

5G: A Massive Embedded Wireless Sensor Technology - It's Impact on Cloud Computing & Internet of Things

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Abstract— 5G technology is the fifth generation of cellular mobile communications with revolutionary services like offering faster speeds, negligible latency rate and improved reliability compared to the 4G, 3G and 2G technologies. 5G technology will enable wireless service providers to develop innovative business models, benefiting various sectors like industrial, commercial, educational, healthcare, agriculture, etc. Therefore, 5G seamlessly connect a massive number of embedded sensors with the ability to scale down its data rates, power, and mobility providing extremely low cost connectivity solutions. Internet of Things or IoT, refers to the practice of connecting different devices that can process and exchange data with each other. Cloud computing- a technology that revolutionized data storage, accessibility, and processing – had been waiting for a network powerful enough to unlock its full potential. 5G technology is what elevated Cloud computing and refined data management, business operations, and digital experiences. Therefore, 5G technology amplifies IoT and Cloud computing capabilities to a level we could only dream of a few years ago. This paper illustrates the impact of 5G technology on Cloud computing and Internet of Things (IoT).

Keywords— 5G, Cloud Computing, Internet of Things (IoT), Wireless Communication.

I. INTRODUCTION

5G technology is the fifth generation of cellular mobile communications with revolutionary services like offering faster speeds, negligible latency rate and improved reliability compared to the 4G, 3G and 2G technologies. 5G technology will enable wireless service providers to develop innovative business models, benefiting various sectors like industrial, commercial, educational, healthcare, agriculture, etc. With the arrival of 5G wireless technologies, communication and connection are about to undergo a radical change that will usher in a new age marked by unheard-of speed, low latency, and widespread device connectivity. The influence that 5G networks will have on different technical sectors will become more evident as they expand out internationally. The Internet of Things and cloud computing are two areas where the widespread adoption of 5G is expected to have a substantial impact. The fifth generation of mobile networks, or 5G, is expected to significantly reduce latency and increase data transmission speeds above previous generations. 5G paves the way for revolutionary applications by enabling faster and more responsive connectivity at peak rates of several gigabits per second and reducing latency to a few milliseconds. The enhanced speed and bandwidth of 5G help to optimize cloud

infrastructure. Faster data transfer between end users and cloud servers improves user experience overall and makes it possible for resource-intensive apps like virtual reality (VR) and augmented reality (AR) to function more smoothly. 5G offers greater data speeds that are advantageous for cloud-based apps that need a lot of capacity, such as streaming HD video. This improves multimedia content delivery via cloud services. The goal of a fully connected and intelligent society is made easier by 5G's capacity to accommodate a vast number of IoT devices per unit area. This creates new opportunities for IoT applications that depend on uninterrupted communication, such as industrial automation, smart cities, and others. 5G's reduced latency is essential for real-time Internet of Things applications like smart grids, remote healthcare monitoring, and driverless cars. The overall stability of IoT systems is improved and more prompt decision-making is made possible by the decreased data transfer latency. Energy-efficient IoT devices can use 5G because of its energy-saving measures built into its architecture. This is essential for encouraging sustainability in the IoT ecosystem and prolonging the life of battery-powered IoT devices. Therefore, This paper illustrates the impact of 5G technology on Cloud computing and Internet of Things (IoT).

II. RELATED WORK

Combining 5G and IoT would also make it easier to get every product online and off the shelves. Consumer goods can transmit and receive data about themselves as linked smart products based on event-driven encounters with customers and other entities through scanning, RFID readers, NFC tags, and more. As hardware, they do not need to be constantly connected to the Internet. Although there are now too many network devices for the present wireless infrastructure to handle, 5G will make it feasible. Retailers may employ digital labels and smart packaging to engage with customers in new and inventive ways while also revolutionizing the way they handle inventory and logistics [3]. What is truly possible with IoT is limited by 4G's inability to handle the data load from the 132 M. constantly growing number of online sensors and linked devices. With its fast data speeds, low latency, enhanced mobility, low energy consumption, cost-effectiveness, and capacity for many bigger devices, 5G is the perfect platform to support the Internet of Things. In addition to revolutionizing communication, 5G has the potential to significantly alter business and society. There are several businesses where 5G

and IoT together might cause disruptions, including:

Self-driving cars: A lot of data is produced by sensors on temperature, traffic, weather, GPS location, and other factors. For the best services, these automobiles also rely a lot on real-time information transfer. However, because of its fast transmission and low latency, this intelligent care will be able to continuously gather a variety of data, including crucial data that will be used by algorithms to monitor the vehicle's performance and inform future design decisions.

