Towards a Greener Future: Sustainable IT Development and Greening IT

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Abstract

Information Technology has become one of the most important sources for carbon emission and greenhouse effect. The smartphone industry is one of the most rapidly growing industry with new features being rolled out every day. There is a rapid enhancement in technology and the way mobile phones handle various features and communication. As a result, users continuously upgrade their smartphones to avoid being outdated. This has increased the amount of e-waste as well as the radiations being emitted by the smartphones. On the other hand, an increase in the number of smartphone users has resulted in an increase of data as well as the need to increase the speed of the computation. As a result, cloud computing was introduced which made use of a number of servers deployed in data centres. But the increase of data centre facilities has also resulted in increase of energy consumption and green-house gases which needs to be addressed.

In this paper, we discuss a few important methods which can be implemented to green the existing IT infrastructure which include wireless sensor networks for green smartphones, greening of smartphones and greening of cloud services.

Keywords – *CUE : Carbon Usage Effectiveness, IaaS : Infrastructure as a Service, MPS :Mobile Phone Sensing, SaaS : Software as a Service, PaaS : Platform as a Service*

I. INTRODUCTION

Green Computing is one of the hottest topics today. The use of Information Technologies like smartphones, personal computers, personal digital applications, data centers and other multimedia has skyrocketed over the past few years with the advent of newer technology. Information Technology is evolving at a rapid pace and users of this technology are continuously adapting to the rapid development by replacing the older gadgets with the new ones. This has resulted in an increase in energy consumption, increased carbon footprints and massive piling up of e-waste which is hazardous to all forms of life on the planet.

This careless and reckless use of technology has led to various environmental degradation, one of the most important being the increase in Green House Gas (GHG) emissions. The increase in GHG emissions has changed the global climate and weather pattern and has led to a phenomenon known as global warming, which is the average increase of the temperature of the atmosphere closer to the Earth's surface.

This paper elucidates the harmful impact of IT on the environment and comes up with holistic approaches to make IT greener and throws light on methods to achieve sustainable development. This involves developing greener software, green data centers and greener smartphones using state of the art tools, technologies and trends.

II. RELATED WORK

Saman Zahoor et al. [1] analyses the current usage pattern of various smartphones which are the main source of carbon dioxide, nitrous oxide, methane and other greenhouse gases (GHG) by making use of state of the art technology, tools, data and based on the above analysis predicts the future trends compared to present usage statistics to create a more greener and environmentally sound world by the year 2020.This paper prescribes various simple as well as elucidate measures in order to counter the increasing carbon footprints due to excessive usage of mobile phones, PDA (Personal Digital Assistant) , laptops and other gadgets by making use of Life Cycle Assessment (LCA) tools.

Soraya Sinche et al. [2] discusses about the opportunities of signal and digital processing methods which can be applied to wireless devices such as a mobile phone in order to sense different types of activities and behavior's. It talks in length about how the Wireless Sensor Networks (WSN) and Mobile Phone Sensing (MPS) methodologies could be integrated in order to look for a greener solution to mobile computing, especially in the urban setup. The paper also demonstrates via a case study on how the integration can provide a more human-centric and environmentally friendly solution which is helpful to the health of humans and nature alike.

Shivam Singh discusses about the implications of widespread usage of computers, smartphones and

other technologies and their contribution to the carbon footprint and their impact on the environment. It examines significant architectural decision points in the infrastructure and discusses holistic methods towards environmental security. This paper talks about Virtualization, Power management techniques, energy efficient coding and the repair, reuse, recycle and disposal of electronic components in a greener way [3].

Akun Chaurasya et al. [4] discusses different methods of reducing carbon footprints cause by cloud computing and also explains the ill effects of data centers and IT from the energy consumption and energy efficiency point of view. This paper discusses about various types of cloud services, their energy efficiency by making use of various reports and calculating the Carbon Usage Effectiveness (CUE) and explaining the Green Broker architecture and the Green Cloud Middleware responsible for handling, processing and serving requests on the cloud.

Janusz Zalewski et al. [5] aims to develop a Green University which enables the students who graduate from college to be equipped with greener ideas and knowledge to combat the various ill effects of Information technology on the environment. The author discusses a three pronged approach to a greener computer science program which involves negating the bad impacts of the student's practices and technology usage on the environment, contribute to the students resources, techniques and knowledge to increase environmental sustainability incorporating both of the approaches into the University's curriculum. And eventually encourage other Universities to adopt the same Education Model and go green.

