RCR Wireless News
INTELLIGENCE ON ALL THINGS WIRELESS

ENHANCING AND EXPANDING 5G'S REACH

3GPP Rel. 16 – Broadband, IoT and beyond

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TANTRA ANALYST

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Executive Summary

5G has been an unqualified success across many dimensions, be it operator interest, device ecosystem traction, customer adoption, and more. From the standards perspective, 3GPP Rel. 15 introduced 5G, setting in motion its unprecedented global proliferation. Historically, such major releases were followed by minor releases which were primarily bug-fixes and minor improvements. But defying that norm, Rel. 16 has become another significant step expanding the reach of 5G and opening new markets and business opportunities for the cellular ecosystem.

Rel. 15's primary focus was enhanced Mobile Broadband (eMBB), offering 5G's famed multi-gigabit speeds, and more importantly, extreme capacity. Rel. 16 is moving the focus to the other two aspects of 5G—Massive IoT (aka mMTC - Massive Machine Type Communications) and Mission Critical Service (aka URLLC - Ultra-Reliable Low-Latency Communications). They together enable 5G's foray into many new industries (aka verticals), and unlock the next Trillion Dollar opportunities. The features such as Time Sensitive Networking (TSN), Precise Positioning, enhanced Coordinated MultiPoint (eCoMP) untether modern factories, and herald the industry 4.0. Rel. 16 also brings C-V2X to 5G allowing vehicles to connect to other vehicles and everything else around them enabling safe and modern transportations systems, revolutionizing the connected car industry. The same side-link concept utilized by C-V2X also enormously benefits public safety, critical communications, and other services.

Additionally, Rel. 16 further improves eMBB and many other features introduced in Rel. 15. Those include enhanced MIMO/beamforming, robust handovers, efficient signaling, interference mitigation, and others that offer even higher performance, longer battery life, robust mobility, lower latency, and even better reliability and efficiency.

There are also features that simplify 5G network deployments, such as NR-Unlicensed (NR-U), Integrated Access Backhaul (IAB), and expanded options for Stand Alone (SA) deployments. NR-U allows 5G to utilize unlicensed spectrum, and IAB solves the challenge of providing cost-effective and rapid backhaul to dense 5G deployments.

Rel. 16 specification was finalized in June 2020, and many of its features are expected to be commercially deployed in early 2021.

This paper explores the features and benefits of Rel. 16, the performance improvements they bring, and new applications, services, and market opportunities they offer as well as what the future holds.

Strong 3GPP Evolution Path

One of the key factors in making 4G a success and propelling 5G even higher is a strong and robust technology roadmap developed by the industry body 3GPP. Fig. 1 shows the various releases and their relative timelines. Because of Covid-19 global pandemic, some of these timelines might shift.

3GPP Rel. 15 was a major step, which defined 5G. Although it included elements of all the three themes of 5G—eMBB, Massive IoT (mMTC), and Mission Critical Services (URLLC), the major impetus was on eMBB. According to the industry organization Global Suppliers Association (www.gsacom.com), as of mid-November 2020, there were 125 operators in 52 countries/territories who have announced 5G service launches in the world. Virtually all of them were offering

Fig. 1 – 3GPP Releases and timelines

2018	Q1	Rel. 15 early drop stage 3 freeze	Release 15
	Q2		
	Q3	Rel. 15 stage 3 freeze	
	Q4	Rel. 15 ASN. 1 freeze	
2019	Q1		
	Q2	Rel. 15 late drop stage 3 freeze	Release 16
	Q3	Rel. 15 late drop ASN. 1 freeze	
	Q4		
2020	Q1	Rel. 16 RAN1 freeze	
	Q2		
	Q3	Rel. 16 stage 3 & ASN. 1 freeze	
	Q4	← We are here!	Release 17
2021	Q1		
	Q2		
	Q3		
	Q4	Rel. 17 RAN1 freeze	
2022	Q1	Rel. 17 stage 3 freeze	
	Q2	Rel. 17 ASN. 1 freeze	

