/AUTOMATED CARS

ASSISTED AND CONNECTED DRIVING REQUIREMENTS:

An overall 5G system architecture could form part of end-to-end V2X network connectivity, providing security, privacy and quality-of-service to support traffic flow management in a multi-radio access and multi-link V2X communication system.

Interworking of multi-radio access technologies that allows embedding existing communication solutions and novel 5G V2X solutions.

An efficient, secure and scalable sidelink interface for low-latency, high-reliability V2X communications.

5G radio-assisted positioning techniques for both vulnerable road users and vehicles to increase the availability of very accurate localisation.

BICYCLE/SCOOTERS

Micro-mobility needs to be managed as part of a Smart City policy. Up to date information and analytics on usage and routes could be enabled by a mass IoT network.

ROAD FREIGHT

Possibility of road freight platooning requires vehicle to vehicle communications and network connectivity for control.

BEYOND THE HEADLINES

5G of course brings with it new standards for the radio and core network - all good news for the large network equipment vendors. But assuring and monitoring the requirements of 5G - throughput, latency, reliability - also opens up opportunities for a whole ecosystem of companies. TMN takes a look at a few key areas.

TEST AND MONITORING

Viavi Solution's Paul Gowans, Wireless Strategy Director says that network planning is moving away from a cell-centric model to a 3D beam-centric environment with new 5G technologies such as massive MIMO, beamforming, network slicing and mmWave utilisation. That is introducing significant network complexity and necessitating new test and measurement processes. 5G test challenges range from over-the-air and downlink testing in the RAN, to testing of fronthaul transport network nodes, and traffic emulation to stress-test network slices.

Gowans says that where simple fibre and RF tools were once sufficient to deploy a 4G site, 5G sites require new, more efficient test instruments, plus greater test process automation. Moreover, with O-RAN becoming a key architectural element, interoperability testing is now paramount.

He adds, "With the recent adoption of O-RAN, we are helping customers ensure compliance and interoperability with a turnkey test suite including instrumentation, automation, systems and processes, so operators can deploy and turn-up 5G networks without impacting existing customers".

Spirent's Stephen Douglas says that 5G is keeping the company busy in three main areas. There's the traditional work of helping equipment and device manufacturers test new equipment.

The second area is that as service providers turn up new services, Spirent is required to validate, assure and guarantee delivering new capabilities. 2019 was about getting those first early 5G networks deployed, with a focus on building out transport networks, underpinning fibre to allow them to build out the cell sites.

The third area has been on the security of network ecosystem - from certification testing to how continuously secure networks of the future on new distributed networks.

China Mobile is testing network slice performance across backhaul using a new test module from Spirent. The carrier, which has deployed 5G commercial SPN transport to offer SLAs across a variety of 5G applications, is using Spirent's FlexE-100 module to test functional, performance and specification aspects related to its 5G transport Slicing Packet Network (SPN).

SPN has been accepted by the ITU Telecommunication Standardisation Sector (ITU-T) for further work towards the G.mtn (Metro Transport Network) standard series, which provides an end-to-end transport network architecture that supports network slicing. Standards-based testing for SPN validates use cases, technologies and solutions prior to deployment.

The network slice testing solution provides protocol emulation and L2-L7 traffic generation over the slicing channel layer to help ensure the diverse bandwidth, latency, security and time synchronisation required by 5G applications.

Slicing is also exercising Anritsu's Jonathan Borrill, who says key challenges lie around network slicing and MEC.

"There is a key challenge for the industry as these services lie above the classic 3GPP protocol layer, and so are "out of scope" for normal 3GPP/GCF test and certification schemes. If we recall the troubles and inter-operability issues in the early days of VoLTE deployment, there is a potential for the same (but order of magnitude more complex) problems when Network Slicing and MEC go commercial," he told TMN.

"The network guys are putting out news on trials about MEC, but in the end when you go to a live service, you have got to take apps and clients into handsets and real devices in the real word and we are not seeing any activity yet in this area."

Borrill says that performance and slice assurance all sits inside the network and can make sure a slice is managed and orchestrated well. "That's all nice, but what if the process to set up and request a slice is not working. What if a UE can't request a slice - then there is no slice. This is a separate area. Slicing is thought of as purely network technology but we must also consider the device role."

"MEC will need a separate client in the device which requests and figures out what MEC instance the app will use. All the demos are of a fixed device talking to one BTS and edge server. In the real world there will be thousands of users and app stalking to multi edge servers. Some apps will use the edge server and some will not, and that requires the handset to talk to the network and negotiate this."

Borrill says that although in theory ETSI specifications show an architecture of a client talking to a network to configure the MEC route, handset and app configurations defined by an operator will make a huge difference as to how a device talks to the MEC and how a link is provisioned and established. Devices may not be provisioned to roam, and services may not be provisioned to accept incoming roamers. IoT devices are not such a potential issue because most of them do not roam. But take an AR app from an edge server at a stadium. All the phones are expecting to see the same video feed but you cannot route all YouTube and FaceBook requests to the same edge server because it will crash. How will that traffic routing be handled?

He wants to see a testbed for the interoperability of different clients, apps and services - perhaps led by a consortia of operators or other industry grouping.

There are other companies wrestling with how to address a consistency of performance at the edge.

One of those is another test company, Accedian. Accedian will be providing its performance management and assurance software to edge cloud platform provider MobiledgeX.

The idea is to create a more trusted environment at the edge, giving enterprise developers the ability to trust the environment in which they are deploying their workloads. That includes radio layer as well as cloud infrastructure monitoring and assurance.

Accedian and MobiledgeX are also part of an initiative that includes participation from the GSMA that will be known as Seamster. Yet to be launched, this initiative will involve edge computing "knowledge sharing, use case exploration and market data analysis, with member companies comprising stakeholders from across the expanding edge value chain." One to keep an eye on.

Accedian's Richard Piacentin tells TMN, "The fundamental difference in the edge business model is that multiple parties are involved. For example, take something like Google Stadia moving from streaming at a best effort level across the public internet to a 5G MEC-enabled telco network. Imagine in this circumstance Google has negotiated a

"In the end when you go to a live service, you have got to take apps and clients into handsets and real devices in the real word and we are not seeing any activity yet in this area."

deal with AT&T so that Google is hosting the game with a remote rendering load and has reserved the capacity to do that in the MEC. Maybe the players themselves have the ability to click a button to be on lowest possible latency. You now have multiple entities in that relationship all of which is predicated on guaranteed QoS."

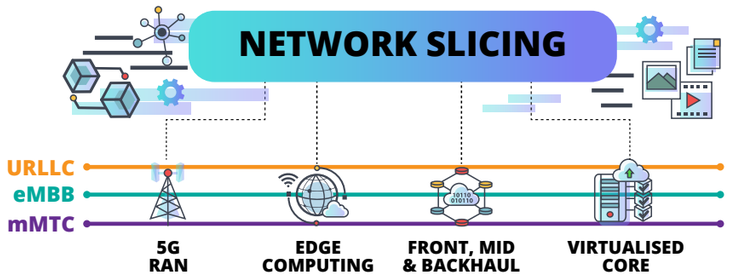
For the past few years Canadian company EXFO has been on an acquisition path that has integrated SON technology, big data analytics, real time inventory analytics, network probes (physical and virtual) and test equipment.

This year the company took the wraps off a new solution - NOVA ASA (Automated Service Assurance) that is designed to automate network and service assurance.

