The Green Internet of Things:A review

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Abstract: The Internet of Things (IoT) is a rapidly growing technology that connects everything in a smart world. It will give rise to an era in which almost every object (e.g. mobiles, laptops, cars, watches, AC..) will be connected to the internet and will intelligently serve people. This will pave way for a smart world, which will not require much human intervention and make things automatic. IoT devices are used to send and receive data without human intervention. Although IoT has provided us with numerous advantages, engineers should also keep in mind the pollution, e-waste and most importantly it consumes huge amounts of energy. This gives rise to Green IoT, which is said to be the future of IoT which is environmentally friendly. Green IoT helps to reduce the energy consumption of IoT machines, machines, communications, sensors, clouds, and internet and reduce pollution and emissions, and minimize operational costs and power consumption. Green IoT will bring about a change in the world by making it greener and smarter. In our paper we review the current usage of IOT systems, analyze the efficiency of the device and provide meaningful solutions to tackle the problem obtained through research of numerous articles.

Keywords— green IOT, green cloud technology, green data center, Environmental hazards, green design, green modeling, E-waste.

I. INTRODUCTION

The Internet of Things is a process of connecting the software and the hardware devices for better utility among the people. It helps make life easier and user friendly and helps reduce human interaction with the devices .It helps the world to turn into a smarter place with using technology such as Sensor networks, Radio-Frequency Identification(RFID), nano-technologies and biometrics which are widely used among the present generation IOT.As see it helps in a fast paced improvement of the technology and provides a lot of advantages to the society enriching the way of living it has a side effect too. Considering the whole life cycle of the IOT process it causes a lot of damage to the environment from its design process , manufacture , packaging and transport and usage in the form of carbon foot-print and waste from raw materials and even additional usage of plastic for packaging and transport and pollution to an extent while transporting and installing. It consumes major amount of electricity as well while it's in use. So, in this paper the green internet of things talks about the energy efficiency in the IOT process and usage. How green IOT could make the usage of this extensively used technology more eco-friendly. The process of making it greener and efficient in various fields like Software, Agriculture, Healthcare, Industry and many more places where it is used.

Green IOT has been successful in developing many technologies for this accomplishment. It involves having a track on the whole life cycle of the process of manufacturing the device and giving its best inputs for reducing the pollution it causes to the environment. This paper gives you an insight as well of its applications, challenges and the recycling process it has adopted in the recent years. It has developed sensor technology as well which helps us monitor the usage of our devices and helps keep a note of the change seen whilst practicing green IOT. Giving an overview of the technology adopted and process it follows in making the environment more green and eco-friendly .It could help draw conclusions ,address the conflicts faced and add more suggestions in continuing this work and even help make better ideas come up in the fields of IT Technology, Health care, Agriculture, Industrial manufacturing process, communication ,Networking ,Storage areas and devices, Automobiles, smart home appliances, wireless sensor technologies, Mobile Computing ,packaging and accessories, Hardware utilization and many more.

II. PROPOSED WORK

The authors in [1] highlight energy consumption by various devises and concerns regarding irresponsible usage of technology and energy, to which the authors analyse and provide possible solutions to these technologies and their efficient usages in our day to day lives. As the author describes it, the key points to improve the existing conditions are: concept of practical working of green internet of things i.e., green IOT, security concerns/issues, technology adaptation trends and how they co-relate with the increase in global carbon footprint and how to better the situation, they also give solutions for how to achieve technological feats whilst keeping the current concerns of global carbon footprint in mind.

Trending technologies in the field of IOT or Green IOT include that of efficient implementations of green IOT and green cloud computing. Hence, the authors in [2] have put together a research paper that discusses

the trend being followed in development of IOT and how it could to careless usage if not used with care and due diligence. The paper provides measures in advancement of development in green IOT while taking enough measures to ensure usage of green technology. The authors have a more focused approach towards the health care systems. Reduction of consumption of energy of CC and IOT in that domain. The paper talks about the history of emergence of IOT and how it transitioned into green IOT. They observe the patterns in evolutions and usage of technology and for see the near future based on the evolution of tech, patterns, usage by end user. This paper talks about sensor cloud integration models in the field of agriculture and healthcare by making IOT devices used in this domain to be greener. The paper also throws light on the models and designing of these models to achieve the objective of efficient use of green IOT in the respective domains.

Achieving a green platform for IOT devices to work on is definitely a technical feat in the field of engineering and innovation. The authors in [3] have observed the ongoing challenges in achieving this feat for the current energy hungry IOT technologies/devices. Mr. Rushan and Mr. Saman have addressed these issues in their paper that offers possible strategies and solutions to minimize the energy consumptions of these devises. Methods suggested by the authors consist of increasing the efficiency of transmitting data from sensors so as to reduce power consumption, design of energy efficient policies, efficient data centres. The paper also talks about the principles required in order to achieve the objective of green IOT.

