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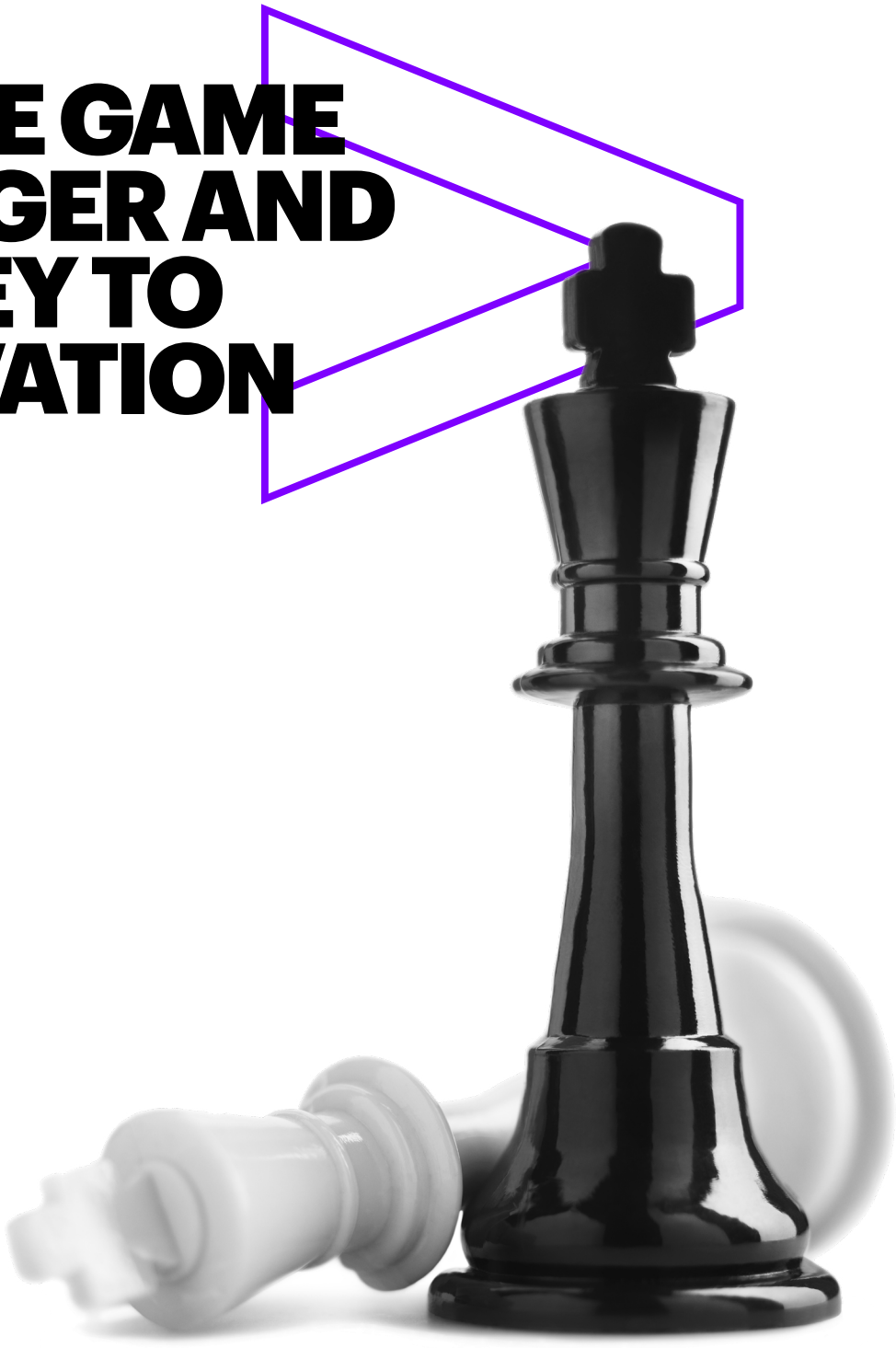
5G: THE GAME CHANGER AND THE KEY TO INNOVATION



5G is the next-generation technology designed to meet future wireless connectivity requirements. The purpose of this paper is to set forth the exciting capabilities and innovations that are possible through 5G; to identify the key challenges that must first be addressed; and to kindle the change needed to make 5G a success.

Communication Service Providers around the world are already preparing for the advent of 5G through trials and technology upgrades intended to ascertain associated new business opportunities. In many instances, business and governments are participating in trials to better understand the need, to ready their environment for new business use cases so they can envision the possibilities 5G offers. Today's enterprises must develop clever techniques to meet their increasing demand for data, and methods such as open sourcing the development of 5G technologies and processes will have an enormous impact in enabling the innovation required to make 5G a reality.

Each generation of mobile internet has brought significant performance boosts to user devices. The expectation for 5G is that it will enable emerging technologies, such as autonomous vehicles and the Internet of Things (IoT), to finally become a reality for both business and consumers.

