Smart World through Green Internet of Things

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Abstract- *In this era of science and technology, being technologically literate is essential for turning a city into a smart city. The Internet of Things (IoT) is like the backbone of such future cities with the help of which a widespread city can be connected. Most importantly we should never forget that smart cities are green cities as they have to use their resources sustainably and are resilient. The green smart cities are not possible to think without green IoT as IoT enabled devices will be needed to solve everyday problems. These IoT devices are needed to be greener and smarter to reduce and control the destroying effects of human activities on our environment. This paper analyses the enabling technologies for green IoT and suggests a regulatory mechanism for ensuring 'green' use of IoT devices in the 'smart world'.*

Keywords: smart cities, Green Internet of Things (IoT), network, environment.

1. INTRODUCTION
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The Internet of Things (IoT) is being utilized today in almost all industries and fields across the board, be it agriculture, textile to manufacturing and healthcare and everything in between. The functionalities and characteristics of IoT have to be understood in order to understand the positive and negative that they have on our environment and that in turn is necessary to formulate the policies and technology of green IoT to be used in our smart cities. The glory of ubiquitous network, i.e. The Internet, is not hidden from anyone today. It has reduced this vast world into a global village where information and data have got the designation of being new 'oil' for the world. We are also aware of the wonders that happen when the devices around us are connected to the internet. It feels like almost everything is at our fingertips, just one click away. IoT is very crucial for development of the smart world that humans across the globe have thought of because it enables not only businesses but also common people to have a better control over the majority of objects and useful devices that as of now remain beyond the reach of the internet. Thus, IoT enables people to be extensively connected to the world that was till now isolated from the internet and do more productive work while simultaneously raising comfort and standard of living. As we know that with almost all of the technological developments there are pros and cons. IoT also is no different from the rest of them. It is generally observed that the Internet of Things is most often related to areas that people come into contact everyday like their air conditioners, cars, water tanks & taps etc. IoT enabling technologies and IoT itself have neither constituted for everything good nor they have been doing all bad to our surroundings or environment, they have been a mixture of positive and negative impacts and it is due to these negative impacts that engineers and scientists need to focus on Green IoT in order to achieve their goals for a smarter world.

Global warming is considered one of the worst impacts of climate change that the world is facing today in which carbon dioxide emissions play a major role. IoT can be used to reduce the impact of global warming and many examples can be cited, like the smart energy meters connected to power grids that can monitor and regulate the CO_2 emissions from the power plants. Also the simple application of connecting vehicles to the internet and guiding them to a better, less congested route could help reduce emissions from vehicles and lower the air pollution also. In this way IoT could reduce CO_2 emission in the smart world.

IoT is also enabling a green technology revolution by another means called resource preservation. Sustainable use of all kinds of resources available to us leads not only ensures a greener future but also availability of these resources for our future generation. IoT enabled devices could play a crucial role implementing green practices and resources conservation across the entire supply chain. Apart from that it can also be used for building management and home management far more intelligently in comparison to non-IoT devices. This would ensure less wastage of water using flow sensors and also real-time leakage alerts. These advancements help in automation of resource management in a way that humans alone wouldn't have been able to do alone. Technologies like IBM Watson are helping farmers to spend their resources in farms in a more systematic and smarter way by making them spend those only when necessary. But as said above, unfortunately IoT has few negative impacts also regarding which solution needs to be researched upon and developed so that we move more and more towards green Internet of Things. It is contributing in the increase of e-wastes and also as most of the IoT devices are electric the energy required by them for their operation comes from conventional sources only and this would lead to a sharp increase in

power consumption as IoT devices are meant to be vigilant all the time. Another matter of concern is the amount of data that will be generated every moment when the expected use of IoT technology is done in our smart cities, all these data would require energy to flow through the network and need mechanisms for their storage and processing. However, a deep analysis of implementing IoT is required as it comes with various vulnerabilities relating to security and privacy issues [14]. Thus, it is important to access the IoT enabling technologies based on these environmental concerns and make IoT devices ready for the smart world that is 'greener '.

