

# *A Brief Overview of 5G Activities*

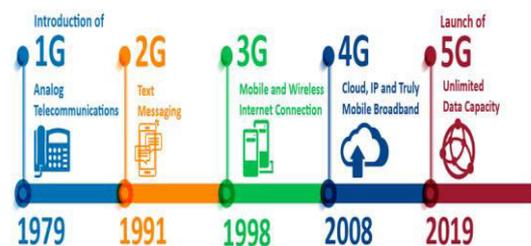
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**Abstract**—This paper summarizes the main initiatives toward 5G wireless communication networks. Emphasis is paid on the program and project activities as well as on the recent literature. A closer look to a wide range of European Union 5G related projects is conducted. The aim is to shed some light on what 5G is about: what are the building blocks of core 5G system concept, what are the main challenges and how to tackle them. The studied references indicate that in addition to capacity boosting technologies 5G needs to offer, e.g., low latency, ultra-reliable communications, and massive connectivity. Thus, the most demanding part in 5G development will be the design of flexible enough system concept platform that allows successful integration and management of various distinct technologies optimized for diverse use cases.

## INTRODUCTION

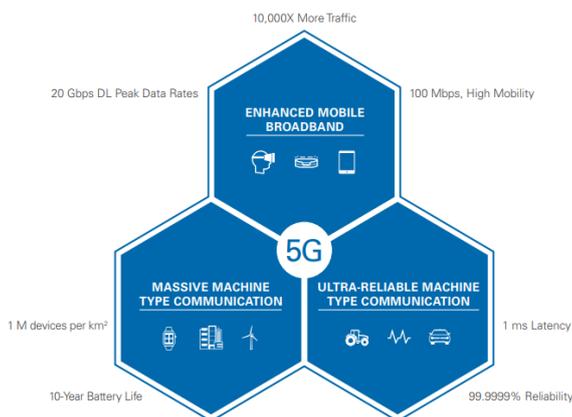
Increasing Internet data traffic has driven the capacity demands for currently deployed 3G and 4G wireless technologies. Now, intensive research toward 5th generation wireless communication networks is progressing in many fronts. 5G technology is expected to be in use around 2020.



In 1G and 2G we were mostly related to 'voice' and in the later part of 2G, data part GPRS and then the edge part is introduced. Then we moved to 3G services which were mixed part of data and voice services and when we had our hsdpa and hsupa introduced in the 3G technology till now and then we moved to LTE in 4G which was the most data

centric technology till now and we have reached to 400-500MHz. Now we have arrived at 5G and as we speak as of 5G is in commercial role out stages in many parts of developed economies. 5G is in its initial deployment state across many countries like USA, Japan, Australia and many European countries. What we need to emphasize on that from 4G to 5G there is a huge shift in terms of technology and impact the cellular communication will have on our lives. Before 5G the major thing that the cellular networks we providing were connectivity, ability to download lots of data streaming and other services.

Right now all the commercial deployments are based on Release-15 and it has been frozen then on Release-16 and Release-17 are in progress.



5G is basically there to provide three use cases:

- **eMBB**(Enhanced multimedia broadband )
- **uRLLC**(Ultra reliable low latency communication)
- **mMTC**(Massive machine type communication)

The initial phase of 5G non-standalone deployments focuses on eMBB, which provides greater bandwidth complemented by moderate latency improvements on both 5G NR and 4G LTE. This will help to develop today’s mobile broadband use cases such as emerging AR/VR media applications, ultraHD 360-degree streaming video and many more.

mMTC has been already development as a part of 3GPP Release 13/14 low power wide area (LPWA) technologies, while includes NB-IoT. These are expected to meet most 5G mMTC requirements, while others that require more bandwidth with ultra-reliable low latency(full uRLLC) will require the 5G core deployment for full end-2-end latency reduction. Mission critical applications that are especially latency-sensitive will also require wide coverage, which is highly unlikely in early 5G deployments, so this development will come later.

MediaTek continues to heavily invest in the development of 5G products and is committed to accelerating its adoption. Our intention is to bring the technology to the mid-tier market from day one in accordance with our brand philosophy. This contrasts with the usual premium-first approach the rest of the industry often focuses on, and we believe we can offer a unique and powerful platform.