Fig. 2 – The three themes of 5G

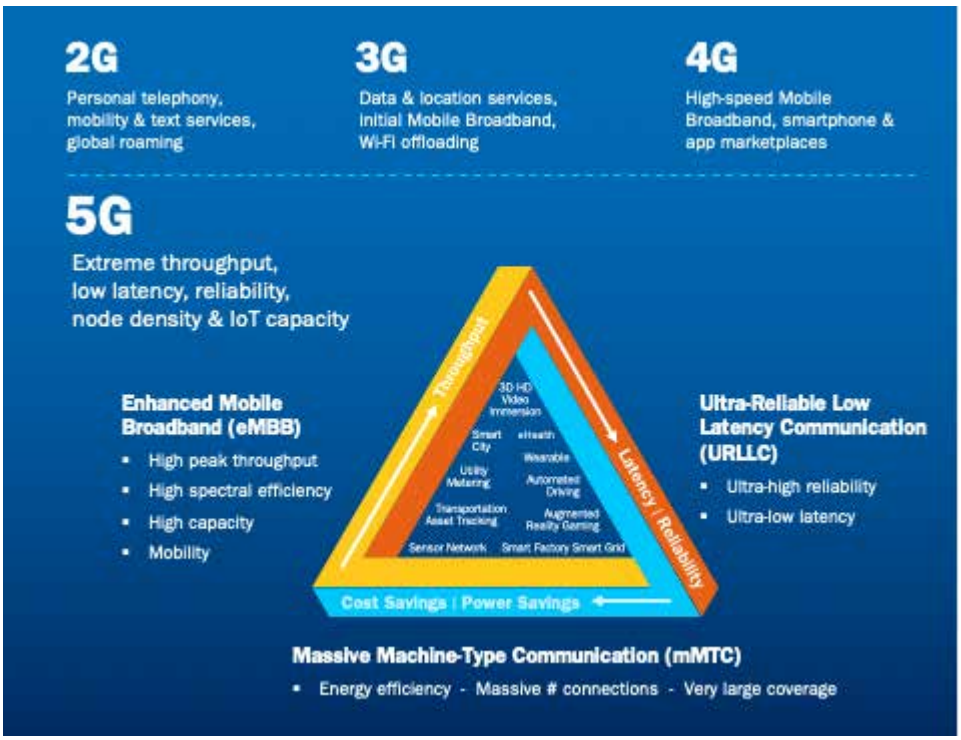


Image courtesy of Intel

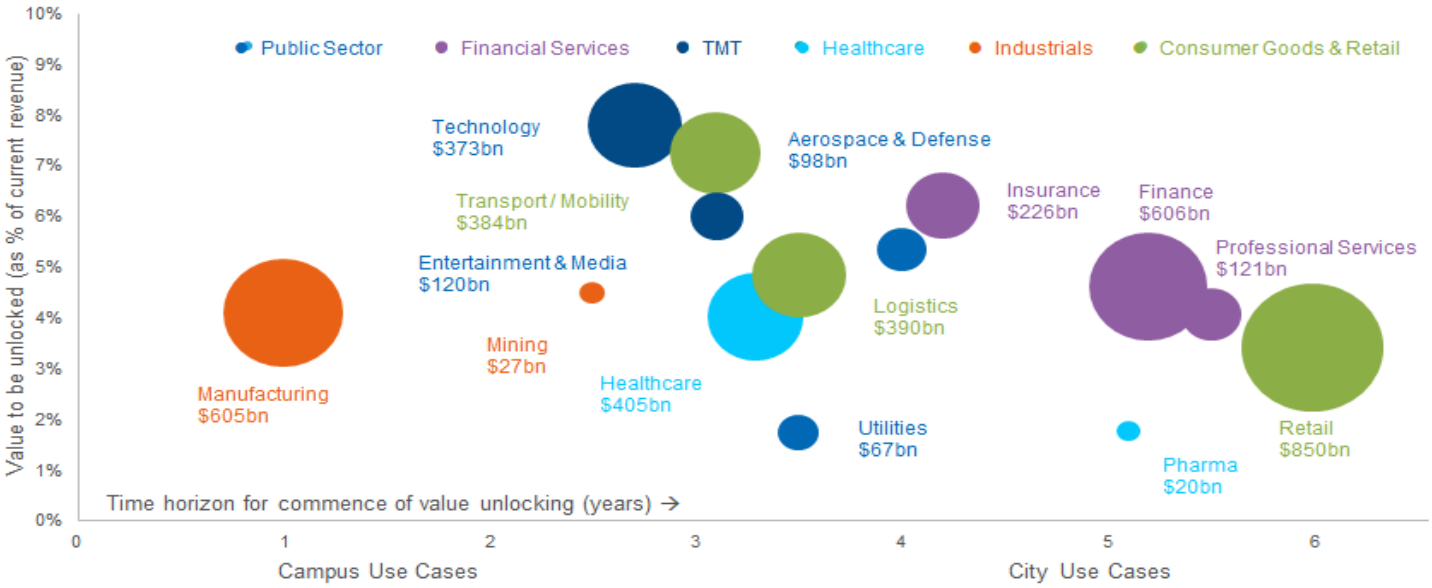
eMBB with the ability to provide gigabit speeds and massive capacity for both mobile (smartphones) and fixed wireless services.

