Green Energy and Technology

Balamurugan Balusamy
Naveen Chilamkurti
Seifedine Kadry *Editors*

Green Computing in Smart Cities: Simulation and Techniques

Springer

Green Energy and Technology

Climate change, environmental impact and the limited natural resources urge scientific research and novel technical solutions. The monograph series Green Energy and Technology serves as a publishing platform for scientific and technological approaches to "green"—i.e. environmentally friendly and sustainable—technologies. While a focus lies on energy and power supply, it also covers "green" solutions in industrial engineering and engineering design. Green Energy and Technology addresses researchers, advanced students, technical consultants as well as decision makers in industries and politics. Hence, the level of presentation spans from instructional to highly technical.

Indexed in Scopus.

More information about this series at http://www.springer.com/series/8059

Balamurugan Balusamy · Naveen Chilamkurti · Seifedine Kadry
Editors

Green Computing in Smart Cities: Simulation and Techniques

Springer

Editors
Balamurugan Balusamy
School of Computing Science
and Engineering
Galgotias University
Greater Noida, Delhi, India

Naveen Chilamkurti
Computer Science and Information
Technology
La Trobe University
Melbourne, VIC, Australia

Seifedine Kadry
Mathematics and Computer Science
Faculty of Science
Beirut Arab University
Beirut, Lebanon

ISSN 1865-3529 ISSN 1865-3537 (electronic)
Green Energy and Technology
ISBN 978-3-030-48140-7 ISBN 978-3-030-48141-4 (eBook)
https://doi.org/10.1007/978-3-030-48141-4

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Green Computing is one of the most attention seeking domains. In recent years, Green Computing has spread its green wings and gained popularity with the goal of educating the next generation to think "Green". Green Computing guarantees the diversity and productivity of organic frameworks through green use, transfer, and manufacturing by minimizing the adverse effect of the procedures. In Green Computing, systems and computer architectures play an important role in telecommunications and computing systems. Increasing internet usage requires Green Computing for cooling and higher power rates. Green Computing is used to protect our environment, and the main focus is on virtualization, power management, telecommunications, and reuse of materials. We have to improve the working practices of software and business users to the adverse effect on the global environment.

In this Book, we explore Green Computing and advanced computing algorithms. We believe that the concepts, techniques, algorithms, and the real-time use cases can be learned and appreciated at this level and can serve as a bridge to various smart applications including the Smart City. The Book requires basic computer science, IT, telecommunication, or related background knowledge although it can still be an interesting read for anyone.

The Book contains ten chapters. Chapter "The Modern Way for Virtual Machine Placement and Scalable Technique for Reduction of Carbon in Green Combined Cloud Datacenter" presents an overview of the modern way for virtual machine placement and scalable technique for the reduction of carbon in Green Combined Cloud Datacenter. Then, chapter "A Review: Recent Trends in Green Computing" discusses a review on the recent trends in green computing technologies, also identifying key research problems in this domain. The next chapter, i.e., chapter "Green Computing and Internet of Things for Smart Cities: Technologies, Challenges, and Implementation" provides a survey of Green Computing and IoT for smart cities highlighting the importance and real-world implementation challenges. Chapter "Designing a Smart City: Technologies, Challenges and Solutions" highlights various challenges that current technologies often encounter, and the solutions to overcome these challenges to build smart cities. Chapter "Better

Transmission of Information Focused on Green Computing Through Data Transmission Channels in Cloud Environments with Rayleigh Fading" focuses on data transmission channels in cloud environments with Rayleigh fading for better transmission of information in the Green Computing environment. In particular, it aims to develop the method of data transmission based on discrete event concepts, named CBEDE (by the acronym); its experiments were matched in the MATLAB software simulation environment, where the memory consumption of the proposed methodology was evaluated. Chapter "Green ICT Communication, Networking and Data Processing" discusses the importance of Green Computing in reducing the energy usage in communication, networking, and data processing devices and various servers. Chapter "Smart Education Using Mobile Green Cloud Enabled Platform and Services" presents smart education using mobile green cloud enabled platform and services. Concepts to green ICT, communication, networking, and data processing are presented in chapter "Green ICT, Communication, Networking, and Data Processing". It presents various smart application systems such as the smart grid and green data centers for better energy management. Chapter "Impact of Green Computing in Shaping Education" goes through the impact of Green Computing in shaping education. Finally, the Book is concluded through chapter "Energy Management and Monitoring Using IoT with CupCarbon Platform", discussing energy management and monitoring using IoT with CupCarbon platform.

Greater Noida, India — Balamurugan Balusamy
Melbourne, Australia — Naveen Chilamkurti
Beirut, Lebanon — Seifedine Kadry

Acknowledgements

The editors would like to appreciate the support of all those involved in the research project of this book. We would like to thank particularly the authors and reviewers who participated in the review process. We would also like to thank Haftu Tasew, who spent his time reading and editing this Book manucsript further.

Furthermore, we would like to thank Springer Nature, particularly the publication team of the Green Energy and Technology Springer series for their immense patience and help to complete and publish this book.

Contents

The Modern Way for Virtual Machine Placement and Scalable Technique for Reduction of Carbon in Green Combined Cloud Datacenter

Arvindhan Muthusamy, Abhineet Anand, T. Vinodh Kannan, and D. Nageswara Rao

Abstract Cloud computing is being utilized broadly everywhere throughout the world by numerous IT organizations as it gives different advantages to clients like cost sparing and convenience. In any case, with the developing requests of clients for processing administrations, cloud suppliers are urged to convey enormous datacenters which devour an exceptionally high measure of vitality and furthermore add to the expansion in carbon dioxide emanation in the earth. Along these lines, we require to create strategies which will get greater condition neighbourly figuring, for example, Green Cloud Computing. In this paper, we propose another procedure to lessen the carbon discharge and vitality utilization in the circulated cloud datacenters having distinctive vitality sources and carbon impression rates. Our methodology utilizes the carbon impression pace of the datacenters in appropriated cloud engineering and the idea of virtual machine portion and relocation for decreasing the carbon outflow and vitality utilization in the united cloud framework. Reproduction results demonstrate that our proposed methodology diminishes the carbon dioxide outflow and vitality utilization of combined cloud datacenters when contrasted with the traditional booking approach of round-robin VM planning for united cloud datacenters.