Sudhir K. Routray et al. [6] consider, the IOT implementation requires huge amount of electricity and also he prefers green IOT is important as well as essential for the people who Implements IOT in their organization for a long term. The projects like "Smart City" includes lots of sensors and other electronic devices and some of the sensors or electric devices pollute the environment also if proper care is not taken. By applying different types of green IOT the organizations can reduce the impacts of IOT on environment. Hence green initiatives is essential for project like Smart City or any IOT projects that needs lots of implementation processes.

Enas Ahmad and Basem Shihada et al. [7] Discusses about modern smartphones consume more power and results in short battery life. The reason for massive drainage of batteries is nothing but graphical performance in smartphones. He presents new methods for handling the smartphones Graphical Processing Unit. They are GPUFreq Scaling Governors and DVFS (Dynamic Voltage and Frequency Scaling). By implementing these methods

consumption of power by GPUs is reduced and results in Green Smartphone GPUs

Paul Teedan et al. [8] discusses about the various impact of Information and communication technologies in the day to day world by considering the amount of time the user has spent and the total bandwidth they consume. They have used broad category of tasks to make sure that the amount of impact of all the tasks add up to 100%.They have also used publicly available data to demonstrate the energy consumed by various devices in US in 2015. They have also demonstrated how a 2015 web based video became a dominant of energy consumption due to high bandwidth.

Michaela Steffens et al. [9] demonstrated how use of embedment of act in industrial process results in the efficient use of raw materials and reduce the waste. They have also explained different ways of design develop and implement green IT in the devices. They have further extended it to the development of green software's and its execution. Things such as minimizing of energy consumption like minimizing the recompiling process have been taken care.

A.Jain et al. [10] explains the harmful effect of the increasing number of data centers and hence an increase in the amount of Carbon Dioxide emissions due to increase in DC power consumption and the increase in power consumed by processor chips, cooling equipment to cool or remove the extreme heat generated and increase effective computation.

III. METHODOLOGY
A. Green Cloud:
Cloud computing is the method of providing resources to host data instead of providing the physical hardware equipment like storage, power source, cooler, servers, etc.

Different types of cloud are:

1. Private cloud
These are the clouds which are subscribed to and used by large private organizations. The main aim of private cloud is to protect the resources belonging to an organization so that it is accessible by everyone within the organization only. Data security is one of the most important aspects of private cloud.

2. Public cloud
This is the cloud which is available to the public. It allows users to store their data on this cloud. Ex: Github

3. Hybrid cloud
Hybrid cloud is a combination of both public and private cloud. It has properties of both public and private clouds. Resources which are too

costly to maintain in a private cloud and data which is not entirely confidential are stored here.

SPI Model of clouds (Figure 1):

4. *Software as a Service (SaaS)*
IT provides the software which is required by the end user and this software is provided and used over the web. Ex : Gmail, Heroku.

5. Platform as a Service (PaaS)
Provides the platform over which the software provided is to be run as a web service. Ex : Google, Youtube, Perforce

6. Infrastructure as a Service (IaaS)
IaaS is the actual physical hardware such as the storage media, networking, server clusters and other hardware over which the platform is hosted. Ex: Amazon web Services

Most of the energy is consumed by the data center which consists of servers, storage, cooling facilities, networking components, etc. Hence there is a need to reduce energy consumption and carbon emission by data centers. An efficient way to do this is to make use of Virtualization technologies.

Virtualization enables the replacement of physical hardware components such as servers and networking cables with the help of virtual servers and virtual networks which are run as software over a virtual operating system. Green cloud makes use of Virtualization technologies. Green cloud is a middleware which runs on the data center and ensures that the storage and retrieval of information follow an optimal path with minimum carbon emission. It accepts the incoming service requests from users and maps it to the corresponding cloud to retrieve the corresponding response and information from the server which is responsible for serving information for the incoming request. It also makes keeps track of the carbon emissions for each of the existing services and their green credibility as shown in Figure 2.

B. Component of Green Cloud:

1. Scheduler:
Schedules the incoming request into an organized and synchronized manner so that it can be easily sent to the appropriate cloud for processing.

2. Task Selector:
Selects the services which are essential for processing the incoming request.

3. Cost calculator:
Records the cost that is required to complete a process fully end-to-end.

4. Carbon Emission Information:
Keeps record of the mapping of the carbon emission for each cloud which is necessary for taking preventive and corrective actions.

