A PRIMER ON INDUSTRIAL IOT AND 5G: IMPLICATIONS AND CHALLENGES

Abstract

By enabling high-speed connectivity for everything, everywhere, 5G is predicted to change every aspect of existence. By connecting everything and everyone with IoT devices, the recently developed 5G technology has altered the phenomenon of life as we know it. Everything from traditional to smart has been altered by 5G enabled IIoT devices, for example. The need for high-speed communication and flexibility are some of the key factors that have made the Industrial Internet of Things (IIoT) a compelling technology. The availability of 5G mobile technology can help address these needs. The approach of this study includes a review of the state-of-the-art, comparison of the findings and the formulation of conclusions as lessons learned from the existing research works. In other words, this chapter aims to provide a comprehensive overview of the current state of research and solutions related to the IIoT, and 5G applications considering the original requirements and promises of these technologies.

Keywords: Industrial IoT, 5G

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I. INTRODUCTION

Internet of Things (IoT) is a system that connects physical entities and devices including computers, networks, machines, sensors, etc. with an ability to exchange data with little or no human intervention. Across the globe, many organizations in their pursuit of digital transformation, have started implementing IoT for staying in their business against other business competitors. IoT plays a major role in transforming the way the manufacturing and production processes are managed. By connecting sensors and other devices, the entire business activities are carried out using a new set of technical possibilities that increases productivity considerably.

Industrial processes involve multiple steps and procedures that help in manufacturing. IoT enables connecting and exchanging data among multiple devices that results in better integration of processes and their control. IoT refers to the use of IoT Technologies in the industry sector for its operations. By harnessing IoT, industrial operations and processes not only improve productivity but also enhance operational efficiency at minimal operating costs. Market trends, global competition, and ever-changing customer expectations are a few factors influencing the use of IoT, in particular in the manufacturing industry. IoT with its inherent potential enables industries to automate, optimize and control the environment with ease.

IoT seen as a breakthrough in manufacturing industry apart from promising great productivity gains, aims at reducing wastage thereby improving the efficiency of the manufacturing operations. Efficient uses of resources, embedding sensors to monitor and trace the damage at the earliest to mitigate the after-effects of the same are few benefits we get through IIoT. To take this advantage, what is required is a significant increase in data transfer speeds among the various things or the devices in IoT.

5G technology is a global wireless standard for broadband cellular networks. In comparison with 4G LTE networks, 5G offers higher speed, lower latency, and more capacity. Hence, 5G offers its clients access to more information faster and also businesses take advantage of such high connectivity benefits. As the number of connected IoT devices keeps increasing, the demand for bandwidth required for access and analysis is also increasing, which in turn is expected to be met by the 5G networks. It is imperative for the industries to gain an advantage from the combined 5G and IoT technologies for competing in the global market.

There is an exponential rise in the data collected from IoT devices whose storage and access challenges are addressed by the cloud. 5G supports distributed access concept which is a key advantage the cloud services can get through it. IoT being a vital component of Industry 4.0 focuses on smart manufacturing and supply chain management using smart digital technology such as machine learning, big data, etc. By adopting 5G enabled IoT practices, undoubtedly the industries get their reliability and communication requirements satisfied while there are few implications and challenges in the same.

There are several benefits of 5G for IoT. By 2035, the switch to 5G, according to Qualcomm, will increase the global GDP by $3 trillion and generate 22 million new employment. Without a doubt, 5G has a lot of potential for Industry 4.0. IoT and 5G convergence in manufacturing will give manufacturers more flexibility and agility in their digital transformation. By combining these technologies, businesses may achieve their vision of Industry 4.0 and create a win-win scenario that maximises consumer happiness and returns on investment. Some of the important advantages of using 5G for industrial IoT are as follows.

1. Preventive maintenance: Research indicates that industrial businesses lose $50 billion annually as a result of unscheduled downtime. IoT capabilities will improve the operational intelligence necessary for smart manufacturing by connecting sensors over 5G to obtain real-time information on equipment performance. The data can aid in predicting and preventing crucial equipment malfunction when integrated with machine learning (ML) and artificial intelligence (AI).

2. Improved process efficiency and troubleshooting: 5G makes it possible for shop floors to have superior and improved process efficiencies. For instance, using deep learning neural networks and advanced vision recognition, robotic systems may accurately and quickly visually check objects connected through 5G networks for quality control purposes. Specialized equipment can be fixed remotely by an expert using augmented reality (AR), made possible by 5G networks' capabilities for high bandwidth and low latency.

3. Increased security with built-in security features: In addition to supporting a more dependable network, 5G will also provide enhanced security with built-in security features, integrating security into the core network architecture and allaying manufacturers' security worries about embracing IoT.