A recent survey by Heavy Reading, Accenture and Viavi Solutions [1] sought to understand operators' attitudes towards 5G and customer experience. Ninety-four percent of the respondents viewed 5G as a new business-to-business growth opportunity. Operators view low latency, higher broadband speed, and massive connectivity between machines as the leading 5G features that will attract valuable customers. Also, more than 60% of the respondents believe Artificial Intelligence (AI) based decisionmaking and high-resolution video-based use cases will be the leading growth areas motivating consumers to use 5G and its corresponding benefits.

INTRODUCTION

5G, the fifth generation of mobile communication systems, is also the next generation of cellular and mobile technology and will have a tremendous impact on our lives and the market. With digitization being the latest saga, IoT will be an inevitable part of 5G. Organizations in every field need to get ready for the 5G revolution.

However, are we ready to embrace the path to 5G? Is there a market demand for 5G? What is the industry's readiness for 5G adoption?

Here is how 5G will make an impact in various market sectors:

- **Telecom Operators.** 5G means greater bandwidth to provide enhanced services to the end customer. Greater bandwidth also ensures better customer experience and higher revenues. There is already a strong correlation between industry adoption of 5G technology and the concept of network slicing, which will assign specific network architectures and paths to serve industry-specific applications. Attitudes towards network slicing among mobile network operators are positive, as they plan to deploy end-to-end slicing for key vertical customers.
- **Equipment Manufacturers.** 5G brings the need to develop ultra-efficient and fast devices. This in turn enables equipment manufacturers to pursue futuristic designs and concepts and introduce them in the market, reaping substantial revenues in return.
- **Retail.** Retailing will be at the forefront of 5G wireless technology adoption, as this industry can benefit from the use of Augmented Reality (AR) to enhance consumers' experience of shopping both online and offline.
- **Health.** 5G will use high bandwidth and ultra-reliable network to provide added capability to the healthcare industry. Use cases that were envisioned earlier, such as remote surgery and efficient emergency response, will turn into reality.

- **Industrial Transformation.** 5G can achieve the full potential of next-generation industrialization by delivering the promise of configurable factories, mobile robots, a time-sensitive network and lower maintenance costs. The combination of 5G and new computing powers such as AI, edge services, powerful processing and enhanced security will lead to true industrial transformation.
- **Education.** With the advent of 5G, Augmented Reality (AR) will be used to its full potential, demanding network resources and end-to-end latency. Online teaching will be empowered by the increased use of AR.

KEY FEATURES OF 5G

New and innovative technologies that have led to standardization of several features in 5G include Software Defined Networking (SDN), Network Functional Virtualization (NFV), Millimeter Wave (MM Wave), Multi-User Multiple-Input and Multiple-Output (MU-MIMO). New technological concepts and features that have evolved in the network space include Multi-Access Edge Computing (MEC) and Network Slicing. These concepts will change the way the service is delivered to customers and will also enhance the customer experience.

- **Multi-Access Edge Computing (MEC)**
  Multi-access edge computing (MEC) is a network architecture concept that enables cloud computing capabilities and an IT service environment at the edge of the cellular network. With MEC, the required computational and content storage capabilities will be brought closer by integration into local cellular base stations. Apart from proximity, low latency and high bandwidth, the MEC environment will offer localized cloud computing capabilities as well as exposure to real-time radio network and context information. Real-time radio network conditions and context information can be used to optimize the network and service operations by enabling improvement in the service experience and more efficient handling of increased traffic, leading to tighter integration of network and service.

  With MEC, various service providers, software vendors, and telecom services can offer a unique and unparalleled experience by leveraging new levels of flexibility and agility as they react to end-user experience in real time, based on actual radio conditions. Their services can be deployed on top of multi-vendor MEC platforms, which can be used by most of the customers of a single mobile operator.

  As one example, AR can utilize the unique capabilities offered by MEC platforms, such as proximity to the user, network edge and serving a highly localized area. AR is the combination of a view of the real-world environment supplemented by computer-generated sensory input, such as sound, video, graphics or GPS data.

  Consider a visitor in a museum. By wearing an AR Smart Glass, the visitor can look at a painting and simultaneously view additional information about the painting that is displayed in the glass using a built-in application. Such an application needs to be context aware regarding the end user's physical position and geographic direction. Using an MEC platform allows the information pertaining to the user's point of interest to be localized and made available quickly. AR data requires low latency and a high rate of data processing to provide the correct information to the user's device, depending on the location and orientation of the user.

  Performing such data processing on the MEC platform also has the advantage of collecting metrics and anonymized metadata to analyze the service usage and provide a better user experience.

- **Network Slicing**
  Communication technology has been a catalyst to the digitalization of society. The sub-optimal use of the mobile network is due to the diverse requirements of new-generation businesses. While one customer may require ultra-reliable services, another may require ultra-high bandwidth communication or extremely low latency. The 5G network needs to be designed to offer a good mix of capabilities to meet these diverse businesses' requirements. An efficient approach is to operate multiple dedicated networks on a common platform, which is called network slicing. Network slicing is the embodiment of the concept of running multiple logical networks as virtually independent business operations on a common physical infrastructure in an efficient and economical way.

  From a mobile operator's point of view, a network slice is an independent end-to-end logical network that runs on a shared physical infrastructure, capable of providing a negotiated service quality. A network slice could span multiple parts of the network, such as a terminal, access network, core network and transport network, and can be deployed across multiple operators.