Healthcare: Since IoT powers many kinds of medical equipment, the industry will see changes in the services provided by these devices. The Internet of Things connection will be very helpful in rural regions and other comparable remote places, even in the absence of adequate healthcare infrastructure. It becomes possible to offer top-notch medical services, including remote surgery, with such low latency [4]. With the use of sophisticated IoT monitoring sensors, 5G networking will enhance end-to-end logistical operations. Not only may real-time data access be facilitated by high speeds and low latency, but energy efficiency can also produce a wider range of information at all stages of a supply chain over an extended period of time. A buyer would be able to view specific details like the location of the fish's capture, the processing temperature, and the time it was delivered to the vendor.

Smart cities: 5G will enable more applications, such as improved health care facilities, traffic control, water and waste management, and smart city initiatives. The advantages of the new generation network will accrue to smart cities as an increasing number of devices. The ideal of a fully linked city will get closer thanks to 5G's ability to manage the enormous data load and enable the integration of many smart systems that communicate with one another continuously [5].

Retail: The introduction of 5G will benefit retail IoT as they work to mold client interaction and experience through mobile phones. With more network connectivity and a greater number of network connected devices, new and creative methods of interacting with customers might be implemented more quickly through improved digital signage. It will gain popularity as virtual reality and augmented reality grow. Retailers who employ Omni channel sales activities more effectively will be able to improve the purchasing experience.

Automotive: One of the primary applications of 5G is the connection of automobiles to VR and AR. Improved automotive communication Direct vehicle-to-pedestrian and vehicle-to-infrastructure connectivity, as well as network-friendly autonomous driving, are among the ways that the Internet of Things (IoT) may impact 5G [133]. Supported use cases would focus on the comfort and safety of the car and include route planning, organized driving, real-time purpose communication, and community updates.

Industrial: We would also offer a very safe network for industrial IoT by integrating 5G security into the core network design. 5G's Effect on IoT Disconnected networks are one of the biggest problems facing IoT technology today. This problem will be immediately resolved and the administration of linked devices will be made simpler by 5G's ability to transfer data more quickly and support more connections. On the other hand, 5G will be able to process data faster over 4G/LTE networks, which has presented difficulties for Internet of Things solutions. As a result, there was a significant lag between when the data was sent and when it arrived. Everyone will be able to recognize the benefits of IoT technology thanks to 5G connection. IoT has a lot of potential right now, but 5G technology will be needed for

true networking to take off. There are countless ramifications for both individuals and municipalities. The "smart" city is already a reality that will benefit local companies and citizens alike [6]. Businesses that engage in IoT technology or develop IoT-based platforms will be able to achieve many of the necessary standards thanks to 5G. More individuals can send more data at once because to quicker connections, lower latency, and better connectivity. IoT solutions will therefore enable businesses to expand continuously without having to worry about the disjointed networks that have hampered IoT advancements thus far. 5G makes it easier to create Internet of Things apps that benefit everyone. IoT will have greater opportunities to grow in terms of capabilities, services, and dependability when new development resources, like as 5G, become available. As stated by Statista, by 2020, it is anticipated that there will be close to 31 billion Internet of Things devices deployed globally. The following elements are necessary to create a 5G-IoT ecosystem:

Automatic power supply: While cables and batteries are now a workable IoT power source, when the sheer number of IoT grows globally, it will be practically hard to keep up. In addition to decreasing income, a dead or malfunctioning battery can raise security and liability issues for M2M, factory automation, and Internet of Things sensors. It's crucial to have wireless power that works beyond range and without pads. [134].

Implementers, integrators, and innovators: It is evident that 5G deployment is costly. For businesses to fully reap the benefits in a safe and secure manner, they require both personnel and a short- and long-term growth strategy [7]. An initiative for electronic recycling our work equipment and household appliances are often kept for many years. The current generation of "non-smart" equipment will soon become outdated and require recycling or up cycling due to the availability of 5G and a continuous and automated wireless power supply for IoT sensors. Industries and cultures that don't make the necessary preparations for this might potentially pose a hazard to the environment [8].

III. 5G TECHNOLOGY

5G technology is the fifth generation of cellular mobile communications with revolutionary services like offering faster speeds, negligible latency rate and improved reliability compared to the 4G, 3G and 2G technologies. 5G technology will enable wireless service providers to develop innovative business models, benefiting various sectors like industrial, commercial, educational, healthcare, agriculture, etc. With the arrival of 5G wireless technologies, communication and connection are about to undergo a radical change that will usher in a new age marked by unheard-of speed, low latency, and widespread device connectivity.