ASA is a streaming analytics platform and automation framework that takes in data from EXFO's own instrumentation and other tools and sources. It relies on a machine learning layer that EXFO calls Nova SensAI. This ML layer is an adaptive monitoring layer that looks for customer experience problems by analysing metrics on KPIs. This allows it to compile detailed evidence to assess and make decisions on the data to enable a higher level diagnosis. EXFO calls this the small data approach - using the algorithms of the ML to pick up on small events that it can correlate to likely performance or service issues in the edge, core or RAN, and in virtualised or container-based environments.

EXFO says that with virtual networks and denser 5G networks, operators are going to need an automation framework that can direct service assurance, based on streaming data analytics, but without overwhelming big data systems or using more reactive ML techniques to interrogate oceans of warehoused data to discover the causes of faults.

WHAT IS NETWORK SLICING?



BACKHAUL

Ciena announced three new fronthaul/backhaul routers and an upgrade to its automation software as part of a boost to its 5G network solutions portfolio.

The routers, which it describes as "network slicing routers", can offer hard and soft slicing via Segment Routing and FlexEthernet (FlexE) / G.mtn (Metro Transport Networking) switching.

The xHaul router (can suit front/mid/back haul applications) has been designed with protocol support for O-RAN fronthaul as well as CPRI and eCPRI. The other two routers offer different capacities in the backhaul.

The routers have been designed to work with an open interface to network slice controllers, either Ciena's or a third party's.

The point is that the backhaul element must fit into the overall slicing control infrastructure, and be able to respond dynamically if routes go down or other parameters change.

Ciena's BluePlanet automation and orchestration software has also been update with new network slicing and dynamic inventory and other planning capabilities.

Brian Lavalle of Ciena Network Solutions says the company already has several links available carrying live 5G traffic over commercial networks. He said the three new routers are all aimed at the crosshaul - that's the term for a mixture of front, mid and backhaul - in the 4/5G space.

"Interworking allows 4G and 5G network elements to share a common infrastructure and L1 offload to reduce the bandwidth required. The CPRI link is pretty inefficient so if we can shrink that capacity by half and rebuild it on the other end in front of the BBU, that's a direct saving on fronthaul capacity."

Aviat's Gary Croke warns that the backhaul network in its whole will need to be a lot more resilient to meet the promise of 5G and meet its stringent demands on reliability. He says operators will need to take steps to make transmission and backhaul much more reliable than they are today.

First, he wants to see more use of microwave. Yes, Aviat is a microwave vendor, but Croke argues that improving media diversity to critical sites needs to be a major trend. Helpfully, an integrated mmWave and lower band microwave single box multi band radio can reduce implementation costs. Croke says that the Aviat single box multiband product can deliver 20x more capacity than a standalone microwave design and 10 hours more uptime than a mmWave radio.

NEW RADIO ECOSYSTEM

Open RAN is not really a 5G thing, but it does come within 5G investment timelines, and geo-politics has made it a sensitive issue as operators seek greater supplier diversity.

TIP (Telecom Infra Project) has officially launched a project to define a low cost "killer" Remote Radio Head (RRH) design that can slot into O-RAN and OpenRAN-based radio networks.

Santiago Tenorio, the newly appointed Chair of TIP, said the Evenstar project will be ready to roll in mid-2020. He told TMN that the aim is to have a RRH that can be priced to the market at about $1,000.

Tenorio first announced TIP's intention to define the radio unit at TIP Summit in November. He described it then as a "killer" radio because it hits a crucial sweetspot for operators.

The TIP-guided Evenstar project is currently working on delivering reference designs for a low cost, 160W Radio Unit in two current versions. These SKUs are for either 1800MHz or 700MHz band support, with 4T4R (4X40W) or 2T4R (2x80W) options. The Evenstar RUs will support the O-RAN CU-DU (Central Unit-Distributed Unit) architectural split known as 7.2. After the intitial reference design, the intention is to produce designs for more versions.

One of the project members, Mavenir, has been stating this year that one thing that would make its life easier would be to open up the market for low cost Radio Units. This would lower the overall Open RAN deployment costs of its customers and give them more flexibility of vendor partner. The project is being led within TIP by operators DT and Vodafone. DT has been a firm proponent of O-RAN since the early days, and Vodafone at the end of 2019 said that it would welcome tenders for radio sites across Europe from companies complaint with O-RAN specifications.

There's a political angle too. Mavenir has also positioned this as a potential route to a US or Western radio unit manufacturer. At present, the majority of low cost radio unit makers are based in China or Taiwan, and with the current US administration looking to boost western 5G vendors a reference design for a low cost radio unit might enable someone to take up manufacturing in a different geography.

At a meeting with the FCC earlier this year, Mavenir executives told the Commission that "availability of radios in the US bands is a fundamental US weakness". It also stated that there was a need for "low cost US managed volume manufacture of radios... with the OpenRAN interfaces." It added that radio pricing in small volumes is also a market barrier to smaller vendors.

Other Evenstar programme members are Parallel Wireless, MTI, AceAxis and Facebook Connectivity.

Altiostar, provider of the vRAN software for Rakuten Mobile's 4G network, has said that it has developed a containerised version for its radio technology that is major client and part-owner Rakuten.

Altiostar, Intel and Rakuten had a lot of work to do to create the initial solution that saw them virtualise the PHY layer of the Altiostar radio for deployment on Intel-based hardware from QCT.

CTO Tareq Amin has described this process as "non trivial", for instance requiring specific accelerations for near and real time processes.

Altiostar says it takes that virtualisation know-how and "further decomposes the network functions into containerised applications that are fast to deploy, can be individually upgraded and offer better network scalability".

As well as giving operators more flexibility in terms of updates in a CI/CD environment, Altiostar says the micro-RAN cloud native approach can give operators the ability to focus on services and applications as they deploy a vRAN.

The server platforms that drive the virtualisation technologies in Rakuten Mobile's network are based on high performance Intel Xeon Scalable Processors. As part of this project, Intel will release various Kubernetes plugins that facilitate RAN and MEC application containers on Intel architecture.

7 SEVEN THINGS I KNOW ABOUT...

how network slicing can drive a business model revolution

By Alla Goldner, Director, Technology, Strategy & Standardisation, Amdocs.

1. NETWORK SLICING IN 5G IS NOT NEW, BUT IT IS DIFFERENT.

Network slicing is not new as a concept specific to 5G. It was talked about in 4G, but 5G is the first time we have a standardised definition of how a slice should work end-to-end in the network. This means that you can build a logical network consisting of different network functions and define the service parameters - bandwidth, latency, security and so on - that are required from each function within that slice.

Service providers can offer this capability up to enterprises, which gives them a new means of differentiation. In that sense, service providers can compete with webscale providers like Google, Amazon, Microsoft and so on; providing services but in doing so actually ensuring those end-to-end requirements.

2. THE INTRODUCTION OF NETWORK SLICING WILL BE PHASED.

The way service providers introduce network slicing will be a phased process. The first phase will be about using slicing to define internal network optimisation - where certain slice classes are used as a means of gaining network efficiency. These slices will not really be tailored for customer requirements.

The second phase will be more about introducing slices that have specific service-related requirements, where customer segment slices are created with optimal parameters for that service. For example, an IoT slice with low latency, or an eMBB (enhanced Mobile Broadband) slice with guaranteed high capacity.