A. Muthusamy (✉) · A. Anand · D. N. Rao
Galgotias University, Greater Noida, India
e-mail: m.arvindhan@galgotiasuniversity.edu.in

A. Anand
e-mail: abhineet.mnnit@gmail.com

D. N. Rao
e-mail: dronamraju8@gmail.com

T. V. Kannan
Mookambigai College of Engineering, Pudukkottai, India
e-mail: stvinodh@gmail.com

B. Balusamy et al. (eds.), *Green Computing in Smart Cities: Simulation and Techniques*,
Green Energy and Technology, https://doi.org/10.1007/978-3-030-48141-4_1

1 Introduction

Over the year nearly $350 billion was consumed by power energy in Computer as well as data centre thought the word wide per year and only 17% of that power is spent on the normal system while the rest of it is just in gusted. A huge amount of end-users without any usage of computers unattended during the office hours and whole day or leaving it on during the weekends. In these activities that the idle energy is saved money on figuring and Personal computer equipment, it may prevent huge amounts of carbon discharges into the climate consistently. For the reason that a harmful effect of IT towards nature; the significance of green figuring has ascended among scientists, governments, associations, advertisements and colleges [1].

The Moment research advances into key territories of utilizing Personal Computers (PCs) as strength powerful as it is relied upon to be, arranging estimations and systems for viability identified with PC developments. As a significance way many research studies carried out on the green gas emission like carbon dioxide and various different forms of gases damaging the atmosphere throughout the world-wide environment where we live in. Protecting the planet is a legitimate objective subsequently saving lives.

Fig. 1 Eco-friendly phase

Utilization of Information technology can be eco-friendly when we are following the green computing method. Which requires different phases in first phase represents planning second phase assembling third phase is designing fourth phase utilizing and final is discarding the equipment in practising leads to reducing of negative energy in the environment [2]. The term Green computing existed in 1992 when the US Environmental Protection Agency (EPA) launched a program called Energy Star. The purpose of that program is to reduce energy consumption, decrease the emissions of greenhouse gases that are caused by the overutilization of power and different types advanced technologies. Green computing aims to achieve economic feasibility and enhance the way the devices are being used. Green Information Technology (IT) includes the advancement of an ecologically manageable creation of technology; outlining energy proficient IT devices and enhancing transfer and reusing strategies, such as; minimizing the usage of harmful materials, boosting energy proficiency amid the item's lifetime.

Therefore, Green Computing guarantees the diversity and productivity of organic frameworks through green use, transfer and manufacturing by minimizes the adverse effect of the procedures. It would secure the ecological and social maintainability as well as financial support, which is important for people's survival (Fig. 1).

2 Literature Review

Green Computing helps in reducing carbon emissions by alternating towards energy-efficient tools that reduce the amount of energy used and produced and using combined resources and load balancing techniques. Companies and organizations around the world can help to reduce the rate of carbon emission by "Greening" their business. There are many examples of green computing implementations by major establishments. For instance; a major establishment stated that because of the energy-efficient computing implementation; their savings on energy bills reduced to 40–95% less on water waste. An Indian University is another example where they used the "Sleep Mode" on a group of servers and as a result, the energy use has reduced to 48.3%. This can be considered as major achievements when viewed in a broader setting. A significant aspect related to green computing may perhaps be the continuously changing trends in the energy costs and electrical requirements of IT inventions. In terms of research, various methods to tackle this issue need to be evaluated to bring about a substantial outcome. Energy consumption and dissipation by the usage of high-performance computing usage is increasing [2] gradually. Therefore, there is a need to balance the system in such a way that the computing speed needs to be maintained same with reduced energy consumption. Sustainable IT practices thus lead to towards the green cloud computing.

Momentum research advances into key territories of utilizing Personal Computers (PCs) as vitality powerful as it is relied upon to be, arranging estimations and systems for viability identified with PC developments.

The information and communications technology (ICT) sector is answerable for about 4% of global carbon dioxide emissions and is expected to increase to 6% by 2020. Though this carbon footprint is comparable to the global aviation industry, calculation shows that ICT will save more energy than it will consume in the future. Making networked devices energy-aware could save energy cost per year. To plan for sustainable energy consumption and reduce GHG emission, it is required to measure, model and predict energy consumption by ICT components such as switches and routers. Organizations need to examine their workstation equipment, networks, data centres and regularly observation should be there regarding their power usage to see if there are ways to reduce usage or implement new technology that consumes less energy. It has been proven that 20% of office employees never shut down their PC's at night or on weekends that produce approximately 800,000 tons of CO_2 emissions.

Logical supports of the Computer in many data centre are served with on-demand resource structure with multiple storage area numbers of hypervisors configurations of operating systems with different set of software tools and configuring the systems. So many virtualization tools are available which reduces the overall system energy. For example VM ware products, VM ware workstations VMware, Vcenter Converter. The data centre faces lots of services problem regarding the customer. The basic facilities required by the end-users are high-speed internet with uninterpreted data accessibility.

There comes the Cloud technology on-demand basic the cloud computing emerges on the demand basis. Likewise the Cloud Computing faces lot of issues like Scheduling, load balancing, scalability and virtualization (Fig. 2).

2.1 The Autonomic Computing Paradigm and Maturity Levels

Manual energy management is a complicated job, particularly when environmental changes and dynamic resource deployment are considered by the administrator. Autonomous Computing is the main paradigm that takes this dynamic autonomously into consideration. In order to integrate self-optimization in our system, a further expanded Energy-aware Autonomic Resource Scheduling Technique is incorporated into our solution, using IBM's autonomous computing idea to automatically plan resources by optimizing energy consumption where the user can readily integrate it using the accessible interface. The loop known as MAPE-K of the Autonomic Computing paradigm is used (Fig. 3).

