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A comprehensive survey on the significance of industrial Internet of Things, energy management and big data analytics

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Abstract

The adaptive worldwide network architecture made up of web-enabled, objects connected through internet generally defines the concept of Internet of Things (IoT). In today's world, IoT is contributing towards the transformation of the traditional industries to the smart industries by integrating the concept of IoT based energy management system into the analytics-based information system of the industries. Manufacturing businesses have concluded that by providing a digital identity to their tangible resources through IoT-based solutions, they can gain higher clarity into their processes and massively improve them. To estimate and analyze the developments in this field, this paper conducts an in-depth survey on the significance of big data analytics and energy management in shaping the progress of

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the Industrial Internet of Things (IIoT). It briefs the components related to the building blocks of the IoT, its application in various domains, benefits and the major challenges faced for building IoT technologies. This review present cutting-edge research on how IoT technology adoption might propel the transformation of industrial companies that are energy-efficient and environmentally sustainable.

Subject Classification: *94-XX.*

Keywords: *Industrial IoT, Internet of Things, Sensors, Energy management, Energy efficiency, Data analysis, Big data.*

1. Introduction

The idea of IoT was proposed in 1970s and further coined by Kevin Ashton while working at P&G in 1999 [1]. The IoT is a very ubiquitous technology that have captured the huge mindset in recent years. With such rapid technical breakthroughs, the IoT is being employed in every imaginable area of the technological world. It is an idea that entails linking all physical entities to the internet resulting in higher efficiency and ease for humans. The IoT is a framework in which all the existing physical entities of universe like people, animal and machinery can communicate with each other without human and computer intervention with their unique ids. In IoT, everything becomes intelligent using the power of efficient data engineering, machine learning and AI algorithms. IoT is an upcoming technology that is used in almost everyday life and it has now become a significant part of every industry [2]. With the onset of IoT in the manufacturing industry, the industry has been blooming and the profit margins have increased on tremendous scales for the industrialists [3,4].

However, with the expansion of such devices, large data centers will process a large number of data points transmitted by sensors, and billions of these network devices are constantly consuming energy. This means that significant processing and analytics capabilities are required, which can be energy-intensive [5, 6]. Now with the advancements in the industry, handling the big data generated by these devices is a big challenge. Consequently, the research focused on sustainable energy management and processing large scale of data in IoT includes a broad spectrum of mitigation strategies and problems.

In order to cover such goals and discuss these challenges, this survey attempts to cover the fundamentals of IoT related to Smart Industries, Energy management systems and Big Data Analytics. The main contribution of this survey is to discuss:

- The fundamental components of the IoT and how these components are interacted with the software to make an automated machine controlled by the human remotely.
- The application of IoT in the development of Smart Industries with efficient energy management systems including recent industrial application developments.
- The problems encountered in managing the IoT and the Big Data, by providing the comprehensive analysis of the recent work done to effectively use of the Big Data Analytics in IoT.

Further, the survey is structured in the following sections: Section 2 outlines the fundamental components of IoT and working, Section3 presents the Industrial Internet of Things (IIoT), addressing Energy Management through IoT and the application of Big Data Analytics in IoT. Section 4 presents applications of IIoT and benefits of IIoT followed by the challenges in Section5. The paper concludes in Section 6, summarizing the key insights gleaned from the study.

2. Fundamental Components of IoT

The IoT commences with the electronic components such as smartphones, smart watches, and devices which facilitate you to articulate with the platform [7]. Some fundamental components of IoT are:

2.1.1 Sensors

Sensors are hardware that senses the environment and then record those changes as Data. These Sensors acts as bridges in IoT System to connect the Digital worlds to Physical world. Sensors detect pressure, motion and temperature etc.

2.1.2 Connectivity

This involves different communication channels through which information is collected and transmitted. Some examples are Bluetooth, WI-FI, WAN, satellite and mobile networks.

2.1.3 Data Processing

The procedures for data collection and transforming data to provide useful information. To derive meaningful information from the collected

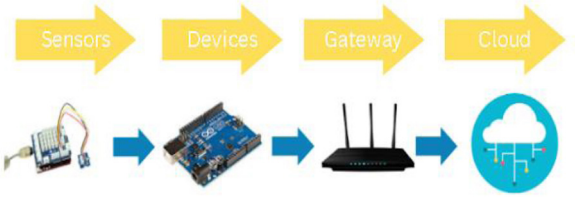

Figure 1

Working of IoT System

data from the sensors and other devices at the cloud or the edge, the data is processed using different machine learning based algorithms. The amount and speed with which data is generated nowadays are incredible.

