

Application of IoT in Green Computing

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Abstract- Internet of Things (IoT) is an emerging concept, which aims to connect billions of devices with each other. The IoT devices sense, collect, and transmit important information from their surroundings. This exchange of very large amount of information amongst billions of devices creates a massive energy need. Green IoT envisions the concept of reducing the energy consumption of IoT devices and making the environment safe. Inspired by achieving a sustainable environment for IoT, we first give the overview of green IoT and the challenges that are faced due to excessive usage of energy hungry IoT devices. We then discuss and evaluate the strategies that can be used to minimize the energy consumption in IoT, such as designing energy efficient datacenters, energy efficient transmission of data from sensors, and design of energy efficient policies. Moreover, we critically analyze the green IoT strategies and propose five principles that can be adopted to achieve green IoT. Finally, we consider a case study of very important aspect of IoT, i.e., smart phones and we provide an easy and concise view for improving the current practices to make the IoT greener for the world in 2020 and beyond.

Keywords- Internet of Things, Green Computing, Green IoT

INTRODUCTION

Internet of Things (IoT) is a concept that envisages the connectivity between daily life things by using different types of sensors like Radio-frequency identification (RFID), actuators that work collaboratively to sense, collect and transmit important information from their surroundings onto the Internet. IoT is a term that envisions connectivity between physical and digital world by using felicitous technologies. In order to make the IoT green, there is a need to study more state-of-the-art techniques and strategies that can fulfill the energy hunger of billions of devices. In this article, we aim to provide a comprehensive overview of energy saving practices and strategies for the green IoT. We consider a case study of smart phones to show that how different stakeholders can play their roles for the green IoT.

IoT TREND

The current era is considered to be fully Internet based. Our dependence on the Internet and the devices is rapidly increasing. How does IoT influence in routine things? This is the main question to be addressed in the subsequent section.

TABLE . . Applications of IoT.

Paper	Application
[7]	Food Supply Chain
[8]	Mining Industry
[8]	Transportation Industry
[9]	Garments Industry
[10]	Smart Cities
[6]	Smart homes

APPLICATIONS OF IoT

IoT is revolutionizing our daily life activities by tracking different scenarios and making intelligent decisions to improve our lifestyle and to protect our environment. There are numerous applications of IoT in daily life. We explore several of them below and are highlighted in Table

Smart Homes: As described in [6], by equipping our home or office with the IoT technologies like RFIDs, we can track the activities of in-habitants in the building and can make decisions that can save energy, money and whole environment in the process. For example, a smart fridge can have RFIDs on every item inside it and we can decide when to go shopping and what we need to buy on the basis of information provided by the sensors attached on the items.

Food Supply Chains (FSC): IoT can have a huge impact on business industry. Using IoT technologies, vendors can track the production of their products from the farm to the end users. A framework for such an application is proposed in [7]. Paper [7] proposes a Business-oriented model of IoT for FSC which can enhance food security and can be used to collect the data related to production processes and that data can be manipulated to make better decisions regarding the business process model.

IoT in Mining Industry: IoT technology can be used to ensure safety for miners and can provide Mining Companies with important information regarding mining process which can help them in enhancing the current practices [8]. RFIDs, Wi-Fi and sensors can be deployed to improve communication between miners and their employers. Furthermore, diagnosis of different diseases in miners can be done by collecting

symptoms using these sensors.

IoT in Transportation: IoT is revolutionary in the Transportation and Logistics industry. We can track vehicles and products using RFIDs and sensors from source to destination in real-time. A DNS architecture [8] is developed for IoT where large scale operations enhances the capabilities of IoT in supply chain management.

IoT in Garments: A new type of E-Thread [9] envisions the idea of collecting data from clothes. This can help in collecting real-time data to track the activities of a patient without using any extra device.

Smart Cities: One of the most scintillating and emerging applications for IoT is Smart Cities [10] which has gained popularity in the last few years. A smart city is a combination of different smart domains like Smart Transportation, Smart Energy Saving Mechanism, Smart Security [11] and many more which provide the users with latest technological facilities all under one umbrella.

GREEN COMPUTING

Green computing is the practice of reducing the technological footprints on environment by using the resources efficiently.

Benefits of Green Computing

Reduced energy usage :- Green computing helps to reduce energy consumption which translates into lower carbon dioxide emissions. Stemming from a reduction in the fossil fuel used in power plants and transportation.

Using resources more efficiently :- Green computing is one of the best approaches to utilize the resources such as heat, light, power etc. in an environmental-friendly way.

Cost saving :- Since Green Computing helps you use the resources such as electricity, office space in an efficient way. There is a significant saving in the operational costs.

Encourage recycling :- Green Computing encourages businesses and government to recycle e-waste and optimise the energy usage to make sure there is no or little impact on the environment.

Improve corporate and social image :- Businesses can improve their corporate image with Green Computing as it helps them by meeting compliance and regulatory requirement.

