



# A Newer Approach to IOT: Green IOT

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## ABSTRACT

*Internet of things (IoT) is gaining huge popularity these days due to the number of applications that it has in the real world scenario. IoT allows several small to large scale electronic devices to communicate with the help of sensors. The tremendous growth in the number of IoT devices is posing a new challenge of energy conservation to the society. In order to cope with this challenge of energy conservation the term Green IoT was coined. Green IoT is nothing but low power consuming version of IoT. A review on what Green IoT is has been done in this paper. The architecture, applications, issues and challenges and major technologies associated with Green IoT have been discussed.*

**KEYWORDS:** *Internet of Things, Green Internet of things, Architecture, Application, Technology*

## I. INTRODUCTION

The Internet of things (IoT) is a system of interrelated computing devices which have the ability of transferring the data over a network without requiring the interaction between human-to-human or human-to-computer [1]. This term Internet of things (IoT) was coined by Kevin Ashton in 1999[3]. IoT is gaining huge popularity as it is applicable in several domains. Ranging from Supply chain, mining to the concept of smart homes and cities IoT is revolutionizing the life of people. It enables communication amongst the objects through the use of sensors. In the current scenario since everything is based on internet hence the dependency on internet is rising and giving rise to such concepts.

The growth in the field of IoT comes up with a challenge of energy conservation. Since the devices that are used in IoT consume lot of energy (also referred to as energy hungry IoT Devices) conserving the energy becomes highly crucial. Here Green IoT plays a vital role. It emphasizes on energy

efficiency in IoT principles. It visualizes the concept of reducing the energy consumption of energy hungry IoT devices thereby making the environment safe [5].

## II. INTERNET OF THINGS (IOT)

IoT is an emerging concept that is gaining significant attention these days. Through IoT we can connect billions of devices. These devices help in sensing, collecting and disseminating information. As stated already IOT is in huge demand and hence has been defined several times from different perspectives by several researchers. As quoted in [3] "IoT is based on the phenomenon that the objects which have the capability of identifying, sensing and processing can communicate with one another and services over the Internet to accomplish some meaningful objective by making use of the concepts of networking". IoT has the capability of connecting numerous devices resulting in lots of traffic. It has brought a significant impact on the society.

IOT makes use of sensors like RFID (Radio Frequency Identification) for connectivity. RFID serves as the foundation technology for IoT. RFID devices are wireless microchips to transmit identification information to reader through wireless communication [13]. Later for implementing IoT sensors, actuators, GPS devices and mobile devices were also started to be used. RFID has the capability of identifying objects wireless without the line of sight. It comprises of a reading device referred to as reader (It's a powerful device comprising of huge memory and computational resources) and tags. Tags can be one or more. RFID tags are broadly classified into Active, Passive and semi passive tags.

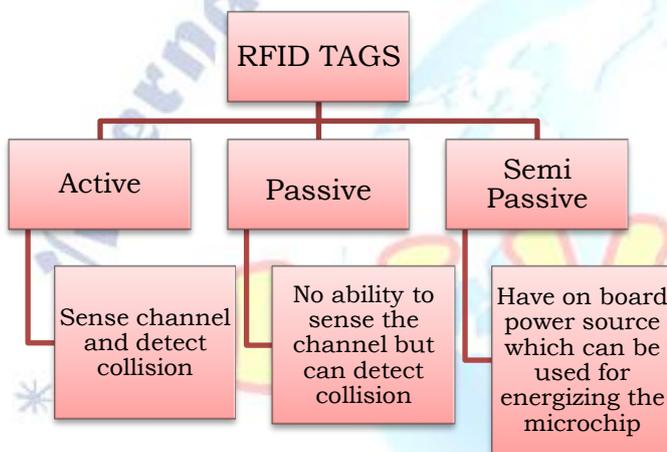


Figure 1: RFID Tags Classification

Name of Technology	Mode of information transmit	Application area
RFID	Microchip	Logistics, Pharmaceuticals, Retailing, Supply Chain Management
WSN	Intelligent Sensors	Environment monitoring, healthcare monitoring, industrial monitoring, traffic monitoring

Table 1: IOT Technologies

### III. ELEMENT OF IOT

This section talks about the major building blocks or elements which are essential for the functionality of IoT. Overview of the six elements

that make up IoT have been given below. Fig 1 also illustrates these major components essential for IoT.