However, Rel. 16, takes a different track, supporting numerous enhancements, many of which are first ever to be conceived in cellular technology. It focuses mainly on the other two themes, while also continuing to improve the performance of eMBB. It substantially expands the reach of 5G across many dimensions and creates many large market opportunities for the cellular ecosystem.

Unlocking new Trillion Dollar Opportunities

5G is set to touch and transform almost every industry on the planet. It starts to deliver on that promise from Rel. 16. There have been numerous forecasts from many leading analyst firms on the estimated size of this opportunity. Although the specifics vary, most of those estimates have been in excess of multiple Trillion dollars This indeed confirms that the opportunity for the ecosystem is very large, wide ranging and long term. KPMG's "*Unlocking the Benefits of 5G for Enterprise Customers, 2019*" report puts the value of this market at $4.3 Trillion. Fig. 3 shows the value of some of the major industry sectors and and tentative time horizon for them to be realized.

Fig. 3 – Various connections of a C-V2X System



Source: KPMG - Unlocking the Benefits of 5G for Enterprise Customers, 2019

Bringing the benefits of 5G to industry verticals

The hallmark of 5G is its potential to transform almost every industry on the planet. In previous generations, wireless technologies were primarily designed for consumers and phone-based applications. They were later adopted for various industrial applications and use cases, long after the standardization was completed. However, for 5G, the industry players and organizations such as 5G Alliance for Connected Industries and Automation (5G ACIA), and 5G Automotive Association (5GAA) are active participants in standardization and are working very closely with 3GPP. Hence, their needs and requirements, such as extreme reliability, extremely low latency, and flexibility, are front and center of 5G development, especially Rel. 16. Such collaboration enables 3GPP to develop standards that are ready for immediate deployment. This is very evident when you closely look at the scores of activities including collaboration between industrial bigwigs, mobile technology providers, operators, and others. There have been many proof-of-concept demonstrations and trials of real commercial use cases at industry events, in many cases when the standards were still in the development phase.

Heralding a New Industrial IoT (IIoT) Era

There are many aspects of Rel. 16, that are specifically designed for IIoT. One such feature is Time Sensitive Networking (TSN). It enables industrial-grade wireless Ethernet and allows modern factories to be fully untethered, uncluttered, and wireless. TSN essentially makes the 5G system work like a bridge

