5G is the next-generation network technology that succeeds 4G LTE network and offers much faster download and upload speeds with low latency than 4G.

The battle for 5G supremacy is in full swing. Disruptive technology holds enormous potential to add economic value to all walks of our lives. It is 5G technology that will make IoT, AR, VR, Connected Cars, and many other unforeseen next-gen technologies commonplace.

The global 5G market is forecasted to touch USD 277 billion marks between 2019-2025 at an impressive CAGR of 111%. Governments and telecom companies around the globe know that the numero uno of 5G is going to be the next tech leader.

5G is going to be a technology that isn't only shifting the tectonic plates of the technological landscape around the world. It is also going to have an enormous impact on geopolitics—I think the recent developments that we have seen, confirm the deep roots of 5G in all aspects of our lives.

So, in this article, we will explain how the journey to 5G looks like, what are its requirements, and enabling technologies to make it happen. Further, we will also talk about the government and standard telecom agencies and the initiatives taken by them for the development of 5G.

Are you interested in knowing who owns maximum 5G patents? Which companies are leading the race of owning 5G technology through patents? Our **exclusive report on 5G SEPs** tells who owns the **maximum standard patents**. The report covers the **actual count of 5G SEPs** that our research team has manually shortlisted from 12000+ patents. Click here to Read it.

The table of contents below will help you gauge what this article has in store for you:

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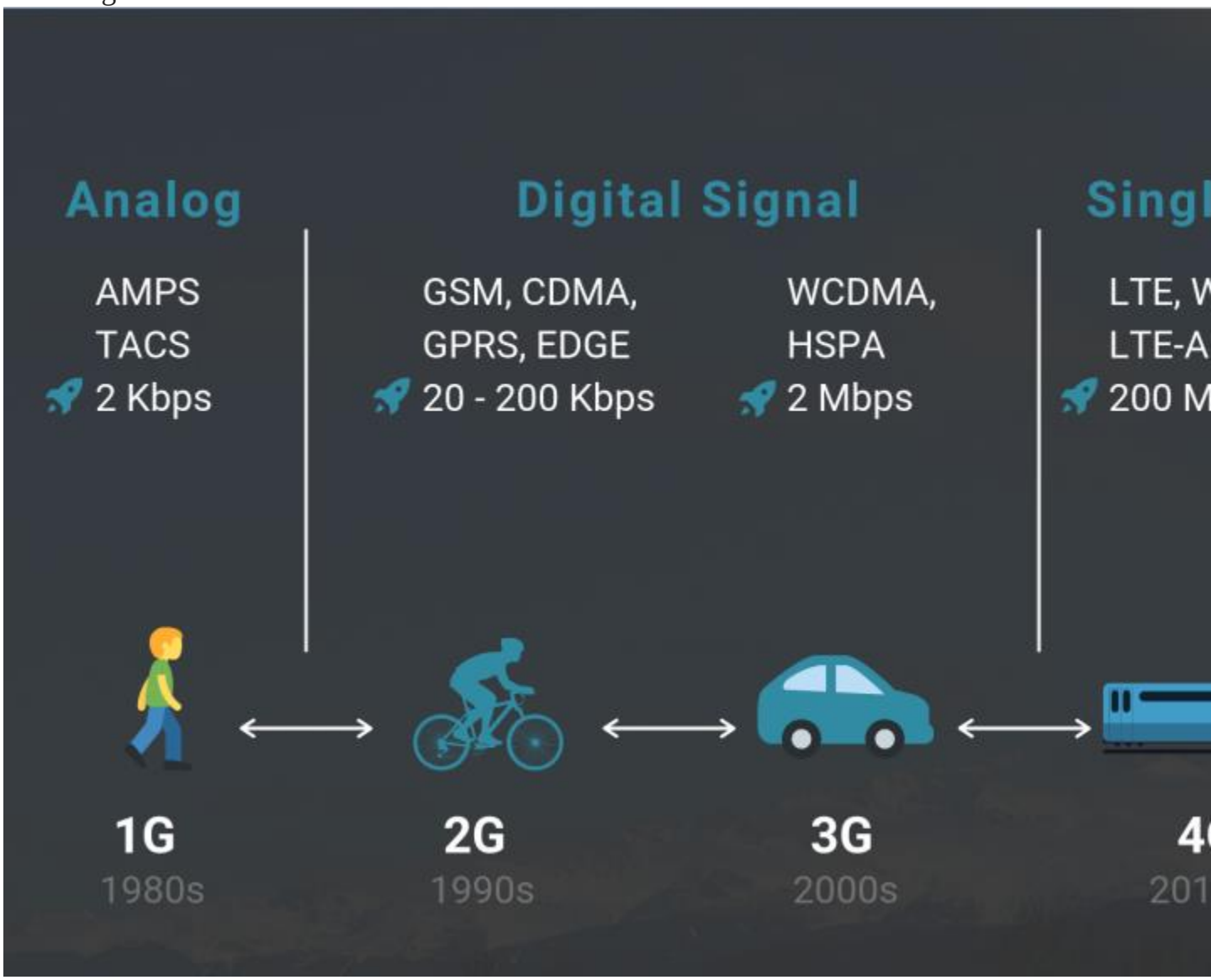
Evolution of 5G Technology

