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# The Industrial Internet of Things (IIoT) and its roles in the Fourth Industrial Revolution: A review

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**Abstract**

The Industrial Internet of Things and Industry 4.0 are now two highly sought-after areas of research and development, attracting significant interest from both academic and industrial sectors. The two ideas, Industry 4.0 and IIoT, share significant similarities, with Industry 4.0 being seen as the use of IIoT specifically in the automation and manufacturing sectors. Within the framework of the present Industry 4.0 paradigm, many growth pathways have emerged, collectively leading to notable enhancements in terms of efficiency, flexibility, communication, adaptability, customization, and modularity in the industrial sector. The Industry 4.0 is rapidly evolving within the framework of the Industrial Internet of Things (IIoT), and the authors are recognizing the necessity for a comprehensive and in-depth overview of the many research areas that are currently expanding. The area will remain intriguing in the foreseeable future due to its significant potential for enhancing the existing industrial technologies. An exhaustive evaluation of the current systems in the automotive sector, emergency response, and chain management on IIoT has been conducted, revealing that IIoT has been widely adopted across several technological domains. Industry 4.0 is the term used to describe the present automation and data sharing trend in businesses. Presently, there is a dearth of agreement about the assessment of an organization's readiness for Industry 4.0. Industry 4.0 encompasses a diverse array of digital technologies that profoundly influence industrial enterprises. The literature on Industry 4.0 has had significant exponential growth during the previous decade. The results of our research confirm the idea of Industry 4.0 as a concept that goes beyond the Smart Manufacturing sector, hence opening up possibilities for collaboration with other interconnected disciplines.

 

## A. Introduction

In the 21st century, we are propelled by the Fourth Industrial Revolution, commonly referred to as Industry 4.0 [1, 2,3], [4], [5], [6,7, 8]. This is an effort that originated in Germany with the aim of effectively automating industrial systems [9], The worldwide upswing is being driven by the fourth industrial revolution, which is defined by the Industrial Internet of Things (IIoT) [10], [11,12,13], [14], IoT gadgets in our everyday lives are interconnected to exchange information autonomously, without requiring human intervention [15], [16,17,18], These gadgets may utilize the internet to gather and share essential data with one another, enabling them to operate correctly. For instance, the energy supply industries are witnessing the rise of Smart Grids, while the healthcare industry is developing solutions for Smart Health. From an industrial standpoint, this technical advancement is sometimes referred to as Industry 4.0.

The objective of Industry 4.0 is to integrate digital technology into the industrial sector and establish global digital connectivity. The notion of Industry 4.0 may be seen as a comprehensive Industrial Revolution that has the capacity to yield significant advantages and revolutionize the lives of individuals across all sectors. The concept of industry 4.0 is closely associated with the Industrial Internet of Things (IIoT) since both emphasize intelligent connectivity among different industrial components. The concept of IIoT is derived from the well-established Internet of Things concept, and its applications continue to grow [19], [20], [21]. Industry 4.0 is a methodical shift from a predominantly machine-based production process to one that revolves around digital technologies. In order to achieve a successful transition, it is important to possess a thorough comprehension of the Industry 4.0 standard and formulate and implement a meticulous roadmap [22,23].

The Industrial Internet of Things (IIoT) provides concrete and immediate benefits to enterprises of all types. Predictive maintenance entails the ongoing surveillance of asset condition to proactively predict and prevent any potential issues. An further practical advantage, relevant to both end-users and OEMs, is the capability to remotely monitor assets. This enables the assessment of whether production is meeting expectations or if the asset is being underused and has untapped potential. The third advantage is provided by the Digital Twin, which is the digital depiction of an item, its behavior, and its integration into the operational environment. The concept of a "digital twin" enables the assessment of whether the actual performance of assets aligns with expectations or the identification of causes for any deviations by comparing the physical asset with its digital representation.

## B. Literature Review

The word I4.0 originated in 2011 to strengthen industrial output, namely under the German phrase Industry 4.0. In [19]. The author that the IoT has been proposed to revolutionize the essential requirements of connection, particularly in terms of extended battery life, cost-effectiveness, and the expansion of its applications to a vast number of devices. Based on these specifications, Several cellular and non-cellular low-power wide area network (LPWAN) technologies are now emerging and competing in the IoT business to offer extensive connectivity.

In [21] The job points during rendering might be further specified by utilizing units that require assistance. They just expanded the infrastructure for sensor networks, which often do not require internet connectivity. The framework provides the possibility of extending current results to another type of units by offering a module for translating and changing data from a transducer electronic data sheet (TEDS), thereby facilitating standardization. Accessing the information may be achieved by utilizing a Modbus wrapper.