The third phase is a more advanced level of network slicing. This is a level of slicing where service providers can provide enterprise customers with the ability to order and manage their own service requirements. This is where we see the full advantages of network slicing coming in: service providers provide parameters such as capacity, latency, security as generic requirements to the enterprise, but the enterprise actually tailors additional services as a service chain on top of those capabilities and builds out its own slice end-to-end.

3. AN END-TO-END MANAGEMENT CAPABILITY WILL BE KEY TO THIS PHASED INTRODUCTION.

Slicing obviously needs to be supported by the network functions themselves within the 5G RAN, transport and core networks, with functions supporting slicing principles as defined by 3GPP. But for any end-to-end approach to succeed, this whole thing needs to be managed in a holistic, end-to-end way.

So, the first phase of that holistic approach is slice preparation, which includes design and onboarding. The second phase is about managing the life-cycle of a network slice, which means the creation, activation, reporting, assurance and monitoring of a slice, being able to amend a slice in closed loop operation. Finally, there is the decommissioning and termination of a slice. For all this you must have network management that is based on clear end-to-end visibility into whatever exists or is defined in the network.

4. THIS END-TO-END SLICE MANAGEMENT CROSSES PREVIOUS DOMAIN BOUNDARIES.

The important thing here, and this goes a bit beyond standards, is that the whole slice management process needs to start from the top - from the definition of the service, or an order request from a customer, all the way down through different VNFs/PNFs/CNFs from different vendors. This is why we in Amdocs couple the BSS and OSS functions along with NFV slicing management functions and provide a single offering where we include ordering and charging per slice into the overall slice management offering.

What was preventing full end -to-end network management in previous generations were claims from the traditional VNF vendors that their VNF Manager (VNF-M) can manage their VNF instances and chains, and that this is sufficient. With network slicing that is not sufficient. Service providers do not have the same vendors in the RAN, core and transport domains, and so even if one vendor comes with its own VNF-M or even NFV-Orchestrator (NFV-O) then that must still be connected with the end-to-end solution with full visibility, again, to assure end-to-end holistic management for the different parameters required per slice.

Network slicing means that for the first time the need for an end-to-end network management solution is clear, justified and a must.

5. WE NOW HAVE A PICTURE OF HOW TO MANAGE NETWORK SLICING, IN THIS HOLISTIC WAY.

We understand the "how" of network slicing. By now, pretty much, we can build a map of that slice management journey. On the top there are some vertical industry organisations such as automotive and manufacturing industries which are trying to bring use cases into the industry, defining their requirements.

Then there are industry alliances such as the GSMA, NGMN, TMForum and MEF, that are building slice templates and profiles, as well as slice models and descriptors. And then after that, standards organisations define how the whole thing should work. So 3GPP is key and defines how 5G network slicing works and how it can be managed. Then ETSI-NFV defines how to orchestrate that based on those 3GPP specifications. ETSI-MEC orchestrates the edge platform and another very important activity is Zero Touch Session Management (ETSI ZSM), addressing how to automate end-to-end slice management.

We are also seeing others fill gaps. MEF is defining end-to-end service level orchestration ZAPIs between domains and carriers. In ONAP, a network slice use case track is introducing capabilities related to network slicing. Amdocs is leading the slicing modelling work in ONAP, and ongoing work on network slicing inventory support.

Eventually, the challenge is to get all necessary pieces from these different organisations and build a single holistic picture. By participating in and contributing to the above-mentioned organisations, are gaining the required knowledge and expertise, and are building our solution accordingly.

6. THAT HOLISTIC CAPABILITY WILL ENABLE A REVOLUTIONARY CHANGE TO SERVICE PROVIDERS' BUSINESS MODELS.

A holistic slice management capability will enable service providers to give enterprises their own slices to manage - delivering that third phase, Network Slicing as a Service.

But beyond that, it will mean a revolution in service providers' business models. That is because, for the first time, service providers will be able to charge not just based on individual subscribers' sessions and activity, but on the utilisation and performance of a slice or a service.

We will soon have the capability, as part of 3GPP R17, for the network management and orchestration entity to become a charging trigger function, by which I mean it will be able to report into the charging function information about for example a slice's capacity, bandwidth, level of latency and performance. And by having all those reports, service providers will be able to charge the enterprise based on for example the capacity and performance of that slice as a whole.

That is revolutionary. For the first time, not only can we generate a subscriber or session-based charging report in the mobile network, but a whole slice level report, providing a new monetisation opportunity for service providers, working with enterprises.

7. END-TO-END NETWORK SLICING ORCHESTRATION IS ABOUT CHANGING OUR INDUSTRY.

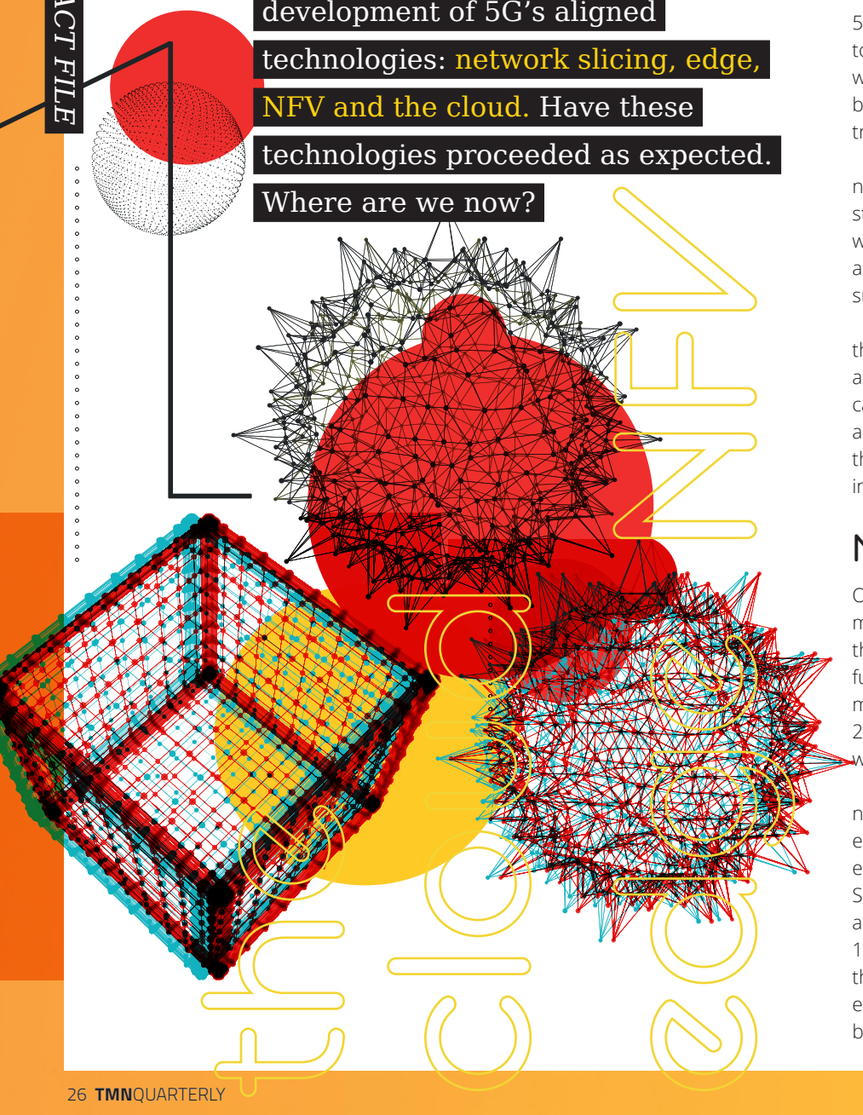
I have described the technical aspects of slice management. But the important thing to remember is that this is about enabling a revolution in how operators monetise their network assets.