Level 1-Basic ML: The administrator separately administers and sets the parts of the framework. Human capacity is then required to monitor the system, examine the readings and metrics observed, and eventually perform activities based on the identified anomalies;

Level 2-Managed ML: the surveillance instruments and techniques can be used to gather metrics and synthesize data from the scheme in order to decrease power. There

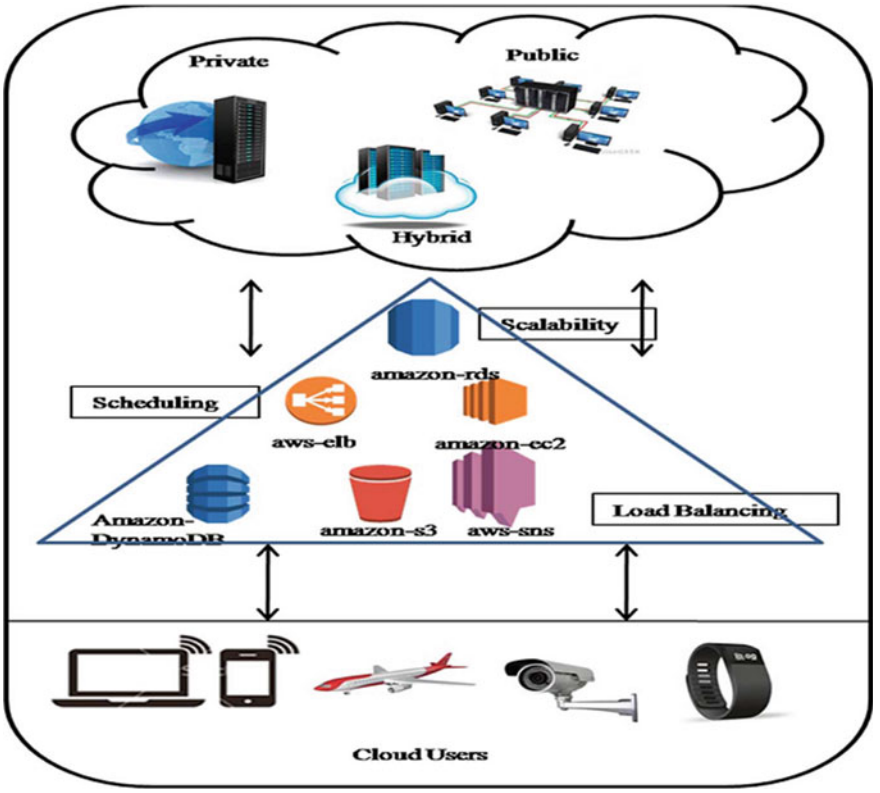


Fig. 2 ICT component of cloud computing

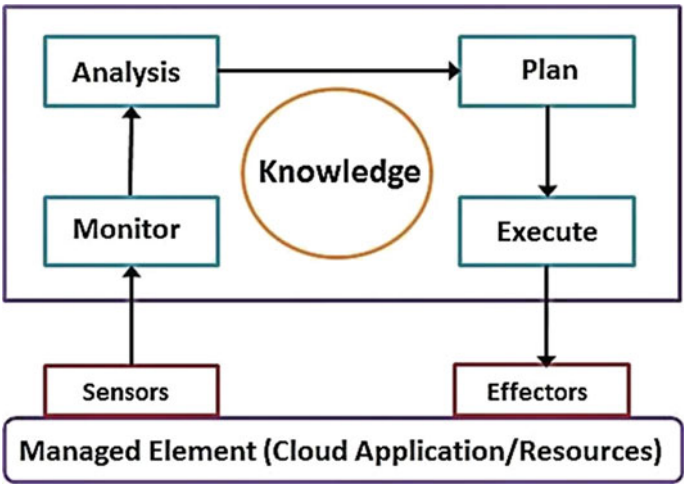


Fig. 3 Levels on cloud application

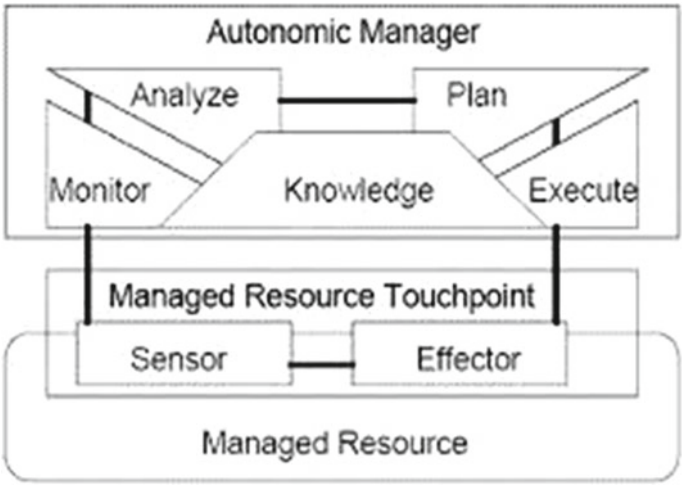


Fig. 4 Managed resource on cloud

is a need for human attitudes to evaluate the information gathered and appropriate behaviour;

Level 3-Predictive ML: the ability to examine and evaluate circumstances and offer feasible activities is known in the scheme. Here it is the responsibility of the administrator to give both the final choice and the action

Level 4-Adaptive ML: the administrator must simply to characterize approaches in light of the correlation between side effects and mechanisms without the need to approve the corrective actions and to activate them. And consequently, the adaptive environment will automatically choose the adequate action in view of the accessible data and the knowledge of what is occurring in the environment

Level 5-Autonomic ML: at the autonomic level, business approaches and objectives govern the autonomic manager with the consideration of applications requirements. The administrator collaborates with the autonomic manager to monitor business processes and modifies the targets if needed. Finally, the system becomes autonomic (Fig. 4).

