COMPARATIVE ANALYSIS OF IOT AND GREEN IOT

Abstract

The Internet of Things (IoT) is the combination of a network of physical devices, vehicles, home appliances, and healthcare & agriculture equipments. It is also used to connect other gadgets, which are embedded with sensors, actuators and Bluetooth. The all connected devices are allowed to exchange data and perform automated tasks without human intervention. Another aspect of technology is, Green IoT (Internet of Things) refers to the application of IoT technology to promote sustainability and eco-friendliness in various industries. The latest development in Green IoT is the growing concentrate on using Internet of Things devices and systems to reduce carbon emissions, minimize waste and promote energy efficiency. This paper discusses Internet of Things and Green IoT structural design & current emerging utility domains such as Healthcare & Agriculture. Certainly, it would help the research scholar to understand the latest trends of technology in healthcare and agriculture and its utility to the 21st century.

Keywords: Green IoT, IoT, Healthcare and Agriculture.

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I. INTRODUCTION

Internet of Things (IoT) is flourishing up-coming conception, which main objective to connect millions of devices with each other [1]. The IoT device sensors are receive, accumulate, and spread important information from their surrounds. Internet of thing is thing that can communicate to each other without human involvement [43]. The IoT communicates directly to each other can save the communication energy with user [2]. The world is becoming "Smart" with the rapid development of science and technology [3]. In a smart world, people will be surrounded by smart devices that can help them with their daily lives. These devices will be able to communicate with each other and with the environment, and they will be able to learn and adapt to our needs. For example, a smart watch could track our health and fitness, and it could also provide us with information about our surroundings. A smart car could drive itself, and it could also communicate with other vehicles to prevent accidents. And a smart home could adjust its temperature, lighting, and security settings based on our preferences.

These are just a few examples of the ways that smart devices can make our lives easier and more efficient. As these technologies continue to develop, we can expect to see even more ways in which they can improve our lives. The combination of smart devices, transportation, and environments has the potential to create a world that is more efficient, comfortable, and safe. It can also help us to live more sustainable lives. As these technologies continue to develop, we can expect to see even more ways in which they can improve our lives [4, 43].

Internet of Things is a new model that has changed the traditional way of living into a high tech life style. Due to Internet of Things transformations like smart world, smart city, stylish homes, and toxic waste control, power saving, smart transport, smart industries can be possible [5]. There is group of essential research studies and important investigation has continuous in order to improve the technology through IoT [6].

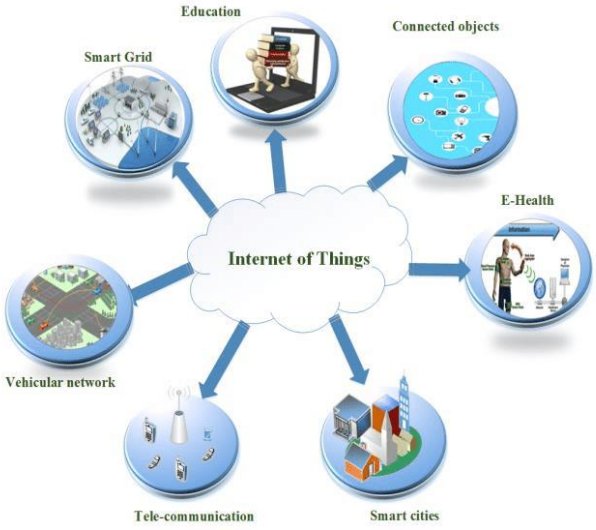

Figure 1: IoT. [39]

The IoT is transforming industries such as manufacturing, healthcare, agriculture and transportation by providing instantaneous data and insights, enabling predictive protection and optimizing operations [7]. In healthcare, IoT devices are being used to monitor patient health remotely, improving patient outcomes and reducing healthcare costs. In manufacturing, IoT sensors are being used to monitor equipment performance, reducing time dependency and increasing efficiency [7].

