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An Overview of the Green Internet of Things (IoT)

Madhav Singh Solanki[1], and Ms. Anuska Sharma[2]

[1,2] SOEIT, Sanskriti University, Mathura, Uttar Pradesh, India
Correspondence should be addressed to Madhav Singh Solanki; madhavsolanki.cse@sanskriti.edu.in

ABSTRACT- In line of the huge scope of the digital context, the number of subscribers of digital services, and the number of digital devices, levels of energy intake have reached alarming levels during the last decade. By 2020, the number of linked devices will have augmented almost to forty nine billion, and in the coming years almost by 2030, it will have increased to 100 billion. As a result, experts anticipate a massive increase in content size and data usage rate (hundreds of thousand times larger in coming decade than it was in past two decades) at the cost of extreme carbon emissions into the atmosphere. As the Internet of Things (IoT) connects everything in the smart world, energy usage is an issue and a promising study field. A green IoT is proposed in order to achieve a low power consumption IoT. The purpose of this article is to offer an overview of green IoT. It also goes through the green IoT life cycle, which includes green design, green manufacture, green use, and green recycling. Green IoT technologies are also explored, such as green tags, green sensor networks, and green internet technologies. In addition, there are studies on IoT using fifth gen technologies and IoT for smart metropolises. Finally, future research topics as well as outstanding issues in the field of green IoT are discussed.

KEYWORDS- 5G, Cloud Computing, Energy Efficiency, Green IoT, Internet of Things (IoT), Smart Cities, Wireless Sensor Networks.

I. INTRODUCTION

The quantity of carbon dioxide (CO2) emanations from mobile or cellular setups is anticipated to reach 345 million tons by 2020, with the number expected to rise in subsequent years. As a outcome of the massive CO2 emanations, environmental, and well-being issues, harmless green technology is becoming a popular study topic in the progression of environment friendly technologies. Furthermore, current gadget battery technology is a key problem that necessitate moving towards green technology [1,2]. Experts of technical and scientific background predict that the fifth generation (5G) of wireless infrastructures will be ready by the end of the decade, with the ability to handle exponential amount of mobile data than the current networks are capable of.

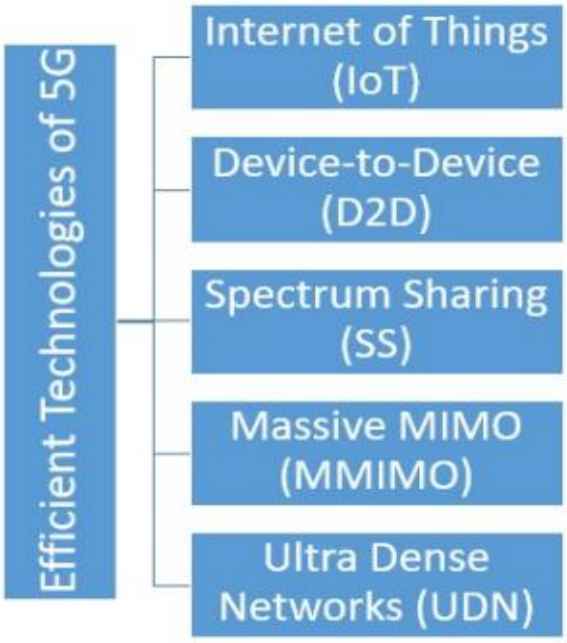

Figure 1: Efficient Technologies of 5G [3]

There are five effective 5G network technologies, as indicated in Figure 1. By reducing latency, Device-to-Device (D2D) communication i.e., interaction among the devices improves the dependability of message transfer between users. Furthermore, the UDNs entail small cell disposition in high-traffic locations that are dense. Aside from that, the huge MIMO is capable of supporting pluralities of antennas while maintaining a greater level of data throughput. Spectrum sharing aids to preclude low band usage efficiency, however IoT serves to link billions of peoples with multitude of devices in a short period of time with great efficiency. This set of four energy-competent and well-organized technologies should allow future 5G networks to consume lesser power and emit less CO2.