3 Cloud Computing Status with Green Computing

Distributed computing is a sort of circulated figuring that relies upon sharing registering assets to give on solicitation premise. It is a model for engaging ubiquitous, on-demand access to a shared pool of configurable figuring assets like PC, systems, servers, stockpiling, applications and administrations. The cloud stage gives on-request benefits, which are consistently on, anyplace, whenever and wherever. The Cloud figuring administrations are accessible to the overall population, firms, asso-

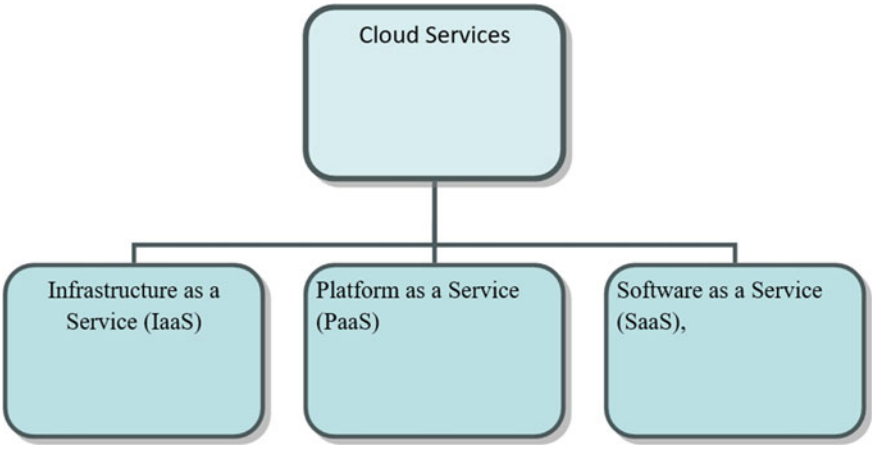


Fig. 5 Cloud services and its administration

ciations and associations markets. The administrations prepared through provider sellers incorporate everything alongside framework, stage, and programming project and network sources. Each such service is viz., Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS). Expanding interest for cloud resources make the services suppliers reevaluate about the energy utilization, as the cloud resources are responsive for unfathomable measure of Carbon-di-oxide emanation. The cloud resources expend around 2.1–2.5% of worldwide power and in the vicinity of 2.7–3.2% in US. Pike looks into estimates clouds resources utilization to very nearly 150 Twh in 2020 (Fig. 5).

The essential technique associated with debilitates control usage is concentrating the work to the base of physical centre points and change sit out of rigging centres off. A load of assets (CPU, circle stockpiling and system interfaces) and make approach change centre point on/off to diminish the power usage. The system switches square measure dynamically reconfigured to alter the dynamic plan of the server once basic. Vitality use is lessened by changing the inward server to powers saving mode (e.g. rest, sleep). Green distributed computing is staggering achieved not only the reasonable method and utilization of figuring foundation anyway moreover to contract vitality use. Asset designation in the cloud is moreover the principal issue to be settled. Better propelled calculations for VM and cloudlet part will help in asset task in a much capable manner. The rule target is to allot asset to the tasks by reducing the CPU utilization of physical machines. It is understood that an ideal machine uses directly around 70% of CPU control. Those physical machines must be killed or made to rest. Operators look for the moving toward employments and calendar the occupations to the diverse host machines. The designation of assets ought to moreover give unfaltering quality, immovable quality and versatile execution of employments in the Cloud. To achieve better execution, stack changing technique can be associated with avoiding over and under-utilization of the assets. The CPU

power is profitably utilized by swapping the endeavours between the running virtual machines as opposed to starting a new VM considering the cutoff estimations of CPU usage of each physical machine. The power utilized relies upon the number of hosts working at a particular period and the power can be lessened using the proposed framework. Moreover this techniques decreases the power utilization on the alternative way by using the VM allocation algorithm where it is used as the parameter like number of component. RAM, transfer speed, number of server farms and number of hosts. VMware can be used to run multiple unmodified PC operating systems simultaneously on the same machine by running each operating system in its own VM. An OS running as a user-level application on top of VMware is called a "guest OS." The native OS originally running on the real hardware is called the "host OS."

4 Green Cloud Environment

Where Para Physical Resource Availability, VRA Virtual Resource Availability, PRAtn is the number of physical assets is accessible in explicit time to execute work. Vern is the number of virtual assets is accessible in explicit time to execute work. An asset designation demonstrates the measure of figuring asset apportion to each activity. The processing limit allots to the assets made to execute the activity [3]. The maximum usage estimates the hour of process assets pay to break away at the useful occupation. The assets usage estimates the assignment during an explicit arrangement of labour in specific arrangement of process assets. Assets use alludes to the employment of making ready assets or the life of labour taken care of by assets the $74000 assets use fluctuates relying upon the total and sort of calculation trip to administrate. Bound assignment needs overwhelming assets usage time, whereas some others need less use time passionate about employment and assets accessibility [4].

Which CRU is registering plus usage, CRU may be a nice chance to be taken use and therefore the amount of shopper solicitation occupation to distribute the process assets. The CRE is cloud plus vitality, it quantifies what proportion vitality has eaten up by every trip and CRE may be a nice chance to vitality utilization in process plus to execute the activity. Once allotting assets to the task of work, there can be associate impediment on the mixture total of registering assets. That may be distributed to activity on assets or set of assets. Such them on top of limitations square measure usually enforced by the assets distributed to stay up acceptable sharing of assets among numerous occupations have an area with numerous shoppers [5]. The green cloud resources energy efficiency as calculated as diferrence between primary energy use between conventional system and cloud computing system