Another important aspect of IoT devices is being used in Agriculture. Crop growing is a main sector which plays important role in the Indian economy [8]. It is the backbone of our country8.70% of the Indian population depends on agriculture for food and money. In agriculture, an IoT device is being used to improve the crop production, regulate the irrigation efficiency and enhances the earnings of farmers [9]. The Smart agriculture is a rapidly growing field that uses a variety of technologies to improve agricultural productivity and sustainability. One of the key challenges in smart agriculture is the integration of heterogeneous objects. These objects can be sensors, actuators, devices, or systems that collect, process, and transmit data.

The ability for different objects to communicate with each other and share data, store, organize and analyze data from different sources. The integration of heterogeneous objects is a complex challenge, but it is essential for the success of smart agriculture. The Internet of Things a based device is being used in smart crop monitoring systems can help to increase the yield of farming [10].

IoT sensors can be used to monitor a wide range of environmental parameters that can affect crop growth. Temperature is one of the most important environmental factors affecting crop growth. Different crops have different optimal temperature ranges, so it is important to monitor temperature to ensure that crops are not exposed to temperatures that are too hot or too cold. Humidity is also an important environmental factor affecting crop growth. High humidity can lead to mold and mildew growth, while low humidity can cause crops to dry out. Moisture is essential for crop growth. IoT sensors can be used to monitor soil moisture levels to ensure that crops are not over or under-watered. Soil nutrient content is another important factor affecting crop growth. IoT sensors can be used to monitor soil nutrient levels to ensure that crops are getting the nutrients they need. Sunlight is also an important environmental factor affecting crop growth. IoT sensors can be used to monitor sunlight levels to ensure that crops are getting enough sunlight. By monitoring these environmental parameters, farmers can make better-informed decisions about crop management practices. This can help to improve crop yields and quality, and it can also help to reduce the environmental impact of agriculture [11]. Farmers can make better-informed decisions by accurately tracking these parameters [12].

IoT-based irrigation systems can monitor soil moisture content, weather forecasts, and crop can help to reduce the amount of time and labor that farmers need to spend watering their crops. This ensures that crops get the appropriate quantity of water, reducing water waste and improving crop health [13]. IoT sensors can collect data on growth of crop, weather conditions, and quality of soil, which can be used to predict crop yields completely [14]. This helps farmers to easily arrange the harvest and maximum use of their resources according to requirement [15]. IoT-based crop monitoring systems are a powerful tool that can help farmers to improve the efficiency, profitability, and sustainability of their farms. As

the technology continues to develop, we can expect to see even more innovative ways to use IoT to improve agriculture.

Farmers can reduce waste and improve efficiency, which can help to protect the environment and save money by using precision farming practices. Precision farming is a set of agricultural management practices that use information technology to collect and analyze data about crops, soil, and weather conditions. This data is then used to make informed decisions about crop management practices, such as when to plant, how much fertilizer to apply, and how much water to use [16]. Farmers can help to optimize the use of water and fertilizer, which can help to protect the environment and ensure a sustainable food supply. These devices are often equipped with sensors that collect data, such as temperature, humidity, and location, and transmit this data to other devices or cloud-based systems [17]. IoT devices can be controlled remotely and can also interact with other devices and systems, making them an integral part of the emerging "smart" ecosystem [18].

Smart Health Sensing System (SHSS) is a rapidly growing field that uses IoT to collect and monitor health data. This data can then be used to track health trends, diagnose diseases, and provide personalized care [19]. SHSS can also be used to monitor other health data, such as sleep patterns, activity levels, and medication adherence. This data can then be used to provide personalized care and improve the quality of life for people with chronic conditions [20]. SHSS is still a developing field, but it has the potential to revolutionize healthcare. As the technology continues to develop, we can expect to see even more innovative ways to use SHSS to improve the health of people around the world [21]. IoT developers and researchers are actively involved in developing IoT-based solutions to improve the lives of disabled and senior citizens. These solutions can help people with disabilities to live more independently and safely, and they can help senior citizens to stay connected with their loved ones and maintain their independence [22]. As the technology continues to develop, we can expect to see even more innovative ways to use IoT to improve the lives of disabled and senior citizens [23]. IoT devices and sensors with the help of internet can assist health monitoring of patients. They also proposed a framework and protocol to achieve their objective [24].