The author in [22] created a gadget that collects data from its environment using sensors and, based on this information, takes actions on its surroundings using actuators. while in [10][11] The development of the Internet of Things is progressing. The potential for additional advancements may be assessed using relevant engineering approaches and concepts. Some examples of advanced technologies are cloud computing, the future Internet, big data, and mechanical technology.

In [23] the author mentioned that the Internet of Things (IoT) is propelled by significant growth in the range and variety of sensor technology and equipment. The necessary components for creating a powered system are sensors, instrumentation, control electronics, information logging, and transmission units, which encompass sensing frameworks. Traditionally, electrical power is often provided through the use of batteries or electric lines. The unique optional method for controlling the supply may be implemented using the fiber (PoF) approach.

In [24] suggested an analysis of the enhancement of printed sensors using flexible polymeric foil for RFID applications. The initial iterations of sensors used for surveillance are categorized into several types of products, such as intelligent labels and RFID tags. This engineering has the potential to introduce sensors to locations where there are now no sensors. This can be achieved by significantly reducing the cost of sensor handling and adding new features. While in [25], explain the key improvements related to the Internet of Things that are now accessible in the market for the creation of apps and prototypes. In addition, cultivating proficiencies related to design.

In [26] the author said that Internet of things joins more units on vaults. Furthermore, networks are employing uncomplicated and secure systems for item identification, enabling the collection and processing of information about these items. Reducing the size and application of nanotechnology will enable the development of smaller and more compact objects, enhancing their connectivity and functionality.

In [27] said IoT could be the potential to become a new standard that connects various objects or devices to the internet using wireless or wired technologies, allowing for the achievement of desired goals. Since its inception in 2005, the concept of the Internet of Things (IoT) has revolutionized the way networked smart devices communicate, interact, and perform various tasks. This technology has found applications in a wide range of fields, including global supply chain management, environmental monitoring, and other stress-free scenarios.

In [28] Stated that the study presents a practical framework for assessing and predicting the establishment of the Internet of Things (IoT) in Korea. This study examines the use of a sociotechnical framework approach to the Internet of Things

(IoT) in order to gain a comprehensive understanding of how the IoT will progress and establish itself in a technologically sophisticated mobile environment.

## C. Applications of IIoT

The IIoT system is utilized throughout several sectors, including smart industries, healthcare, energy consumption, transportation, logistics, and more. There are three distinct categories of industrial applications: IIoT applications, sensor-based applications, and smartphone-based apps. These applications were developed to evaluate the existing IoT solutions in the industry [29]. Upgraded efficiency, observations and the modification of the workplace all these things are included in the Industrial Internet of Things (IIoT) [15], [30]. By the end of 2030, it is believed that global GDP will rise to $15 trillion when IIoT is in-stalled worldwide [15].