"I'm ringing you just to see if my call sounds good at your end,' or something to that effect", said Martin Cooper, a Motorola employee, during a call that commenced the mobile phone era.

It was the first mobile call made (in April 1973) using a base station of 900 MHz and a prototype which was later known as the world's first commercial cell phone. It used the analog service called Advanced Mobile Phone Service (AMPS) on which 1G or the first generation of mobile communication was based.



1G was introduced in 1979 and continued until being replaced by 2G or the second generation of mobile communication that's based on digital radio signals.

GSM is one of the most popular standards developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks. It was first deployed in Finland in 1991.

While in North America, they mostly used Code Division Multiple Access (CDMA), another 2G standard proposed by Qualcomm, and launched in 1995.

The third generation or 3G networks were introduced in 1998 as 3GPP was established to develop a specification for a 3G mobile phone system based on the 2G GSM system, within the scope of the International Telecommunication Union's International Mobile Telecommunications-2000 (IMT-2000).

Another 3GPP2 standard organization was formed to develop the competing 3G system based on CDMA.

In March 2008, the International Telecommunications Union-Radio communications sector (ITU-R) specified a set of requirements for 4G standards and named it International Mobile Telecommunications Advanced (IMT-Advanced) specification.

It set the peak speed requirements for 4G service at 100 megabits per second (Mbps) for high mobility communication (such as from trains and cars) and 1 gigabit per second (Gbps) for low mobility communication (such as pedestrians and stationary users).

Mobile WiMax and LTE were released as successors of 3G, but since they were not able to match the numbers set by IMT-A. So they were not considered true 4G. However, service providers marketed them as 4G to sell their services. Improved versions of both the systems with improved numbers, which were matching 4G requirements were later released 2011 and 2013.

Since 4G is based on IP telephony, the 3G spread spectrum was abandoned and replaced by OFDM multicarrier transmission and other frequency-domain equalization (FDE) schemes, making it possible to transfer very high bit rates despite extensive multipath radio propagation (echoes). The peak bit rate is further improved by smart antenna arrays for multiple-input multiple-output (MIMO) communications.