### How much spectrum does 5G need?

The 3GPP’s 5G New Radio(NR) specification includes traditional mobile bands as well as never, wider bands designed for 5G. It supports channel bandwidths ranging from 5MHz to 100MHz for bands below 6GHz, and channel sizes from 50Hz to 400MHz in bands above 24GHz. The full capabilities are best realised through the widest channel sizes in new 5G bands. 5G supports carrier aggregation to enable very, high speeds, however making spectrum available in the largest contiguous block possible supports faster, lower latency and greener 5G services.<sup>3</sup> The ITU’s minimum technical requirements to meet the IMT-2020 criteria<sup>1</sup> – and thus the fastest speeds – specify at least 100 MHz of bandwidth per operator. They also specify support for up to 1 GHz per operator in bands above 6 GHz such as mmWave bands.

### How will 5G impact the network?

The positive impact of the Fourth Industrial Revolution and its related emerging technologies will be fully realized through the wide-scale deployment of 5G communication networks in combination with other connectivity solutions. The key functional drivers of 5G will unlock a broad range of opportunities, including the optimization of service delivery, decision-making, and end-user experience. This will result in \$13.2 trillion in global economic value by 2035, generating 22.3 million jobs in the 5G global value chain alone.

To better understand how to realise this large estimated economic output potential, PwC collaborated with the World Economic Forum on a new report, which proposes a bottom-up approach analyzing 40 use cases that identified key industrial advances and social impact areas in addition to the main functional drivers of 5G and the required maturity levels of these drivers. Additionally, it maps the 5G ecosystem to identify its components, its stakeholders and interdependencies, and the actions needed to accelerate 5G deployment and fully realize the potential.

### Is Massive MIMO mandatory for 5G deployment?

When service providers plan for the big changes 5G brings to their networks, massive MIMO (multiple-input and multiple-output) antenna technology often tops the list. Massive MIMO uses “beamforming” to deliver big benefits for service providers and customers alike. By targeting radio signals precisely for each endpoint, massive MIMO 5G provides:

- Increased throughput

- Extended range
- Reduced inference
- More reliable connections
- Improved spectral efficiency

These benefits add up to better overall performance and a better experience for users. But massive MIMO also brings new challenges in the way service providers design and deploy their radio networks. Here are the top five considerations to keep in mind.

### What is multi-connectivity in 5G?

One of the key features of 5G NR enumerated earlier is multi-connectivity (MC). It refers to the concurrent use of multiple independent communication paths, nodes, access points (APs) or base stations (BSs) for data transmission to a UE. In MC mode, the UE accesses radio resources from multiple nodes that have distinct schedulers. The nodes could be of the same or different radio access technology (RAT). The MC architecture is a very promising feature for 5G as it has been shown to enable the realization of the stringent constraints (high reliability, low latency and high throughput) for all the broad classes of 5G use cases, from eMBB that targets high-capacity applications (which Release 15 focused on) to the mMTC and URLLC applications which are the primary focus of Release 16. MC also enables ultra high speed and low latency communication (uHSLLC) that represents a mix of the aforementioned use cases.

While the throughput-oriented eMBB targets up to 1 Gbps user-experienced data rates, URLLC applications require 99.999% reliability for 32-byte packet size with 1 ms latency on the user plane (UP). This translates to a packet loss ratio (PLR) or block error rate (BLER). Industrial, automotive and health care application scenarios (such as industrial automation, autonomous driving, remote surgery, etc) require these stringent requirement to be met and MC is being extensively explored to facilitate delay-sensitive, error-free and/or ultra-fast communication for these applications.