GREEN IoT

IoT and the earlier we tackle this problem, the Green Internet of Things basically focuses on the energy efficiency

in the IoT principles. Green IoT is defined as the energy efficient ways in IoT either to reduce the green-house effect caused by existing applications or to eradicate the same in IoT itself. In the first case, IoT will help in eliminating the greenhouse effect but in the second scenario, the IoT will be further optimized to stop the green-house effect. Every step in IoT should be made green, from design to implementation. The Green IoT concept is shown in Figure



Figure. Green internet of things

In order to implement the Green IoT, a number of strategies should be adopted. Various technological solutions for Green IoT are proposed in. The details of all these strategies will be discussed in the later sections but we will provide a summary in this section. For implementation of Green IoT a framework was proposed in for the energy efficient optimization of IoT objects. Furthermore, Green IoT may be implemented by using Green RFIDs, Green Datacenters, Green Sensor Networks, Green Cloud Computing. Details of these will be discussed in later sections. IoT is an emerging technology that is changing the way we see the IT industry. IoT is going to have a huge impact on how we deal with certain problems in our daily life and it is certainly going to make our lives easier and better but with ease come the challenges. We have to deal with the large scale consumption of energy resources by more efficient will be the IoT.

Recycling for Green IoT

Use of recyclable material for the production of devices in an IoT network can help make it an environment friendly one. For example, Mobile phones are made from some of the scarcest natural resources like copper, plastic and consist of some elements that are non-biodegradable and can increase greenhouse effect if not properly dealt with when the phones are no longer in use. According to an estimate, 23 Million mobile phones are present in the drawers and cupboards in Australia [47] which are no longer used and 90% of the material in the phones is recyclable so the need for

recycling is ever increasing if we are to tackle the problem of greenhouse effect and huge energy consumption. Although, it is an unrealistic assumption to recover 90% material but it still can make a considerable difference to save energy. Figure 4 depicts the process of Mobile Phone Recycling. Many methods were introduced in [57] for the improvement of the power consumption and performance of the smart phones. As a source of metal, EEE (electric and electronic equipment) recently focused and take into account the effective collection and recovery system of the specific feature for the each EEE type [58]. In [59], the sensitivity analysis showed that it is recommended to use the solar energy when the charger is connected, more than 20 % of use. In the next two generations of the product expected to increase energy consumption correspondingly

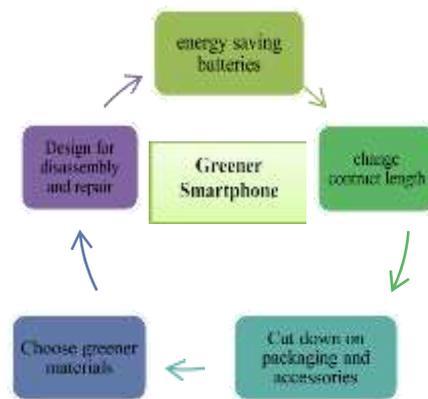


Figure. Lifecycle assessment of smart phones



Figure. Mobile phone recycling process

LIFE CYCLE ASSESMENT OF SMARTPHONE

An environmental LCA (life cycle assessment) method is used for conducting the analysis of smart phones product life cycle [88], it exceeded the traditional production and manufacturing processes so that the environmental and social and economic effects of the entire life cycle of the product, including the consumption and should be taken into account during use. In a mobile phone functional unit, the LCA method is used for 3 years in production [59]. LCA results showed that refurbishing creates the highest environmental impacts of the three reuse routes in every impact category

except ODP (ozone depletion potential) [89]. The usage of electricity and the CO₂ emission is reduced by 20-55% and 18-74% in virtual desktops (VD). Through this method environmental effect/impact of recycling was analyzed [68], [90]. This method is used to compare the environmental effect of the various chargers, efficiency and the environmental impact of the material selection. LCA software found that the damage assessment of a charger is higher as compare to the other parts of a smart phone [66]. In the comparison of the feature phone of 2008 and the smart phone LCA result shows an increment of 34 kg CO₂ [91], [92]. It is more consistent than PCs, for the mobile phone and TVs. Figure 6 presents the LCA of smart phones.

CONCLUSION

In this paper, the major challenges of energy efficiency and carbon footprints in the IoT network have been discussed and different solutions to solve these problems have been critically evaluated. Furthermore, a detailed taxonomy of methods to achieve Green IoT has been provided in this paper. Five principles have been proposed to realize the concept of Green IoT. The impact of IoT on economy is going to be paramount and it is predicted to revolutionize the entire ICT industry. The need of research for a generic architecture, recyclable material and policy making to achieve Green IoT has been highlighted. IoT can undoubtedly change the course of technological advancements in the world if focused and dedicated work is put in the right direction. The world awaits the wonders it can unfold.

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