The ability to change the business model, to charge by slice and not per subscriber, to enable B2B and B2B2B models based on Network Slicing as a Service, rests on the ability to manage slices in an automated, zero-touch and closed-loop way, top down and across the network.

Amdocs 5G Slice Management, by delivering lifecycle automation for cross-domain, multi-vendor slicing fully integrated with ordering and charging, enables the customer-centric slicing segmentation that will revolutionise our industry.

More than a supporting cast

Looking at the simultaneous development of 5G's aligned technologies: network slicing, edge, NFV and the cloud. Have these technologies proceeded as expected. Where are we now?



5G, we are told, brings with it the potential to serve a host of new use cases from within the same shared infrastructure, bringing with it the potential transformation of several industries.

Yet much of this transformation depends not so much on the specifications and standardisation of 5G itself, as on the way 5G network functions - in the RAN and core - will interact with a cast list of supporting or enabling technologies.

For network slicing to work in 5G, the networks must be orchestrated, automated and architected in a way that can truly deploy services as logical slices across the network. This is where NFV and the cloud, and especially the edge, come into play.

NFV and the cloud

Operator updates on NFV vary. AT&T makes it clear that it has a 75% target for the virtualisation of all its core network functions is still on target. After virtualising more than 55% of its network functions in 2018, AT&T's goal was to hit 65% in 2019, which it did early last year.

"We aim to control 75% of our core network functions with software by the end of 2020, and by reaching 65% at the end of 2019, we're nearly there," said Scott Mair, president of AT&T technology and operations, in early 2020. "Today, 100% of the data traffic that runs through the infrastructure connecting the elements of our core network together is backed by SDN."

Analyst company AnalysysMason says that there was a significant increase in the number and scale of NFV deployments in 2019, particularly in the mobile core domain, where NFV spending grew by 66% year-on-year between 2018 and 2019.

That said, it admitted that "it is true that the current status of NFV networks is not exactly what the industry had envisioned when NFV was first launched because the majority (73%) of these networks are still siloed 'virtual boxes' that rely on manual processes and the same management systems as physical boxes."

However, 2019 marked a major change. "We are seeing a steady movement towards common, horizontal NFV platforms, led by AT&T, Etisalat, Rakuten, Telefónica, Telenor and Zain. Moreover, the next wave of NFV platforms (that is, cloud-native technologies and ecosystems) are emerging with the promise of delivering the desired automation, scalability and cost-efficiency benefits of true cloud infrastructure."

The move to demand Cloud Native operations, rather than the siloed, virtualised instances of specific network functions, is behind many current telco cloud initiatives. TIM is building a 5G Digital Business Platform, incorporating a 5G access layer, network slicing, AI and analytics led automated operations, cloud native operations and API-based "exposure" of business and network capabilities. The aim is to be able to expose capabilities of its network to platform partners that use them to develop services and applications for their customers. That means having a network domain that is sliceable, programmable and accessible, with security, IT, OSS and assurance capabilities developed to support that goal.

The platform includes a Cloud Native infrastructure layer, an Intelligence block (big data and algorithmic analytics), plus a sliceable network formed of a cloud native core network infrastructure and a 5G RAN. The cloud native infrastructure layer depends on a cloud infrastructure that TIM is building on RedHat Openstack for NFV and Openshift for containerisation.

Edge

Several other operators are making plays that combine the edge with the capabilities of public cloud providers, as well as their own in-house operations.

Verizon said MEC would form part of its key network investment priorities through 2020. In a note looking back on 2019, it said 2020 would see "a more aggressive build out of our 5G network, greater innovation in how that 5G network is used, dynamic spectrum sharing to drive efficiency in how our spectrum resources are used, advancements in Mobile Edge Compute (MEC) technologies and partnerships, [and] continued innovation in fibre."

Verizon also said that it would be collaborating with location and mapping company HERE to use the operator's edge platforms to support use cases in vehicle and pedestrian accident avoidance and visual positioning.

HERE will be providing Verizon with access to a range of location data, SDKs, and APIs from the HERE platform.

AT&T in January that it is "doubling down on edge computing solutions".

Mo Katibeh, EVP/CMO, AT&T Business, said, "We're working with cloud service providers to add edge compute technology into our network centers as we're upgrading them for our 5G deployment. And we plan to have edge compute capabilities live in more markets by the end of the year."

Katibeh also said the company was pressing ahead with plans to work with other cloud providers.

The current status of NFV networks is not exactly what the industry had envisioned

"Whether the compute is in our network, or on the customer's premise, we can't do edge computing alone. It's a coordinated effort that we're working on with other key players in the ecosystem.

"With all the different things companies can do with edge compute, there are all types of cloud applications and cloud companies in the mix. And we're working with cloud companies across the board to deliver on the promise of 5G with edge computing."

AT&T is far from the only operator engaging with public cloud providers at the edge.

Amazon Web Services (AWS) has launched an edge compute service known as Wavelength that will integrate Amazon cloud platforms into a mobile network operators' 5G edge. Verizon, Vodafone, KDDI, and SK Telecom have signed up to test the service out.

The issue of "which cloud" at the edge has been a key determinant in the commercial viability of mobile edge computing. Wavelength means that developers can deploy a bit of an application at the network edge, with the rest of it running on the central AWS cloud. That gives them the same developer tools and APIs to work with, instead of integrating with a telco edge in some way.

Amazon has an IoT-focussed edge platform called Greengrass. In this case Greengrass is more of an on-site solution that links IoT devices to a Greengrass Core that controls and connects devices locally, and then connects back to the cloud for analytics, storage and management.

Wavelength Zones are designed to be sited at an aggregation point in a mobile network - say a Central Office or metro exchange.

Developers then extend their Amazon Virtual Private Cloud (VPC) to create AWS resources at the Wavelength Zone.

AWS Wavelength will be available first in the UK and Germany on the Vodafone 5G network, expanding to other Vodafone markets across Europe. Verizon has live trials with customers in Chicago.

NTT DOCOMO and MobiledgeX will jointly conduct a proof of concept (PoC) in Tokyo to verify a solution that leverages multi-access edge computing (MEC) for the worldwide distribution of applications.

In the PoC, a "markerless" augmented-reality (AR) application based on the Edge Realities platform offered by 1000 realities will be distributed to the MEC platform, DOCOMO Open Innovation Cloud, connected to 5G and LTE networks operated by DOCOMO in Japan. The MEC platform will enable the content to be positioned in space and displayed, without any time lag. DOCOMO and MobiledgeX aim to collaborate on a range of 5G solutions for the global market, which will be distributed in cooperation with partners in Japan and other countries.

Vodafone has MEC testbeds in its UK lab and at the Aldenhoven (automotive) Testing Centre in Germany, as well as involving edge as part of 5G programmes in Milan. The same applies for internationally funded test facilities like the Living Edge Lab of the Open Edge Computing initiative in Pittsburgh, USA. It identifies the edge as a mid-tier between the device and the centralised cloud.

Guenter Klas, Manager, Internet and Standards, Vodafone Group, said that the existence of a middle-tier offers several additional benefits. "The new tier 2 will reduce the bandwidth required to utilise cloud applications in a single location, because the steps in a processing chain can be more geographically distributed. This becomes relevant in applications like real-time high definition map generation based on huge amounts of crowd-sourced sensor data (showing for example when a tree has just fallen in the road ahead of a car).