### **MEETING CONSUMER EXPECTATION ON 5G**

Analysis of the 5G network experience has mostly focused on 5G speeds and availability, based on independent network measurements. But it is equally important to understand how 5G early adopters perceive the 5G network experience. This report, the biggest ever 5G consumer study, uncovers key trends influencing the adoption, usage and perception of consumers towards 5G. The report suggests five ways that service providers can meet consumer expectations and improve their 5G experience, now and in the future:

1. Enhance the value: address the knowledge gap to educate and better market the value of 5G.
2. Consumers expect the quality of indoor and outdoor coverage to be consistent.
3. Adapt to network requirements of new services enabled by 5G
4. Focus on the jobs consumers want 5G to do, to envision new use cases.
5. Go beyond just showcases: accelerate the commercialization of existing and new use cases.

Key findings:

1. **Consumer intent to upgrade to 5G accelerates despite the pandemic.** At least 300 million smartphone users could take up 5G in 2021. By the end of 2020, 22 percent more smartphone users with 5G-ready smartphones could have adopted 5G if knowledge gaps had been addressed.
2. **5G triggers changes in usage behavior, starts to displace Wi-Fi.** 5G users spend two hours more per week using cloud gaming and one hour more on augmented reality (AR) apps compared to 4G users. 20 percent say they have decreased their usage of Wi-Fi after upgrading.
3. **Indoor 5G coverage more important for consumers.** 5G early adopters rate indoor 5G coverage as two times more important than speed or battery life in driving satisfaction.
4. **Early adopters are pleased with 5G speeds but expect more innovation.** Seventy percent are dissatisfied with the availability of innovative services and expect new applications making use of 5G.
5. **Consumers value 5G plans bundled with digital services and are willing to pay 20–30 percent more.** However, two-thirds of use cases highly valued by consumers have not yet been commercialized.

The number of live 5G markets is increasing daily as consumers become more aware of the technology and hype gives way to reality. But there is a wide disparity across the globe in

terms of knowledge and intention to upgrade to 5G.

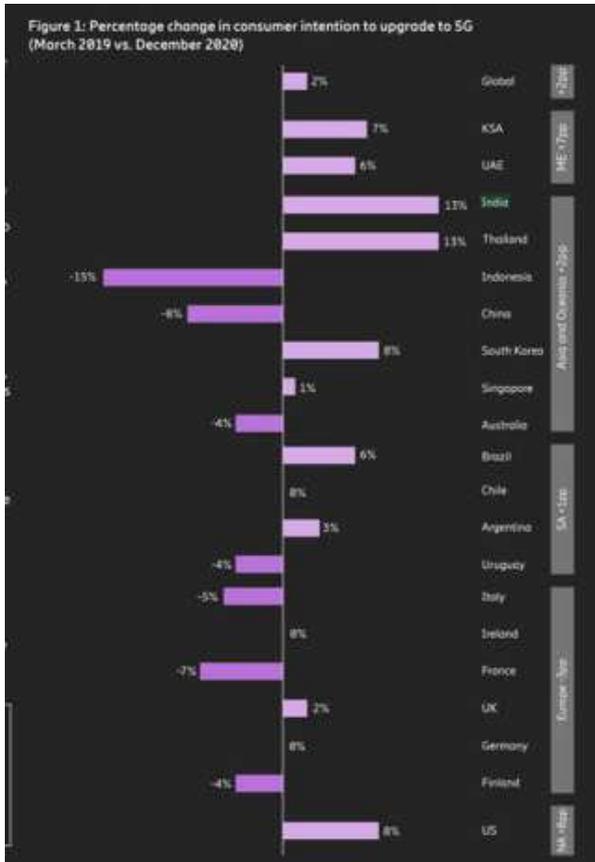
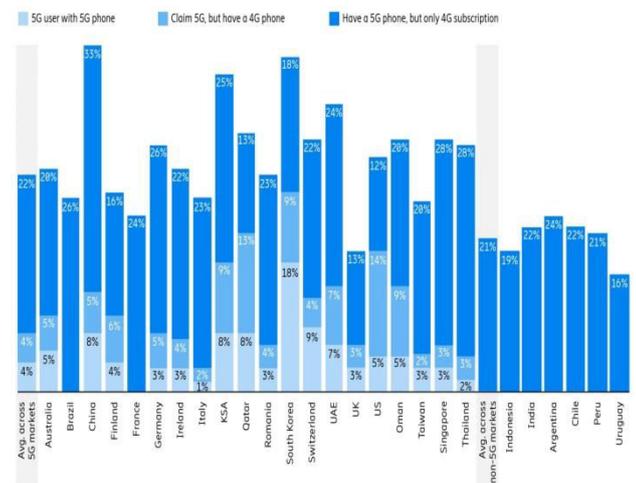