- Identification- This is the most important element in IoT as it ensures that the data is delivered to the correct recipient.
- Sensing – involves the use of sensors for collecting the data, sending it to data centers and then analyzing the data collected using different parameters. This is the most critical element of IoT.
- Communication – This is achieved by making use of internet technology or Bluetooth etc.
- Computation- It is carried out using microcontrollers, microprocessors etc.
- Semantics- It basically talks about extracting knowledge smartly or decision making on the basis of data that has been collected.
- Services- IoT offers a variety of services. These services are broadly categorized into identity related, information aggregation related, Ubiquitous Services and Collaborative aware [3].

### IV. ARCHITECTURE

IoT is gaining huge popularity. The reason for this success is that it has the capability of connecting several devices that we are using merely by internet. Although this concept is becoming a buzzword but no single agreement on the architecture of IoT has been approved till date. After doing the research we found that commonly there are three types of architecture which are being discussed. The first and the most commonly used one is the threelayer architecture. The other two architectures which have been proposed are four layer and five layer.

#### Three-layer Architecture

This architecture is the most popular architecture. It has also been referred to as the basic architecture. It comprises of three layers namely Application Layer, Network layer and Perception Layer. An overview of the three layers is given in the figure below [3]:

Name of Layer	Devices used	Function
Application Layer	Deals with the end user	Application Management, specific services are delivered to the end user.
Network Layer	Wifi , 3G,IR	Routing and Secure data transmission
Perception Layer	Physical devices and sensors like RFID, Infra-Red, WSN etc.	Identification, Tracking, Information acquisition, Processing from environment

Table 2: Three Layer Architecture of IOT

#### Four-layer Architecture

In this architecture an additional layer is added. This layer is referred to as the Service layer. It is placed in between Network and Application Layer. This layer is used for creating and managing the services [3] [18] [19].

#### Five-layer Architecture

A Five-layer architecture has also been proposed [3][20][21] This architecture comprises five layers. The five layers are Perception Layer, Transport Layer, Processing Layer, Business Layer and Application Layer. The transport layer is responsible for data transmission and confidentiality of information. Service management and data storage are being looked upon by the Processing layer. Finally, the business layer manages the entire IoT system and also monitors the other 4 layers. The functionality of the other two layers i.e. Perception and Application remains the same.

#### V. WHAT IS GREEN IOT? WHY IT IS CALLED SO?

Green IoT as we all know talks about how we can reduce the energy consumption of IoT devices thereby making the environment safe[5]. IoT works by mounting of various sensors. These sensors help in tracking and can be controlled remotely. The collected information is then transmitted to data centers via internet[5]. These devices are also referred to as energy hungry or powerhungry devices due to the amount of energy they consume. Green IoT addresses this issue of reducing energy consumption by making use of various strategies like awareness campaigns, smart meters, smart

sensors, designing energy efficient data centers etc. [5][4][10]. These strategies have been discussed in detail later in this chapter. A lifecycle of Green IoT has also been given in [6] which starts with Green Design, followed by Green Production, Green utilization and ends with Green recycling. It is an iterative process that generally ends at recycling so that there is minimal impact on environment. It is highly essential that while making any application of IoT that at every step we are focusing on the Green aspect, starting from design to final implementation. When we talk about Green IoT we should focus on environment friendly and energy efficient initiatives.

A few principles have been proposed in [5] that can help us in achieving Green IoT. They are making certain policies, making use of hybrid architecture (combined usage of active and passive sensors), using selective sensing by collecting data only which is required, reducing size of network by placing nodes properly and finally by intelligently doing tradeoffs by prioritizing costs and processing for saving energy.