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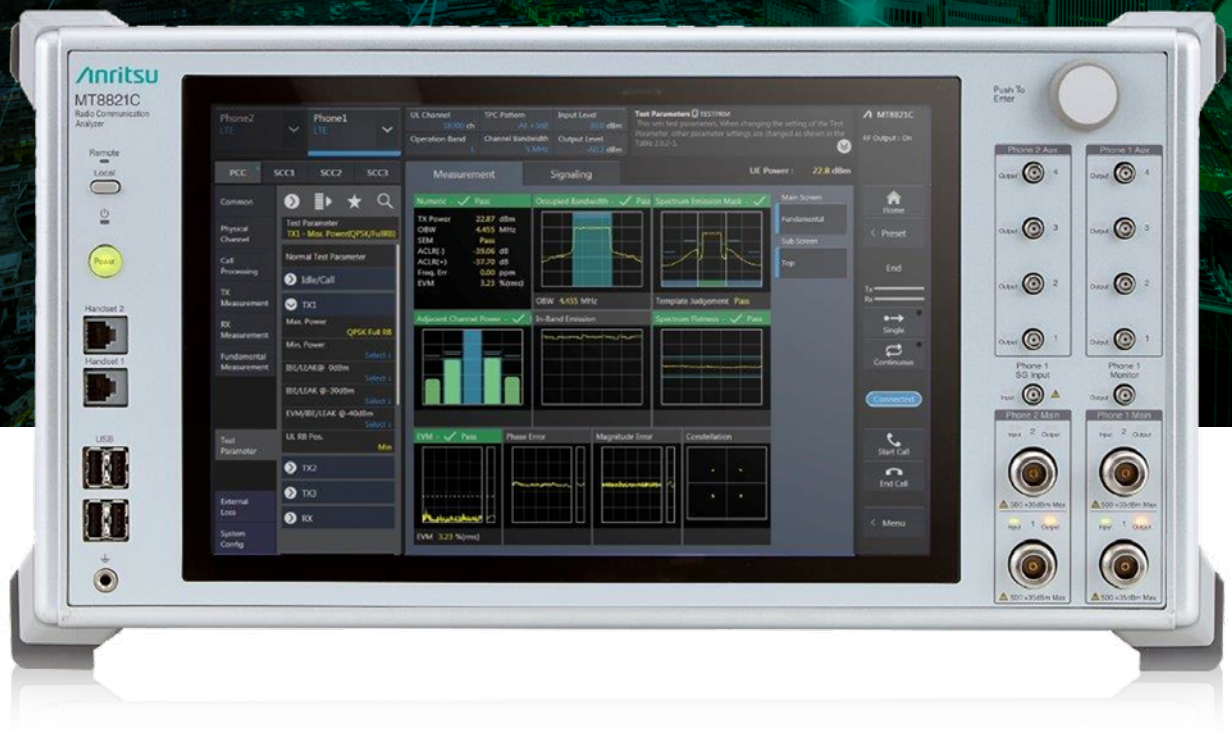

The Internet of Things is driving innovation for many industries but also presents increased risk. Anritsu's test equipment supports all key IoT technologies and provides the means to develop confident designs and produce well-performing IoT devices efficiently.

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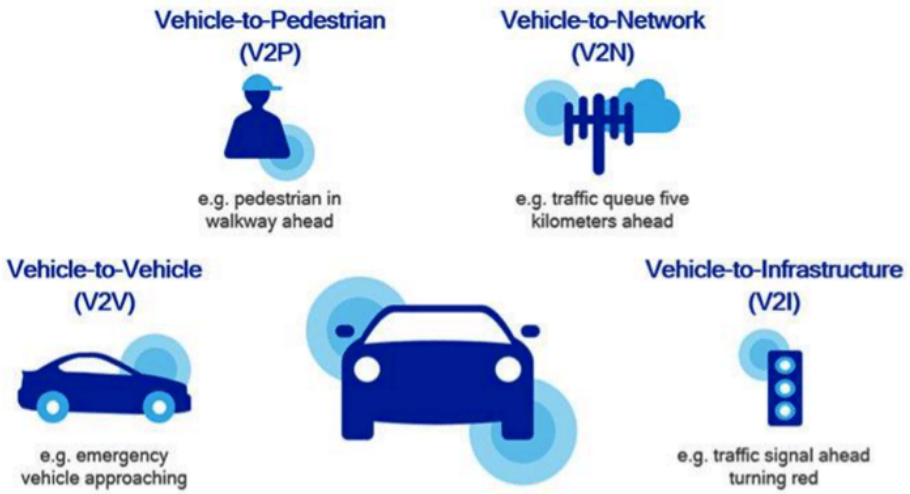
Fig. 4 – Various connections of a C-V2X System