$$CDCEE = ITU \times ITE/PUE \tag{1}$$

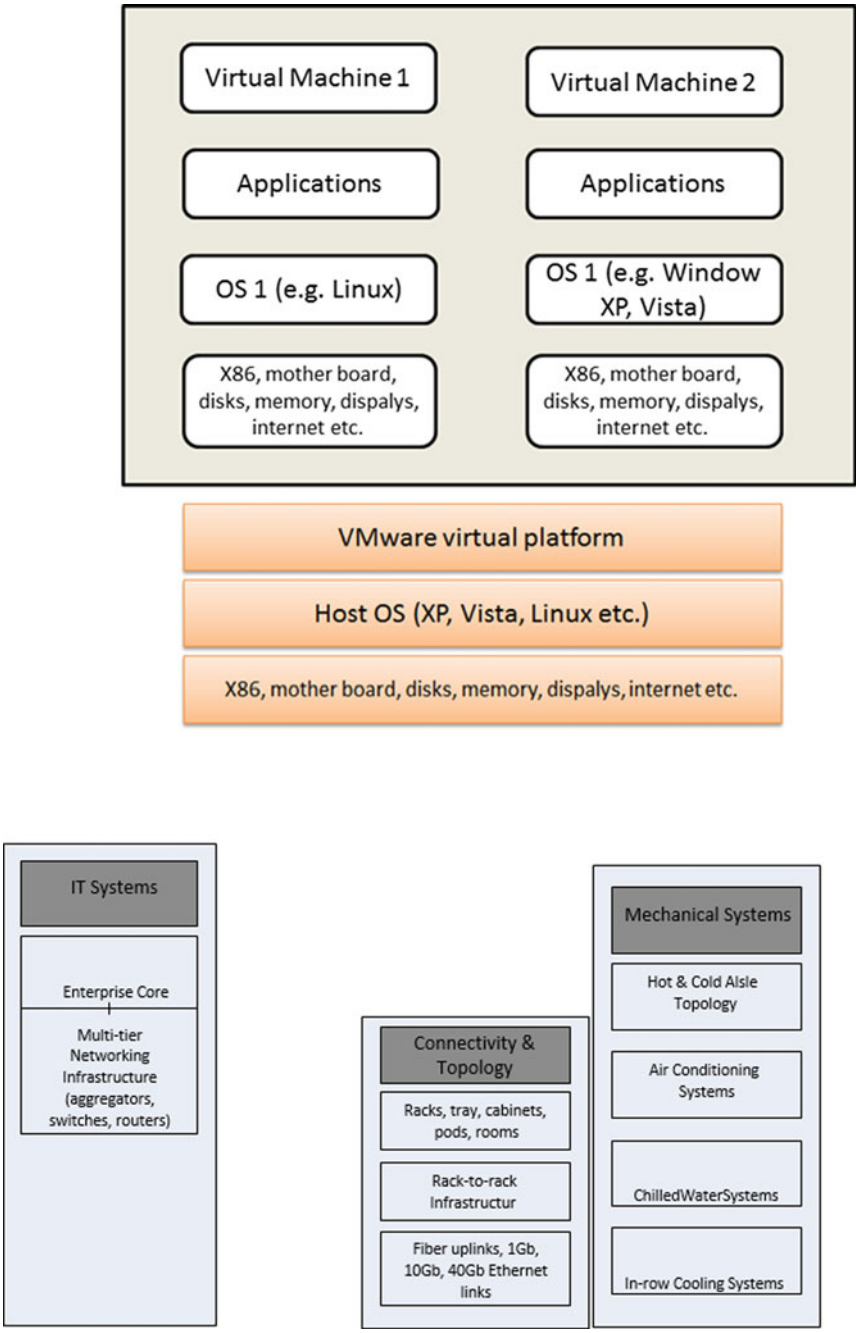


Fig. 6 High-level components comprising a cloud computing environment

where the IT utilization (ITU) denotes the ration of average IT use over the peak IT capacity in he cloud datacenter, and the IT efficiency (ITE) is the amount of useful IT work done per joule of energy.

CREE Cloud Resources Energy Efficiency, CRU Cloud Resources Utilization, CRE Cloud Resource Energy. The solution for the green cloud environment to minimize its environmental impact and energy consumption under new model by considering the static and dynamic portion of resource allocation and resources utilization for Unceasing Green Cloud Environment [6] (Fig. 6).

High levels of Carbon dioxide can cause health problems. According to the Occupational Safety and Health Administration, the maximum allowed concentration of CO_2 in an 8 h working period is 6,000 ppmv. Severe and hazardous CO_2 Levels can cause nausea and raise of cardiac and respiratory frequencies from oxygen deficiency, which is in the range, 40,000–60,000 ppmv. Unconsciousness and death may occur at 200,000 ppmv.

5 Energy-Efficient Cloud Environment

Distributed computing situation is a huge digital-physical structure consisting of electrical, mechanical and IT frameworks running an assortment of errands on a vast amount of server pools and capacity gadgets connected with multi-tiered aggregate, switch and switch chain of significance. Using vitality is the main concern in the context of the circulation of substances and the most distributed frame The energy consumption of data centres worldwide is estimated at 46 GW corresponding to about 3.4% of worldwide electrical energy consumption with a growth rate of 12% per year [2, 7]. The Barcelona medium-size Supercomputing Center (a data centre) pays an annual bill of about £1 million only for its energy consumption of 2.2 MV [8], which is equivalent to the power of 1,400 houses [9]. Considering a U.S. Environmental Protection Agency (EPA) report to Congress [10], in which it is reported that U.S. datacenters 2.5% of all power consumed in the U.S. and represents a cost of $6.5 billion.

Electrical consumption of data centers in the U.S., which hosts precisely 40% of the world's cloud datacenters servers, increased by approximately 40% during the financial breakdown [11], while energy consumed by servers, cooling, communication, storage, and power distribution equipment (PDU) accounts for between 1.7% and 2.2% [7]. This increased from 0.8% of U.S. energy consumption in 2000 and 1.5% in 2005 [12]. The environmental impact of cloud datacenters was estimated to be 116.2 million metric tons of CO_2 in 2006 [10]. Google datacenter used about 2.26 million MW hours of power to operate in 2010, resulting in a carbon footprint of 1.46 million metric tons of carbon dioxide [13]. The inter-government Panel on Climate change has called for the total reduction of 60–80% by 2050 to avoid digital-physical environmental damage. Energy costs are the fastest-rising cost element in the data centre portfolio, and yet data centre managers are still not paying sufficient attention