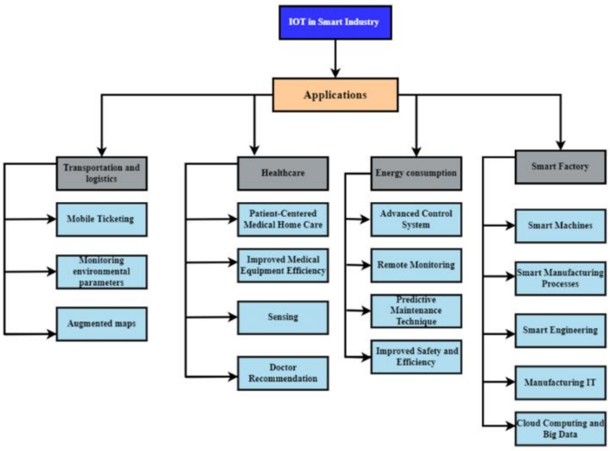


**Figure 1**. IoT applications in smart industry [20].

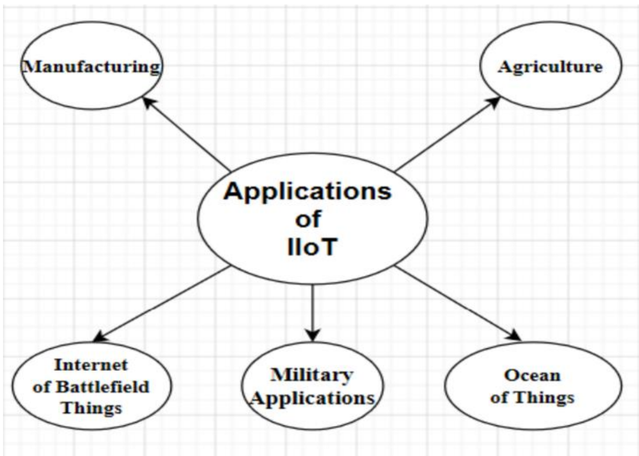


**Figure 2.** Applications of IIoT [10]

## D. Challenges Faced by IIoT

The world of life is gradually transitioning into the digital realm due to the presence of intelligent technology and gadgets, enabling continuous connection between users and equipment. Thanks to artificial intelligence and machine learning, it has become more efficient. The integration of machine-to-machine communication with big data analytics in an industry leads to varying degrees of productivity, efficiency, and performance in IIoT systems. Currently, the majority of commercial businesses are seeking to collaborate with IoT development companies in order to incorporate the most up-to-date technology into their operations. This presents novel problems and prospects for corporate executives. It has been determined that in the future, 72% of those organizations may experience a decline in their market share if they fail to implement a comprehensive big data strategy. The issues encountered by IIoT [31] are illustrated in Figure 3.

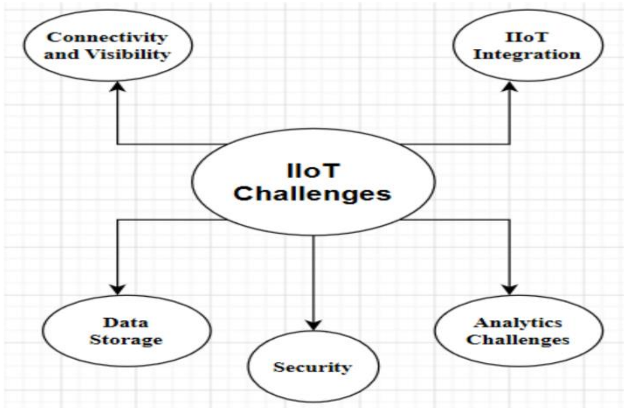


**Figure 3**. Challenges of IIoT [10]

## E. Key Elements Associated with IoT-Based Intelligent Industry

The IoT sector consists of four components: data collecting, physical infrastructure, data analytics, and data processing, as seen in Figure 4. The paramount element in the intelligent industry for preventing critical circumstances is the physical infrastructure that governs all sensors, gadgets and actuators. A sensor is accountable for performing a range of duties, including measuring temperature, humidity, vibration, current, and pressure. IoT devices, however, provide diverse control activities, such as identifying devices, discovering nodes, and providing naming services. Any sensor or device that is under the control of a microcontroller has the capability to carry out all of these activities. Every control action may be executed remotely by any remote device or computer connected to the internet.

Data acquisition refers to the systematic monitoring and analysis of diverse sensors, gathered data, and hardware. It may be divided into two constituent parts: traditional data acquisition and IoT data acquisition. There are six protocols for IoT data collection. (i) A node is a fundamental unit in a network that may send, receive, or forward data. (ii) A message refers to the data that is transmitted or exchanged between nodes in a network.[29].

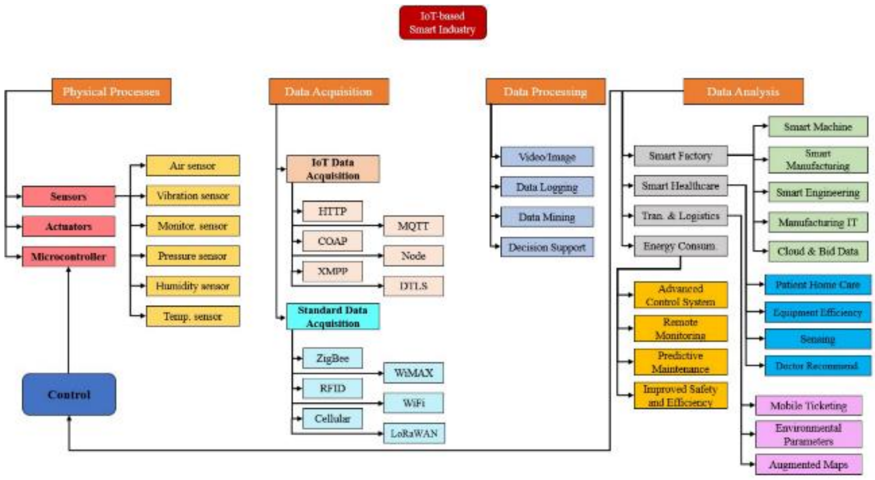


**Figure 4.** Key components of IoT smart industry.[20]

The protocols used are: queuing telemetry transport (MQTT), hypertext transfer protocol (HTTP), datagram transport layer security (DTLS), extensible messaging and presence protocol (XMPP), and constrained application protocol (CoAP). The inclusion or exclusion of additional protocols is contingent upon the unique conditions and requirements of the system being developed.