Figure : Percentage change in consumer intention to upgrade to 5G(2019-2020)

**THE 5G KNOWLEGE GAP**

Across the 20 markets in our survey where 5G commercial networks are available, an average 4 percent of consumers own a 5G smartphone and have a 5G subscription. While 22 percent of smartphone users who own a 5G-ready smartphone are still using a 4G subscription, a further 4 percent claim they are on a 5G plan, but use a 4G smartphone. In China, this is 5 percent, and the blanket term “5G package customers” is often used by Chinese service providers to refer to anyone on a 5G subscription, regardless of whether they actually have a

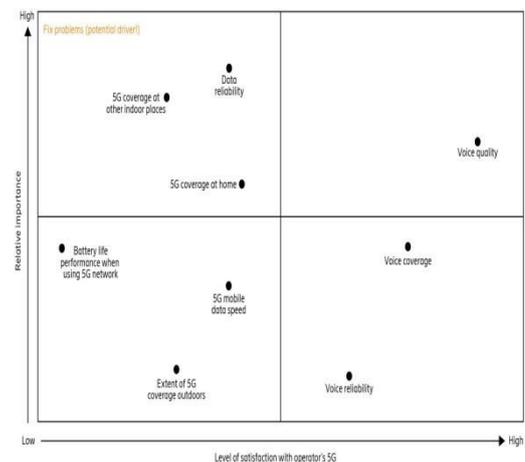
5G device or access to a 5G network. In the US, our survey found 14 percent of smartphone users who claim they are on 5G were using a 4G smartphone and 12 percent who own a 5G smartphone say they have a 4G subscription. This suggests a lingering confusion and knowledge gap among consumers around device capability and compatibility, 5G network availability and lack of clarity on whether access to 5G is included by default or requires a change of plan or a specific smartphone model. Another factor is the inability to differentiate between Wi-Fi types like 5GHz vs. cellular 5G. In addition, different versions and flavors of 5G network capabilities being marketed using tech jargon by service providers are contributing to this knowledge gap. If the value of 5G technology had been better marketed, in terms that were more relevant to consumers’ needs, an additional 22 percent of consumers globally, who already owned 5G-ready smartphones in 2020, could have upgraded to a 5G plan. In markets such as India and Indonesia, where commercial 5G networks were not live, the survey found an existing installed base of 22 percent of smartphone users with a 5G-capable smartphone. This could provide a secure foundation for service providers to drive quick adoption of 5G.



**PANDEMIC FUELS FOR BETTER INDOOR 5G**

The recent spread of Coronavirus Disease (COVID-19) due to Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) [1] has caused substantial changes in the lifestyle of communities all over the world. By the end of June 2020 at the time of this writing, over eleven million positive cases of COVID-19 were recorded, causing over 500,000 deaths. Countries have been facing a number of healthcare, financial, and societal challenges due to the COVID-19 pandemic. Overwhelmed healthcare facilities due to rapid growth of new COVID-19 patients, are experiencing interruptions in provision of regular health services. Moreover, healthcare personnel are also becoming vulnerable to COVID-19 and this is taxing the healthcare resources even more. To cease the wide spread of the virus, governments impose strict restrictions and control on travel within and between countries, negatively affecting the economies. While the remote work was considered as an alternative with limitations, certain jobs became obsolete. 5G supports direct connectivity for IoT and mMTC between IoT devices. This will fuel the possibility to use large amount of IoT devices to increase the efficiency of supply chains. Deployment L5GOs to serve the needs of industries is a better way to integrate IoT sensors, actuators, robots directly into 5G network enabling a 5G based smart manufacturing system. The proper network connectivity for the sensors, actuators, robots in the manufacturing plants will be enabled by the mmWave 5G small cells deployed indoors. Massive MIMO will provide connectivity for a large number of devices and beamforming technique ensures a better quality of the network connection. The direct connectivity of goods into the 5G systems makes the supply

