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Revolutionary Green IoT–An Environment Friendly Application beyond Conventional IoT

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Abstract—*In today's world, IoT (Internet of Thing) is an emerging concept that aims to connect billions, millions and trillions devices or things with each other. They can able to sense, collect and sends data or messages from their surroundings and exchanges it. Because of making network with billions and trillions devices/things to a single network, it requires huge amount of energy consumption for functioning the different protocols properly. Increase of energy increases the chance of pollution in environment because of presence of toxic pollutants and e-waste. In order to achieve this, there is an increasing desire for shifting into Green IoT (GIoT). It is the future of IoT which is fully environment friendly. Green IoT is very much necessary for long term evolution or sustainability of IoT itself. This paper represents overall deployment of Green IoT, its potential technologies, different protocols, applications of GIoT , challenges and opportunities and finally the differences between conventional and Green IoT.*

Keywords: *IoT, Energy consumption, Green IoT, environment, deployment.*

Introduction: With the rapid increases of science and technology, our world becomes 'smart'. It is only possible because of Internet which brings every devices or things in a single network to communicate with each other using IoT (Internet of Things). Here the things include not only communication nodes but also physical objects like cars, computers, home appliances etc. To communicate all this things to each other IoT needs huge amount of energy or power this increases no. of hazardous pollutants in environment. People-now a day's become more aware of the formidable consequences of environmental degradation [11]. This led to the concept of Green IoT, a low power consuming version of IoT. The paper is organized in following manner; Sec I based on energy saving practices beyond conventional IoT, Sec II discusses definition narrowband IoT or Green IoT, Sec III discusses different enabling technologies of Green IoT, Sec IV gives few challenges and its opportunities of Green IoT and finally Sec V depicts the differences between conventional and Green IoT.

Sec I- Energy saving practices beyond conventional IoT: Intelligence for IoT is as vital as brain for human body. A system with sensors but no intelligence is added then it is not IoT, then it is just a thing but when intelligence is added then it becomes 'smart'. Transforming anything into 'smart' is not just about making it energy efficient but also to reduce resource usage and optimizing space. There are some bulky and expensive measurement devices are available which is used to measure battery life of IoT devices but they are difficult to handle becomes major obstacle in IoT devices. Recent innovations towards the IoT has brought major adaptations for IoT devices that includes different protocols like LTE (Long term evolution) and NB-IoT(Narrowband IoT) that demonstrates the duty cycle process to extend the battery life up to 10 years as compared to traditional[11]. Different wireless protocols like Bluetooth, 6LowPAN, Wi-Fi and Zigbee for IoT uses higher power consumption which is also replaced in NB-IoT. This NB-IoT is actually nothing but Green IoT. For energy harvesting purpose Green IoT uses Photovoltaic cells, piezoelectric generators etc. So it is necessary to design an application of power consumption amount of specific IoT device for operations in elongated manner.

Sec II- Definition of Green IoT or NB-IoT: As name implies NB IoT uses different narrow band frequencies like 180-200 KHz for transmission and 180 KHz for LTE band. It is leaner, thinner and greener than other IoTs proposed in the recent years [4]. In today's era Green IoT is a hot cake topic because as the traditional energy resources decrease rapidly and energy increases exponentially. Green IoT increases the sustainability of conventional IoT in digital world.

Sec III- Different enabling technologies of Green IoT: Deployment and sustainability of Green IoT in real world is only possible through the co-operation of several enabling technologies as discussed below:

i. Green RFID: Combination of RF (radio frequency) and ID (identification) is known as RFID. It consists of several RFID tag and a small reader. The use of electromagnetic in radio frequency and the barcodes of RFID used to track items and store information in things. Two types of RFID tags are used; Passive tag which has not batter along with and transmission efficiency is minimum on the other hands active tags have batteries in it and used high power for transmission purpose. FID tags remain idle but they are powered ON because they

do not know when they need to communicate and causes huge wastage of energy resources.

Green RFID reduces the size of tags and decreases the amount of non degradable material which reduces the emission of toxicated recycled material. Energy efficient techniques and protocols should be used to avoid tag collision, estimation and overheating avoidance and also adjusting transmission power level dynamically [7].

ii. Green Wireless Sensor Technology (WSN): Wireless Sensor Networks (WSN) is vital component in development of Green IoT that provides a detailed taxonomy of technique that can be used for harvesting energy resources in WSN. Sensors consume unnecessary energy when they are idle but powered ON, so an energy efficient scheduling algo is proposed for Green IoT that changes states of sensors to on duty, pre-off duty, and off duty according to the requirement of the situations in order to prevent un-necessary energy usage [15].

Green WSN also supports radio optimization technique because for large scale deployment of IoT, WSN cannot be re-used. So sensors can utilize energy harvested directly from the environment such as sun, vibrations, temperature variations etc.

