WHITE PAPER

PUSHING THE REALM OF IOT POTENTIAL WITH 5G

Abstract

5G networks bring significant benefits to consumers, community and the industry as it provides near zero latency, ultra-reliability, increased coverage and support for higher density of devices. Current internet of things (IoT) use cases can utilize the power of 5G to boost operations and efficiencies. While 5G adoption is still in its early stages, there is significant research, investment and trials across the globe to satisfy the near-term user demands.

This paper outlines unique IoT solution connectivity requirements such as range, reliability, latency, power consumption and throughput, and discusses how 5G will help realize the vision of seamlessly connected systems to deliver value to enterprise and consumers. This paper provides a detailed commentary on how 5G-IoT will redefine current use cases and build new ones across several industries such as manufacturing, healthcare, mining and automotive.

Infosys®
Navigate your next

5G – State of Art

As of July 2020, there were 129 wireless operators across the world who have deployed 5G with commercial availability in 12722 locations [Source: Ookla 5G Map]. IDC Forecasts that worldwide 5G connections is expected reach 1.01 Billion by 2023. With 5G going live in more locations, it has generated considerable excitement across industry segments for 5G enabled use-cases. According to Infosys' report on the state of 5G, the retail, logistics, healthcare and life sciences industries have taken the lead in defining applications that exploit 5G.

Industry experts tout 5G as a fundamental transformation in the way mobile technologies will impact our lives, communities, cities and industries. The technology is built with three principal dimensions to meet the performance requirements of industry use-cases:

- eMBB – enhanced mobile broadband
- URLLC – ultra-reliable and low-latency communications
- mMTC – massive machine type communications