"The middle-tier can also be used for filtering sensor data still inside the telecom network before such data is further sent to private and public clouds or made openly accessible via APIs to third parties for smart city use cases. For privacy reasons, this is particularly useful for video sensor data. For example, a policy could be applied to blur faces of any children as they might show up in raw video streams."

The Expert View:

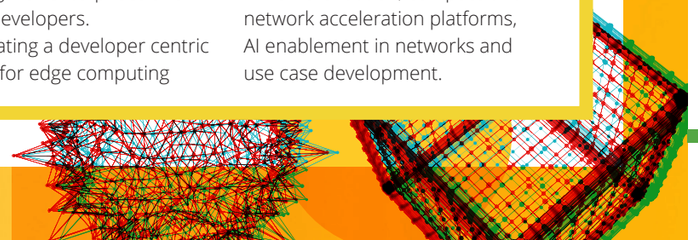
Shamik Mishra, VP of Research and Innovation at Altran.

Operators are at the early stages of adopting edge computing. There are three distinct opportunities for the operator to leverage this technology.

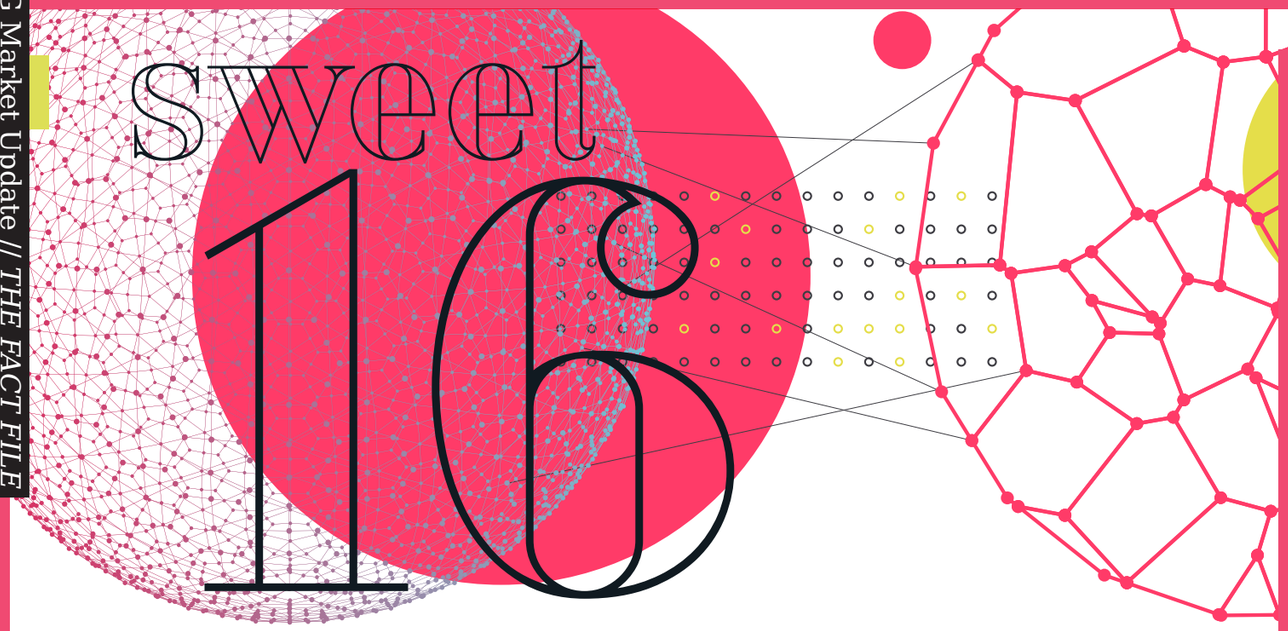
- First to generate new revenues by hosting low latency sensitive applications at the edge and provide better user experience to the end user. This opportunity is also considering location based services for the end users
- The second one is aiming to save costs primarily through backhaul savings on transfer costs of data from devices to cloud.
- The third opportunity is to leverage edge for better operational efficiency, localised services and productivity improvements.

Current discussions are mostly centred around how the operators can provide network insight and differentiate on the application experience due to their control of the network. Monetisation models are also key as operators look to build offerings for enterprises and application developers.

We are creating a developer centric architecture for edge computing where application developer's requirements are prioritised by operators while building their network edge compute. This includes building distributed PaaS architectures, developer experiences and providing network agility to the application developers through APIs and SDKs. We are also helping the operators build network and compute architectures for edge micro-data centers, define business and consumption models, network integration, network API differentiation, compute and network acceleration platforms, AI enablement in networks and use case development.



sweet 16



Want to know what's next for 5G? Then read on.

Release 16 is 3GPP's IMT-2020 submission to bring an initial full 5G system to its completion. As well as 5G New Radio (5G NR) it also contains specifications for enhancements to LTE.

Often called "Phase 2" 5G, (the geniuses amongst you reading this will have worked out R15 was Phase 1) Release-16 NR started in the RAN working groups in early 2018 with the study item phase. The work item phase followed in early 2019. The physical layer aspects were completed by the end of 2019, with higher layer aspects expected to be completed during the first half of 2020. The schedule calls for a freeze by the end of March, and completion by the end of June.

Release 16, as you might expect, extends out from R15 on a variety of topics: Multimedia Priority Service, Vehicle-to-everything (V2X) application layer services, 5G satellite access, Local Area Network support in 5G, wireless and wireline convergence for 5G, terminal positioning and location, communications in vertical domains and network automation and novel radio techniques.

Further items include security, codecs and streaming services, Local Area Network interworking, network slicing and the IoT.

Mission critical services will be extended to address a wider business sector than public security and civil defence service - addressing a wider variety of verticals with similar demands on reliability. A 3GPP explanatory statement said that for the verticals, there are three distinct pillars: Automotive, Industrial IoT and operation in unlicensed bands.

For 5G based V2X, which builds on the two iterations of the LTE-V2X, 3GPP is adding advanced features – primarily in the area of low latency use cases. For industrial IoT and URLLC enhancements, factory automation is a strong development area.

3GPP's statement said, "We are trying to ensure that the radio side covers all of the functions that all the verticals need for factory automation. What this means in practice is that we are trying to make sure 5G NR can fully replace a wired ethernet – currently used – by adding time sensitive networking and high reliability capabilities."

The third pillar is operation in unlicensed bands. The biggest change here is that R16 codifies standalone 5G NR operation in the standards - a different scheme from LAA that requires an LTE anchor, and different from MulteFire because MulteFire sits outside the standards.

Release 16 also delivers generic system improvements & enhancements that target Mobile Broadband use cases, but can also be used in vertical deployments – these include positioning, MIMO enhancements and Power consumption improvements."