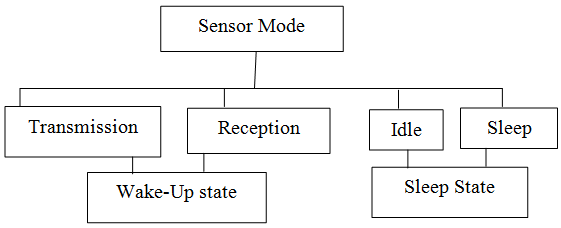

Figure 1: Different sensor modes in Green WSN

iii. Green Cloud Computing (CC): Cloud computing provides high performance computing resources and high capacity storage to the end user of the Internet [9]. It gives unlimited storage of data and service delivery through the Internet. There is no need to buy or manage their own resources. In CC resources are treated as services, i.e. IaaS (Infrastructure as a Service), PaaS (Platform as a Service), and SaaS (Software as a Service). Based on user's demands, CC offers various resources to them [8].Increasing demand of various resources and power consumption causes environmental pollution and CO2 emissions. So to use properly and efficiently the resources of CC, energy consumption has to be reduced. For Green Cloud supports the above condition and also able to design such applications that is used to consume less amount of energy without losing the quality of performance and provide efficient S/W applications.

iv. Green Machine to Machine Communication (M2M): With the use of Artificial intelligence (AI) machines are able to collect data or information with human involvement. It is an advanced version of IoT. Recent researchers have estimated that in next 5-10 years, 100 billions of devices will be connected via Internet and communicating within each other but it requires higher amount of energy. Green M2M concerns following methods for increasing the energy efficiency:

A. Sharply adjust the transmitted power.

B. Design resourceful communication protocol using proper algorithm.

C. Uses different energy saving techniques.

D. Evolve harvesting of energy.

v. Green Data Centre (DC): GDC is a new and advanced technology for storing, managing and dissemination of data created by end users, system and things etc. To deal with massive amount of data, huge and large amount of energy with high operational costs and CO2 footprints.

There are various techniques used for improving energy efficiency for GDC discussed below:

A. Design more energy-efficient H/W technology

B. Develop energy conservative data centre.

C. Utilize efficient dynamic power management technologies.

vi. Green Communication & Networking:

Green wireless communication plays an important and vital role in Green IoT. The idea of Green communication and network is used to make Carbon emission smaller. If network coding algorithm is applied then only energy saving is possible in Green IoT. As we know 5G is always focused on decreasing energy utilization so green IoT is promised to make 5G as efficient as possible by saving energy resources. 5G technology enables to provide the large coverage connectivity, saving of energy and supports higher data rate and also the capacity of system. 5G technology is used in e-health, transportation, robotics etc.

After discussing all the different enabling technologies for Green Internet, there is a summary of general rules for following regarding green IoT:

(i). Turn off or switch off facilities that are not needed. When it requires then make it switch on otherwise keep it in switch off mode. By this process energy consumption will be reduced.

(ii). If data that are necessary to send them only transmit the data or information. Because unnecessary data transmission consumes a lot of amount of energy.

(iii). Change the longest path to shortest path. If the path of data transmission is too long then routing path metrics are so high which increases the energy consumption, so better to choose smaller path instead of longer path.

(iv). Advanced communication technique to reduce the energy consumption advanced communication protocols are developed like MIMO, SISO, CR (Cognitive Ratio).

(v). Different types of renewable resources like oxygen fresh water, solar energy, and timber, bio-mass replaced naturally the power resources and utilized again and again.

Table 1: Comparison of Green IoT enablers

1. Green Tags	Sensing	Range	Data Rate	Power	Life time
1.1 Active Tags	Passive	5-10 m	Low	Battery	Less than 5 years
1.2 Passive Tags	Passive	1-2 m	Fdfjsad;	Harvested	Infinity
1.3 NFC	Passive	mm-cm	Very Low	Harvested	Infinity
2. Green Sensing Network	Sensing	Range	Data Rate	Power	Life time
2.1 Smart Object	Available	Not available	Low	Battery	<3 yrs
2.2 WSAN	Available	10-50m	low	Battery	< 2 yrs
3. Green Internet	Sensing	Range	Data Rate	Power	Life time
3.1 Cloud Network	Not available	Very High	Not available	Grid	<12 yrs
3.2 Smart Internet	Not available	Very High	Not available	Grid	infinity
3.3 Smart Web services	Not available	Very High	Not available	Grid	<5 yrs

Sec IV- Challenges and opportunities for Green IoT: As Green IoT plays important role for energy efficiency in IoT but it faces few type of challenges issues:-

i) Green IoT architecture –

For conventional IoT, OSI or TCP/IP model are used. But for Green IoT, it is important to understand whole architecture that makes it energy efficient.

ii) Green Infrastructure –

For conventional IoT, a clean idea is there but for Green IoT till now attention and research is required.

iii) Green Spectrum Management –

In today's life, users are cofined/limited to RF band which is quite crowded and difficult to use optimally. CR approach is used to allow devices to tune in different transmission and reception channel just to avoid interference. Huge experiments are needed to apply this.

Sec V- Application: Several applications of GIOT are possible and it can be deployed for any LPWA applications in which all the elements of IoT are available [4]. There are various new sectors may be indoor and outdoor, where G – IoT can be used. GIoT can be used to design ' smart homes', 'smart cities', 'e-health care', automobile pollution control, agriculture and farming, retail management and waste management.

Sec VI-Differences between conventional & Green IoT: After studying all the related articles that main differences between this two is in the name of energy. Energy consumption is much more in conventional IoT rather than Green IoT, which makes G – IoT devices chip with respect to conventional IoT devices.

Conclusion: In this paper major challenges of energy efficiency in IoT network have been illustrated and to solve this type of problem how Green IoT will help is also discussed here. NBIoT or Green IoT is a popular low power wireless technology uses narrow band frequencies and it is thinner, greener technology also. Major challenges and its solution has been discussed and finally this paper summarizes the differences between conventional IoT and Green IoT.

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