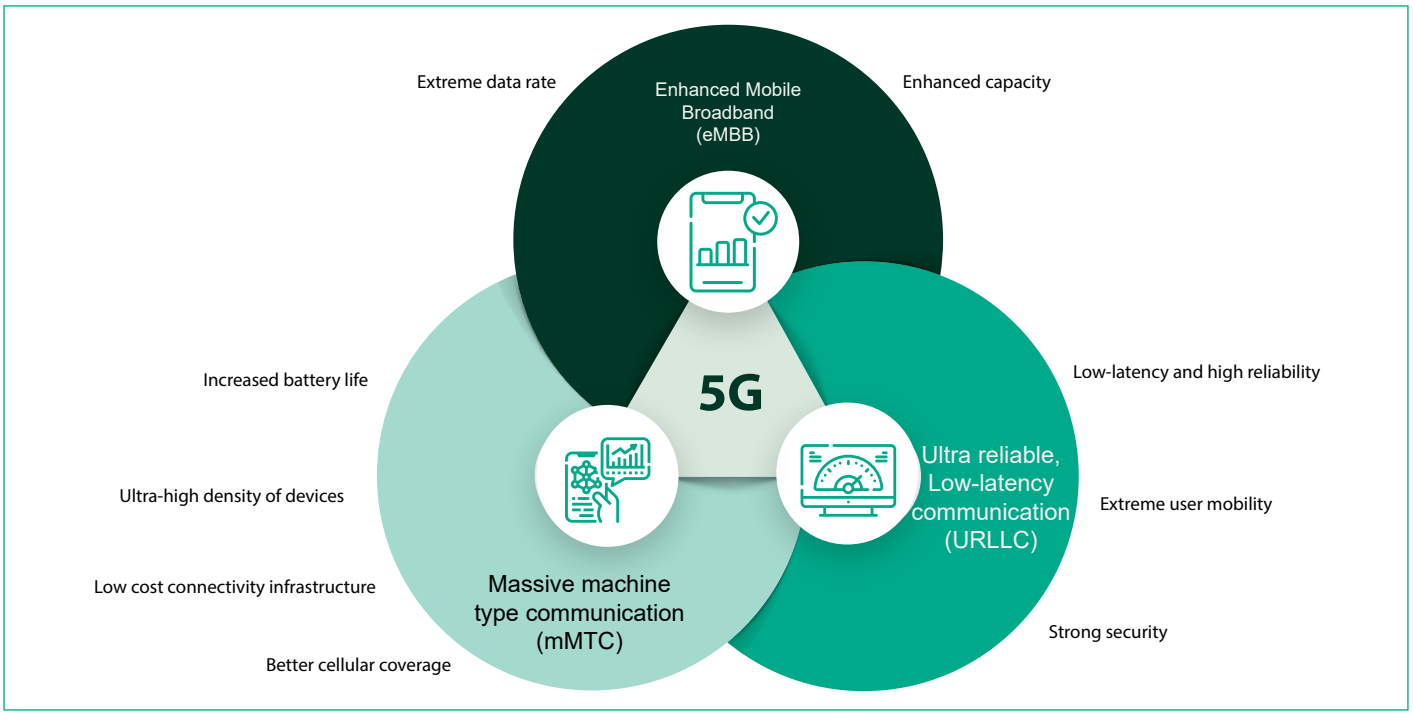

Figure 1. 5G usage scenarios

5G has been designed to support diverse IoT requirements including range, speed, latency, device power management and quality of service. While 4G will deliver the connectivity requirements for IoT use cases, 5G will help enhance impact of existing use cases and re-imagine new applications using the attributes. This will deliver enhanced innovation, productivity, improved experience and better quality of life across industries for the ecosystem and consumers.

Figure 2. 4G versus 5G for IoT

Digital Transformation with IoT – State of Art

By merging the physical and digital universes, IoT has rapidly changed the consumer and business landscape and enabled digital transformations over the last few years. The growing awareness of the benefits of this transformation triggered a growth in the number of connected devices. As per the report "Internet of Things (IoT) Market - Growth, Trends, Forecasts (2020-2025)" published by Reportlinker.com, revenues from the global IoT market is forecast to grow from $690 billion in 2019 to $1256 billion in 2025.

IoT enabled devices connect to IoT platforms on the cloud. They connect over a wide range of solutions, including field connectivity solutions such as Zigbee, ZWave and LORA, depending on the device capabilities. These solutions, in turn, connect to gateways to reach platforms on the internet. Other devices have inbuilt gateways with Wi-Fi or 2G/3G/4G capabilities to connect directly to platforms on the internet.

Most consumer and enterprise use cases, especially those that do not require near real-time response and high bandwidth requirements, are achievable with current connectivity infrastructure. 5G is the way forward for evolving high value use cases that count on low latency, high bandwidth, highly reliable and low power consuming connectivity solutions. For example, autonomous cars, high-definition content for in-vehicle entertainment, security cameras in public areas that enable facial recognition to help law enforcement, remote control of robot-driven procedures in healthcare, enabling sensor connectivity in large and remote farms or difficult terrains like oil-wells, AR/VR use cases around remote service operations and training require reliable, low power and high bandwidth connectivity solutions. A study of the potential use cases has led research firms like MarketsandMarkets to predict the growth of the 5G-IoT market size from USD 0.7 billion in 2020 to USD 6.3 billion by 2025.

5G as the connectivity bedrock for IoT deployments

Connectivity is the bedrock of IoT applications, and choosing the right connectivity option is crucial. If the data that is acquired or sensed is not streamed to the platform at the right time and correct velocity, it is not useful. Currently, there are four connectivity options, each with its pros and cons – unlicensed, licensed, low power wide area (LPWAN) networks and extra-terrestrial. The Mobile Network Operators (MNOs) that provide these services offer extensive coverage, low data costs and unified management. However, these technologies were designed for broadband telecommunications, and when current technologies extend the network to connect devices and sensors, they are not optimized.

IoT connectivity requirements vary by industry, and in fact, similar use cases across sectors can have differences. For instance, predictive maintenance in manufacturing has different range and reliability requirements compared to the oil and gas industry requirements. The key attributes of connectivity include power consumption, reliability, range, latency and throughput.

A connected vehicle infotainment system requires high throughput, while autonomous driving demands high reliability and low latency. Similarly, monitoring solutions expect low latency and high reliability. For a sensor-based solution to measure the wear and tear of railway bridges, device longevity with low battery consumption, is a crucial parameter to be considered.

Careful analysis of use cases across industries against 5G connectivity attributes provide a holistic view of the requirements from IoT applications and how 5G addresses them is captured in Figure 3.