Here are the new features planned for 3GPP Release 16:

- **Enhancement of Ultra-Reliable (UR) Low Latency Communications (URLLC)**
- **Enhanced support of Vertical and LAN Services**
- **Cellular IoT support and evolution**
- **Advanced V2X support**
- **5G Location and Positioning Services**
- **UE radio capability signalling optimisation**
- **Satellite Access in 5G**
- **Enablers for Network Automation Architecture for 5G**
- **Wireless and Wireline Convergence Enhancement**
- **Mission Critical, Public Warning, Railways and Maritime**
- **Streaming and TV**
- **User Identities, Authentication, multi-device (Network) Slicing**
- **Other cross-TSG Release 16 Features**
- **NR-related Release 16 Features**
- **Release 16 Features impacting both LTE and NR**
- **LTE-related Release 16 Features**

Release 16 progressing towards completion:

- **5G V2X**
  - **Targeting advaned use cases beyond LTE V2X**
- **Industrial IoT and URLLC enhancements**
  - **Adding 5G NR capabilities for full wired Ethernet replacement in factories: Time Sensitive networking, etc...with high reliability**
- **5G NR operation in unlicensed bands**
  - **Includes both licensed Assited Access (LAA), as well as Standalone Unlicensed operation**
- **System improvements and enhancements**
  - **Positioning**
  - **MIMO enhancements**
  - **Power Consumption Improvements**

Key developments we can expect in release 17

1. **NR performance improvements**
   Based on learnings from existing commercial deployments
   → MIMO enhancements, UE power saving, SON/MDT enhancements
2. **NR radio for industry 4.0**
   IIoT, Private Networks
   → NR-Lite (low complexity devices), Non-public network enhancements, NR extended coverage, URLLC/IIoT enhancements
3. **More spectrum & flexible usage**
   Extension of FR2 for NR
   → NR up to 71 GHz, NR-U in 60 GHz
4. **Support for diversified devices**
   FWA, eV2X, NTN
   → Sidelink enhancements, NTN Multi-SIM, AR/VR (XR)

The Expert View:

Scott Sumner, Director, Commercial Insight, EXFO, on the implications of R16's introduction of V2X, Industrial IoT enhancements and 5G NR.

As the number of connected cars and industrial IoT devices relying on low-latency, high-reliability 5G services increase, the connection performance to each will need to be monitored in real-time. This is required to enable closed-loop performance to meet strict SLA requirements, and to provide evidence of compliance for legal liability agreements between operator, vehicle/device manufacturer and owner/end-user.

Real-time machine-learning, streaming analytics employing anomaly detection and prediction will be required to not only maintain performance, but to prove to industrial and enterprise customers that the service can be delivered, monitored and assured—necessary to make the sale.

5G NR in unlicensed bands

Interference and cell site optimisation, including the ability to strategically locate and position NR will become significantly more complex and dynamic in unlicensed bands. The ability to relate user experience and device performance mapped to RF geo-analytics will be critical to enable a new class of AI-powered SON.

The technology to perform this kind of monitoring is just now becoming available, and relies on the effective automation and correlation between multiple monitoring systems: RF, network, user experience and fiber monitoring. The emergence of adaptive service assurance, that efficiently automates probe and agent location and scale to diagnose a specific service issue will ensure that big data overhead can be side-stepped to ensure real-time diagnosis and problem resolution is possible.

Release-17

For **Release-17** the physical layer work in RAN1 will start at the beginning of 2020, whilst radio protocol and architecture work in RAN2 and RAN3, respectively, will start in the 2nd quarter.

From January, RAN1 3GPP started working on several 5G NR features: MIMO, Spectrum Sharing enhancements, UE Power Saving and Coverage Enhancements. RAN1 will also undertake the necessary study and specification work to enhance the physical layer to support frequency bands beyond 52.6GHz, all the way up to 71 GHz.

In addition, several features have been approved to address different needs of vertical industries, such as sidelink enhancements to address automotive industry and critical communication needs and positioning enhancements to address stringent accuracy and latency requirements for indoor industrial cases. Further functionalities will be added to better support low latency and industrial IoT requirements, and also to terrestrial Low Power Wide Area systems (NB-IoT).

Specification support will be added to support lower capable NR devices, realising the needs of certain commercial and industry segments for such features.

The combination to support lower capable NR devices, and enhancements done for NR coverage constitute key elements to enhance support for the Low Mobility Large Cell (LMLC) scenarios.

There will also be 5G NR enhancements to support satellites and High-Altitude Platforms (HAPs), with studies also paving the way to introduce both NB-IoT and eMTC support for satellites.

In the second quarter of 2020 work starts on the protocol enhancements for the newly added physical layer features. From April, the RAN2 group will also start working on: Multiradio DC/CA enhancements, IAB enhancements, enhancements for small data transfer, UE Power Saving enhancements, SON/MDT enhancements.

There will also be work on support for Multicast transmissions, focusing on single-cell multicast functionality with an evolution path towards multicell. The aim is that multicast will re-use the unicast 5G NR physical layer to enhance the opportunity for an accelerated commercial uptake of multicast.

The architecture group, RAN3, will also start R17 work in the 2nd quarter of 2020. It will address the QoE needs of 5G NR, initially starting with a study to understand how different the QoE function would need to be compared to what was specified for LTE.

Release 18 planning is coming in March 2021.

The Expert View:

Alla Goldner, Amdocs, Director, Technology, Strategy & Standardisation, Amdocs,

We will soon have the capability, as part of 3GPP R17, for the network management and orchestration entity to become a charging trigger function, by which I mean it will be able to report into the charging function information about for example a slice's capacity, bandwidth, level of latency and performance. And by having all those reports, service providers will be able to charge the enterprise based on, for example, the capacity and performance of that slice as a whole.

That is revolutionary. For the first time, not only can we generate a subscriber or session-based charging report in the mobile network, but a whole slice level report, providing a new monetisation opportunity for service providers, working with enterprises.

TOWARDS 6G

Researchers' minds have started to turn to 6G. But what would a next G try to achieve, and what technology would it involve? From THz communications to integrated AI, TMN looks at some early 6G thinking.

In March 2019, 300 people attended the first 6G Wireless Summit, hosted by the 6G Flagship project at the University of Oulu, Finland. Following that summit, a working group of 70 reconvened to author a paper: 6G Research Visions.

The paper breaks down why 6G might be needed and what it might achieve. It then looks at what the KPIs might be for the use cases to meet those needs. Further, it explores the areas where technology development is needed to meet those KPIs.

"6G Research Visions" says that with mobile network generations following a ten year cycle, "Now is the perfect time to identify future communication needs, performance requirements, system and radio challenges, and major technical options for 6G to establish the research goals towards the 2030s."

WHAT IS 6G ALL ABOUT?

The paper first addresses the fundamental question of why a "G" beyond 5G might be needed. Taking a tentative step forward, it then asks what sort of systems, business and regulatory models might be required to meet those needs. Finally, it identifies some technologies that could meet those system requirements.

Its proposal is that whereas 5G was targeted at meeting advanced consumer broadband, enterprise and IoT requirements, 6G could be about meeting the needs of society as a whole – with the UN's Sustainability Development Goals as a key driver. As the global population grows, as urbanisation increases but remote and rural areas also require connected services, tech will play its part in meeting human needs – and part of that will go beyond what 5G can offer.

There's an implicit acknowledgement that some might think 5G is already supposed to address all this stuff. But the paper says that 5G – even in its later releases – only gets us so far.

"Societal and business drivers will increasingly shape 6G development, including political, economic, social, technological, legal and environmental (PESTLE) drivers."

GENERAL OUTLINES

- This shift is going to require new technology, new participants and new means of measuring the network.
- Speeds will move towards 1Tbps, over very high bandwidth and short range links in super-high frequencies. At these bands, wireless starts to operate a bit like radar, and sensing applications become possible.
- Other potential targets: 0.1 ms Radio Latency, 100 devices per square metre, 10cm indoor positioning, 10x more energy efficient, 10,000x traffic increase. There could also be new KPI classes related to trust and security.
- Radio research should concentrate on THz and near-THz bands to achieve this.