2. LITERATURE SURVEY

In [1], the authors provide an overview for the green internet of things used in smart world. They present a unique concept called sensor-clouds in which a dedicated cloud based infrastructure which will enable effective computation using sensors. It proposes the use of the internet as the communication medium, clusters involving data-computing as cyber backbone and sensors as the interface between them. This infrastructure would also help in virtualization of storage units that will be comparatively more energy efficient. Wireless Sensor Networks (WSNs) play an important role in development of this infrastructure which is already easy to implement according to the standards of green computing. Apart from this the state of the art work also describes how the various IoT enabling technologies like green M2M, green CC etc. can be put together and Information and Communication Technology (ICT) could be formed according to the norms of green computing. Such IoT enabling technologies will take us to the dream of seamless connectivity between all the devices within a city and ensure modernization.

In research work [2] a narrative of deployment of IoT technology that is green is provided. It highlights how the Internet of Things (IoT) is acting as a crucial bridge connecting our physical world to the cyber world. Thus, it is of extreme importance in networking paradigms. Authors have realized that developing deployment schemes for IoT that are green and adheres to green computing norms is a challenging task. The reason for the same being the large scale of IoT that leads to complexity due to which the present scheme for the deployment of WSNs cannot be used directly in IoT. They further address this challenge by proposing a deployment scheme to achieve a network for IoT deployment that is 'green'. The contributions made in this paper include -

1. A hierarchical system framework for a general IoT deployment
2. An optimization model on the basis of proposed system framework to realize green IoT
3. A minimal energy consumption algorithm for solving the presented optimization model

The numerical results on minimal energy consumption and network lifetime of the system indicate that the deployment scheme proposed in this paper is more flexible and energy efficient compared to typical WSN deployment scheme; thus is applicable to the green IoT deployment.

In [3] authors express concern over the increase in the carbon footprint and the need to do more research in the field of increasing efficiency in the IoT and thus pave the way for an emerging area called green IoT. They have highlighted various aspects of IoT -

1. Key enablers
2. communications
3. services
4. applications

And at each of these aspects efficient energy utilization techniques are needed to be developed to enable a green IoT environment. They explore and discuss how the various enabling technologies (such as the Internet, smart objects, sensors, etc.) can be efficiently deployed to achieve a green IoT. They also review the challenges that are on the way and need to be addressed to enable green IoT. In this paper, they have surveyed the green perspective of the IoT and discussed recent efforts in the green IoT area resulting in identification of potential areas where the focus should be in the future for green IoT.

The state of the art work [4] gives an insight on utilizing cooperative WSNs for resolving the energy supply problems for fueling green Internet of Things (IoT). They have focused on energy harvesting (EH) techniques and put forward the EHC-WSNs i.e. EH cooperative wireless sensor networks which happens to be a relatively new energy harvesting technique in which the steady supply of power is ensured by integrating EH and wireless energy transfer technologies. They propose the graphene-grid strategy for deployment of energy to ensure coverage as well as network connectivity. Also a management mechanism named Graphene-based Energy Cooperation Management (GECM) is proposed for maximizing the harvested energy utilization. They highlight that traditional battery powered WSNs have energy limitations that will be resolved by GECM. They have proposed an algorithm named GOCR aimed at resolving the energy distribution imbalance.

In state of the art work [5], the authors have emphasized on resource management in order to get a green IoT network. They have expressed their concern over the very much evident possibility of billions of objects being connected with the help of sensors which includes embedded devices as well for the purpose of gaining extensive intelligence in the upcoming smart world. Authors underline the fact that the performance of such networks depend upon the availability of network resources in the form of both spectrum as well as energy supply. They have tried to put in place a stochastic problem for optimizing the usability of the IoT network minus the energy costs incurred for purchasing it.