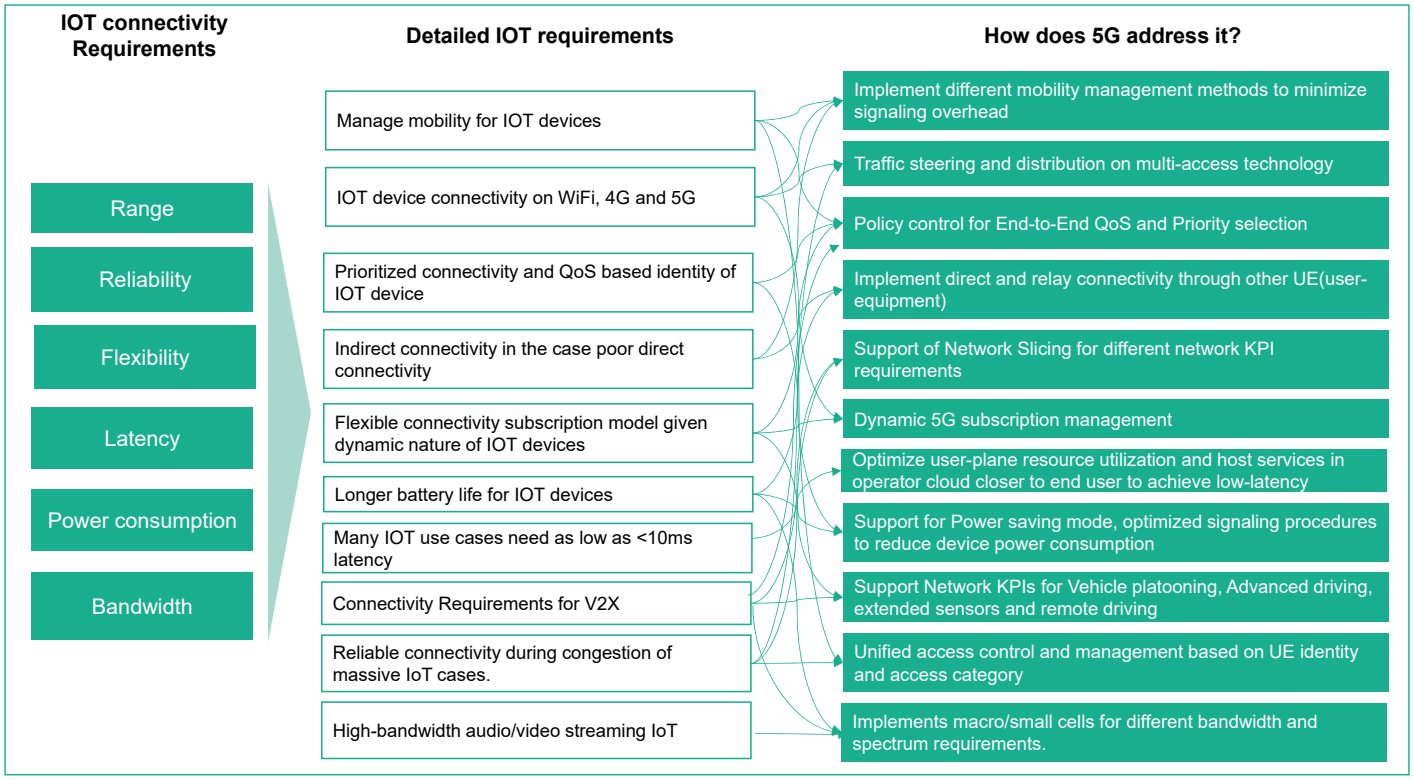

Figure 3. IoT requirements and how 5G addresses it

Longer battery life, multi-access connectivity and V2X connectivity are critical requirements that are addressed by 5G.

i. **Longer battery life for IoT devices:** 5G IoT devices are expected to have ten years of battery life. To meet this, 5G supports power saving mode (PSM) at the device, which allows low power consumption. On the network front, optimized signaling procedures, such as reduced paging procedure to minimize power consumption, are carried out.

ii. **Multi-access connectivity for IoT:** 5G technology enables selection of the most appropriate access for IoT devices (amongst NR, LTE, Wi-FI and other mechanisms) - thus enabling resource optimization and efficiency. This means seamless handover or switch between different types of access will be supported.

iii. **V2X connectivity:** Vehicle platooning, advanced driving, extended sensors, remote driving and vehicle QoS support are V2X scenarios to be supported. 5G systems must support communication by V2X UE and meet the performance requirements of each of the situations.

Transforming industries with IoT and 5G

Figure 4 shows a map of the key benefits of industry-specific use cases. The table highlights how 5G capabilities can enhance specific IoT use cases. The height of the bar demonstrates the impact that the 5G feature has on the use case. Our research indicates that 5G will amplify the impact of some IoT applications and will help reimagine new use cases that were not earlier possible.