2.1.4 User Interface

This provides the devices through which the user can interact with the IoT devices to control the mechanism of the devices as per the need. These devices include application software or web interfaces.

An IoT system comprises various devices and sensors that establish communication with the cloud through various channels. Figure 1 depicts how sensors, devices, gateways, and clouds are interconnected and form the foundation of an IOT system [3]. All these devices are integrated with different software for the collection and the processing of the data enabling the issuance of the signals to modify sensors or devices seamlessly without requiring user interference.

3. Industrial Internet of Things (IIoT)

The Industrial Internet of Things (IIoT) constitutes the subset within the broader IoT framework, concentrating on devices and products employed in the settings of industries. A subclass of IoT technology known as the IIoT was created as a result of IoT solutions for manufacturing using smarter technologies, which are at the core of industrial digital transformation. The IIoT incorporates contemporary Information and Communication Technology (ICT) with advances in industrial manufacturing [8]. It is a crucial facilitator for the development of network-based monitoring and control devices that are included in different manufacturing processes, which transform factories into smart manufacturing environments.

Increasing human-machine interaction, using intelligent robots to detect and identify components, and improving manufacturing through

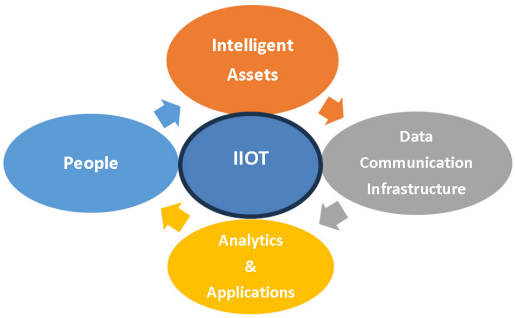

Figure 2

Components of IIoT System

Internet of Things (IoT) connectivity are all part of Industry 4.0 [9]. Companies based in heavy sectors, have been forced to reassess their strategy beyond automation as a result of the decreased production margins. The concept takes automation a step further by defining intelligent, automated, and constantly learning factories. It is highly utilized in energy, transportation, smart home, and retailing industries for different purposes [10].

Figure 2 shows the basic components of IIoT [6]. Here intelligent assets are made up of devices with hardware controllers, application software and network management and security control components.

3.1 *IIoT and Energy Management*

Interconnections between smart objects are rising as the IoT technology advances in industrial manufacturing that involves development of smart cities, smart houses, smart healthcare, and smart transportation, complicating analysis of performance parameters on intelligent systems. With the proliferation of IoT devices, one of the most difficult concerns is increased energy usage. Therefore, methods for managing the energy consumption are highly desirable. One of the most crucial concerns in green IoT-enabled devices is managing energy efficiency and power usage [11-14].

Energy efficiency refers to reducing the energy waste or utilizing less energy to accomplish same kind of task. Energy efficiency has benefits such as decreased costs for households, cutting greenhouse gas emissions and a decrease in the need for energy imports and improving worldwide economy [15]. The following are some of the concepts that designers,

engineers, and architects have integrated or considered to decrease energy waste as much as feasible and promoted the concept of Green IoT.

3.1.1 For Generation and Distribution of Energy

- IoT based systems are designed for generation of power using solar panels and renewables forms of energy. The energy generated from these systems are used for heating the water and supplying that water to different resources. This enhances the energy efficiency of power generation, increasing it from approximately 33% to as much as 80%.
- The efficiency can be further enhanced by using smart grid for the purpose of distribution.

3.1.2 For Transport

- The electric vehicles have designed and promoted to reduce the environmental pollution and save the energy resources. These vehicles are more energy efficient and promotes the concept of Green IoT.
- By improving the efficiency of heavy vehicles such as bus, truck and rail results in the improvement of the transportation services with respect to different sectors of the industries.