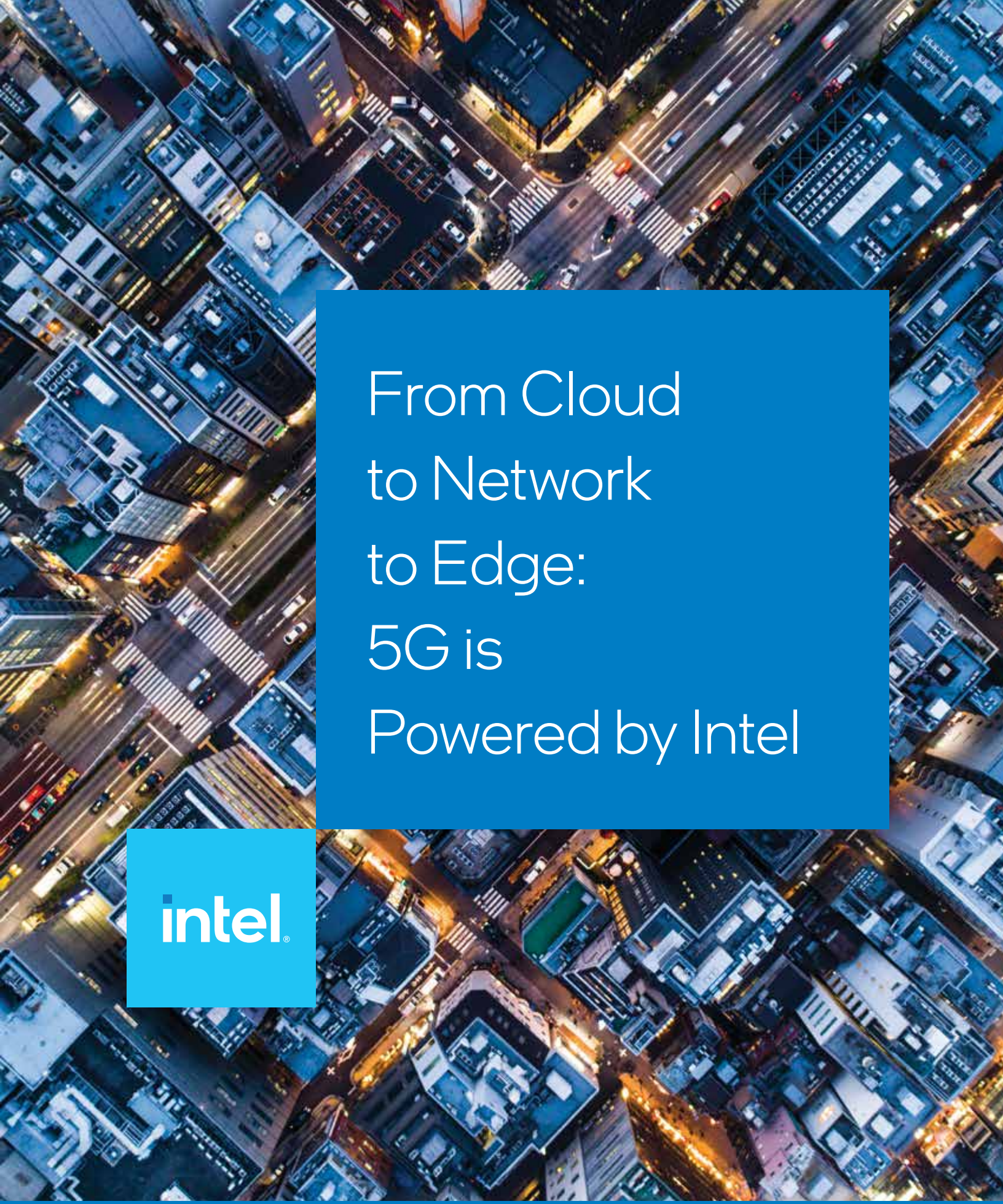
between the TSN network controller and IoT devices with micro-second-level time synchronization. It provides equivalent or better performance than today's industrial wired Ethernet. This was never possible before with any wireless technology. Additionally, Rel. 16 maps TSN configurations to 5G QoS framework for deterministic messaging and traffic shaping.

Precise indoor positioning is another key feature that greatly benefits IIoT. The target is to achieve an accuracy of 3 meters in indoors and 10 meters in outdoors, at least 80% of the time, both in single-cell and multi-cell scenarios. This is made possible through a mix of network triangulation, and calculations based on signal Round Trip Delay (RTD), Angle of Arrival and Departure (AoA, AOD), as well as Time-Difference of Arrival (TDOA). There is a multitude of use cases that can benefit from precise positioning, ranging from simple asset tracking to in-factory flow management, robot, and drone operations, and many more.