The speed of 5G adoption would follow a classic push and pull model between the industry and technology operators. As industries continue to innovate and explore newer technology capabilities to enhance value, reduce costs and differentiate from the competition, there will be a strong pull to adopt 5G. On the other hand, technology operators (wireless telecoms, communications equipment providers, semi-conductor manufacturers, device and handset manufacturers, hi-tech software companies) developing new technology to enhance current experiences, address critical challenges and generate newer revenue streams will push for 5G. Adoption will depend on how soon the 5G ecosystem strikes a balance between industry pull and operator push. Additional factors such as cost, regulations, spectrum availability and device readiness will accelerate 5G adoption. Similar to earlier technologies, adoption rates will also differ by geography.

Industry	Use Case	eMBB	URLLC	mMTC	Benefits
Manufacturing	Factory floor flexibility				> Increase utilization > Maximize throughput > Lower downtime
	Connected assembly lines				
	Remotely managed smart factories				
Healthcare	Remote diagnosis				> Increased health care coverage > Reduce hospital visits > Better asset utilization
	Real time health data				
	Connected ambulances				
Energy and Utilities	Distributed energy management				> Efficient generation > Reduce distribution loss > Personalize energy solution
	Smart transmission and distribution				
	Smart consumption				
Automotive	In-vehicle experience				> Improve safety > Increase convenience > Personalize driving experience
	Enhanced telematics services				
	Intelligent transport systems				
Mining	Autonomous vehicles				> Increase safety > Maximize throughput > Increase utilization
	Remote operations center				
	Safety in underground mining				
Transportation and Logistics	Enhanced location tracking				> Increase safety > Improve efficiency > Minimize downtime
	Order picking in the warehouse				
	Intelligent autonomous vehicles				
Smart Farming	Sensor deployments in large farms				> Improve yield with intervention > Reduced manual effort > Improved coverage of large farms
	Automation of drone flights				
	De-weeding robots				

Figure 4. 5G Capabilities empowering IoT use cases across industries

1. Manufacturing

Manufacturing requires deterministic time synchronization with demand for high throughput, high reliability, low latency and precision positioning for shop floor tracking. Industrial IoT riding on 5G attributes can truly help manufacturers create a transparent and connected supply chain – efficient planning of the sales process, optimized manufacturing, integrated distribution and product-consumption. Use cases that can be enabled on the manufacturing floor include:

i. **Factory floor flexibility:** Manufacturers aim to rapidly reconfigure and customize assembly lines to handle new requests based on market demands. The elimination of expensive cabling, support for time-sensitive synchronization, high capacity, and high-speed help achieve these objectives. In addition, wearable technologies such as smart helmets, glasses ensure that the workers are mobile as well to work on smart cells. "Time Sensitive Networking," an, essential attribute of 5G technology, helps reconfigure the factory lines.

ii. **Connected assembly lines:** In this case, humans and robots work seamlessly - for example, a robot lifts parts while a human attaches them. These collaborative robots are called "cobots" and work in proximity with humans. There is constant communication between the robot, human and the environment, made possible by thousands of sensors transmitting data at high velocity, to enable real-time decisions. The low latency is enabled through small cells "on-site" to ensure coverage and signal penetration through the equipment.

iii. **Remotely managed smart factories:** Remote teams will require public wireless networks using devices like smartphones and AR devices for easy access to work instructions or to restart processes and implement preventive measures that can require human intervention. This access is valuable in unsafe and hazardous environments. High reliability and high bandwidth attributes of a 5G network are relevant here.

2. Healthcare

Enhanced connectivity in the healthcare sector can save lives. While digitization efforts started with electronic medical records, electronic health records and medical data digitization, IoT application has an impact on the remote diagnosis of healthcare equipment, patient monitoring and medical data transmission. IoT, when powered by 5G will act as a catalyst for these applications, as they require reliable communication.

i. **Remote diagnosis:** Diagnosis in rural and remote areas can be kickstarted through 5G enabled phones or kiosks. 5G's attributes high reliability, low latency connectivity and wide coverage, help achieve the diagnosis and extend it to treatment or surgery as well. Remote-controlled robots can perform surgery and carry out medical inspections in highly infected areas where a healthcare worker will be at risk.