Research work [6] gives us a model in which a solution is proposed for the giant problem of data collection and management in an environment friendly way. They propose the use of low-earth-orbit satellites for collecting data from the IoT networks that would be huge in amount. The LEO satellites would be reliable for this purpose as they have been gaining attention towards their effective use as a supplementary to land communication networks. Authors have highlighted the problem of data collection from IoT networks that they have constantly varying uplinks and the added pressure of collecting data in an energy efficient 'greener' way adds further to this challenge. In order to resolve this issue they have proposed an algorithm which is based on Lyapunov optimization Theory in order to uphold their commitment of green data upload from IoT networks. Their model works on the basic principle of maximizing the data upload capacity and simultaneously minimizing the energy required to do so. The proposed algorithm is much like an online data scheduling algorithm.

In [7] authors have proposed a model for building a reliable routing infrastructure to help in establishing green IoT networks. Their concern is also the same as most of the other state of the art works as they have also highlighted that a huge amount of energy is needed to support all the devices being IoT enabled in a sustainable manner. The proposed algorithm uses multipath techniques and clustering to lower the energy requirement. An assembly area is created inside the network hence it can also be called as a rendezvous-based routing protocol. In the protocol, they have proposed two methods for transmission of data -

1. The source will send the data packet to the nearest coordinating device and then this received data packet will move till it reaches the hub.
2. The source only retrieves the hub location by connecting with the coordinating device and data packets being sent directly towards the hub through the intermediate devices.

In [8] the authors propose a green-IoT or G-IoT system model that incorporates green IoT practices with the energy efficient scheme proposed by them with the different stages of devices in an IoT network. They have also acknowledged the resource constraints of the IoT environment, especially when ensuring a green IoT implementation as various kinds of devices all having different properties and requirements would be merged to a single IoT network. The basic challenge or hurdle in implementing green IoT has been the limited energy sources available to IoT devices since they often run on batteries. Towards the end authors have discussed the performance data of their proposed system which actually supports the necessity of the proposed scheme to endorse green IoT.

In [9] the authors have presented a research work on energy saving practices that would help in transformation from IoT to green IoT .Figure 1 gives the author's understanding from the term green IoT. Authors have categorized different energy efficient models as-

1. Hardware Based
2. Software Based
3. Habitual Based
4. Awareness Based
5. Policy Based
6. Recycling Based

on the basis of technologies or methods used by them. They lay emphasis on uses of smartphones and their life cycle leading to an increase in carbon footprint as well as talk about the recycling of electronic devices in a sustainable way because increasing use of IoT would require a sharp increase in the number of gadgets people have. They have formulated five green IoT principles, which are as follows-

1. Use Hybrid Architecture
2. Reduce Network Size
3. Use Selective Sensing
4. Intelligent Trade-offs
5. Policy Making

Fig-1: Green IoT [9]

In [10] the authors give an insight on the use of green IoT in the field of agriculture and healthcare which are no doubt a major backbone of our society. Cloud computing and IoT are two technologies that can create wonders in this field of agriculture and healthcare. It presents GAHA i.e. Green IoT Agriculture and Healthcare Application that is implemented using sensor-cloud integration based models. They have also issued the direction in which the researchers should work in order to successfully utilize GAGA architecture. Authors also highlight that the following problems or challenges posed due to sensor based technologies and can be undertaken by sensor-cloud patch-

1. Data management
2. Resource utilization
3. High utility cost.

In [11] the authors present give green IoT principles along with current trends in it and future scope of this technology. They present IoT as a combination of Information science along with operation and consumer technology, as it involves customers using operations technology over their IoT enabled devices and all this happens by the means of information exchange. In current trends in IoT they have talked about the extensive research work taking place in the field of machine to machine communication using IoT as well as in developing communication protocols for use in IoT networks. Also the authors highlight that extensive research work is needed to take IoT to grass root level so that its real time use can be implemented. Paper also defines various applications of green IoT like smart home, industrial automation, smart healthcare, smart grid etc. The state of the art work underlines several important startups that are building the future directions for green IoT technology, some of them are ENERTIV, BRIGHTFARMS, CALMENERGY, RADIATOR LABS, and BANDWAGON etc.