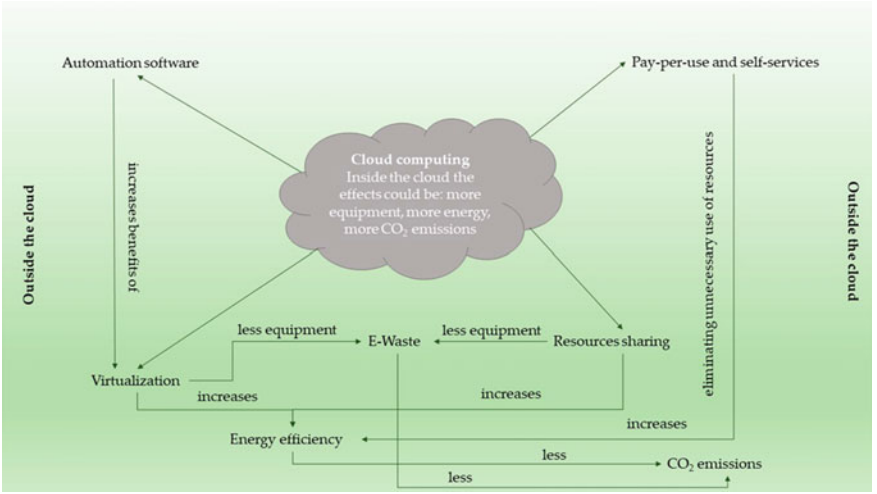


Fig. 7 Attributes of cloud computing and their carbon footprint

to the process of measuring, monitoring and modelling energy use in data centres (Fig. 7).

6 Energy Profiling

Use of energy profiling can be classified according to the computing resources and the corresponding services them provide. Following is one classification developed here (Fig. 8):

1. Server Usage
2. Cloud Usage
3. ICT infrastructures usage
4. Capacity usage

Server energy use can also be categorized into server type as follows:

1. Database servers
2. Web servers
3. Data servers

By further partitioning into SMALL, MEDIUM and LARGE depending on their size, the vitality used by a threshold can be regarded in detail and this scheme is used here. Usage data is collected from the expertise fields of Information Technology and Services (ITS) at three distinctive universities of different limits in this inquiry. The data includes the use of vitality. The information comprises of separate computing resources using energy. A model is created at these universities of varying scale and

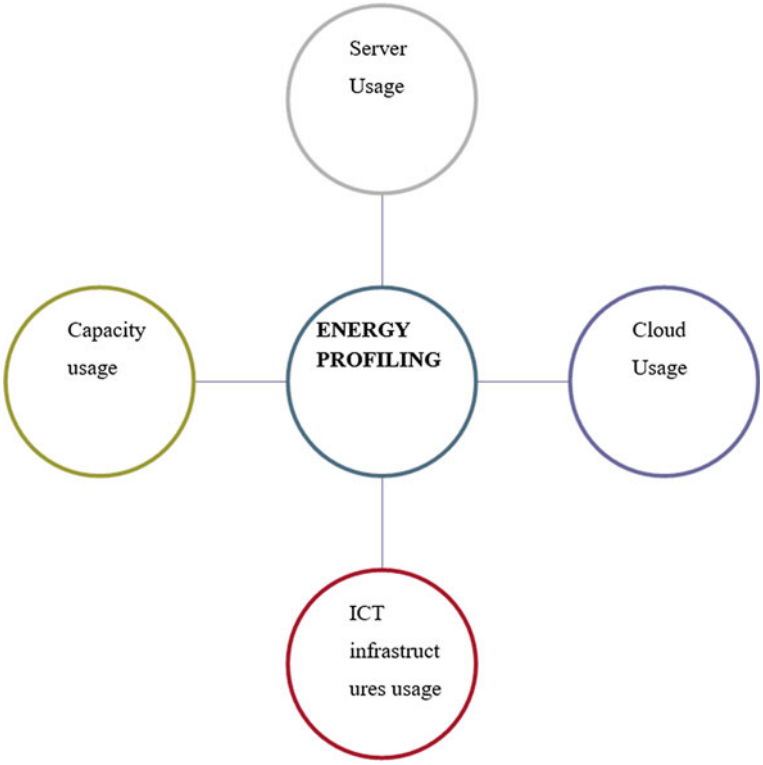


Fig. 8 Energy profiling method for green computing

size to discover the carbon footprint or GHG emissions of computing resources. The model is used to further assess an organization's carbon footprint, leading in a useful technique for determining the impact it will have on the carbon footprint if technology changes. The aim here is to contemplate the different limits of carbon discharges from different academic units. The associations are called small, medium, and enormous for the inquiry of correlation to do this. Other units can use this model to decide an association's carbon discharges. In each class, data is collected and dissected for a college to test this model (Fig. 9).

7 Energy-Inefficient Cloud Environment with Green Computing—Model Development

Cloud computing environment comprises thousands to tens of thousands of server machines, working to render services to the clients [14, 15]. Present servers are far from energy uniformity. Servers consume 80% of the peak power even at 20% uti-

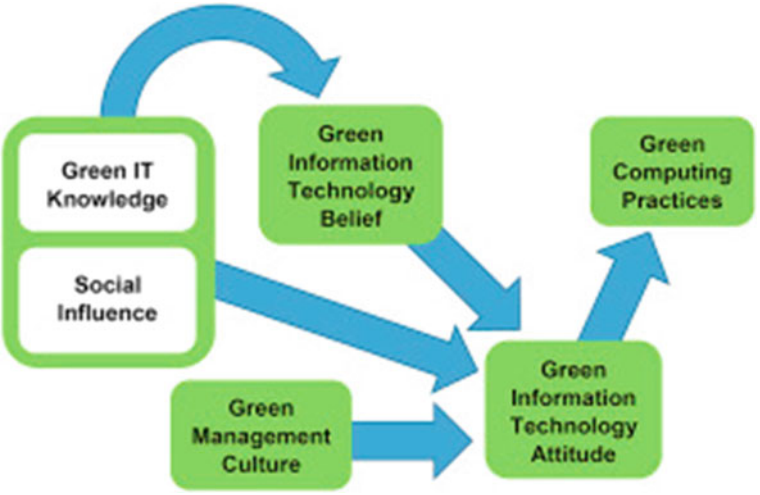


Fig. 9 Green information technology management

lization [3]. The energy non-uniformity server is a key source of energy inefficiency in the cloud computing environment. Servers are often utilized with between 10% to 50% of their peak load and servers experience frequent idle times [4]. This means that servers are not working at their optimal power-performance trade-off points mostly, and idle mode of servers consumes big portion of overall power.