A. Internet of Things (IoT)

Ashton K. initially introduced a phrase "Internet of Things" in a presentation in 1998, saying “The Internet of Things has the capacity to alter the world to a next level of technical perspective, just as the Internet did or perhaps much more than that”. One of the famous research group “MIT Auto-ID

Center" presented their Internet of Things concept in 2001. The Global Telecommunication Merger (GTM) first used the phrase "Internet of Things" in 2005.

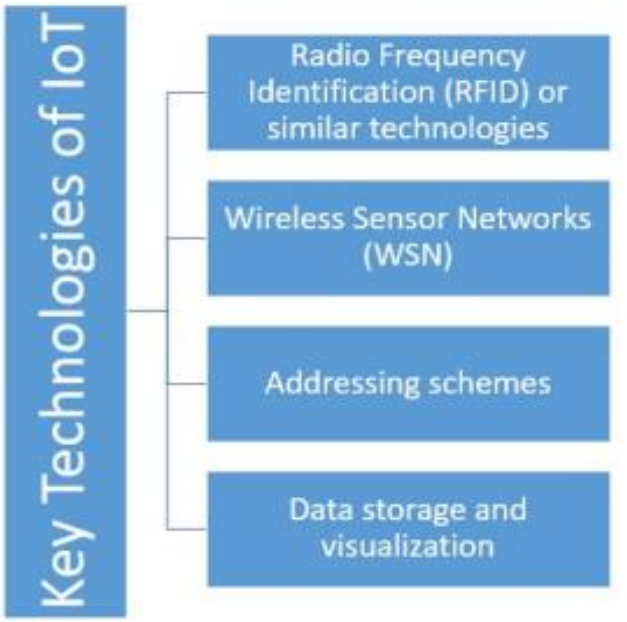

Figure 2: Key Technologies of IoT [4]

The Internet of Things (IoT) has been hailed to a greater extent as one of the most fascinating technical development of the last decade. It enables people and things to connect everywhere, at any time, with almost everyone, via any link generated to provide service. It provides a framework for sensors and equipment to be seamlessly integrated inside a smart environment in order to provide enhanced and intelligent human services. Figure 2 depicts the main technological concepts that are necessary for IoT, in which instruments and sensors detect and collect a wide range of data, which can then be administered and examined so as to excerpt usable facts and figures for providing intellectual facilities to the users. In general, IoT technology has four major components

- *Hardware:* The instruments including transceivers, sensors, tags, actuators and are few of the best examples of embedded communication hardware.
- *Middleware:* It's used for data storage, computation, and awareness of context.
- *Presentation:* It entails learning how to use visualization and interpretation tools on a variety of platforms and apps.
- *Internet:* This is to ensure that everything can communicate irrespective of its physical location and at any time when required. Cloud computing, IP for smart things, and smart online services are all included.

Figure 3: Applications of IoT [5]

Data administration, visualization, analytic, heterogeneous network monitoring, application development, and research are only a few examples of IoT applications, as illustrated in Figure 3. Figure 4 is a lovely infographic created by Libelium World that features smart cities and IoT applications. It is obvious that the IoT is transforming verticals, and it is easy to see why it is considered to be the next technology revolution. Though, IoT research is still emerging and is in its early stages, and many key issues must be resolved, including battery life concerns, straightforwardness of the technology, data and context awareness, security & privacy concerns, and interference-free communication, terminal device budget, scalability, and heterogeneous terminal devices.