4. Superior facilities for tracking employees and production: With the help of 5G wireless technology, employees may move about the facility with ease, even outside the boundaries of the buildings, making asset and logistics tracking simple. Secure wireless accessibility makes it simple to track and integrate logistics tracking data for both inbound and outbound freight. Through third-party integration, this can be expanded to include supply chain management tracking outside of the plant perimeter. With 5G wireless connectivity, monitoring employee movement and ensuring workplace safety across the facility is also made simpler.

This chapter is organized as follows: first, a background for the integration of IIoT with 5G and its impact on the industrial processes and operations is presented. Secure data storage and management apart from other challenges of 5G-enabled IIoT are discussed in the subsequent sections followed by future directions.

II. BACKGROUND AND RELATED WORK

Several new prospects are brought about by the quick progress of 5G standardization including augmented reality (AR), eHealth, telepresence, and the IoT. The IoT is one of those, in our opinion, that stands to gain the most from the positioning capabilities of 5G networks, as position data may aid in process automation and optimization across a variety of vertical industries, from mining and transportation to logistics and manufacturing. The IIoT is generally understood to be divided into three primary categories: industrial control, factory automation, and process automation.

The Industrial Internet of Things (IoT) is a technology that enables the sharing of data and automation in the manufacturing industry. Highly digitized and connected production facilities in an industry are termed as 'smart factories' which are developed and driven by IIoT technologies. Such physical and computer components constitute cyber-physical systems in a smart factory and are used to monitor physical processes, and reproduce the actual environment virtually. The cyber-physical systems are used to collect, process, and feedback data from various industrial endpoints.

IoT is not just for manufacturing, but also has a wide range of applications including building project operations as detailed in [2]. The construction domain framework proposed in this paper intends to identify and debate the obstacles brought in by connectivity issues dominated by the influence of 5G technology. The cyber-physical systems are a vital part of the Industrial Internet of Things (IoT). They collect, process, and store data. That paper presents a case study that explores the potential of 5G technology to improve the efficiency of industrial IoT.

The three basic categories in information security often referred to as CIA (Confidentiality, Integrity, and Authenticity), are applicable for a majority of applications. However, the security requirements of each of these categories are no longer applicable to IoT and in particular to IoT. With changing times, the CIA triad is no longer sufficient to confront emerging security concerns. Although more industrial IoT applications are emerging, IoT systems still lack a standardised broad layered structure. As mentioned in [3], the conventional strategy frequently uses three layers: the physical layer, the network layer, and the application layer.

The manufacturing sector has undergone an unprecedented dramatic change over the past ten years, and smart manufacturing has garnered a lot of attention. This is due to the permeation and applications of advanced technologies in manufacturing, such as big data, Internet-of-Things (IoT), cloud computing, edge computing, digital twin, advanced sensing technology, and service-oriented technology [16]. At the same time, a number of national or advanced manufacturing modes have been proposed, including Industrial 4.0, Made in China 2025, the US National Strategic Plan for Advanced Manufacturing, American Industrial Internet, and Cloud Manufacturing.

The development of mobile networks has thus far been able to meet the rising demands for improved performance, availability, portability, elasticity, and energy efficiency posed by the continuously expanding network services. According to evolution, 5G represents the following generation of mobile networks, which also promises to deliver outstanding performance enhancements as well as the development of new value chains. Parallel to 5G, the Internet of Things (IoT) has arisen as a new paradigm for connecting heterogeneous, large-scale smart objects with communication capabilities. IoT's potential application areas and scope are expected to grow with 5G. However, given that existing mobile networks and more general IoT systems are based on centralised models, it is projected that they would encounter enormous problems in order to satisfy the demands of upcoming 5G-enabled-IoT use cases.

Decentralized applications built on the IIoT platform's blockchain are intended to automate the creation of end-to-end manufacturing services. Users can control their production processes via smart contracts. The operation of IIoT-based businesses depends on these services.

The IoT platform uses a blockchain to create decentralized applications that are designed to automate the production of end-to-end manufacturing services. Through smart contracts, users can manage their manufacturing operations. These services are necessary for the operations of IoT-based businesses.

III. IMPLICATIONS

An IoT system is a composition of five major subsystems namely, sensors/devices, network connectivity, data management, a user interface, and a cloud environment. A cloud environment supports various IoT devices and applications with infrastructure, storage, and processing capabilities [16]. Further, the cloud ensures security aspects with appropriate authentication and encryption protocols.

IoT is ascending as the number of connected devices is set to increase from 700 million to 3.2 billion by 2023. Current networks lack the bandwidth to support the anticipated exponential growth. One of the vital factors adding to this rise is the evolution of 5G networks. The launch of 5G aids in performance improvement in terms of data transfer speed and reliability of connected devices, especially for connected devices like locks, security cameras and other monitoring systems which depend on real-time data updates.