The authors in [4] shed some light on the vast expanse of IOT and it being used in our everyday lives, hence responsible and efficient usage of power and technology becomes critical. On observing the paradigm shift in usage of energy to green energy over the upcoming years, it becomes critical in order to support the advancement in technology using green energy.
This paper highlights the shift in a battery supported ubiquitous technology to a more viable platform to obtain energy from the surrounding. The approach to achieving the objective lies in the design of an IOT module and key to efficient power management for an IOT system.

The Authors in [5] aim to shift the way modern technology uses IOT networking to a greener platform for IOT networking. In the process of achieving the set objective, the emphasis is given to optimizing the performance of network coding which indulge into

communication and reliable storage. For the given problem the paper addresses two parts: 1) IOT core network where the data transmitted. 2) Distributed cloud storage, where the IOT network is stored.
To tackle the enlisted objectives, an adaptive network for coding scheme is proposed to enhance the efficiency of transmission. The authors have demonstrated superior performance of the proposed scheme and performance over the existing schemes. They also have deployed algorithms to compute the most reliable allocation in distributing N data components among N data centres whilst considering the probability of each data centre. Hence through the analysis and simulation the storage reliability can be superseded when compared to existing systems.

The authors in [6] dive into a futuristic design of implementing Cloud Based Green IOT for smart cities. The paper stresses on sustainability achieved through collaborative measures. Necessities such as reduction in energy consumption, emission of carbon footprints are being stressed upon by the governments to achieve a healthy transition to a green IOT for smart cities. The paper demonstrates the green IOT architecture for smart cities to reduce energy consumption and to establish movement towards green energy at every stage. The movement is directed at using cloud technology to reduce the hardware usage, hence reducing wastage.

The authors in [7] have focused issues with energy consumptions in IOT based systems, since most of these devices demand high power. Thus, aiming for a sustainable environment. The paper indicates the efficient ways of using IOT systems. In order to achieve the set objectives, the authors have systematically categorised pre-existing system techniques in tabulated form based on components and different layers of IOT.

The authors in [8] give a briefing of IOT and green IOT and the distinction in design and usage of such technologies and its impact. The following topics discussed in the paper are green wireless sensor network, green radio-frequency identification, green machine to machine, green cloud computing and green datacentre. To solve the current issue of usage of hardware, the vision of sensor cloud is reviewed and introduced. Along with the solutions presented the paper touches upon the future threats or shortcomings the world could face if not careful in using green energy. Hence the paper not only throws light on the possible solutions to solve the ongoing crisis but has a vision to predict the future short comings and offer us

warning much in advance, which yields to advancement in using green energy.

The authors in [9] throws light on the technologies and researches that have emerged from green IOT. Technologies such as smart grid, e-health, and intelligent transportation are upcoming and very promising. Nonetheless, the focus on green IOT is crucial as if not foreseen, could land the world in huge trouble with an upsurge of E-Waste. Hence the goal of the paper is to reduce emissions and pollution, exploiting environmental conservation and surveillance, and minimizing operational costs and power consumption. The given paper is a review of several other papers that indulge into the advancement of technology in IOT. A few of such technologies enlisted here are: "An IoT Architecture for Assessing Road Safety in Smart Cities", "Power Profiling of Context Aware Systems: A Contemporary Analysis and Framework for Power Conservation", "Congestion Control and Prediction Schemes Using Fuzzy Logic System with Adaptive Membership Function in Wireless Sensor Networks", "An Open IoT Platform to Promote Eco-Sustainable Innovation in Western Africa: Real Urban and Rural Testbeds".

The authors in [10] describe the ongoing trend on the development of IOT and hence 1) need to design energy efficient devices for computation, tools for communication and networking architectures to interconnect the world. 2) To enhance the usage of green energy plus reduce the carbon footprint generated by E-waste to achieve the objective green IOT. Green IOT targets few of the technologies such as: Cellular networks, Sensor networks, RFID, Intra Machine communication, cognitive radio, big data analysis and cloud computing. Substantial advances are being made in the field of IOT and it hence becomes critical to shift to G-IOT.

The authors in [11] bring to light of the energy consumption of powerful IOT devices and the efficient ways to reduce the energy consumed by these devices. The paper in itself is a review of current optimization methods of these sophisticated devices. The paper helps other research to better their study by providing information on current energy efficient methodologies.

III. CURRENT SYSTEMS

There are multiple models proposed for the deployment of energy efficient IoT. Green IoT is a trending topic now as it provides efficient ways of reducing the energy required and saves a lot of money as well. Green IoT is useful in multiple fields to make the systems greener and better.