ii. **Real-time health data:** Wearables are expected to reduce hospital visits by up to 16% over the next five years. Hospital visits will be scheduled based on vital parameters crossing defined thresholds (e.g. blood count shooting up). As a result, hospital visits reduce, and medical facilities can better prepare since they monitor the patient's data thanks to 5G's low latency.

iii. **Connected Ambulances:** Emergency responders can share critical patient data on the go including high-resolution images, live videos to emergency units in hospitals. 5G's low latency, high bandwidth and high reliability characteristics help hospitals to be better prepared. In addition, video conferencing with experts while on the move, coupled with the patient's history, should be analyzed to create models and recommend specific actions.

3. Energy and Utilities

The energy and utilities industry is ripe for disruption, given the growth in energy generation through renewables, and the financial distress that many of them are going through. The industry is highly regulated; hence safety and reliability of new technologies must be proven before adoption. However, the industry is always looking for opportunities to improve efficiencies and reduce the burden of high capital and operational expenditure. While 4G propelled enterprises in this direction, 5G will transform the energy and utilities sector across the entire value chain of power generation, distribution and consumption.

i. **Distributed energy management:** Low latency 5G connectivity combined with real-time sensor data allows distributed energy management that will balance across renewable sources of power generation, manage micro-grids, and utilize power from home to grids. An energy management platform will seamlessly handle massive amounts of data in real-time from geographically spread endpoints with near-zero latency delivered by 5G.

ii. **Smart transmission and distribution:** Sensors throughout the distribution and transmission path transmit data that help in real-time load balancing. It helps diagnose and fix transmission losses and unanticipated outages in real-time. Like a virtual network in the software domain, virtual power networks using 5G's network slicing can be created and managed to handle emergencies. These virtual networks can be isolated to protect national infrastructure.

iii. **Smart consumption:** Dense (high device density) sensor networks at the endpoints will provide real-time consumption data that can be analyzed for patterns. These insights can help utility companies in designing newer personalized energy management solutions for residential and commercial users. The smart metering infrastructure can also provide for consolidated billing solutions for the consumer. 5G delivers connection density requirements for such a smart sensor network.

4. Automotive

As per global consultancy and research firm Analysys Mason, the automotive industry is expected to account for 20% of IOT connections by 2027. The market drivers for connected services are consumer buying behavior, safety regulations and integration with digital lifestyles. Currently, services such as infotainment, telematics and assisted driving are offered as part of the connected vehicle offering. These services address the occupant (infotainment), vehicle (telematics) and environment (assisted driving). With 5G, the impact of these services will multiply and improve safety, convenience and efficiency of driving experience. As an example, a car traveling at 30 miles per hour needs to receive a signal to avoid objects. With the current 4G latency of ~100 milliseconds, the car will travel four feet or 1.2 meters. With 5G latency of approximately ten milliseconds, the car will travel only five inches or 12 centimeters, a 100x reduction in latency can mean the difference between life and death.

i. **In-vehicle experience:** 5G can transform the in-vehicle experience. Newer applications such as AR/VR based navigation and marketing-based apps will exploit 5G infrastructure to deliver services. 5G attributes like high bandwidth and stringent QoS can provide high-definition video for entertainment and education. These can be supplemented with live interactions, gaming support, high-speed Wi-Fi, video conferencing, web browsing to enable a next-gen in-vehicle experience.

ii. **Enhanced Telematics services:** Currently, automotive companies collect and analyze vehicle data for vehicle tracking, diagnostic and driving behavior services. However, latency and bandwidth constraints do not allow for real-time driving insights. 5G's high bandwidth and low latency attributes can enable real-time insights that improve driving efficiency. In addition, on-demand diagnosis, anonymous vehicle and surrounding data can be shared with transportation systems to maintain maps, road and city infrastructure.

iii. **Intelligent Transport Systems:** 5G is expected to be the backbone of new peer-to-peer communication protocol Cellular Vehicle-To-Everything (C-V2X). Autonomous vehicles generate almost 2.5 TB of data every hour, and this data must be sent to the connected vehicle platform for analysis and insights. The advanced V2X will be long range, high density, high throughput, high reliability, low latency, and enable "see-through sensing." An example is Nissan Intelligent Mobility Technology's Invisible to Visible (I2V), which will help drivers spot objects at a distance quicker through real-time analysis of vehicle and environment sensors.