For enabling Massive IoT, Rel. 16 leverages and enhances LTE-IoT i.e. eMTC and NB-IoT. Thanks to the scalable and flexible framework of 5G, Rel. 16 brings in-band, native support for both of these technologies. That means they are supported within the same 5G carrier, allowing them to operate seamlessly even when the infrastructure is upgraded, and the spectrum is harvested to 5G. This provides crucial protection for the investments the entire ecosystem, including operators, OEMs, users, and others, is doing today. Also, LTE-IoT becomes the foundation for 5G Massive IoT, targeted to support the extreme density of up to one million devices per square kilometer area.

Additionally, Rel. 16 supports many more configurations for the Stand Alone mode of 5G deployment (without 4G anchor) with the ability to connect directly to the 5G-core and provides even higher efficiency through features such as group wakeup signal, preconfigured uplink, multi-block scheduling, early data transmission, multiplexing between services with different QoS requirements (e.g., eMBB and URLLC, etc.) and many more.

All the Rel. 16 enhancements make future factories completely wireless, hence highly modular, and customizable to address rapidly changing market needs. In essence, it is heralding a new IIoT era, and the next industrial revolution, i.e. Industry 4.0.



From Cloud to Network to Edge: 5G is Powered by Intel

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Fueling the connected car revolution with C-V2X

Today's cars sport advanced connectivity technologies. C-V2X takes that to a whole new level. C-V2X Sidelink is one of the major new features of Rel. 16. Actually, the C-V2X concept was introduced as far back as Rel. 14, and there have already been many trials and small deployments. But Rel. 16 will make large scale commercial deployments of C-V2X possible. Additionally, the concept is utilized beyond vehicles as well, for example, to public safety and critical communication use cases.

Specifically, Rel. 16 allows real-time situation awareness and sharing of sensor data between vehicles and everything else around them, such as Road Side Units(R-SU), pedestrians, cellular network, traffic lights, road construction signs, and many others. It brings QoS, and congestion control mechanisms, unicast (one-to-one), groupcast (one-to-few), and broadcast (one-to-many) communications, as well as supports the coexistence of C-V2X based on 5G and LTE.

All these features together enhance safety, improve driving comfort, and enable autonomous driving.

Further Enhancing eMBB Performance

While expanding 5G to industry verticals is the hallmark of Rel. 16, it brings in a wide range of equally important enhancements to eMBB as well. Here are some of the major ones.

MIMO Enhancements. Higher Order Multi-User MIMO, which allows a lot more users to efficiently share the same air link resources to increase capacity, better multi-beam management such as early detection of beam failure and fast recovery, reduction of signaling overhead and latency, extended uplink and improved power efficiency.

Device Power Saving. Low-power wake up signal, and flexible active-time configuration to increase sleep cycles, dynamically reducing MIMO layers based on the traffic need, as well as more efficient radio resource management.

Mobility Enhancements. Robust handover between inter and intra-band (sub-6GHz and mmWave), as well as single and dual-connectivity (5G+LTE) configurations. "Zero milliseconds" handover by concurrent transmission/reception to both source and target cells. Fast handover failure recovery.

Band Extensions. Support for new Sub-6GHz bands (n13, n14, n18, n29, n30, n48, n65, n89, n90, n91, n92, n93, n94, n95) and mmWave n259 band (39.5 to 43.5 GHz). New carrier aggregation and dual-connectivity combinations. High Power UE for band n41, LTE/5G spectrum sharing in the CBRS (n48) band.

Interference Mitigation. Devices measure and report inter, and intra-cell Cross Link Interference (CLI) caused by different TDD configurations. Base stations coordinate and mitigate Atmospheric Duct Interference (ADI) caused by tropospheric ducting.

Single/Dual-Link UL switching. In deployments with both FDD and TDD allocations, uplink can rapidly switch between transmitting on both carriers and on only one carrier. This improves uplink performance for higher bands, especially in low coverage areas.

Efficient Signaling. Reduces the current access procedure (RACH) from four steps to only two. This reduces latency and signaling overhead, as well as improves capacity and power efficiency. Also enables small "grant free uplink" for extremely low latency applications.

All these features together significantly increase speeds and capacity, reduce latency, and improve broadband user experience.

Advancements to Simplify 5G Deployments

While the initial 5G deployments have gotten a lot of attention, 5G's success ultimately relies on the rapid increase of coverage and proliferation of 5G services. That requires more efficient deployment methods and solutions to challenges such as cost-effective and easy to deploy backhaul, need for more spectrum, and others. Keeping that in mind Rel. 16 introduces many advanced features to simplify 5G deployments.