5G services were launched in India in October 2022. The 5G network has been rolled out in all 28 states and 8 UTs now. This is one of the fastest 5G rollouts in the world. As of October 2023, the number of 5G users now stands at over 100 million.

- According to the **Ericsson Mobility Report**, by the end of 2028, there will be **700 million 5G users in India**.
- **5G services** are also expected to play a major role in achieving the economic goal of making India a \$5 trillion economy by 2024-25.

- **Promoting Digital India:** Fast and reliable mobile communication technologies provided by 5G are helping the government realize the objectives of the Digital India programme by empowering citizens through services like **Unified Payment Interface (UPI)**.
- **BharatNet Phase-III:** It aims to provide broadband connectivity to all gram panchayats (village councils) in the country, with the ultimate goal of connecting every village in India to the internet.
 - 5G and BharatNet will together have 1.2 billion internet users, making India the single largest connected nation.

The following are the several steps for the 5G rollout in India taken by the government:

- **5G High-Level Forum:** It was set up in 2017 to articulate the vision for 5G in India and to recommend policy initiatives & action plans to realize this vision.
- **‘Indigenous 5G test bed’:** This three-year program began in March 2018 to build proof-of-concept 5G prototypes that are broadly compliant with the 3GPP standards.
 - The Department of Telecommunications (DoT) has offered the usage of 5G test beds free of cost to the Start-ups and MSMEs recognised by the Government of India up to January 2024.
- **The National Digital Communication Policy-2018:** It envisages the following with respect to the rollout of 5G services:
 - Enabling high-speed internet, the Internet of Things, through the rollout of 5G technologies
 - Implementing an action plan for the rollout
 - Ensuring availability of spectrum for 5G in 6 GHz bands
 - Reviewing industry practices with respect to traffic prioritization to provide 5G-enabled applications and services

Challenges for 5G Rollout in India:

- **Lack of infrastructure:** To have ubiquitous 5G network connectivity in India, it is important to enable the use of **street infrastructure** for hoisting small cells, deployment of in-building solutions, and fabrication of towers.
- **5G standards:** A variant of the global standard for 5G (3GPP- **3rd Generation Partnership Project**) has been developed in India, known as **Telecommunications Standards Development Society, India** (TSDSI)’s Radio Interface Technology (TDSI-RIT).
 - **TDSI-RIT** improves rural coverage while lowering costs to cover a specific, defined area. As TDSI-RIT standards are not globally harmonised this could lead to increased costs for network and customer devices and interoperability issues.
- **Low tower fiberization:** India’s low tower

fiberization is hampering the ambitious 5G deployment, which has not yet reached the halfway level against a goal of 70% by 2024.

- **Setting up of 5G use case labs:** Telcos are struggling to develop relevant use cases, besides faster speeds, for wider adoption and monetisation.

A. Evolution from 1G to 5G Technology:

Table 1: Illustrates Evolution of Wireless technologies 1G to 5G

1G	- It was the first wireless telecom network system introduced in the 1980s. - Early devices like “brick phones” and “bag phones” operated on 1G technology.
2G	- Launched in the 1990s, 2G represented a shift from analogue to digital cell phones.
3G	- The 3G came with the new Wireless Code-Division Multiple Access (CDMA) technology. - Introduced in the 2000s and provides mobile phones with broadband-speed internet access. - Further development led to the creation of 3.5G; Speed- up to 7.2 MBPS.
4G	- The 4G, was launched in 2009 globally (India 2012). - LTE (Long-Term Evolution) is a fourth-generation (4G) wireless standard that provides increased network capacity and speed. <ul style="list-style-type: none"> • LTE is also called 3.95G and has been marketed as 4G LTE and Advanced 4G. - VoLTE (Voice over Long-Term Evolution) allowed voice calls via the 4G network, supporting simultaneous voice and data services. - Speed: Upto 1 Gbps.
5G	- 5G, the 5th Generation Mobile technology, revolutionised the use of cell phones with its high bandwidth capabilities. - The network utilises advanced technologies to deliver ultra-fast internet and enhanced multimedia experiences. - It supports a virtual private network and offers high resolution in cell phones. - It also provides subscriber supervision tools for fast action.

B. Different Bands of 5G

A **band** refers to a specific range of frequencies in the **electromagnetic frequency spectrum** assigned to certain applications. There are essentially **three types of 5G bands** supported in India.