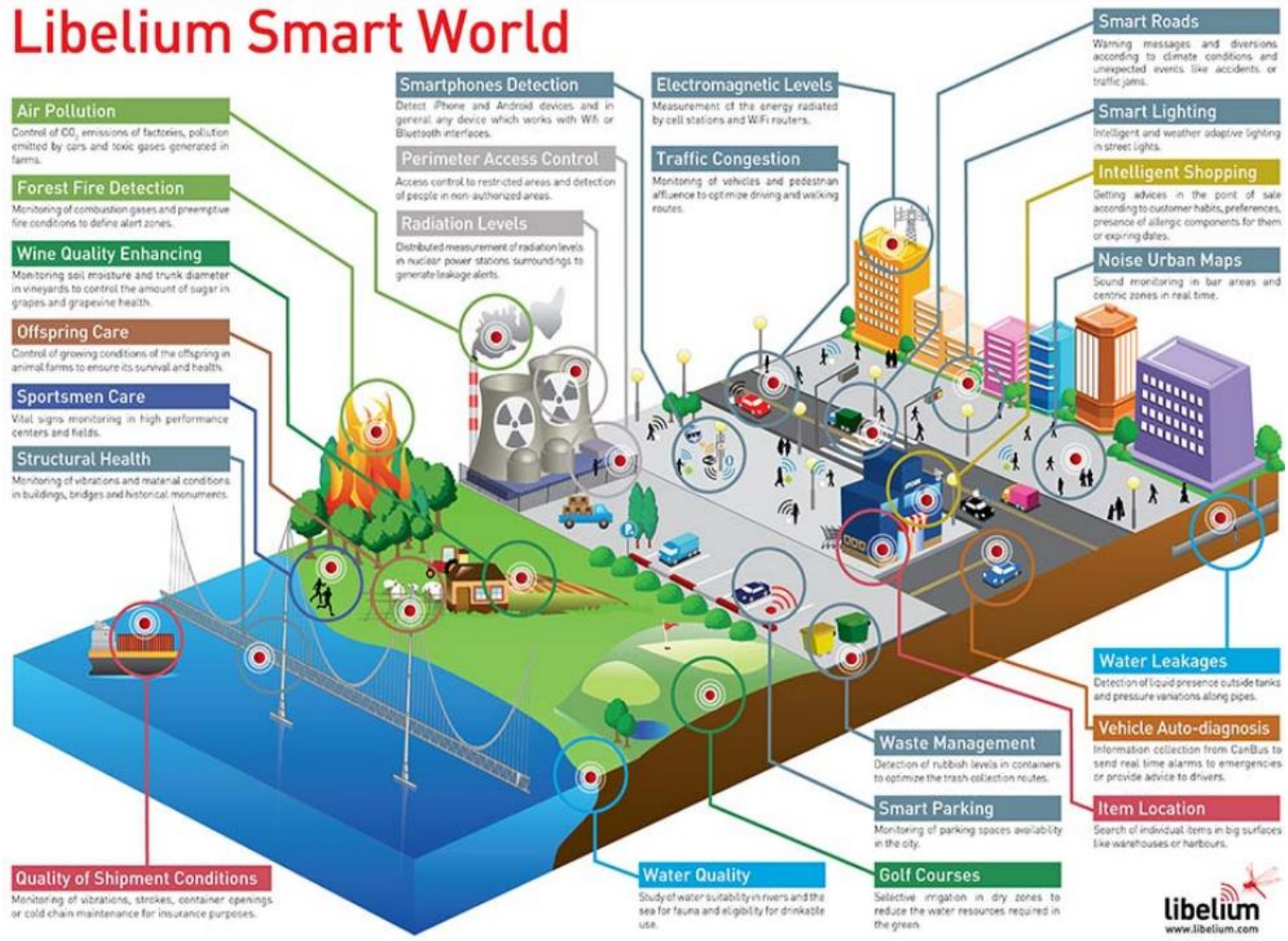

Figure 4: Usage of IoT technology in a virtually intelligent world [6]