5. Green cloud information and metrics:
Contains a database of all available services along with a mapping for their green ability. The service which is greener than the other services is chosen for processing the incoming request.

C. Wireless Sensors for Green Smartphones:
Cell phone functions as an arrangement of sensors that engages the memory, preparing and circulation of distinctive kinds of data. There are a few difficulties to think about when as a cell phone functions as an arrangement of sensors, like programmability, constant detecting and telephone setting. In the instance of the programmability, the test lays in transit of getting to the low-level sensors; be that as it may, the new versatile telephone innovations offer open source stages with simple access to their sensors. Foundation handling and multitasking can bolster the requirement for constant detecting. In this way, the utilization of vitality can be overseen through low-vitality calculations. At long last, the telephone setting issue can happen when the client conveys the telephone in startling ways, which may influence the information gathered by its sensors.

D. Sensors
Sensors give data about parameters that empower the surmising of human conduct. Numerous sensors are incorporated in a cell phone, similar to the GPS, accelerometer, gyrator, computerized compass, light and vicinity. Further, sensors, for example, the mouthpiece and camera, which are universally useful, have an awesome potential in acquiring data about

Individuals' conduct. Likewise, Bluetooth and Wi-Fi can be utilized as sensors for human movement acknowledgment. The blend of these sensors speaks to a chance to enhance the accumulation of information about individuals and their surroundings. Moreover, the human cooperation with informal communities empowers us to surmise data about the general population's specific circumstance.
Every single cell phone have a mouthpiece and we can create numerous applications utilizing this sensor to get data about the earth and the client. Through voice, a man can transmit states of mind or feelings. For instance, we can know when an individual is in a loud site, which, thusly, can be corresponded with changes in state of mind. Along these lines, it is conceivable to create applications for cell phones that utilization their sensors to enhance

the nature of human life or to construe human movement.

The Figure 3 demonstrates the procedure of information securing utilizing a cell phone, its mouthpiece and accelerometer. To start with, we separate the component determination of information gathered by these sensors, at that point, we should enter to characterization process situated in machine learning calculations. With the receiver, we can know whether the client is talking or not, while with the accelerometer may give us data about his action. At last, the outcomes are joined in the square of induction motor to acquire the human conduct data.

E. Applications

MPS not just offers data about human conduct, it additionally permits to help individuals. Applications where it is conceivable to acquire the human state, can be connected to determine individuals' issues. The accompanying sections depict two intriguing cases of uses in the zone of social collaboration. CenceMe is a participatory MPS framework that was demonstrated in the Dartmouth University. It utilizes the sensors in the portable telephone to order unique individuals occasions. Online interpersonal organizations, for example, Facebook or MySpace, this application got data about individuals' propensities and their condition. EmotionSense is an artful MPS framework for social and mental investigations that permitted the detecting of singular feelings as cooperation's in a social gathering, utilizing the mouthpiece, accelerometer and Bluetooth innovation. This work was acknowledged with social therapists' coordinated effort. With the accelerometer, it was conceivable to deduce the current movement.

The framework additionally distinguished different gadgets adjacent utilizing the Bluetooth interface. The restriction of the client was acquired with GPS. EmotionSense included two subsystems, the feeling discovery and speaker acknowledgment. There are different works identified with the reconciliation of WSNs with cell phones. In is exhibited an application that employments cell phone sensors to gather data about air quality what's more, atmosphere. The cell phone is associated with a focal web framework, which got and gathered the information. At that point, information are prepared in a distributed computing framework and the application exhibited the outcomes to client. Regardless of touching the subject, this work does not give a Fog-like incorporation between WSNs. In is displayed a model that incorporates WSN hubs. In a first case, the correspondences are acknowledged with IEEE 802.15.4 and the second case, they utilized Bluetooth. Be that as it may, these mixes required equipment expansions.

There are numerous applications ceaselessly being created that get data about human conduct utilizing the versatile telephone as detecting framework. There exists different applications that permit coordination amongst WSN and cell phones, requires extra equipment for adjusting the correspondence conventions. In any case, a Fog-like approach could permit applications that coordinate these advances without the need for extra equipment. Truth be told, in a perfect world these new applications can be situated towards adjusting the human conduct and its impact on the earth.

F. Green Smartphone

Smartphone is a necessary evil in our day to day life. Every day we use smartphones for various purposes such as calling, SMS, listening to music, etc.