Integrated Access Backhaul (IAB). One of the biggest innovations of 5G is the introduction of mmWave bands. However, these bands have a smaller coverage footprint and require hyper-dense deployment to provide adequate coverage. The best example of such an approach is utilizing lampposts and utility poles in the cities to deploy mmWave base stations. However, the biggest challenge of such unconventional site locations is the lack of backhaul. Bringing fiber to these locations is expensive and time-consuming, because of permits, construction, and other issues. IABs effectively solve that challenge. They utilize the wireless link for both backhauls as well as user traffic, essentially eliminating the need for fiber connectivity to every site. Instead, only a handful of host sites could be connected with fiber, and others replaced by IABs. mmWave bands because of their small coverage footprint are ideal for IABs.

Fig. 5 – IABs can simplify 5G deployment without requiring fiber connectivity

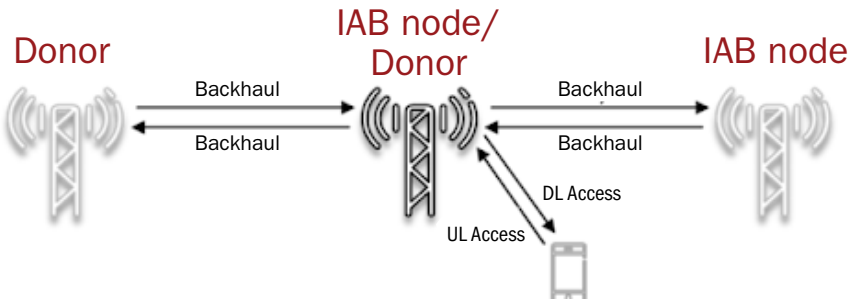
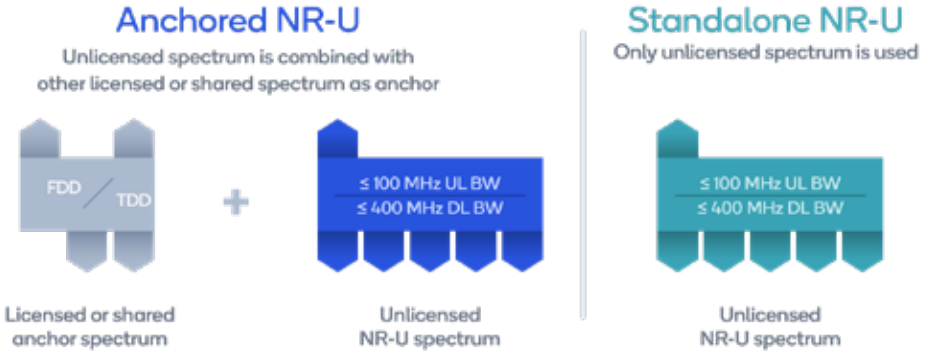


Fig.6 – NR-U Can be deployed in Anchored or Stand Alone mode



Source: Qualcomm

NR-Unlicensed (NR-U). Spectrum is one of the major challenges for operators all around the world. Rel. 16 brings the support for unlicensed spectrum for 5G, similar to that of 4G. However, unlike 4G, where this was an afterthought, in 5G with Rel. 16, the unlicensed spectrum is natively supported. Also, going forward, support for unlicensed bands will be considered and included for all the new features.

NR-U allows operators to access the unlicensed 5GHz and recently cleared more than 1200 MHz of 6GHz spectrum for 5G, while fairly sharing it with Wi-Fi. NR-U can be deployed in the "Anchored" mode where unlicensed spectrum

is combined with the licensed or shared spectrum, or in "Stand Alone" mode where unlicensed spectrum is used on its own.

NR-U opens a new world of possibilities for 5G in terms of market opportunities. It could be used to boost the capacity of public networks, or for private, enterprise, IIoT, or neutral host networks.

Rel. 16 commercialization timelines

Rel. 16 has a heterogeneous mix of features. Hence, its commercialization will be varied and achieved in phases. Operators typically deploy groups of relevant features together, based on the specific applications and services they introduce or enhance. Some of the features that improve eMBB such as MIMO enhancements, band extensions with new carrier aggregation, and dual connectivity combinations will be the first to be implemented. The new concepts and features for verticals will probably take longer. They will initially be trialed and tested in controlled conditions and deployed widely much later.