Let's take a look at some of the Green IOT systems currently under use component wise:
1)Sensors:
Energy Consumption: Sensing data, through continuous sensing. Energy Saving Method: Self Powering Sensors/Selective automated Compressed Sensing, Sleep Scheduling. Parameters Improved: Mobility, Sensor placement, QoS, Latency, context, extra resources, awareness.

2)RFID:
Energy Consumption: Identification of sensed data. Energy Saving Method: Passive Sensors Parameters Improved: Performance, communication delays.

3)Data-Centres:
Energy Consumption: High computation tasks performed, Processing of data in the cloud. Energy Saving Method: Minimizing path of data, Distribution of load. Parameters Improved: Qos, Complexity, Position accuracy.

4) Sink-Nodes: Energy Consumption: Communication linkage between nodes and sensors. Energy Saving Method: Scheduling processing by triggering events. Parameters Improved: Battery level of sensor node, Quality of Information, Sleep interval, Conflict factor, control of power.

5)Resource-Allocator: Energy Consumption: Allocation of data to resources from gateway. Energy Saving Method: Tuning and allocation of sensing and processing components. Parameters Improved: Fairness, access scheduling, throughput.

6)Wireless sensor nodes:
Energy Consumption: Communication along with networking. Energy Saving Method: Routing techniques such as multi hop routing, routing with multiple constraints and Cluster head communication. Parameters Improved: Latency, Transmission Power level, which intern increases the efficiency, lifetime of the network, coverage and mobility of the network.

7)eNode / Base Station: Energy Consumption: Consumption occurs because the processing layer is allocated with sensor data and obtaining information from cloud that is passed on to the gateway. Energy Saving Method: A highly efficient Path of communication is obtained between cloud and sensors resources, calculation of resource-allocation factors, Efficient algorithms intended at load balancing for gateway nodes. Parameters Improved: Topology Deployment, Interaction with cloud, Load allocation, Interoperability.

8)Processor/Cloud: Energy Consumption: Assigning different tasks to different cores, High computations, context aware allocation of servers. Energy Saving Method: Methods such as fog and edge computing, Data path reduction, using of downloading of Dynamic packet, controlled scheduling of allocation of dynamic tasks.   Parameters Improved: By reducing complexity, hence observing a decrease in QoS cost, throughput of transmission/processing and Resources used.

9)Actuators: Energy Consumption: Actuators are triggered due to a stimulus consuming energy, when triggered.
Energy Saving Method: Prediction and keeping a track of different energy consumptions.
Parameters Improved: User pattern, privacy, security.

10)Gateway Nodes: Energy Consumption: Communication linkage between nodes and sensors. Energy Saving Method: Scheduling with triggering events and controlled storage. Parameters Improved: Sleep Interval, QOI, sensor node's battery level, power node.

The above listed components are analysed categorically based on the cause of energy consumption, Energy saving method and parameters Improved.

IV.PROPOSED SYSTEMS

The future of Green IoT is bright and will bring a change in our environment by making it greener and healthier, socially and economically sustainable. It will also increase the QoS. The main focus is on greening things such as green networking and communication, green design, green IoT services and implementation and energy saving strategies. Research has to be done in the following fields for an efficient and optimal solutions for greening IoT:

1. In order to reduce power consumption and pollution in traffic, agriculture and monitoring there is a need to replace a large number of IoT devices by UAV. This is a promising technology that will make Green IoT highly efficient and of low cost.
2. The smart machines need to be made smarter in order to enable automated systems. Also, the delay in automation needs to be reduced in terms of traffic. To reduce the energy use and the harmful emissions.

3. A thorough research must be done on how to use recycled materials for the development of sensors.
4. The devices as well as the protocol used to communicate need to be made energy efficient by consuming less power.
5. The green internet of things can lead to a sustainable future and green environment by using new resources and less energy having lesser impact on the environment and human health.
6. Considering an option of radio frequency energy harvest helps in gaining an energy balance which helps in supporting green communication between IOT devices.
7. The major task of the future having to be to reduce the CO2 emission and reduce the energy consumption further studies and ideas for a better IOT architecture should be developed.

V. CONCLUSION

IoT has become a very important part of our lives and helps bring a change in the quality of life. Although it has gained so much importance in our lives, the side effects of IoT have a drastic negative impact on our environment. If nothing is done to bring a change in the way these things work, we could never be able to reverse the effect of it once it's too late. So, the idea of Green IoT came into place. Green IoT not only helps reduce the harmful emissions from IoT devices but it can be used to make other machines more efficient and greener. Green IoT is said to revolutionize the IT industry. In this paper, it has been discussed the need to transition to Green IoT and the applications of it and how it is bringing a change in the world and its future scope.

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