The IoT basically is a kind of an environment in itself that is not only a internetwork for transferring data, but also interlinked with other technologies including Cloud Computing (CC) and Big Data (BD) to provide a level of smartness or intelligence to the devices connected within the ecosystem, in order to recognize behaviors apart from explaining actions based on data captured by smart objects that are available throughout emerging smarter cities without requiring human-to-human interaction. Figure 5 depicts the IoT ecosystem architecture, in which incoming data from Smarter Cities is incorporated into CC. The proposed flow allows interaction between the cloud and people, who are becoming more active in recent years (prosumers). The centralization of data from each sensor and object is handled by the cloud computing system. It also enables people to connect and communicate by establishing a worldwide network. It also addresses the issue of connectivity. The cloud also enables the integration of Big Data analysis in order to get a knowledge of human dynamics patterns that may be determined. Finally, the system offers the tools and feedback mechanisms necessary to motivate behavior change. The primary goal of this article is to provide a high-level overview of green IoT ideas implemented in CC & BD, their usage and technological difficulties. The first segment introduces the central principles of the IoT as well as its requirements. Section 2 covers the life cycle of ecofriendly IoT and the tools needed for ecofriendly IoT. It also covers IoT in 5G and shows how IoT may be used in smart cities. Section 2 goes into more detail on the difficulties and potential research objectives for ecofriendly IoT. As a final point, section 3 brings the paper to a close.

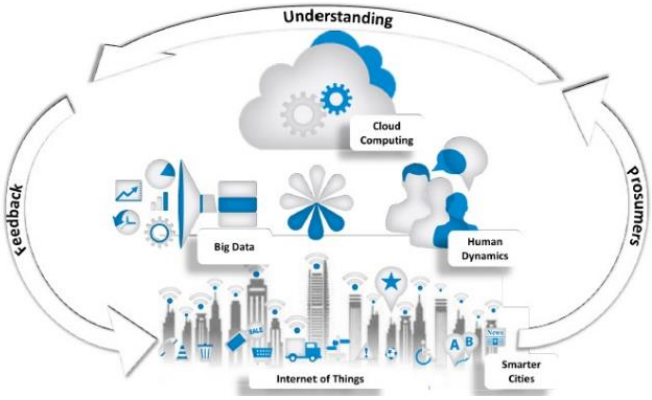

Figure 5: IoT Ecosystem [7]

II. DISCUSSION

A. Eco-friendly Internet of Thing (IoT)

The IoT is anticipated to have a massive increase in network use and number of nodes in the future. As a result, the resources which are mainly needed to implement IoT among all of the components connected to the network, as well as the energy used by their operation, must be reduced. To achieve ecofriendly IoT steadfastness and smart world deployment, power usage is gradually becoming state-of-the-art. The IoT should be represented by power proficiency to minimize the CO2 emanations and greenhouse effects of sensors, other connected devices and apps so as to create a smarter world. The life cycle of green IoT is shown in Figure 6, which considers green design, green manufacturing, green usage, and ultimately green disposal and recycling to have little or no environmental effect.

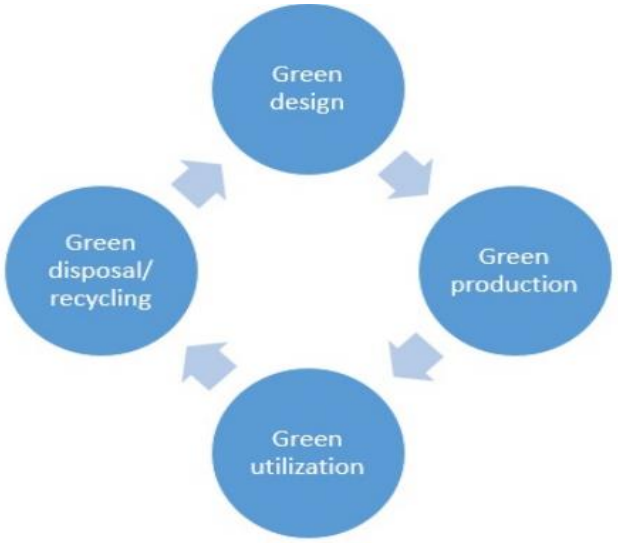

Figure 6: Life cycle of green IoT [8]