There is expected to be a substantial improvement in smart manufacturing in IoT abilities by interfacing sensors on 5G to acquire real-time data about hardware execution [8]. When IIoT gets enhanced with machine learning and artificial intelligence, the information can be predicted, thereby avoiding critical equipment crashes. Further, particular hardware can be fixed through Augmented Reality support from remote experts empowered by high data transmission and low latency support of 5G.

Large amounts of data will be generated as a result of the deployment of applying IoT in power systems and is fundamental to understanding the association among various IoT devices [9]. For this scenario, 5G is giving considerable benefits to Power IoT (PIoT) with better opportunities. With IoT [10], there is greater energy efficiency, reduced costs, better quality products, less hardware downtime and also significant improvement in decision making.

Despite meeting the necessary expectations, the security architectures currently being employed for mobile networks and general IoT systems are centralized [17] [18] [19]. For 5G and 5G-enabled IoT applications, using such centralized security solutions will present a number of challenges, including higher costs because of inherent heterogeneity, complicated and static security management processes, excessive network resource use, the development of a network bottleneck, single points of failure, high OPEX, etc. As a result, centralised security solutions are not only unable to keep up with demand, but also have a negative impact on the future of 5G and IoT.

IV. CHALLENGES

With 5G, data transfer speeds will be faster than ever and thus increase efficiency and reliability. However, there are challenges in the adoption of IOT such as failure to align key performance indicators with clear business objectives, improper organizational alignment, and IoT security threats [10]. As modern IoT gadgets go on the web and industrial facilities further mechanize various tasks, whole production lines may be adversely impacted in the event that a solitary sort of sensor becomes helpless against cyberattacks [11]. A modern Denial-of-Service (DoS) attack on such gadgets could impact and disrupt the entire system. There is a need for the developers to offer proper support and handle administration issues arising from such vulnerabilities.

Lots of challenges exist in IoT as well as IoT [12]. Authentication, identification, and device heterogeneity are the security and privacy concerns in IoT. The major challenges are integrity, scalability, ethical communication mechanism, and business surveillance. In IIOT, as the devices are always turned on, they are visible to hackers leading to cyber vulnerability. In addition, there are no strong passwords and security protocols used. Outdated common code libraries are used and the firmware generally becomes obsolete.

There are deficiencies in the existing security patterns and testing of security pattern architectures [13]. Smart industries demand connectivity and interoperability to improve their performance which makes them vulnerable to attacks. The research work in [14] proposes an IoT attack taxonomy that aids in reducing the risks of such attacks.

V. FUTURE DIRECTIONS

There is a need for security, consistency, and accuracy in IoT. 2G and 3G networks are becoming obsolete while 4G to a certain extent supports HD video streaming and fast web browsing. 5G solves issues and challenges faced by smartphones and other smart technologies. 5G results in better performance as it uses a wide range of frequencies when it comes to connectivity. However, there are challenges in IoT and IIOT and there are blockchain-based solutions to counter these challenges.

5G and IoT are the two vital components for transforming how cities connect and operate. With IoT’s boundless potential and 5G’s faster speeds and low latency, these technologies leverage critical infrastructure for the future of connected communities. Nevertheless, scalability issues arising while building a design infrastructure to develop new applications enabled by 5G are still a concern [15].

IoT devices and 5G networks combined together are anticipated to intelligently detect and control traffic flows, keeping an eye on the state of the roads to ease traffic congestion. The use of connected devices in cities and buildings to track, monitor, and manage energy is greatly facilitated by 5G.

The world's business, industries, and services are being significantly impacted by the emergence of disruptive technologies including artificial intelligence (AI), fifth-generation (5G) communication standards, blockchain, and the Industrial Internet of Things (IoT). By combining AI, IoT, and 5G technologies with blockchain to create intelligent and potent systems, the full potential of these technologies may be achieved. Intelligent and efficient interactions between machines, computers, and humans are made possible by IoT technology. Blockchain technology is a decentralised network that enables safe online transfers from sender to receiver without the involvement of a third party. Super connection for billions of businessesIIoT devices is made possible by 5G technology.

As we move forward, 6G (sixth-generation wireless) is the successor to 5G cellular technology. In the future, 6G networks will be able to utilize higher frequencies than 5G networks and provide substantially higher capacity and much lower latency for various applications

VI. CONCLUSION

IoT devices engaged in industrial operations are vulnerable to cyberattacks which may create gaps in the overall manufacturing process and sometimes result in catastrophic effects on the rest of the system. Further, data management for 5G networks and dependency on the cloud are critical for the effectiveness of IoT-enabled industrial needs. These challenges when addressed will definitely aid IoT to take full advantage of the emerging 5G network technologies.

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