5. Mining

The mining industry is where reliable connectivity, high throughput and low latency response communication can make a big difference to ensure miner's safety while maximizing productivity. Reliable connectivity in remote mining locations is the biggest challenge, which 5G or private-5G can address. As per the Smart Mining Market - Growth, Trends And Forecasts (2020 - 2025) report published by Mordor Intelligence, the global smart mining market was valued at USD 6.8 billion in 2019 and is expected to reach USD 20.31 billion by 2025, driven by IoT solutions.

i. **Autonomous Vehicles:** Optimal utilization of mine haul trucks with several hundreds of tons of payload is vital to reduce the operating costs of mines. 5G enabled autonomous vehicles can address this by transmitting vehicle and environment data to a remote operations center in real-time. 5G enables positioning precision of less than a meter, which is critical to autonomous vehicles operating in the mine.

ii. **Remote Operations Center:** Aligned with the vision of unmanned mines, most global mining companies are already implementing remote operation center (ROC). Today's ROCs implement more monitoring functions than control functions. 5G helps elevate ROCs to the next level through low-latency communication and high throughput connections to fulfill control functions.

iii. **Safety in underground mining:** The hazards associated with underground mining are many - including flood, toxic contaminants, collapse and gas explosion. Hence, real-time video streaming to assess the safety of miners when underground is critical. 5G, with its low-latency, high-bandwidth and reliable connectivity, addresses the challenges associated with wireless communication systems for underground mines.

6. Transportation and Logistics

The transportation and logistics sector can gain substantially from 5G deployments as continuous coverage across rural and suburban areas (because of low/mid-band frequency range of 450-6000MHz in rural areas and high-frequency range of 24250-52600MHz in urban areas) will help end-to-end continuous monitoring, tracking and theft detection.

Some of the relevant use cases are:

i. **Enhanced location tracking:** 5G's capability to provide wide coverage will help track cargo across regions that were considered dead zones earlier. Continuous monitoring of shipment will provide logistics operators with enhanced visibility on delays because of improved geo-location technology.

ii. **Order picking in the warehouse:** 5G can help new workers to understand the picking process using AR/VR based training. Warehouse-based robots for product identification and pickup can benefit from the high bandwidth, low latency and coverage (basement warehouses) characteristics of 5G.

iii. **Intelligent autonomous vehicles:** Autonomous vehicles enabled by 5G's low latency, high bandwidth, high reliability characteristics will enable logistics providers to solve several problems such as driver scheduling. This is relevant across the logistics supply chain – including warehouse (autonomous forklifts), ports (unmanned intelligent ground vehicles) and in last-mile deliveries of tomorrow (autonomous drones).

7. Smart farming

Smart farming encompasses crop farming, horticulture, dairy, meat production, sheep production, poultry, seafood and more. IoT deployments facilitate field data collection and analytics on this data and support farmer interventions at the right time to maximize production. In precision agriculture, sensor-based monitoring of underground and ambient conditions along with drone-based image analysis is now becoming common.

i. **Sensor deployments in large farms:** 5G-based nodes deployed on fields enable data transmission over large distances with longer battery life. Farmers own large farms where access is difficult, and frequent replacement of sensor nodes and gateways is an overhead, making sensor deployments significant.

ii. **Automation of drone flights:** 5G can control drone flights over large fields remotely (drones enable standing crop count, identify disease, monitor livestock locations and bio-medical data). Many regions have regulations that require drones to be flown at specific heights and in the line of the view of the operator. 5G will enable service guarantees for flight automation where drones connect with multiple base stations to ensure service continuity.

iii. **Automated de-weeding:** Robots on the field can eliminate weeds that hinder the growth of crop. Robots send images over a 5G network to platforms, where cognitive algorithms distinguish weeds from crop and assist the robot in spraying herbicides locally - capitalizing on the low latency and high bandwidth attributes. The same process helps identify diseased leaves in a plant. Further, experiments are underway in horticulture to use remote controlled robots to pluck the right fruits and vegetables.

Conclusion

The market for IoT is expanding as more things connect to the internet. Industries have moved on from "the trial stage to full-scale adoption". As the number and complexity of smart things increase, the infrastructure to support and enable IoT solutions also grows. Cloud computing, edge compute, artificial intelligence, AR-VR based technologies have enhanced the landscape and accelerated innovation.