Another key contributor to power inefficiencies in a cloud computing environment is the energy cost of Cooling and Air Conditioning Units (CACU), accounting to about 30% of the overall energy cost of cloud environment [5]. These values are reduced by introducing new cooling methods and new server and rack configurations for cloud computing environments. However, these values can also be reduced drastically for cloud datacenters located in good geographical locations so that they can benefit from ambient cooling. Yet, cooling energy consumption in cloud data centres is still a major contributor to energy inefficiencies in cloud computing environments.

Yet another reason for energy inefficiency in cloud data centres is the need for multiple power conversions in the power distribution system. Precisely, the main ac supply from the grid is first connected to dc so that it can be used to charge the battery backup system. The output of this electrical energy backup system then goes through an inverter to produce as power, which is then distributed throughout the cloud environment.

These conversions are necessary due to the oversized and highly redundant uninterrupted power supply (UPS) modules, which are deployed for voltage regulation and power backup in the cloud computing environment. However, most UPS modules in cloud datacenters operate at 10–40% of their full capacity [6]. Unfortunately, UPS conversion efficiency is quite low. The power usage effectiveness (PUE), which explains how much power is lost in power distribution and conversion as well as in

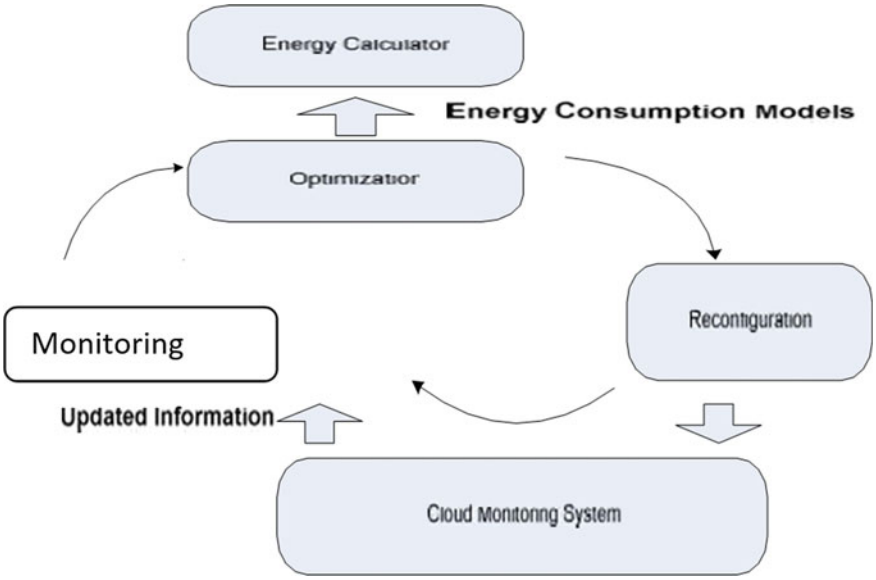


Fig. 10 Energy consumption model

cooling and air conditioning in cloud computing environments, is calculated as the ratio of the total energy consumption in a cloud data centre to the overall IT equipment power consumption [16]. The PUE metric has been steadily reducing over the last decade. In 2003, the PUE metric for a typical data centre was estimated to be about 2.6 [17]. In 2010, Koomey estimated that the average PUE was between 1.83 and 1.92 [1]. Most recent cloud datacenters built by Google, Microsoft and Facebook have pushed PUEs under 1.2 or 1.1 [18, 19].

Where IT Use (ITU) refers to the ration of average IT use over peak IT capacity in the cloud datacenter and IT Efficiency (ITE) refers to the quantity of useful IT work per energy joule (Fig. 10).

8 Model Development

Our objective is to look at machinery Carbon-di-oxide emissions from a separate capability organization. We need to classify an organization by size to do this. Based on the number of students, the universities were classified as: SMALL, MEDIUM and LARGE. Table 1 shows the classification adopted here.

Considering the majority of computer and network systems in a campus network, the information was gathered. Table 2 lists the details of the information collected for every networking device.

Table 1 Algorithms and scheduling types for energy consumption parameters

Algorithm type	Energy consumption	QoS	Resource utilization	Server utilization	Workload	Response time
VM scheduling	Yes					
Distributed and localized VM scheduling	Yes	Yes				
Most efficient server first task scheduling	Yes	Yes				
Prepower, load first algorithm	Yes		Yes		Yes	Yes
Genetic algorithm	Yes		Yes			
Genetic algorithm with multiple fitness	Yes			Yes		
Dynamic round robin	Yes			Yes		
Ant algorithm	Yes	Yes				

Table 2 Lists the details of the information collected for every networking device

Device type
Manufacturer
Model
Power requirements in KW
Number of devices
Average use of hours

9 Challenges and Future Work

Environmental protection research is a challenge for winners and losers. Every effort is essential and could result in positive outcomes. The ultimate winner is society as a whole and the next generation. In this area, green ICT is very crucial and is seen as a solution and environmental issue. Green cloud computing is a key element of this area. An important portion of the studies concentrated on the safety of cloud computing and service quality. This quality must include both client satisfaction and environmental security requirements. There are two types of challenges in designing a green cloud: technical and non-technical. Software design, virtualization methods, and thermal-aware leadership methods are some of the technical elements linked to green cloud computing. For green cloud computing, software development is essential. Applications can enhance resource management and energy efficiency.

The correspondence between programming parts must be productive. The typology must be dynamic: assets ought to be consequently included or evacuated based server stacking. A portion of the open issues is the dynamic allotment of assets and vitality, the decrease of execution expenses and time of the assignments, and the decrease of vitality utilization.