B. Technologies for Eco-friendly IoT

A multitude of eco-friendly technological advancements, such as eco-friendly RFID tags, green sensor networks, and green cloud computing networks, should be incorporated in the green IoT. Fig 7 depicts main scientific techniques required to create an environment-friendly IoT ecosystem. RFID stands for Radio Frequency Identification, and it is an electronic instrument that consists of numerous radio tags and a tiny tag reader. Radio tags may hold info of things to which they're usually bonded. RFID have a transmission choice within limited meters in general. Active RFID tags and passive RFID tags are the two types of RFID tags. The active tags have batteries that allow them to continually broadcast their signal, while the passive tags do not. The passive tags must collect the electric power in order to operate from the reader signal instead of having an inbuilt battery. Several research projects have been undertaken in order to accomplish the aim of green RFID. One of the suggested solutions, as indicated in Table 1, is to decrease the required length of the tags and therefore reduce quantity of the material that is non-degradable. There are other RFID tags that can be printed. Different protocols are also suggested in order to create electric power proficient RFID tags. An eco-friendly WSN is also an important technology for enabling green IoT. A WSN is made up of an enormous sensor nodes that have limited power and storage. Several methods should be explored in order to obtain green WSN:

- Make use of renewable energy in order to charge and use. Kinetic energy along with the sensations may also be utilized.
- After performing the necessary action, the sensor is switched to idle mode i.e., the sensors temporarily sleep for some time.
- Make use of energy-saving optimization techniques.
- Reduce mobility power usage by using energy-efficient routing methods.
- Condense the scope of data and hence the space for storage by using data and context-aware algorithms.

Hardware including devices and sensors and software including program and algorithms considerations should be taken into account for green internet technologies, with hardware solutions producing devices that use less energy without sacrificing quality. On the other hand, the algorithms provide efficient designs that use lower level of electric power by maximizing resource usage. Furthermore, energy-efficient virtual machine methods should be developed. There are many applications and services available for green IoT technology, as illustrated in Figure 8.

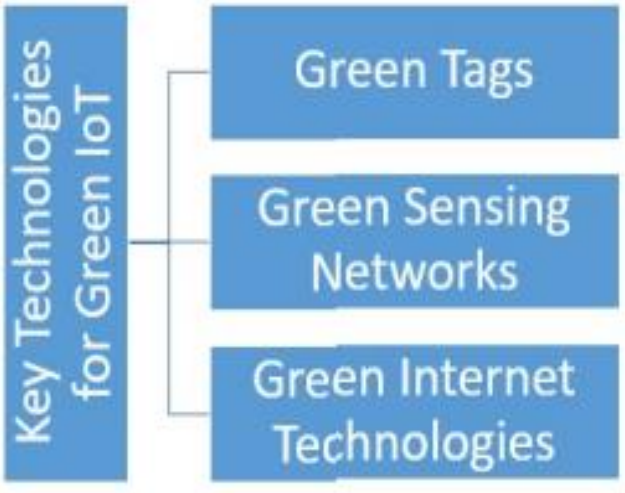

Figure 7. Key technologies required in eco-friendly IoT [8]

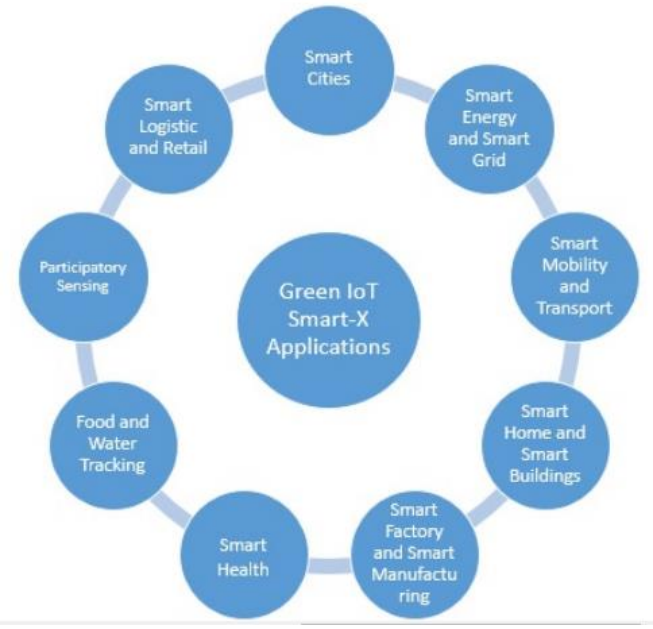

Figure 8: Green IoT Applications[8]