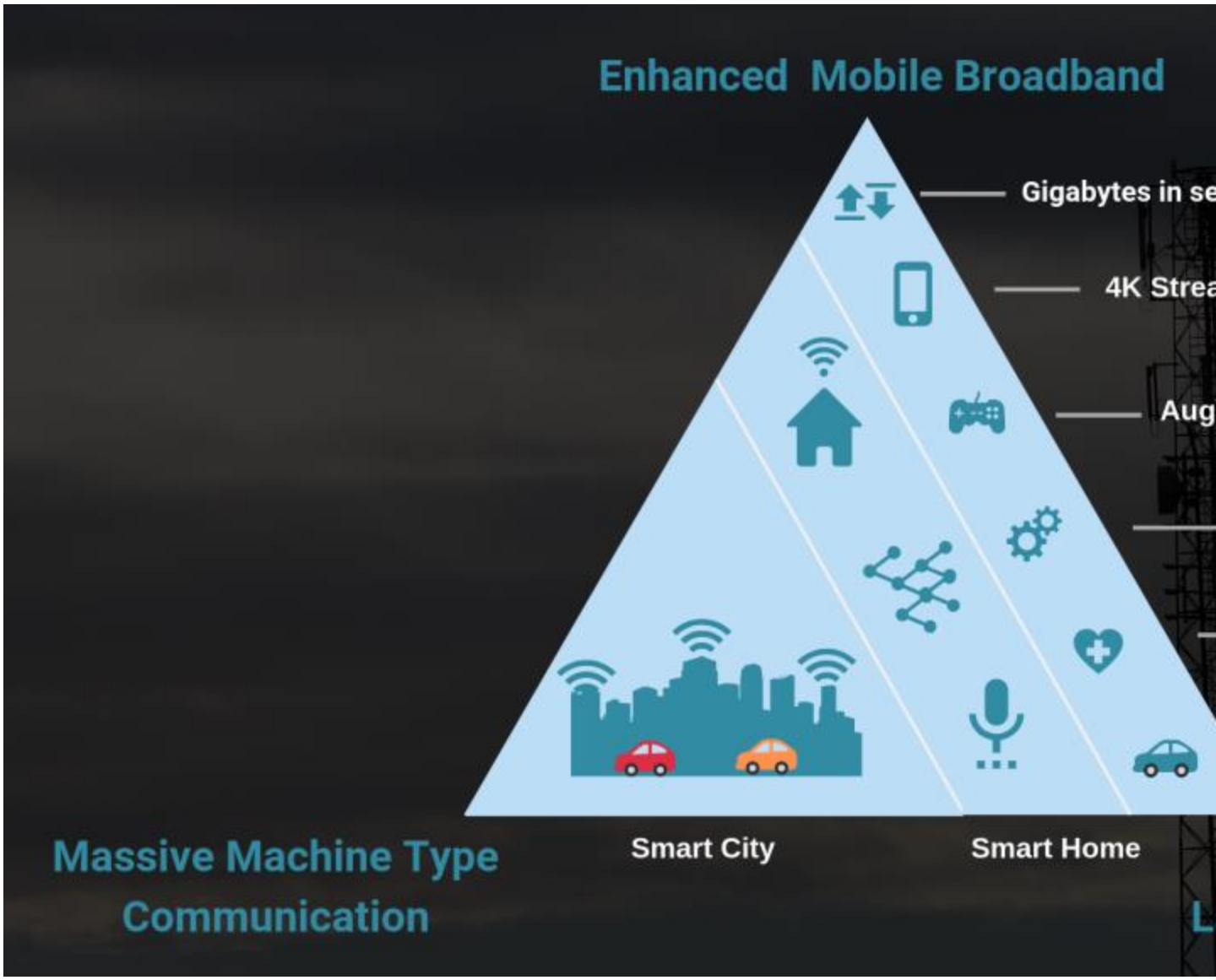
And now for 5G, the standard organizations already established the requirements to consider a system 5G. 3GPP defines any system using "5G NR" (5G New Radio) software as "5G", a definition that came into general use by late 2018.

ITU also formed a standard called IMT-2020 which includes the requirements issued by ITU-R for 5G services.

Key Requirements of 5G Technology as per IMT-2020 standard

As per requirements by IMT-2020, 5G systems are expected to provide an **enhanced device and network capabilities, faster data transfer, low latency, low energy consumption, increased number of devices, and broad bandwidth.**

It does not only provide enhancement to the traditional mobile broadband scenarios, but extending the application of this technology to use cases involving ultra-reliable, low latency, and massive machine-type communications.