BUSINESS SHIFT: BEYOND THE MOBILE OPERATOR

Very high bandwidth short range communications, often on a device to device basis, may shift the market beyond the traditional mobile operator.

The Oulu paper: "6G will introduce super-efficient short-range connectivity solutions that are likely to be driven by new players in the market resulting in new ecosystems outside traditional MNOs. Having a more inclusive view outside of MNOs will help shape the needs of 6G."

There could be other system shifts. It will not be possible to have a lot of overlapping, extreme bandwidth, short range networks, so there would need to be a heavy reliance on automation to enable enhanced resource sharing. It may also be that resource prioritisation means regulation will be challenged.

Another disruption is that smart phones themselves "are likely" to be replaced by pervasive XR experiences through lightweight glasses. Necessary supporting technologies include: **1)** imaging devices such as light field, panoramic, depth-sensing, and high-speed cameras; **2)** biosensors for monitoring health conditions such as the heart rate, blood pressure, and neural activity; **3)** specialised processors for computer graphics, computer vision, sensor fusion, machine learning, and AI, either in the device or in the surrounding network infrastructure; 4) wireless technologies including positioning and sensing.

RADIO HARDWARE CHALLENGES

Radio hardware research will focus mainly on THz bands or just below. Getting those very high throughputs will require short range, very wide bandwidth communications in the THz spectrum bands. Short wavelengths and wider available bandwidths above 100 GHz will enable increased data rates but also angular and ranging precision not seen before for imaging and radar applications for localisation, 3D imaging and sensing. "Therefore,"said the authors, "hardware needs, bounds and opportunities for ultra-high-speed low-cost communications and advanced sensing systems should be studied together on an unprecedented scale."

In early 2020 a second white paper came from another direction - Japanese operator NTT DoCoMo.The white paper summarises the related technical concepts and the expected diverse use cases of evolving 5G and new 6G communication technologies, as well as the technology components and performance targets.

THESE INCLUDE:

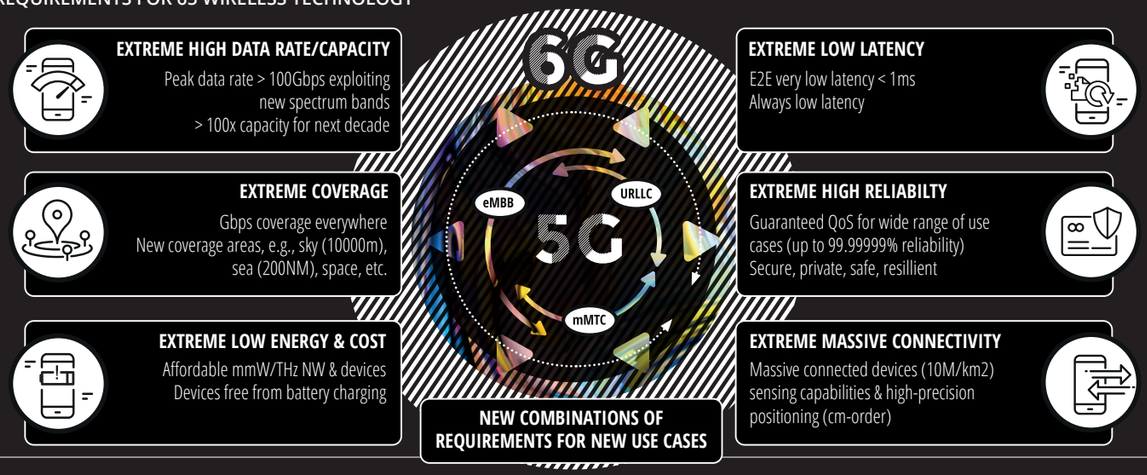
- pioneering new frequency bands, including THz frequencies
- expansion of communication coverage in the sky, at sea and in space
- ultra-low-energy and ultra-low-cost communications
- highly reliable communications
- massive device connectivity and sensing

The NTT paper also touches on another likely 6D buzzword, that it could be a 3D standard - with the air and space being more involved in delivery communications. ("High-rise buildings, drones, flying cars, airplanes, and even space will be natural activity areas.")

The NTT researches also think we might need a new network topology. "When ultra-high speed, high capacity (especially uplink), and the reliability of wireless communications are pursued, it is ideal to communicate at as close a distance and in an unobstructed environment (low-loss path) as possible, and to generate as many communication paths as possible to increase path selection candidates (increase redundancy). To achieve this, a network topology that is distributed in the space domain is required. A topology of spatially non-orthogonal distributed networks will be pursued by abandoning the concept of cells.

It seems that interference can be technically avoided by beam control and path selection, but the fundamental problem of how to achieve this at low cost remains. Various approaches are considered, but the paper concludes that the solution will be one that does not use conventional base station antennas. There are various investigations proposed such as using glass antennas, reflectors, integration of sensors and communication antennas, cooperation between terminals and terminal-like base stations.

REQUIREMENTS FOR 65 WIRELESS TECHNOLOGY

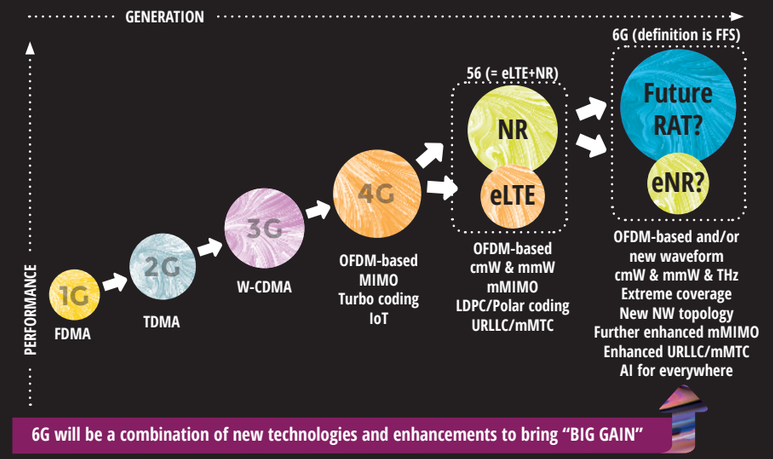


NO 6G FOR A LONG TIME

Alan Carlton, InterDigital, says that there is a lot of road left in 5G, and standards releases that might be termed Beyond 5G, before we get to 6G.

He says, "5G was designed, as a software designed network technology, to last longer than other standards. R17 is the ground zero of Beyond 5G, and there will be at least seven or eight releases of 5G before we see a discussion of 6G technology. We won't see commercial 6G until well into the 2030s, if we do 5G correctly."

One easy way to define the difference between Gs is defined by one G being able to do things, or meet use cases, that the previous 5G could not. So for 6G to make sense, it must provide capabilities that go beyond what 5G can do. Carlton terms this as looking at areas where 5G might start to break apart, and a new G might work.



One area is the air interface. Carlton says OFDM's digital modulation (used for 4G and in modified form for 5G) will simply not work at much higher frequencies – and we may even see a return of analogue radio, in a hybrid form with digital.

NTT's paper suggests the industry could research faster-than-Nyquist (FTN) signaling, which compresses and transmits signals non-orthogonally using a sampling rate faster than the frequency bandwidth in the time domain. It adds virtual massive (VM)-MIMO technology as a means of achieving a spatial multiplexing gain equivalent to mMIMO with a single antenna. The antenna characteristics are varied at a very high speed and periodically to generate a large number of virtual antennas and to increase the number of layers for spatial multiplexing.