In paper [12] a survey on IoT is done and documented. Authors have described IoT as a convergence of different visions namely 'Things' oriented vision, 'Internet' oriented vision and 'semantic' oriented vision. Also the enabling technologies for IoT have been described, few of them being-

1. Identification, sensing and communication technologies - these include sensor networks with large numbers of nodes, RFID tags etc.
2. Middleware - it refers to the software that is functioning between the application level and technological level.

They have categorized the application areas of IoT into different domains, as follows-

1. Futuristic
2. Personal & Social
3. Smart Environments
4. Healthcare
5. Transportation & Logistics

The authors have also specified the research issues that are ongoing in field of IoT enabling technologies, some of them being issues like-

1. Mobility support
2. Traffic characterization and QoS support
3. Data integrity
4. Privacy
5. Transport protocol

3. PROPOSED SYSTEM

It is evident that the future cities that are going to be smart cities would be employing a large number of IoT enabled devices not just for the personal use of the people living in them but also for the public regulations authority and service providers like the police departments, Municipal corporations etc. This will require that all devices are connected to the internet constantly for nearly all purposes across the city. A new system is proposed that will have a separate network for all the IoT enabled devices in a particular area, all IoT devices used by public or government agencies would have internet access through this network only and the conventional or pre-existing network would be there to cater to all the other needs that it was serving before. This network could be used to monitor the uses of IoT in a particular area because to ensure a green IoT environment, a strict regulation and monitoring of device uses is necessary, which would be difficult if the pre-existing network is used to connect the IoT devices. A dedicated network would ensure that people follow all the green practices advised by the authorities and also it would help governments to modify the green practices according to needs meanwhile the other services would be able to run as usual, as they would be connected to pre-existing internet networks. The analysis of state of the art work suggests that sensor cloud and an ad-hoc model for any such network would be more effective in serving the purpose and these models have better threat mitigation plans that could prevent attacks like DDoS, location disclosure, Sybil attacks etc. [14]. The proposed system would help in integrating all the technological measures developed to enforce green IoT for the new smart world.

4. CONCLUSIONS

Growing population is becoming a major concern for people across the world not only it leads to over utilization and scarcity of resources but also it is one of

the major causes of environmental degradation. The increase is tremendous which is setting a trend of migration of people from villages to the cities in search of employment and better living standards. It seems that the day is not far when the majority of the population in the world would be concentrated in the cities. This overload would lead to increase in demand of energy and more space to live. All these factors when accumulated will lead to a huge increase in carbon footprints as more and more cities would be growing into a metropolis. Thus, there is a strong need that these future cities be 'smart' cities in which the resources are utilized in a sustainable manner and the care for our environment is top concern for the dwellers of such cities. Therefore, a smart city would use technology to minimize the impacts on the environment and to let the cities remain sustainable, making it a healthy and safe place to spend life and work.

The Internet of Things (IoT) has become one such solution that gives answers to the city's problems of managing traffic, cutting pollution and improving infrastructure as well as promoting their better use [13]. Thus, it has become an integral part of smart city development mainly because of its applicability and usability in a wide range of areas ranging from transportation to healthcare and even agriculture. The resolution of waste management issues with the help of IoT enabled technologies would help people to go green and IoT technology used in that could be called green IoT [15]. The need of the hour is to utilize this potential of IoT and turn it into 'green' IoT. It can be used for controlling water wastage in our cities. All these green practices will be usable only by enabling green IoT systems, which in turn requires a deep analysis of the background components that are required to run the IoT devices.

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