Connectivity is the core of IoT solutions, and flexible infrastructure such as 5G can support expanding requirements. 5G also helps reimagine existing use cases and explore newer ideas that could not be supported by current connectivity technologies. Key factors that will determine 5G availability are device readiness, regulations, cost of connectivity and infrastructure readiness.

The key attributes of 5G, such as low latency, high reliability, support for high density of devices, positioning accuracy, high bandwidth and data rates, will revolutionize and accelerate IoT adoption in industrial and consumer markets.

About the Authors

Balaji Thangavelu is a Principal Consultant with Infosys Engineering Services and has over 21 years of experience. He has executed multiple consulting engagements for clients across industries for the successful adoption of next-gen networking and communication technologies. His research and focus areas include SDN/NFV and 5G, and how to enable them for various industry use cases.

Suraj Nair is a Senior Technology Architect with Infosys Engineering Services with over 21 years of experience. He has executed several projects in the IoT domain over the years. His current focus is connected vehicles. His current focus is Connected Vehicles and has worked with many large automobile manufacturers and tier1 suppliers in developing connected platforms.

Vinod Venkateswaran is an Industry Principal with Infosys Engineering Services and has over 22 years of experience. His research and focus areas are IoT and its application across industrial, consumer electronics and automotive domains. He has established and run innovation Centers of Excellence (CoE) for clients to experiment and rapidly prototype new technologies to identify risks and challenges.

References

AnalysysMason (2019) 'The automotive sector will drive the demand for 5G', (March). Available at: https://www.analysysmason.com/Research/Content/Comments/iot-forecast-comment-rdme0/

Ericcson (2020) 'Understanding car connectivity options and implications', (March). Available at : https://www.ericsson.com/en/blog/2020/3/future-of-smart-car-connectivity World Economic Forum (2019) '5G-Next Generation Networks Programme Repository of use cases', (November)

Qualcomm (2018) 'How will 5G transform Industrial IoT?', (April). Available at: https://www.qualcomm.com/media/documents/files/how-5g-will-transform-industrial-iot.pdf.

Alsen, D., Patel, M. and Shangkuan, J. (2017) 'The future of connectivity: Enabling the Internet of Things,' McKinsey & Company, (December), pp. 1–13. Available at: https://www.mckinsey.com/global-themes/internet-of-things/our-insights/the-future-of-connectivity-enabling-the-internet-of-things.

Ericsson (2018) 'The guide to capturing the 5G industry digitalization business potential'. Available at: https://www.ericsson.com/link/327ebf21ccce428e81062e1288504936.aspx.

5G Americas (2019) '5G-THE FUTURE OF IOT', p. 368.

MarketsAndMarkets (2019) '5G IoT Market worth $6.3 billion by 2025'. Available at: https://www.marketsandmarkets.com/PressReleases/5g-iot.asp

5G Subscriptions quadrupled https://www.rcrwireless.com/20200402/5g/gsa-5g-subscriptions-quadrupled-in-q4-2019

State of 5G: The Road Ahead - https://www.infosys.com/services/engineering-services/insights/state-of-5g-road-ahead.html

A report produced by GSMA in partnership with KPN (2020) 'Smart Farming: Weed Elimination with 5G Autonomous Robots'. (February 2020), pp. 1-10. Available at: https://www.gsma.com/iot/wp-content/uploads/2020/02/Smart-Farming-weed-elimination-final-for-web-170220.pdf

Inbound Logistics (2019) 'Three ways 5G will benefit the logistics industry', (November 2019). Available at: https://www.inboundlogistics.com/cms/article/three-ways-5g-will-benefit-the-logistics-industry/

SupplyChain247 (2020), 'Logistics Service Providers and the Benefit of 5G Technology', (January 2020). Available at: https://www.supplychain247.com/article/logistics_service_providers_and_the_benefit_of_5g_technology

The Global Smart Mining Market: Growth, Trends and Forecasts (2020-2025). Available at: https://www.globenewswire.com/news-release/2020/01/16/1971226/0/en/The-Global-Smart-Mining-Market-Growth-Trends-and-Forecasts-2020-2025.html

5G and the Factories of the Future. Available at: https://5g-ppp.eu/wp-content/uploads/2014/02/5G-PPP-White-Paper-on-Factories-of-the-Future-Vertical-Sector.pdf

For more information, contact askus@infosys.com

Navigate your next