II. IOT ARCHITECTURE AND TECHNOLOGIES:

The IoT structural design consists of five important layers that define all the functionalities of IoT systems. IoT offers a framework for interconnecting devices to permit the communication seamlessly. Most of the IoT applications are highly focused on the middleware layer of IoT structural design for information processing [28, 43].

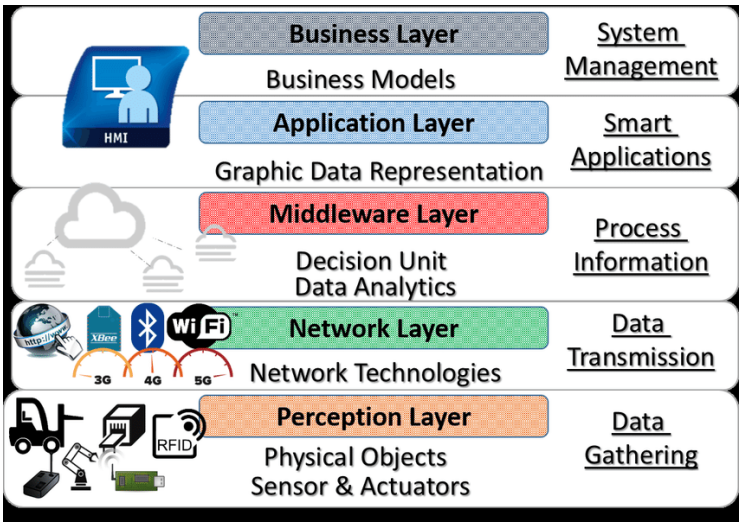

Figure 2: Five-layered IoT Architecture [40]

The five-layered IoT architecture is shown in Fig.2 which includes perception, network, middleware, application, and business layer [28].

1. **Perception Layer:** The perception layer is the first layer in the Internet of Things (IoT) architecture. It is responsible for collecting data from the physical world through sensors and actuators. The data collected by the perception layer is then processed and analyzed by the next layer[29]. The perception layer is an important part of the IoT architecture because it is responsible for collecting the raw data that is used to create insights and make decisions. The perception layer devices are Sensor, Actuator, cameras and RFID tags. The data collected by the perception layer can be used for a variety of purposes, such as:

    - Monitoring and controlling physical devices
    - Collecting data for analytics
    - Providing feedback to users

2. **Network Layer:** The network layer is an important part of the IoT architecture because it is responsible for ensuring that data packets are delivered reliably and efficiently. The network layer also plays a role in security, as it can be used to authenticate and encrypt data packets [30,31]. The network layer in IoT is responsible for: Routing data packets between IoT devices and gateways, Encapsulating data packets into frames for transmission over the physical layer, Fragmenting data packets into smaller packets if necessary(Bluetooth) & Reassembling data packets at the destination(Wi-Fi). The network layer in IoT uses a variety of protocols, Internet Protocol (IP), Routing Protocol for Low-Power and Lossy Networks (RPL) & 6LoWPAN.

3. **Middleware Layer:** The middleware layer is an important part of the IoT architecture because it provides a way to connect the perception layer and the application layer. The middleware layer also helps to manage the complexity of IoT projects. The middleware layer typically includes a variety of services, such as: Data storage and management, Data processing and analytics, Device management, Security & Messaging [32].

4. **Application Layer:** The application layer is an important part of the IoT architecture because it provides a way to interact with IoT devices and data. The application layer also helps to make IoT data more accessible and useful to end users [33]. The application layer typically includes a variety of services, such as Data visualization, Analytics, Reporting, User interfaces, Device control and Alerting.

5. **Business Layer:** The business layer is the highest layer in the Internet of Things (IoT) Architecture. It is responsible for providing business value to the organization [34]. The business
Layer typically includes a variety of services, such as:

- Business rules
- Business processes
- Business intelligence
- Reporting.
- User interfaces.

Moreover, for IoT technology the real achievement lies in well-constructed business models. After analyzing data, the business layer helps in decision making about upcoming activities and business strategies [35].