The ***ITU-R*** has defined three main types of uses of 5G:

- *Enhanced Mobile Broadband (eMBB)*
- *Ultra-Reliable Low Latency Communications (URLLC)*
- Massive Machine Type Communications (mMTC)

Let's take them one by one:

Enhanced Mobile Broadband (eMBB)

It refers to using 5G as an evolution to 4G LTE mobile broadband services with faster connections, higher throughput, and more capacity. Enhanced Mobile Broadband (eMBB) will be instrumental in enabling rich media applications such as mobile AR and VR, as well as 4K and 360° video streaming.

Ultra-Reliable Low-Latency Communications (URLLC)

It refers to the use of the network for mission-critical applications that require uninterrupted and robust data exchange. It is targeted toward extremely latency-sensitive or mission-critical use cases, such as factory automation, robot-enabled remote surgery, and autonomous driving.

Massive Machine-Type Communications (mMTC)

It refers to the type of usage that connects to a large number of low power, a low-cost device in a wide area that has high requirements on scalability and increased battery lifetime.

Here are the performance targets for 5G networks:

Capability	Description
Peak Data Rate	Maximum Achievable Data Rate
User Expirenced Data Rate	Acheivable Data Rate Across the Coverage Area (hotspot case Acheivable Data Rate Across the Coverage Area
Latency	Radio Network Contribution to Packet Travel Time
Mobility	Maximum Speed for Handoff and QoS Requirements
Connection Density	Total Number of Devices per Unit Area
Energy Efficiency	Data Sent/Received per Unit Energy Consumption (by device c
Area Traffic Capacity	Total Traffic Across Coverage Area
Spectrum Efficieny	Throughput Per Unit Wireless Bandwidth and Per Network Ce

Key Takeaways:

5G promises to accelerate cellular data transfer speeds from ***100 Mbps to a peak rate of 20 Gbps***. Moreover, 5G networks are capable of latency rates of under a millisecond in ideal conditions making the technology highly suitable for critical applications that require rapid responsiveness, such as remote vehicle control. Such numbers can make next-generation wireless networks *stand taller even against the fastest fiber-optic wired networks.*

Besides, the eight parameters (mentioned in the chart above) to define key capabilities for IMT-2020 5G:

5G can support up to a million devices per square kilometer, while 4G supports only up to 100,000 devices per square kilometer. 5G can also use new radio millimeter

bands in the 30 GHz to 300 GHz range whereas current 4G networks operate on frequencies below 6GHz.

5G Initiatives Taken By Government and Standard Agencies

South Korea

On 9 April 2019, South Korean President Moon Jae-in drafted government plans to support the 5G ecosystem by providing more than KRW 30 trillion ($26.2 billion) for the next four years. Investments are for supporting different segments of 5G technologies such as autonomous driving, smart cities, IoT, digital healthcare, and smart manufacturing.

New Zealand

The first allocation of the 5G spectrum will be the 3.5 GHz band, with national rights to this portion of the spectrum expected to be auctioned early in 2020, the Government announced.

National spectrum rights in the 3.5 GHz band will be available to use from November 2022 when the existing rights in this band expire. With the agreement of the existing rights holder, an operator may be able to use the rights earlier. Spectrum in this band will also be available to regional wireless broadband service providers.

Australia

The Australian government wants to create an environment that allows its telecommunications industry to be at the forefront of seizing the benefits of 5G across the economy. To that end, they have released the paper, 5G—Enabling the future economy which helps to define the next wave of productivity and innovation across different sectors of the Australian economy.

Canada

The Canadian Government declared to invest $400 million and formed a public-private partnership focused on 5G technology and development of its use cases such as smart cities, healthcare, education, connected and autonomous vehicles, entertainment and media, and the Internet of Things.