#### VI. APPLICATION OF GREEN IOT

- Smart home: The concept of smart home in context of green IoT ensures that the energy consumption is significantly reduced. It involves making smart decisions like turning the appliances switch off when we are away. Green IoT allows us to control electronic devices by using a smart phone.
- Industrial automation: It talks about the industries which are making use of IoT technology by automating the machines completely or minimum human intervention.
- Smart healthcare: We have already discussed above the use of IoT in healthcare sector. Energy efficiency can be achieved by taking readings from IoT sensors and running energy awareness campaigns.
- Smart cities: This is the most promising and prominent application of IoT. In this concept almost everything used makes use of IoT technology. If we are properly monitoring the readings from IoT sensors substantial energy can be saved. Another way is by launching energy awareness campaigns substantial amount of energy can be saved.[27]

## VII. TECHNOLOGY IN GREEN IOT

Green IoT talks about a variety of Green Technologies. The major ones are Green RFIDs [15], Green Data Centers, Green Wireless Sensor Networks and Green Cloud Computing [5][6][9]. However, in [9] a few more technologies have been discussed green machine to machine, green internet and green communication network.

- a) Green RFID: RFID or Radio Frequency Identification can be referred to as the backbone of IoT. This was the first technology used for implementing IoT. Apart from reader and tags two other components which are considered to be a part of RFID are RFID antenna and RFID station. RFID stations are responsible for processing of data. RFID uses radio waves for retrieving, identifying and storing data remotely. RFIDs are typically used in transportation, shipping, inventory control etc. Some of the techniques have been suggested in [9] which must be followed for Green RFID are : size reduction of RFID tags since recycling them is a tough task ; use of energy efficient techniques and protocols for avoiding collision of tags , estimation of tags etc.
- b) Green Cloud computing – The main purpose of GCC is maximizing the energy consumption and enhancing the recyclability of old products and wastes. Green cloud computing relies on supporting communication and networking technologies. [Emerging Trends of Green IoT for Smart World]
- c) Some possible solutions proposed in [9] for implementing GCC are: adopting software and hardware so that energy consumption is minimized; power saving using VM techniques; efficient methods for energy saving schemes and making use of various energy efficient resource allocation mechanism.
- d) Green Wireless Sensor Networks- Wireless sensor networks are a combination of wireless communication and sensing. It is amongst one of the key technologies which have revolutionized IoT. They have been used in various applications such as healthcare, environmental monitoring, traffic management, surveillance etc. WSN works by deploying sensor nodes and base station nodes. These sensor nodes are categorized into planned and random. The sensor nodes perform the reading from the surroundings e.g. temperature. They

can also communicate amongst themselves and deliver this sensory data to the base station. The sensor nodes used here are normally battery operated with constrained power. If in case the number of nodes increases changing of battery becomes challenging and is normally not feasible. Due to low cost making a change in the entire network turns out to be easier as compared to individual batteries. Optimizing energy in sensor nodes is gaining huge popularity in the research community these days [27].

- e) Green Data Centers – Green Data Center (GDC) technology is a latest technology. The data centers are responsible for managing and processing of data created by the users. It consumes a lot of energy for processing since the amount of data that is stored is huge. The current technique utilizes renewable and green source of energy e.g. wind, water, solar etc. Some techniques have been cited in [9] for GDC. These can be achieved by making use of renewable sources of energy; utilizing efficient dynamic power management system, designing much more energy efficient hardware techniques; constructing efficient and accurate data center power models and finally by drawing support from communication and computing techniques.

## VIII. ACCOMPLISHING GREEN IOT

It has been said several times that Green IoT eradicates the problem of energy conservation which is posed by IoT technology. Various approaches have been proposed by researchers [5] [4] [10]. A study has been carried out in [5] which categorizes these methodologies into namely six categories. The first one is hardware based, second software based, third habitual based, fourth awareness based, fifth policy based and finally the last one is recycling based. In software based methods software's are used for saving on energy. The hardware based approach talks about making changes in the hardware which will ultimately lead to substantial conservation of energy. E.g. designing smart integrated chip or keeping the RFID tags on sleep mode when they are not being used. Policy based approach talks about making policies that can help in energy efficiency like monitoring, user feedback etc. Awareness based approach talk about raising awareness amongst the users. Habitual based states that first track the habits of users and then take action accordingly. In case of recycling based approach the author states

that recycling plays a very crucial role in making the environment eco friendly.

A performance comparison was carried out for all the above methodologies. The parameters that have been identified for comparison are the focusing technology, reason for energy consumption, energy saving method, parameter improved and the tradeoffs made. The most promising ones (highly practical) have been presented and proposed in the table given below [5][10].