3.1.3 For Smart Homes

- To integrate smart devices with AI based energy management systems and using machine learning based algorithms that can enhance the efficiency of the IoT systems.
- To develop the devices with the intelligent sleep mode through which devices consumes less power while remains working even if idle.
- To design the IoT devices to run on renewable power sources, that can replenish on their own, is crucial because it makes it possible to deploy autonomous and sustainable IoT networks.

3.2 *IIoT and Big Data Analytics*

With the advancement of Industrial IoT market and the predicted future trends, it is estimated that with the increase in this traffic the data collected by the sensors and the other smart devices will be huge in future.

These smart devices will allow to communicate the data anytime, from any place within the network [16]. The collection of data is facilitated by different systems that identify and transmit information through a multitude of communication devices within the IoT infrastructure [17]. To process this data in an effective manner, IOT big data analytics is the process of examining a range of IOT data to identify trends, undetected patterns, hidden relationships, and new information. As a result, IoT and Big Data analytics may help business associations in different sectors to gain better insights from the present data and helping them to take better decisions and make well-informed judgments [18].

IoT and Big Data are two versatile technologies that can be united to achieve significant results in industry revolution. Advancement in big data will give more enhanced big data architecture analytical capabilities that will surely improve decision making. [19].

4. Applications and Benefits of IIoT

IoT can be employed in the development of the smart industries with the significant impact on the economical and the environmental development. Some of the applications and benefits of the IIoT in the current day scenario includes:

- **Smart Logistic Management: -** One of the crucial areas in many companies that need constant improvement to meet rising demand is logistics [20].
- **Warehouse and supply chain management: -** Supply chain professionals can establish an accurate and real-time inventory tracking system by deploying advanced IoT sensors that autonomously identify and assess inventory placements at different levels.
- **Building Smart Cities: -** With the revolution in the Industry 4.0, it results in building smart cities with the installation of the devices that are automatically controlled and are more energy efficient [21].
- **Energy Efficiency:** - IoT devices helps to monitor the real-time consumption of the energy and identification of areas for optimized energy utilization in the manufacturing of the products in the industries. By implementing IoT technology helps to build the procedure that can be used to lower energy costs and increase sustainability [22].

5. Challenges in Industrial-IoT

Various Industries have widely adopted IoT and big data analytics. These technologies are still in their infancy, nevertheless. Numerous current research problems remain unresolved [8]. Some of the major challenges faced by the IIoT in the different applications are followings:

- **Cost of Production**: - The overall cost of production is still high and rising of many of the technologies used for the IoT.
- **Managing the IoT Mechanism**: - Connectivity and interoperability are two considerations that developers take into account when integrating IoT management.
- **Security**: - The IoT has turned into a utopia for hackers since there are so many devices, platforms, and interfaces using and receiving important data. If the correct security measures aren't put in place after devices are linked to the Internet, hackers may be able to access them.
- **Privacy**: - As the IoT opens up new technologies, it's getting harder to "go off the grid," thus businesses need to uphold customer and developer trust.

6. Conclusion & Future work

The Indian government's 'Smart Cities Mission' and 'Digital India Mission' are intended to yield the necessary push for the country's IoT business to grow. In this paper a detailed comprehensive survey of IIoT applications with respect to Energy management and Data analytics has done. This paper provides an insight to the interdependency of these areas and the technological advancements in these areas will be led to the increase in energy effectiveness of the society. In this work the various component of IoT System is explained briefly. This work also gives valuable insights to reduce the energy waste measure to promote the concept of Green-IOT. In the end the paper concluded with challenges of IoT in Industrial IoT and data analytics.

References

[1] Atzori, L., Iera, A., & Morabito, G., The internet of things: A survey. *Computer networks*, *54*(15), pp. 2787-2805, (2010).

[2] Alsharif, M. H., Jahid, A., Kelechi, A. H., & Kannadasan, R., Green IoT: A Review and Future Research Directions, *Symmetry* 15(3): 757, (2023).

[3] Singh, K. J., & Kapoor, D. S., Create your own Internet of things: A survey of IoT platforms. *IEEE Consumer Electronics Magazine*, *6*(2), pp. 57-68, (2017).

[4] Alsharif, M.H., & Nordin, R., Evolution towards fifth generation (5G) wireless networks: Current trends and challenges in the deployment of millimetre wave, massive MIMO, and small cells. *Telecommun. Syst.*, *64*, pp. 617–637 (2017).