Japan

Japan's Internal Affairs and Communications Ministry planned to start carrying out research and development activities for succeeding 5G technology by forming a new telecommunications standard, the Japanese press reported citing sources from the ministry. The ministry said that Japanese operators will be in a position to commercialize this post-5G standard around 2025.

United Kingdom

A new initiative was launched by Cambridge Wireless (CW), TM Forum, and the Knowledge Transfer Network (KTN) to promote the UK's 5G ecosystem in 2018. The UK Government announced the consortium that will run its new 5G Innovation Network. They also released a report which outlined £600 billion investments in national infrastructure.

Germany

Germany's Minister for Digital Infrastructure has vowed to make the country an innovation leader in 5G technology – by unveiling its strategic roadmap for the implementation of 5G in Germany.

Germany's regulator has already earmarked some of the spectra it intends to use in order to enable the new service – whilst it has been reported further frequencies set to be allocated by the end of 2018. In a statement issued by the German Ministry for Digital Infrastructure, it claimed that its strategy would make the country a leader in 5G.

Singapore

China-Singapore Tianjin Eco-City, a joint project between the two countries, will add 10 5G base stations to the existing two by 2020 to expand its 5G network, Chinese telecom giant China Mobile said Monday. The base stations will enable the eco-city, located in northern China's Tianjin Municipality, to use 5G technology to transmit high-definition pictures and videos to improve city management, according to Zhang Lei, deputy general manager of China Mobile's branch in Tianjin's Binhai New Area.

Malaysia

Malaysia is still studying the use of fifth-generation technology (5G) pioneered by China. In the meantime, on measures that could be taken by MCMC to ensure that the existing networks provided by telecommunication operators were expanded into non-economical areas before shifting towards 5G, Ahmad Nasruddin said the government

had many initiatives, among others, under the Universal Service Provision (USP) Programme.

United States

The Trump administration and government regulators unveiled a major push at the White House to accelerate the rollout of the high-speed, next-generation mobile data technology known as 5G.

Under the plan, the Federal Communications Commission will release a wide swath of high-frequency airwaves for cellular use in what will be the largest trove of U.S. wireless spectrum ever to be auctioned off. As much as 3.4 gigahertz of the "millimeter-wave" spectrum could be sold to wireless carriers such as AT&T and Verizon in the sale, which will begin Dec. 10, according to FCC Chairman Ajit Pai.

The FCC also proposed a $20 billion fund to expand broadband in rural America over the coming decade, connecting up to 4 million households and small businesses to high-speed Internet, Pai said. The "Rural Digital Opportunity Fund" could launch later this year, after a period of public notice and comment.

India

The Indian government has set a commercial rollout target for consumers by 2020 at par with global timelines with the telecom department poised to unveil its 5G technology roadmap by June.

Initiatives by Standard Telecom Agencies

IEEE

In December 2016, IEEE Future Directions launched the IEEE 5G Initiative which later, in August 2018 was re-branded to IEEE Future Networks with the tagline *'Enabling 5G and Beyond'*. The initiative helps in the development & deployment of 5G technology and addresses challenges associated with it.

The initiative involves gathering the researchers, scientists, engineers, and decision-makers from industry, academia, and government bodies to solve the challenges and disclose the opportunities associated with current and future networks.

ATIS

ATIS announced its agenda to advance the 5G network evolution at its 5G Symposium to be held on 2019, June 8 and 9 in Chicago. The role of this initiative is

to ensure that the ultra-high-capacity and future network performance delivers the full opportunity envisioned by 5G.

ETSI

ETSI's initiative, Multi-access Edge Computing (MEC), is an Industry Specification Group (ISG). The purpose of this initiative is to create a standardized, open environment that will allow the efficient and faster integration of applications from vendors, service providers, and third parties across multi-vendor Multi-access Edge Computing platforms.

Multi-access Edge Computing (MEC) offers cloud-computing capabilities and IT services at the edge of the network to application developers and content providers. This environment is characterized by ultra-low latency and high bandwidth as well as real-time access to radio network information that can be leveraged by applications.