There has been an unprecedented collaboration between the mobile players and major industry conglomerates in making IIoT a reality. There have been many proofs-of-concept and use case demonstrations at industry events, trials, paving the way for commercial solutions in the near future. For example, recently, Intel and Bosch worked together to successfully demonstrate the TSN proof-of-concept for the motion control use case.

Some operators have already announced the deployment of IABs in 2021 and NR-U will soon follow, as they both provide immediate benefits. LTE IoT deployments have been happening for a few years now. Rel. 16's in-band support will further accelerate them. Operators will continue LTE-IoT proliferation in parallel to 5G deployments.

C-V2X has seen phenomenal ecosystem traction. FCC in the USA is moving swiftly to authorize C-V2X in its designated 5.9GHz spectrum, and European Union is stepping back from its DSRC mandate, which gives the much-needed opening for C-V2X to prove its worth and be considered for mandatory vehicle safety requirements in the region. There have been already quite a few trials based on the 4G version. Those will provide a solid foundation for the 5G based commercial C-V2X adoption.

Considerations for 5G operators

With the initial 5G deployments completed and operators looking to expand their networks, the focus is moving to optimization and network performance improvement. The introduction of mmWave bands has drastically changed the testing and optimization regimen for both networks and devices. From the network perspective, mmWave performance varies depending on the density of the sites, urban landscape, availability of Line of Sight (LoS) and

"Rel.16 with its broad range of innovative features is set to usher in fundamental transformation of new industry verticals, and will help to deliver on the promise of 5G. Intel is proud to be one of the leaders of this transformation.
Richard Burbridge, Intel

rich reflecting surfaces, location and direction of the users, and other considerations. The mmWave device performance, on the other hand, depends on the number of antenna modules the device has, location and design of antennas and other RF components, device material, how the devices are held in hands, etc. That means networks and devices have to be tested and optimized for all these variations.

Further, when the new enhancements are implemented for verticals, the testing optimization aspects will make another major shift. Hence selecting suitable test and optimization partners should be a key consideration for operators when they are embarking on their next 5G journey.

Looking into the Future

As Rel. 16 is finalized and its commercialization is underway, 3GPP is already busy with the next step—

Rel. 17. Rel. 17 is another major step in the evolution of 5G, which will further expand its reach and scope. It will 1) enable new capabilities for applications such as XR; 2) create new categories of devices with NR-Light; 3) bring 5G to new realms such as satellites. With the development in full swing, although complicated by the global Covid-19 pandemic, Rel. 17 standardization is expected to be finalized in late 2021 or early 2022.

Conclusion

Although coming after major release such as Rel.15 that introduced 5G, Rel. 16 has bucked the trend and has shaped up to be another significant release, opening new business opportunities for the ecosystem. It primarily focuses on Massive IoT and Mission Critical Services aspects of 5G and expands it to industry verticals, while also enhancing the performance of eMBB.

Rel. 16's path-breaking enhancements herald a new IIoT era. 5G C-V2X defined in Rel. 16 ushers in the connected car revolution that brings enhanced vehicle safety and robust autonomous driving. Additionally, it brings a whole slew of enhancements that substantially improve performance, battery life, mobility, reliability, latency, and efficiency of eMBB and overall 5G networks. Finally, its features such as IAB and NR-U allow operators to deploy 5G networks rapidly and efficiently and utilize all types of spectrum bands including unlicensed bands. Some of the features of Rel. 16 are expected to be commercialized in 2021, while many new features that enable industry vertical will probably take a little longer, after proof of concept development and extensive filed trails. Many of these are already underway.

"3GPP release 16 will greatly expand cellular networks capabilities with new features and enhancements. Testing Release 16 capabilities will be more critical than previous generations due to the tougher requirements and more complex devices. As 5G evolves, Anritsu's wireless equipment can be cost effectively upgraded by ease and scale.
Brian Davis, Anritsu

Operators who are embarking on their 5G journey, need to pay special attention to their testing and optimization regimen, specifically because of mmWave bands and expansion toward industry verticals, as they address different markets with different requirements.

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