[5] Tsai, C.-W., Lai, C.-F.,Chiang, M.-C., & Yang, L.T., Data Mining for Internet of Things: A Survey. *IEEE Commun. Surv. Tutor.*, 16, pp. 77–97 (2013).

[6] He, M., Forootan Fard, H., Yahya, K., Mohamed, M., Alhamrouni, I., & Awalin, L.J., Optimal Design of Hybrid Renewable Systems, Including Grid, PV, Bio Generator, Diesel Generator, and Battery. *Sustainability*, *15*, 3297, (2023).

[7] Pattar, S., Buyya, R., Venugopal, K. R., Iyengar, S. S., & Patnaik, L. M., Searching for the IoT resources: Fundamentals, requirements, comprehensive review, and future directions. *IEEE Communications Surveys & Tutorials*, *20*(3), pp. 2101-2132, (2018).

[8] Kiel, D., Arnold, C., & Voigt, K. I., The influence of the Industrial Internet of Things on business models of established manufacturing companies–A business level perspective. *Technovation*, *68*, pp. 4-19, (2017).

[9] Qi, Qinglin, and Fei Tao., Digital Twin and Big Data Towards Smart Manufacturing and Industry 4.0: 360 Degree Comparison. *IEEE Access*, (2018).

[10] Zarei, M., Mohammadian, A., & Ghasemi, R., Internet of things in industries: A survey for sustainable development. *International Journal of Innovation and Sustainable Development*, *10*(4), pp. 419-442, (2016).

[11] Pawar, P., Design and development of advanced smart energy management system integrated with IoT framework in smart grid environment. *Journal of Energy Storage*, *25*, 100846, (2019).

[12] Shivaprakasha, S.P.K., Energy-efficient communication using data aggregation and data compression techniques in wireless sensor networks: A survey. In Advances in Communication, Signal

Processing, VLSI, and Embedded Systems: Select Proceedings of VSPICE 2019; Springer: Berlin/Heidelberg, Germany, pp. 161–179, (2020).

[13] El-Hosseini, M., ZainEldin, H., Arafat, H., & Badawy, M., A fire detection model based on power-aware scheduling for IoT-sensors in smart cities with partial coverage. *J. Ambient. Intell. Humaniz. Comput.*, *12*, pp. 2629–2648, (2021).

[14] Tuyishime, C. R., Nz Anyway Ingoma, F., & Gatera, O., IoT-based Intelligent Energy Efficiency Management System for Smart Industries (IoT-IEEMS). In 2021 IEEE International Conference on Industry 4.0, Artificial Intelligence, and Communications Technology (IAICT), pp. 248-254, (2021).

[15] Wang, D., Zhong, D., & Souri, A. Energy management solutions in the Internet of Things applications: Technical analysis and new research directions. *Cognitive Systems Research*, *67*, pp. 33-49, (2021).

[16] Sood, S. K., Sandhu, R., Singla, K., & Chang, V., IoT, big data and HPC based smart flood management framework. *Sustainable Computing: Informatics and Systems*, 20, pp. 102-117, (2018).

[17] Silva, B., Moreira, J., Costa, R-L., Logical big data integration and near real-time data analytics, *Data & Knowledge Engineering,* 146, 102185, (2023).

[18] Gulia, P., & Chahal, A., Big data analytics for IoT. *International Journal of Advanced Research in Engineering and Technology (IJARET)*, *11*(6), (2020).

[19] Khare, S., & Totaro, M., Big data in IoT.*10th International Conference on Computing, Communication and Networking Technologies (ICCCNT)*, *IEEE*, pp. 1-7, (2019).

[20] Lee, C. K., Lv, Y., Ng, K. K. H., Ho, W., & Choy, K. L., Design and application of Internet of things-based warehouse management system for smart logistics. *International Journal of Production Research*, *56*(8), pp. 2753-2768, (2018).

[21] Zhang, X., Pipattanasomporn, M., Chen, T., & Rahman, S., An IoT-based thermal model learning framework for smart buildings. *IEEE Internet of Things Journal*, *7*(1), pp. 518-527, (2019).

[22] J. L. Chong, K.W. Chew, A.P. Peter, H.Y. Ting, P.L., Show Internet of things (IoT)-Based environmental monitoring and control system for home-based mushroom cultivation. *Biosensors*, 13, 98, (2023).