ZigBee, LoraWAN, WiFi, radio frequency identification (RFID), mobile cellular networks and WiMAX are the protocols most frequently utilized for standard data collecting. Data processing involves several elements, such as video or image processing, data mining, decision support systems, and data loading. Thus, any characteristic may be incorporated in accordance with the specifications of the system and performed simultaneously to provide supplementary services.

The objective of data analytics is to decrease expenses by developing more effective approaches for storing substantial quantities of data. Analysis of data encompasses four specific sub-applications: smart manufacturing, smart healthcare, transportation, logistics, and energy consumption in the Industrial Internet of Things (IIoT). Every gadget within an Intelligent factory is interconnected with the internet and integrated with actuators and sensors.

The Industrial Internet of Things (IIoT) facilitates the interchange of data between service providers and consumers in intelligent industrial facilities [32]. Furthermore, the implementation of IIoT in healthcare can lead to enhanced patient care, expedited and precise diagnosis, and tailored treatment options [33]. The use of intelligent transportation systems inside the Industrial Internet of Things (IIoT) has shown to enhance many devices and sensors, including Automotive control systems, speed monitoring systems, automobile navigation systems and traffic signal management systems [34]. Furthermore, the Industrial Internet of Things (IIoT) has the capability to decrease energy consumption, enhance the utilization of sustainable energy, and mitigate the environmental consequences associated with energy usage [35].

## F. Sensing And Communication

Furthermore, expenditures are allocated to single-board machines and microcontrollers such as Raspberry Pi and Arduinos, in addition to the essential hardware required for virtualizing traditional computers. These gadgets have built-in sensors that control the application programs, Supervise the cloud platforms responsible for storing the data, and closely monitor the security technologies [36]. One benefit of transitioning to 'Industry 4.0' is the ability to utilize PLC logic in the form of function blocks defined by IEC 61499. These function blocks govern the emerging data collecting infrastructure and automated synthesis methods in industrial facilities [37]. These technologies enable the utilization of real-time operating systems that enhance productivity and efficiency, while also serving as predictive signs of failure.

Sensors are employed throughout many sectors such as manufacturing, food processing, and the automobile industry. Common sensor types utilized in these sectors encompass temperature, flow, force, position, pressure, and vibration sensors. Within a production or industrial setting, these tools enable operators to oversee various systems. Temperature, flow, and pressure, sensors are capable of detecting alterations inside a system or its environment, while vibration, force, and position, sensors may provide information on the movement of the system itself. In addition to Large Area Networks (LANs), these sensors have the capability to communicate and operate independently, therefore minimizing workplace hazards and assuring optimal productivity. As stated in reference [38], The purpose of implementing sensors on older machines is to identify the points of congestion in the manufacturing process and rectify any mistakes resulting from machine operators during quality control.

Previous discussions have shown other uses for adopting the Industrial Internet of Things (IIoT), and doing a thorough examination of several equipment might be arduous. Large-scale wireless networks are specifically engineered to efficiently and precisely transmit information across nodes for data storage. However, defining a sensor network can be challenging owing to many restrictions [39]. The primary cause of sensor failure is ascribed to periodic cycles of energy slumber. To enhance the efficiency of communication between systems, the term [40] pertains to the utilization of low power long-range technologies like as LoRaWAN and NB-IOT. These technologies have the capability to operate for around 10 years without the need for battery replacement. LoRaWAN, while its potential long-range capabilities, experiences coverage challenges in congested locations and when faced with impediments often seen in industrial settings.

## G. Conclusion

The Industrial Internet of Things (IIoT) is at the forefront of revolutionary technologies, defining the landscape of the Fourth Industrial Revolution. As we move through this era of unparalleled connectivity and decision-making powered by data, the interdependent nature of IIoT and Industry 4.0 becomes increasingly clear. By seamlessly blending intelligent devices, cutting-edge analytics, and automated processes, IIoT not only heightens efficiency, but also paves the way for unforeseen avenues of advancement and prosperity. While we embrace the potential that IIoT holds, it is imperative that we also acknowledge and address concerns encompassing security, interoperability, and ethical considerations, for a sustainable and conscientious evolution into a digital future.

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