#	Focus ing Tech.	Reason of Energy Cons.	Energy Saving Method	Para mete r Impr oved	Trade Offs
1	Senso rs	Sensing data Continuous Sensing	Selective Sensing, Sleep Scheduling	Latency, Sensor Placement, Context awareness, Mobility, QoS	Privacy , Energy Overheads for Context Aware Sensing, Extra resources for QoS.
2	Smart Buildings	Users are not smart	Policies and strategies to minimize energy consumption	Not stated	Effective user participation is required
3	Smart Metering	User dependent	Tracking different types of energy consumption and devising measures to minimize loss of energy.	Not stated	Security of data and Privacy .
4	Mobil e Phone s	User dependent	Recycling the unused parts in order to make them	Not stated	Chanc e of wastage of recyclable materi

			once again productive		al
5	IT	Not stated	Data is collected from different parts of building for creating energy efficient policies	Not stated	Privacy of data and security.

Table 3: Performance Comparison of IOT Technology

Apart from the abovementioned techniques awareness based approach also seems to be a viable solution for implementing Green IoT. If we raise awareness amongst users it can lead to positive thinking amongst people thereby reducing the energy consumption highly. But it has to be planned very smartly. Proper planning and analysis also needs to be carried out so that in case the current campaign is not so successful we can look for the flaws and can improvise it the next time.

Smart metering as stated above also is another viable solution to this problem of energy conservation. They provide the readings to the user at real time and make the user aware of his consumption easily. Smart meters can be easily applied in home networks, neighborhood or wide area network. The readings obtained can be used further for predicting the future usage of energy. Recycling is another solution to the problem of IoT. Recycling of products helps in reducing the green house effect e.g. recycling mobile phones. IoT is contributing a lot to e waste and the process of recycling will contribute a lot in making the environment eco friendly. In order to promote recycling of products awareness campaigns needs to be launched so that people get a better understanding of the hazardous effects on the environment if it is not done.

Some of the other strategies which can help in reducing the consumption of energy [5]have been stated below:

- Energy efficient transmission of data from sensors
- Designing energy efficient policies
- Designing energy efficient data centers

## IX. ISSUES AND CHALLENGES OF GREEN IOT

This implementation of any technology comes up with several challenges. It is very difficult to make a transition from IoT to Green IoT. Although the major challenge of Privacy and data security remains the same in case of IoT as well as Green IoT. A few other challenges that were discovered while implementing Green IoT as part of this research activity have been given below [5]:

- a) Privacy
- b) Extra resources for Quality of Service (QoS).
- c) User needs to participate actively for efficient policies.
- d) Data Security
- e) Changing attitude of people is not easy
- f) Cost of implementation in case of Green RFID devices.

## X. CONCLUSION

This chapter emphasizes on why a transition is required from IoT to Green IoT. The concept of IoT is in great demand these days but unfortunately it comes up with a tradeoff of energy efficiency. The concept of IoT has been discussed deeply in this chapter. The elements, architecture, technologies, issues and challenges, application areas of IoT have been explained properly. The concept of Green IoT has been presented and the reason why it is required is also discussed. The potential application areas where Green IoT can be applied have been stated. Although the applications of IoT and Green IoT remain the same but in case of Green IoT the emphasis is on energy conservation while deploying IoT technologies. The issues and challenges arising in both IoT and Green IoT have been studied and presented. The technologies involved in the implementation of Green IoT have been elaborated. A study was carried out on the various methods available for transforming IoT to Green IoT. The study has been used for finding out the most promising solutions while implementing Green IoT. On the basis of certain parameters this study was conducted. In the nutshell the best practices that one should follow if Green IoT has to be implemented have been stated like the concept of smart metering, recycling and launching of energy awareness campaign amongst the users. In the end the launching of energy awareness campaign was found to be the most effective one apart from the ones given in the table. If a person takes the responsibility on his own of conserving

energy then definitely there would be no threat to the environment. Finally, some other strategies have been pointed out which can help in reducing the energy consumption. This chapter would help the reader in having a clear understanding of the concepts of IoT as well as green IoT, the detailed difference between the two technologies and how we can switch from IoT to green IoT.

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