III. GREEN INTERNET OF THINGS:

Green IoT can be applied to various industries, including transportation, energy, and manufacturing. Green IoT can also be applied to agriculture and healthcare. In agriculture, Green IoT can be used to optimize crop production, reduce water usage, and minimize the use of harmful chemicals, promoting sustainable and eco-friendly farming practices [35]. In healthcare, Green IoT can be used to promote healthier living environments, reduce waste, and improve patient outcomes. Overall, the latest development in Green IoT is an increasing focus on using IoT technology to promote sustainability and decrease environmental impact in various industries. By promoting energy efficiency, reducing waste, and minimizing carbon emissions, Green IoT has the potential to help create a more sustainable and eco-friendly upcoming opportunity [36-37].

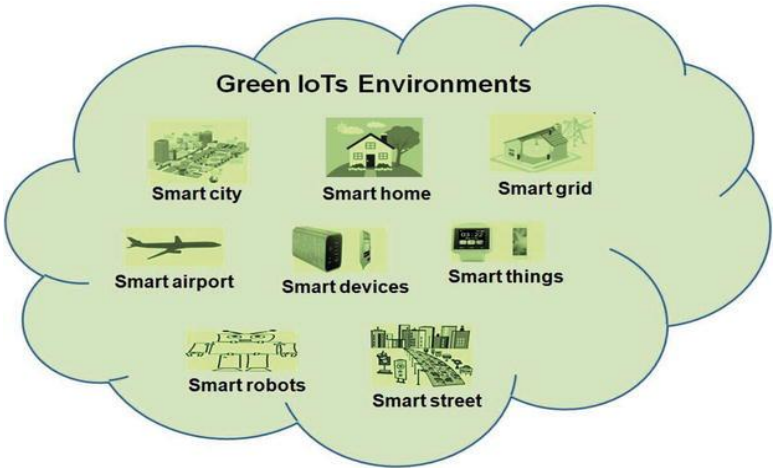

Figure 3: Green IoT [41]

IV. GREEN IOT ARCHITECTURE:

Green IoT architecture is a design approach that takes into consideration the sustainability of resources for future generations. It is a set of principles and practices that can be used to design, develop, and deploy IoT systems that are more environmentally friendly. Green IoT focuses on the three main concepts, namely design, leverage, and enabling technologies. In the design phase, the technologies such as energy-efficient devices, network architectures, communication protocols, and interconnection are considered [36]. Green IoT leverage focuses on the use of cloud computing, edge computing, and big data analytics to reduce the energy consumption of IoT devices. It also focuses on the use of machine learning and artificial intelligence to optimize the operation of IoT systems. Green IoT enabling technologies include technologies such as energy harvesting, smart sensors, and low-power wireless communication. These technologies can help to reduce the energy consumption of IoT devices and to improve their scalability[37]. By focusing on the above principles, total environmental sustainability can be achieved. Figure 4 shows the lifecycle of Green IoT, which has four phases green design, green construction, green operation and Application of IoT in Green Computing [38].

1. **Green Design:** Green design is a design approach that takes into consideration the sustainability of resources for future generations. One of the key principles of green design is the use of environmentally friendly materials :

    - IoT devices should use energy-efficient components, such as low-power processors and sensors. This will help to reduce the amount of energy that the device consumes.
    - IoT devices can be powered by renewable energy sources, such as solar or wind power. This will help to reduce the environmental impact of the device.
    - IoT devices should be designed for disassembly and recycling. This will help to reduce the amount of waste that is generated when the device is disposed.

2. **Green Production:** Green production is the practice of manufacturing products in a way that minimizes environmental impact. It includes using environmentally friendly materials, reducing waste, and using energy-efficient processes.

    - Green production can help to reduce the environmental impact of manufacturing. This can help to protect the environment and conserve natural resources.
    - Green production can help to reduce costs and improve efficiency. This can make businesses more competitive and profitable.
    - Green production can help to improve the health and safety of workers. This can create a more sustainable and healthy workplace.

3. **Green Utilization:** Green utilization is the practice of using IoT devices in a way that minimizes environmental impact. It includes using devices efficiently, recycling them when they are no longer needed, and disposing of them properly.

    - Green utilization can help to reduce the environmental impact of IoT devices by minimizing the amount of energy that they use and by reducing the amount of waste that they generate.