The key advantage of network slicing is the ability of the communication operator to customize the capability and functionality that it can provide to its end user. The network slice service can be logically separated into two services: Network Connection Service and Network Resource Service.

- **Network Connection Service** describes the functionality offered to business customers at a connectivity level. The network connection service comprises a set of technical attributes that determine the behavior of the slice, as well as the topology and geographical spread of a slice. Here is a list of characteristics a connection service is expected to provide from a network operator to its end customers:

- Near real-time latency
- Stable and reliable speeds
- Guaranteed SLA
- Coverage to ensure seamless service experience
- Connected device management for high density of devices
- Seamless mobility for uninterrupted service delivery in high velocity scenarios

- **Network Resource Service** is a service in which business customers may be granted access to the operator's network resources for running proprietary applications. The operator will commit to provide a lifecycle management service, that is, open lifecycle management capability to the business customer. Here are a few examples of customized platform services that a network operator can provide:

- Data analytics offered as a service to support the data management for orchestration of complex processes or ecosystems
- Platform security offered as a service to provide various levels of security
- Cloud computing, which is global access to the operator's resources
- Edge computing for distributed computing and data storage for services with low latency requirements to enable ultra-fast interactions/responsiveness
- Positioning as a service which is tailored to the requirements of the specific service
- APIs providing different control and management capabilities to a vertical, such as adapting the geographical spread of a slice, as well as provisioning of various types of information from different sources

Here are several examples of industry sectors with high potential for application of network slicing:

- **Automotive Slice.** A connected vehicle that can simultaneously deliver high throughput of in-car entertainment, ultra-reliability, and low latency (URLLC) for assisted or autonomous driving, data gathering, and analysis from telemetry sensors.
- **Industrial Automation.** A factory may order an URLLC slice from the operator for industrial automation production, allowing the robots in the production line to be controlled and monitored.
- **Massive IoT Slice for Transport.** A transport traffic management department may order a massive IoT network slice to monitor and manage the real-time status of their systems. With this slice, they can collect the real-time traffic situation through massive Machine Type Communications terminals. They can then analyze their information and publish it on their monitor screens to inform related users.

CHALLENGES

There are a number of acknowledged challenges as we move forward in the development of 5G; and there may be additional challenges that have not yet been recognized. But without facing challenges, we would not have achieved the innovations that make up so much of today's telecom network infrastructure.

Here are a few challenges we are likely to face soon:

- It is difficult to understand what the latest technology should be, given that it should meet the requirements of people and enterprises.
- 5G, like any other network, has two attributes: capacity and speed. Capacity refers to the number of devices that 5G can serve successfully, and speed refers to the data rates that 5G provides. While both are important, achieving both to a very high efficiency is cumbersome.
- Security is dependent on both business requirements and system architecture. With the huge number of devices now being connected and communicating with each other, there are risks of more severe Distributed Denial of Service (DDoS) attacks than ever before. As an example, an isolated 5G network has more vulnerabilities than a legacy system. Signaling System 7 (SS7) attacks are also a major point of concern for network security in the signaling landscape.

- Although MM Wave and MU-MIMO may seem to be the answer to all the problems of 5G, they can also pose issues, such as the vulnerability of MM Wave when performing in non-LOS conditions, and the high attenuation it suffers from particles in the atmosphere, such as water drops.
- 5G is set to provide access to information and sharing of data anywhere, at any time, to anyone and anything. As we improve 5G radio access technologies, simultaneous development and adoption of the transport network needs to be carefully managed in order to cater to the new radio technologies. The level of flexibility that is required in the transport network is dependent on how the 5G radio is deployed, and must be able to reach very high levels of capacity.

SUMMARY

5G is being developed based on market requirements and available technologies. NFV, SDN, Cloud, and open source development of 5G technologies and process, as well as educating professionals and students about 5G, will bring transformation in network systems and operations. After all, we are looking to pool the best brains and resources to make 5G happen.

As far as 5G and legacy systems are concerned, the existing two-factor authorization for 5G and legacy systems need to be carefully evaluated for security consideration, as it mostly uses SMS for authentication, which can be easily intercepted, allowing an impersonator to illegally use the identity of a customer and cause disruption. To make 5G secure, and to enable businesses to make the most of it, in our opinion requires a robust new architecture throughout the signaling landscape, as traditional methods alone would do no good.

5G will change the world even more profoundly than 3G and 4G. It will be as revolutionary as electricity or the automobile, benefitting the economy and society. Many developing nations have gained more than their industrialized counterparts from the deployment of mobile technology. It is estimated that the global economic impact of 5G in new goods and services will reach $12 trillion by 2035, as 5G moves mobile technology from connecting people to people and information, towards connecting people to everything.

Last but not least, the evolution of wireless communication to 5G is not only one of the greatest leaps in wireless technology, but also a forerunner for innovation. This innovation will not be limited to network technologies that support the service to end users, but also will prompt allied industries to innovate and develop new technology services geared to those end users, revolutionizing the way humankind uses those technologies in its day-to-day activities.

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