Interdigital has a 100Gbps THz demo using Forward Error Correction (FEC) coding that is based on its work within the H2020 EPIC project. The Interdigital demo shows an FPGA-based chipset that can support such high rates with FEC coding. At such high bit rates, there is a need to re-invent coding algorithms, and the H2020 EPIC project aims to develop a new generation of Forward-Error-Correction (FEC) codes.

Another example where Carlton sees a breaking point in 5G is in the network slicing model. Take for example a slicing model to serve an AR-enhanced video stream to an operative in an industrial plant - that needs to deliver both low latency and be ultra reliable, as well as have a high capacity and throughout for the video and AR layer. Carlton argues that being able to combine difference slices into a single, managed slice, is not something the 5G architecture can do. In his words, "There's no seamless way of knitting that together. Potentially we could see 5G not being as flexible as it needs to be, and that could be an inflection for 6G."

It is, then, extremely early days - we are at the beginning of 10-15 years' of work, and the proposed goals of 6G are still very vague. But for all the talk of THz communications, a new air interface, new topologies etc, the key takeaway might just be that disruption to the device and mobile operator industry are already on the cards, and for that reason alone we should take notice.

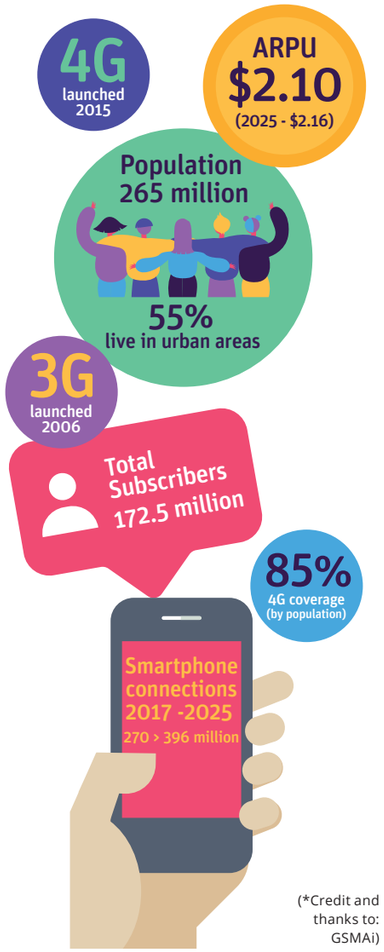
Indonesian journey

A market with a consolidating number of players and diverse and scattered geography is on track to become the world's third largest smartphone market, with increasing 4G growth and the first 5G development efforts.

The country's mobile market was characterised for many years by the large number of players players active in the market. At one stage seven mobile operators were competing in the Indonesian market: Telkomsel, Indosat, XL Axiata, 3 Indonesia, SmartFren, Bolt and Bakrie Telecom (BTel). Now, according to Budde Research, five players split the market: as of H1 2018, Telkomsel held a 46% share of total connections, followed by Indosat (23%), Tri (15%), XL (13%) and SmartFren (2%).

GSMA Intelligence said in a position paper looking at new spectrum possibilities at the end of 2017 that there were 194 million unique subscribers in Indonesia, making it the third largest mobile market in AsiaPacific and fourth largest in the world. With subscribers owning on average 2.3 SIM cards, there were 439 million connections at year-end 2017, representing a market penetration of 165%.

The paper said: "The exponential growth in uptake of mobile services since the beginning of the century has resulted in unique subscriber penetration levels in Indonesia rising from less than 3% in 2001 to just over 73% at the end of 2017. While growth has slowed in the past few years, penetration is still forecast to reach around 77% by the end of 2025, equivalent to 220 million individuals.



(*Credit and thanks to: GSMAi)

Evolving 4G

According to a recent report by London-based Opensignal entitled "The State of Mobile Network Experience", after Singapore and Thailand, Indonesia performs the best in ASEAN in terms of providing 4G availability. The country's 4G connections jumped from 34 million in Q3 2016 to 85.5 million in Q3 2017, according to data from GSMA Intelligence (GSMAi). LTE penetration in Q3 2016 stood 7.9 per cent.

To support the growth, mobile operators almost doubled the number of 4G base stations deployed in the opening six months of 2017, with 55,700 sites at end-July compared with 26,000 at end-2016.

Telkomsel, with a 44 per cent market share, sourced network equipment for its 4G deployment from Ericsson, Huawei, Nokia and ZTE. It is using 20MHz of 1.8GHz spectrum combined with 4×4 MIMO technology in the country's capital city Jakarta and also Medan, Bandung, Denpasar, Mataram, Pontianak, Makassar, Manado and Ambon.

After paying $74 million for 30 MHz of spectrum at 2.3 GHz, Telkomsel now has a total of 77.5 MHz LTE spectrum across five bands.

XL saw mobile turnover climb 12 per cent in Q1 2019, with total revenue increasing 8.8 per cent as it added more than 500,000 subscribers year-on-year to finish the quarter with 55.1 million subs. Data revenue accounted for 86 of service revenue in the quarter.

The operator said continued network investments in Indonesia, in particular outside of Java, boosted its 4G base stations count to 33,000 across 405 cities and towns.

5G Trials

Telkomsel and Huawei held a live demo of 5G technology in Jakarta, while Telkomsel also confirmed plans to test 5G technology at the Asian Games.

Smartfren selected ZTE of China to collaborate on the development of 5G technology in the country.

Telkomsel selected Ericsson's NFV infrastructure (NFVI) core network technology for a major core network upgrade as it moves towards 5G deployment.

XL Axiata selected Ericsson to supply a 5G-ready transport network over the next three years.

Innovation Fund

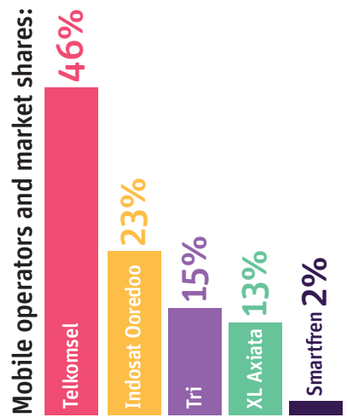
Telkomsel established a $40 million investment fund in collaboration with its venture capital initiative MDI Ventures and Singtel's innovation arm Innov8.

The fund will be managed by Telkomsel Mitra Inovasi (TMI), a 100 per cent-owned subsidiary of Telkomsel, and will invest in promising new companies.

Telkomsel president director Ririek Adriansyah said: "We recognise that Southeast Asia is a region that is growing very fast. Our collaboration through TMI will provide Telkomsel the ability to bring engagement models that are more flexible, responsive and reliable for start-ups looking for access to our strategic capital, and at the same time can provide a better user experience with mutually beneficial cooperation in the long term."

TMI CEO Andi Kristianto said it will work with start-ups in building strategic plans to maximise long-term value.

> "Telkomsel has also confirmed plans to test 5G technology at the Asian Games."



Devices and Makers:

As of January 1, 2017, all 4G devices in Indonesia must have at least 30 percent of their components made locally -so many phone brands have partnered with local manufacturers for production. Devices that connect to a network must also be sold with a minimum of 40 percent local content and apps.

Of the smartphone brands, Chinese makers dominate. Local provider Advan is the only home grown player to feature in the top ten devices, and features a locally optimised OS – IDOS - based on Android. TSM Technologies is also the first official Qualcomm licensee for 4G and 5G in Indonesia. TSM says it is ready to use its dometic platform to compete globally.

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