chains more transparent. MEC integrated with 5G, can be used to process the data locally to improve the scalability of the systems as well as security and privacy of collected data. Moreover, MEC integrated with 5G can easily be used to implement decentralized solutions via Blockchain [17], [18]. The delivery of items to the final destination can be performed via Beyond LineOf-Sight (BLOS) UAV guided by the 5G network. This could minimize unnecessary interactions in COVID-19 period and reduce human efforts. Real-time data is available for the authorized users for monitoring and tracking, which increases the transparency of the operation.

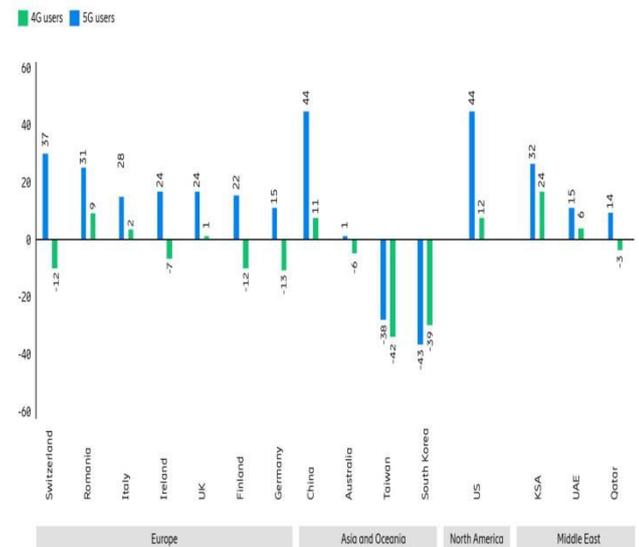


**EARLY ADOPTERS RECOMMEND 5G BUT EXPECT MORE INNOVATION**

The survey shows that higher satisfaction with 5G network performance means 5G users are more likely to recommend their mobile service operators, but they

also expect more innovative services to be offered.

In most markets we see that 5G users are very likely to recommend their service provider’s brand to others, resulting in higher Net Promoter Scores, a metric used to assess brand referability. As early adopters of new technology, these users are more forgiving and trust that operators are doing their best to build out the network, so are patiently waiting for coverage to improve. But this patience won’t last long. While early adopters are pleased with 5G network speeds, they are already expressing dissatisfaction with a lack of bundled new and innovative apps and services, which they feel were promised in the marketing pitch for 5G. While 5G users seem to be satisfied with network speeds, 70 percent are dissatisfied with the innovative apps and services bundled on the 5G plans. Apart from some Asian markets such as South Korea, Japan, Taiwan and China, in most markets globally, service providers, while attempting to drive a service-led strategy, have been slow in bundling 5G with digital services beyond what is already being offered on 4G – such as music and video steaming services and other apps. Instead, service providers need to offer exclusive content and services that could differentiate a 5G experience from 4G and promote a sense of novelty and exclusivity.



**FROM SHOWCASES TO COMMERCIALIZING USE CASES**

Identifying and understanding the jobs consumers want 5G to do is the first step in envisioning and offering use cases that consumers want, especially ones they are likely to pay for. 5G offers many possibilities to provide new digital services

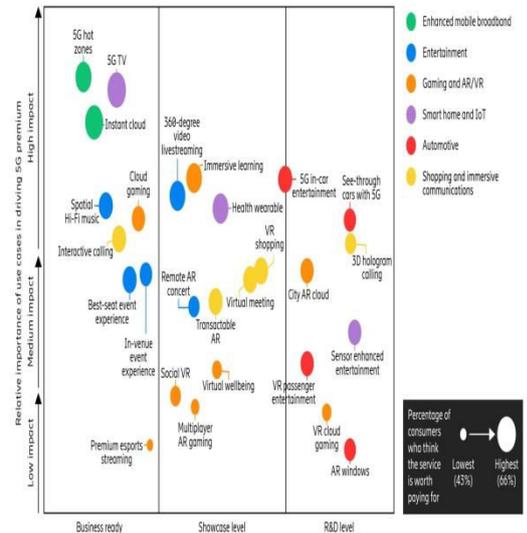
In this study we use the jobs-to-be-done framework<sup>3</sup> to help understand both the consumer’s specific goal, or “job”, and the thought processes that would lead to the use of 5G to complete it. When looking at 5G through a jobs-to-be-done lens, consumer needs are shown by studying the consumer core functional job or outcomes that they wish to accomplish using 5G. The study identified five jobs or outcomes that consumers hope 5G will accomplish.