- Green utilization can help to improve the energy efficiency of IoT devices by using them efficiently and by recycling them when they are no longer needed.
- Green utilization can help to reduce the costs of IoT devices by reducing the amount of energy that they use and by reducing the amount of waste that they generate [30].

4. **Green Disposal:** Green disposal is the practice of disposing of IoT devices in a way that minimizes environmental impact. It includes recycling devices, donating them to organizations that refurbish and resell them, or disposing of them in a way that does not harm the environment.

- Green disposal can help to reduce the environmental impact of IoT devices by minimizing the amount of waste that is generated and by preventing hazardous materials from entering the environment.
- Green disposal can help to improve the energy efficiency of IoT devices by recycling them and by preventing the need to manufacture new devices.
- Green disposal can help to reduce the costs of IoT devices by recycling them and by preventing the need to dispose of them in landfills.

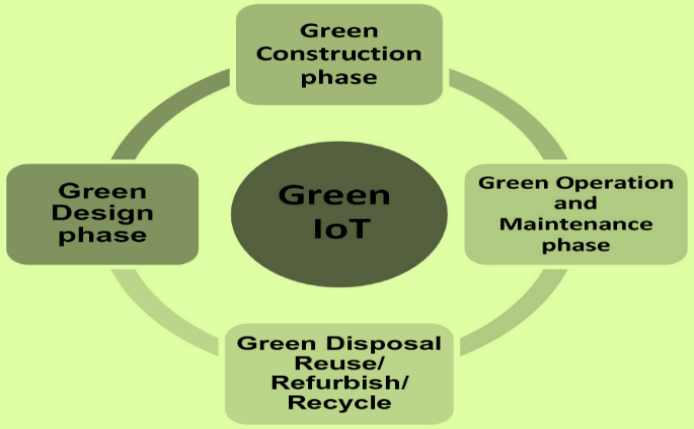

Figure 4: Green IoT Architecture [42]

Table 1: Comparison

Focus Technology	Type	Energy Saving Mechanism	Practical	Trade Offs
Data Centre[10]	Software Based	Context Aware Allocation of Servers	Practical	Extra Resources for QoS.
Sensors[22]	Software Based	Selective Sensing Highly	Practical	Practical Privacy, Energy Overheads for Context Aware Sensing
Sensors [19]	Software Based	Sleep Scheduling	Highly Practical	Extra Resources for QoS
Data Centre [16]	Software Based	Workload Distribution Among Geographically Dispersed DCs	Not Practical	Too Much Complexity
Smart	Policy Based	Policies and Strategies	Highly	User Dependency

Buildings [20]		to Minimize Energy Consumption.	Practical	(User needs to participate actively for efficient policies.
Processor [5]	Hardware Based	Assigning Different Tasks to Different cores by scheduling	Practical	High cost and complexity for large scale Network.
Sensors [25]	Software Based	Compressed Sensing	Practical	Quality of Service .
Cloud [26] Computing	Software Based	Reducing Data Path	Practical	Quality of service might fall.
RFID [14]	Hardware Based	Use of Passive Sensors	Practical	Communication Delays
Integrated Circuits[17]	Hardware Based	Reducing Network Traffic using Sensor on Chip.	Practical	High Cost
Mobile Phones/ Sensors [31]	Recycling Based	Recycling the unused elements to make them productive again.	Highly Practical	Chance of wastage of recyclable material.
Virtualization [6]	Software Based	Separating Network and IoT Devies using MILP	Practical	Performance issues in Large scale Network.
Smart Phones [38]	Software Based	Prediction of energy consumption for different application of smart phones	Practical	Privacy and Security of Data.

V. CONCLUSION

IoT and Green IoT are two different approaches to the Internet of Things. IoT is the general term for the network of physical objects that are connected to the internet and can collect and exchange data. Green IoT is a more specific term that refers to IoT devices that are designed to be energy efficient.

Green IoT is a rapidly growing field, and there are many new developments happening all the time. As the technology continues to mature, we can expect to see even more Green IoT devices and applications in the future. Overall, Green IoT is a promising approach to the Internet of Things that can help to reduce energy consumption and minimize environmental impact. However, there are still some challenges that need to be addressed before Green IoT can become conventional.

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