- **Low-band 5G** transmits around the **600 to 700 MHz** range, providing blanket coverage but offering slow speeds around 50 Mbps.
- **Mid-band 5G** transmits around **1.7 GHz to 2.5 GHz**, offering a solid balance between coverage and speed (**100-900 Mbps**).
- **High-band 5G** operates at **24 GHz or higher**, providing the fastest speeds (**1 Gbps speeds**) over short distances.

IV. THE IMPACT OF 5G TECHNOLOGY ON THE SOCIETY

The impact of 5G technology on society is the way it will transform the Internet of Things (IoT). IoT refers to the growing network of connected devices that communicate with each other, including smart homes, smart cities, and wearable devices. With 5G networks, these devices can communicate with each other faster and more reliably, enabling new and innovative applications such as autonomous vehicles, smart cities, and wearable devices.

5G technology also has the potential to change the way we work. With the increased speed and reliability of 5G networks, it will be possible to work from anywhere, at any time, with the same level of productivity as in the office. This could lead to a more flexible and efficient workforce, as well as new opportunities for remote work and telecommuting.

In addition, 5G technology has the potential to improve healthcare and make it more accessible. With 5G networks, medical professionals will be able to access patient data and communicate with each other in real-time, making it possible to provide better care and faster diagnoses. Additionally, 5G networks can be used to connect remote patient monitoring devices, making it possible to provide care to patients in remote and underserved areas.

Finally, 5G technology will also have a significant impact on entertainment. With 5G networks, users will be able to stream high-quality video, play online games, and access virtual and augmented reality experiences with ease. This will lead to a more immersive and interactive entertainment experience, enabling new and innovative forms of storytelling and entertainment.

V. THE IMPACT OF 5G ON THE INTERNET OF THINGS

These 5G will provide a faster communication medium; you can expect speeds up to a few gigabits per second. As a result, your devices can coordinate and accomplish tasks faster. In addition, it will provide an ultra-low latency network; according to Verizon, early 5G deployment showed a latency of 30 ms. That will help use IoT devices to do delicate tasks such as surgery. Finally, because 5G has a high bandwidth, we can connect more devices to it without experiencing quality loss.

A. IoT Challenges in 5G

5G will indeed have an enormous impact on how industries work. However, there are many challenges that researchers need to address before fully implementing them.

1. As 5G technology uses short waves, you need towers close to each other. That means you need more cellular towers for a 5G network.
2. Because many 5G components will be virtual, there are increased security risks. Additionally, the increase in users in a network will need more drastic security measures.
3. The cost of implementing new network devices will be immense. You require more equipment, and these must support high-frequency band operation. However, you may reduce these costs if vendors share hardware.

B. 5G Internet of Things Applications

5G and IoT will have a lot of applications:

- People can use a 5G IoT network to park their cars without going to a parking spot. Similarly, we can directly summon it.
- Farmers can use the IoT network to monitor crops and livestock and control equipment remotely.
- Doctors can perform surgeries remotely with low latency equipment.
- The low latency can also improve your entertainment. For example, we would be able to play games without installing them.
- People can monitor and maintain their houses while they are at work. For example, we can track our robot vacuum cleaner while working in the office.

Currently, the world has over fourteen billion IoT devices. These devices have a significant impact on our economy. The IoT applications have improved the standard of living. Home automation gives people more time to focus on their jobs. They can do chores quickly. For example, consider an automatic vacuum cleaner programmed to clean houses at a specific interval. People no longer have to spend their valuable time doing that. That can make them more productive.

VI. THE IMPACT OF 5G ON CLOUD COMPUTING

A. The Evolution of Cloud Computing

Cloud computing is a transformative technology that has reshaped the way businesses and individuals interact with digital resources. It is the on-demand availability of computing resources like storage, infrastructure, and software services over the internet. This model offers immense flexibility, scalability, and cost-effectiveness, eliminating the need to buy and manage physical servers and data centers. Organizations can choose from various service models like Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) based on their specific needs and objectives.

As a segment of IT services, cloud computing was expected to generate over \$400 billion in revenue in 2022. Despite this meteoric rise, the full capabilities of cloud computing have yet to be unlocked.

While 4G and 4G LTE offered substantial improvements in speed and data capabilities, they fell short in providing the ultra-low latency and massive data handling capabilities required to unlock the full potential of cloud computing. The advent of 5G technology brings the promise of a network designed to elevate cloud computing to a whole new level.

The following is about that how 5G Impact on Cloud Computing:

While the symbiosis between the two technologies is multi-faceted, the interaction can be boiled down to some key attributes. Each of these aspects sets the stage for an unprecedented era of digital innovation.