1. To be productive and efficient.
2. To be creative.
3. New ways of connecting and socializing.

4. The need for novelty (thrill, surprise, discovery).
5. Rewarding me-time.

The value of the jobs-to-be-done theory is that it provides an anchor point from which service providers can create value via new or existing use cases. Despite the pandemic, smartphone users surveyed are willing to pay 10 percent more on average for 5G plans that offer enhanced mobile broadband access. However, they are willing to pay even more for plans with bundled innovative digital services. Globally, the inclusion of relevant use cases on a 5G plan increased the 5G premium further, by 20–30 percent. However, there are marked differences in markets across the globe. In Australia and the UK, smartphone users were willing to pay an additional 7 percent, while in UAE and China it was 30 percent and 45 percent more respectively, compared to what smartphone users say they pay today for a 4G plan. Using the jobs-to-be-done framework, we tested 27 different use case concepts aligned with the consumer needs, to assess which concepts consumers feel are worth paying for, while also assessing their current stage of commercialization. Figure 8 shows the stage of each of the individual use cases, mapped against their relative success in persuading consumers to pay more for a 5G plan that includes a combination of them. With 27 use cases included in this roadmap, two-thirds of valuable use cases rated by consumers were found to be only in the technology showcases or research and development stage, and

not available for consumers to experience.



## THE ROAD TO FUTURE

### What we expect from 5G?

The arrival of 5G will not only transform tech but it will also provide an entirely new mobile experience. This wireless technology is being introduced with the primary aim to reduce maintenance costs and energy consumption.

According to a study, 5G is expected to deliver speeds up to 100 times faster than typical 4G technology. As 5G technologies have been continuously evolving, it will certainly change the way we spend our lives, our communications will be faster than you can imagine plus our connections will be stronger. But with such sky-high expectations also come some challenges. When you imagine a future powered by 5G, connected factory devices that “talk” to each other, mobile internet-connected to multiple devices at the same time, different vehicles communicating with the roads they travel on, and accessibility of information at

unprecedented speeds will come to mind. This goes without saying that the new generation of technology opens new opportunities for telecommunications service providers. The arrival of 5G, the fifth-generation network has been the talk of the town lately.

To fully understand the potential of 5G, it's important to know how it will take the technology world by storm.

Albeit the fact that 5G is bound to change the way we consume information, entertainment and how we communicate with each other, the change will not happen overnight. Even though some companies have successfully introduced 5G-capable handsets, it might require more time for the proper availability of 5G. But it is expected that the maximum number of 5G connections would exist in the years to come.

Once 5G is fully operational, there will no need for any kind of cable or wire to deliver entertainment or communications service to your mobile device. If everything works, 5G would be the optimum solution for the people who want to stream 8K video in a flash and also wish to download feature-length movies in a matter of seconds. With 5G speeds and connectivity, consumers would be able to crystal-clear video calls and enjoy graphics-rich mobile games without having to deal with lag.

### **CONCLUSION**

5G will be able to sustainably satisfy the requirement of the 1000-time traffic growth. 5G will provide users with fiber-like access data rate and "zero" latency user experience. 5G will be capable of connecting 100 billion devices. 5G will be able to deliver a consistent experience across a variety of scenarios including the cases of ultra-high traffic volume density, ultra-high connection density, and ultra-high mobility. 5G will also be able to provide intelligent optimization based on services and users awareness and will improve energy and cost efficiency by over a hundred of

times, enabling us all to realize the vision of 5G, "information a finger away, everything in touch."