Smartphones that we use are not eco-friendly. They contain some toxic chemicals such as aluminium, mercury, gold lead etc. They are also built of non-recyclable substances such as plastic. Their disposal is a big challenge. In 2014 40 million tonnes of e-waste was produced. The smartphone manufacture factory contributes to more than three quarters of the carbon dioxide which is a key component of the greenhouse effect. Thus this contributes greatly to the global warming.

So an efficient smartphone must be

1. Recyclable
2. Power efficient
3. Contain less toxic chemical

G. Reducing the power consumption

Power consumption is another key factor of a smartphone. The power consumption pf a smartphone affects the battery life of it as battery is the key source of the power to the smartphones. Every battery has a lifetime. The lifetime of a battery is decided by the charging and discharging cycles. After the battery is dead, it has to be disposed. Disposal of the battery again leads to the discharge of lots of chemicals into the environment, thus causing the environmental pollution. On the other hand, the batteries with high capacity are costly and are not portable. Thus there is a great need of the efficient power management of the smartphone.

CPU consumption of a smartphone is one of the key factors of the power consumption. If we govern the performance of the CPU, we can save power. Normally every CPU of a smartphone, uses a fixed frequency rate for running any process. If the load of the process on the CPU is less, then there will be unnecessary power consumption by the CPU because of the constant frequency. So there should be an additional layer for governing the frequency of the CPU. If the load is greater than the threshold load, them the frequency should be maximum. Else, the

frequency should be reduced accordingly by the differential value required, like the algorithm shown below.

If(Load_on_the_cpu>threshold value){

Frequency = max_frequency

}

Else{

Frequency =max load freq /(threshold value-Differential value required) }

Using better raw material for the smartphone

Instead of using the non-renewable materials such as the plastic, PLA(polylactic
acid plastic) can be used . Polylactic acid plastic is made up of corn starch or glucose. This is both biodegradable and recyclable.

We can further reduce the environmental impact of the smartphones by not supplying the unnecessary components while packing the smartphone. This will lead to the less manufacture of the unwanted substances.
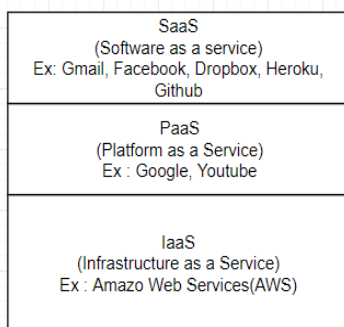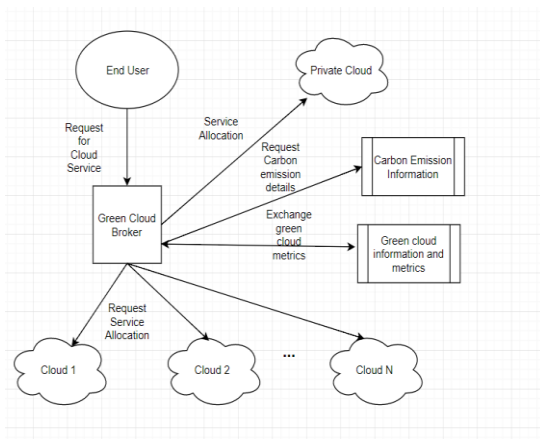
IV. FIGURES

Fig: 1 SP Model for Clouds
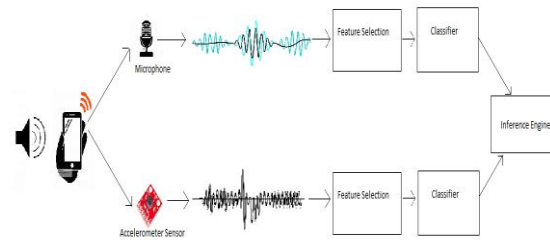

Fig 2: Green Cloud broker

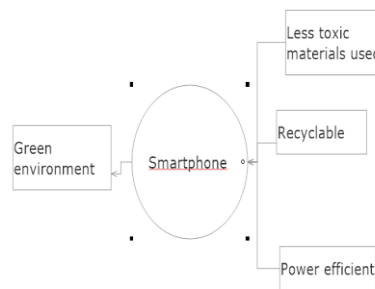**Fig 3: Diagram of acquisition data using cell-phone sensors**

Fig 4: Green Environment and Smart Phone

V. CONCLUSION

In this paper, we have suggested methods of greening the smartphones and cloud services which appear as immediate threats to the green ecosystem. These simple and easy to implement methodologies can help in greening the Information technology world and also contributing to the sustainable development of Information Technology and hence ensure a greener future.

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