1. Speed and Latency

One of the most significant benefits of 5G technology is its ability to drastically reduce latency. In cloud computing, latency refers to the time it takes for a request from a device

to travel to the server and back. 5G technology promises to reduce this time lag significantly, thereby enabling real-time interactions with cloud-hosted applications. This is especially beneficial in scenarios demanding immediate responses, such as autonomous vehicles, telemedicine, and real-time data analytics.

Faster data transfer rates allow for quicker upload and download of data to and from the cloud. This is vital for applications that require instantaneous data access or have to transfer large sets of data.

Take the example of a healthcare organization that relies heavily on medical imaging like MRI, CT scans, and X-rays. These images are both high-resolution and data-intensive. Uploading these images to the cloud using 4G technology would take considerable time, potentially delaying diagnoses and treatments. With 5G's faster data transfer capabilities, these medical images can be uploaded to the cloud in mere seconds. This swiftness allows radiologists and medical experts to access the images almost instantly, enabling quicker diagnoses and immediate commencement of treatment protocols.

2. Scalability

The introduction of 5G technology dramatically amplifies the scalability of cloud computing platforms, a pivotal feature for the expanding IoT ecosystem. For instance, a smart city project that relies on thousands of sensors to collect data on everything from traffic patterns to air quality can now manage and process this data more efficiently. With 5G's ability to connect exponentially more devices simultaneously, the cloud can handle larger data sets and enable more dynamic resource allocation. This means the city's management can gain real-time insights into various metrics, thereby making timely and informed decisions.

This increased scalability provided by 5G will make existing operations more efficient, opening the door for new applications and services previously constrained by connectivity and data-handling limitations.

3. Flexibility

5G also brings about a new level of flexibility in cloud services. The higher speeds and lower latency offer businesses the adaptability they need to meet evolving demands. With quicker data transfer and real-time analytics, companies can be more agile, adapting their services without worrying about network limitations.

Let's take the example of a healthcare organization that utilizes cloud-based telemedicine platforms to serve patients in remote locations. With 5G's higher speeds and lower latency, the organization can now offer more robust and responsive services, such as real-time video consultations and remote monitoring of patient vitals. This new level of flexibility allows the healthcare provider to adapt more quickly to changing needs, whether that's scaling up to handle a surge in patient queries or integrating new diagnostic tools.

Just as 5G's increased scalability improves existing operations and opens doors for new possibilities, its enhanced flexibility also allows for dynamic resource allocation and automation in the cloud, thereby meeting the evolving demands of businesses and consumers alike.

4. Security and Data Protection

In a digital world where cyber threats are continually evolving, ensuring data security is paramount. 5G technology comes with robust built-in security protocols that offer an extra layer of protection when data is being transferred to and from the cloud.

Traditionally, the slight lag in detecting security breaches provided enough time for cyber-criminals to infiltrate a system and cause considerable damage. 5G's real-time analytics capabilities allow for quicker threat identification and faster response times, thus mitigating risks more efficiently.

Imagine a financial institution that handles sensitive customer data and high-value transactions. With cloud storage and computing becoming the backbone of such organizations, the integration of 5G can bolster encryption protocols and enhance identity verification processes, thereby reducing the risk of data breaches. This protects the institution from potential legal repercussions, while also helping build trust among its customer base.

5G's network slicing feature also contributes to enhanced security. This function allows operators to create multiple virtual networks within a single physical 5G network, enabling better isolation of data and services. For example, a hospital could have one network slice dedicated solely to patient data, another for administrative tasks, and yet another for medical devices. By segregating these slices, even if one aspect of the network were compromised, the integrity of the others could remain intact, offering an additional layer of security.

Therefore, in an era where data is the new currency and connectivity the new norm, staying ahead requires embracing cutting-edge technologies like Cloud Computing. As 5G rolls out, it's vital to assess how it can synergize with our existing or planned cloud infrastructure.

VII. CONCLUSION

5G technology is the fifth generation of cellular mobile communications with revolutionary services like offering faster speeds, negligible latency rate and improved reliability compared to the 4G, 3G and 2G technologies. In conclusion, 5G technology is set to have a profound impact on society, Internet of Things (IoT) and on Cloud Computing by offering faster and more reliable communication, transforming the IoT & Cloud Computing by changing the way we work, improving sectors like industrial, commercial, educational, healthcare, agriculture, revolutionizing entertainment etc. As 5G networks continue to roll out, it is likely that we will see even more exciting and innovative applications in the future.

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