C. IoT in 5G Technology

Experts predict that the fifth generation (5G) of digital infrastructures that will be wireless shall be available by end of the decade, and that it will be capable of handling 1000 times more internet usages than current cellular networks. It will meet customer needs at reasonable prices, with high dependability and outstanding applications. It is expected to become a cornerstone of Internet of Things, connecting mobile devices with the fixed ones and ushering in a rising commercial and technological revolution. IoT and 5G are two of the most popular technological developments. They've come together to change our future by linking everything. However, numerous new difficulties in developing systems relying on the Internet of Things (IoT) that could seamlessly be linked with 5G information exchange through cordless medium are on the horizon. One of the most significant issues for IoT in 5G is security. Little packets of data, vast links of hardwares with limited energy sources, and delay-tolerant message transferring are other characteristics of IoT technology. Narrow band system design in 5G may enhance coverage, decrease power consumption, and lower terminal costs. Several IoT solutions for 5G networks have been suggested to enable enormous communication frequency of reduced power using devices.

D. Internet of Things for Smart Cities

By the end of the decade, the Smart City market is valued at approximately millions and millions of rupees, with annual spending exceeding thousands of crores of rupees. It has a central design, in which a dense and heterogeneous pool of peripheral hardware dispersed across the city produce many types of data that can be related via any technique. As an outcome, extensive study on the IoT is being conducted in the areas of sensing and automated control, network infrastructure and communication, and big data analytics. Smart parking, environmental monitoring, traffic control and trash management are just a few of the IoT applications for the Smart City that are especially appealing. Ganchev et al. propose a categorization of IoT platforms as well as a general IoT architecture for smart cities (9). The major difficulties encountered in implementation and administration of an IoT set-up in Santander, Spain are discussed, along with practical solutions. Zanella et al. study's outlines the scientific explanations to the challenges faced in the Padova Smart City initiative in the country (10). Marjani et al. explore the connection within big data and IoT (11). They also suggested a new architecture for big data from the IoT.

E. Challenges and Future Research Directions

Despite massive investigative determinations to develop eco-friendly technology, eco-friendly IoT know-how is still in its early stages. There are numbers of barriers and difficulties that must be overcome. The following are the major challenges:

- Green applications should be used to reduce environmental impact.
- The communication equipment and protocols utilized should be electric power efficient.
- Eco-friendly IoT set-up complexity reduction.
- Energy-efficient IoT system with context awareness.
- Efficient cloud management in terms of energy use.
- Energy-efficient IoT mechanisms, such as wind and sun to make IoT viable.
- Safe keeping tools that are operational, such as encryption and control instructions.
- Energy efficiency integration throughout the IoT architecture to ensure acceptable performance.
- Energy consumption models and the reliability of green IoT.
- The trade-off between effective vibrant band sensing and effective band management

III. CONCLUSION

Energy usage is an issue and a promising research field as the Internet of Things (IoT) connects everything in the smart world. To achieve a low power consumption IoT, a green IoT is proposed. This article's goal is to provide an overview of green IoT. It also goes through the green IoT life cycle, which includes eco-friendly design, manufacturing, use, and recycling. Green IoT technologies, such as green tags, green sensor networks, and green internet technologies, are also investigated. In addition, studies on IoT in 5G and IoT for smart cities have been conducted. Finally, future research topics in the field of green IoT are discussed, as well as outstanding issues. In the current paper, the topic of ecological IoT infrastructure was discussed. The reasons, challenges, and benefits of green IoT are discussed in detail in this article. The paper moreover focused at the life cycle of greener IoT and the solutions required to build an eco-friendly IoT platform.

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