A VM assignment system could diminish vitality utilization and costs. The virtualization methods could be improved by the movement of the remaining task at hand between machines, alongside VM relocation, between topographically disseminated

server farms. The remaining tasks at hand could be moved in green cloud server farms. Open issues, for this situation, are: adjusting the remaining burden between

Thermal-aware management techniques are important for the heating problem in cloud data centres. To solve this problem, the workload schedule has to be performed based on thermal aspects, Symmetry 2017, 9, 295 13 of 20 and the heat recirculation has to be improved. The building of data centres in areas with free cooling resources is a non-technical solution for this problem.

"Non-specialized angles" alludes to models, inward and universal guidelines with respect to the earth, and the inside approaches and methodologies of the association. There are two issues for this situation: the universal guidelines are centred around security issues in the cloud, and the worldwide guidelines are distinctive crosswise over nations. Some of them have received and connected exacting natural security guidelines. Others are extremely tolerant in this field—they either don't have guidelines or don't make a difference them appropriately. Another non-specialized issue is the expense of green distributed computing. These expenses are moved from the cloud suppliers to the cloud clients, and suppliers will expand the cost of administrations. The utilization of sustainable power source is a non-specialized issue. The irregularity of this vitality is a test for distributed computing suppliers and disturbs the traditional techniques for arranging activities in the cloud. To guarantee that SLAs' prerequisites are regarded, the utilization of a blend of vitality sources that supplement each other is fundamental. Some cloud suppliers have officially assembled server farms in geological zones where sustainable power sources are accessible or may end up accessible during the operational stage.

10 Conclusion

Cloud computing is a new model that integrates already-existing technologies in order to increase the efficiency of resource use. The results of using these technologies are varied. The suppliers of such services and the authors of studies undertaken by organizations interested in environmental protection have highlighted both favourable and unfavourable aspects of the effects of cloud computing on the ecosystem. Broadly speaking, cloud computing is likely to favour a harmonious relationship with the environment to the extent to which the ICT equipment producers and the companies supplying services in the field align themselves with environmental policies and agree to the proposals of non-governmental organizations regarding methods of diminishing the negative effects of hardware and software. This paper discusses the contribution of cloud computing to environmental protection according to the studies on this topic is undertaken so far. The most important aspects are as follows:

- The main advertised benefits are those which refer to energy efficiency. In order to comply with regulations on environmental protection, the companies which offer cloud services should reduce to a minimum the consumption of energy from non-renewable sources and replace it with renewable energy consumption. The

studies undertaken so far have highlighted that the index of clean energy usage is still quite high, outrunning the energy obtained from non-renewable sources.
- An increase in the consumption of energy from renewable sources will lead to lower CO_2 emissions, but considering that the first indicator is not yet accomplished as expected, carbon emission reductions are unlikely to meet the expectations of environmental organizations.
- Minimizing e-waste is another controversial aspect leading to high expectations. The use of cloud computing may influence the reduction in the amount of equipment required by organizations and the speed of replacement. Nevertheless, this is a long-term benefit and it is difficult.

References

1. Anand A, Krishna A, Tiwari R, Sharma R (2018) Comparative analysis between proprietary software vs. open-source software vs. free software. In: 5th international conference on parallel, distributed and grid computing (PDGC), pp 144–147
2. Anand A, Arvindhan M (2019) Scheming a proficient auto scaling technique for minimizing response time in load balancing on amazon AWS cloud. SSRN
3. Saraswathi AT, Kalaashri YRA, Padmavathi S (2015) Dynamic resources allocation scheme in cloud computing. Procedia Comput Sci 47:30–36
4. Choi Y, Lim Y (2016) Optimization approach for resource allocation on cloud computing for IoT. Int J Distrib Sens Netw
5. Omara FA, Khattab SM, Sahal R (2014) Optimum resource allocation of database in cloud computing. Egypt Inform J 15(1):1–12
6. Seddigh M, Taheri H, Sharifian S (2015) Dynamic prediction scheduling for virtual machine placement via ant colony optimization. In: Signal processing and intelligent systems conference (SPIS), Tehran, 2015, pp 104–108
7. Saha B (2014) Green computing. Int J Comput Trends Technol 14(2):46–50
8. Murugesan S (2008) Harnessing green IT: principles and practices. IT Prof 10(1)
9. Vosoogh A, Nouramandi-Pour R (2015) Scheduling problems for cloud computing. Cumhur Sci J 36(3):2628–2652
10. Kapoor S, Dabas C (2015) Cluster based load balancing in cloud computing. In: Proceedings of 8th international conference on IEEE contemporary computing (IC3), pp 76–80
11. Buyya R (2013) Introduction to the IEEE transactions on cloud computing. IEEE Trans Cloud Comput 1(1)
12. Lee YC, Zomaya AY (2010) Energy efficient utilization of resources in cloud Computing systems. J Supercomput
13. Lemay M, Nguyen K-K, Arnaud BS, Mohamed C (2012) Toward a zero-carbon network converging cloud computing and network virtualization. IEEE Computer Society 12:1089–7801
14. Boru D, Kliazovich D, Granelli F, Bouvry P, Zomaya AY (2015) Energy efficient data replication in cloud datacenter. Springer Science
15. Akhter N, Othman M (2016) Energy aware resources allocation datacenter. Clust Comput 19(3):1163–1182
16. Chheda R, Shookowsky D, Stefanovich S, Toscano J (2008) Profiling energy usage for efficient consumption. Arch J
17. Mallinger S (1996) Potential carbon dioxide (CO(2)) asphyxiation hazard when filling stationary low-pressure CO(2) supply systems. http://www.osha.gov/dts/hib/hib_data/hib19960605.html

18. Francis K, Richardson P (2009) Green maturity model for virtualization. Microsoft Arch J Green Comput
19. Koomey J (2007) Estimating total power consumption by server in the U.S and the world. http://enterprise.amd.com/Downloads/svrpwrusecompletefinal.pdf
20. Torres J (2010) Green computing: the next wave in computing. In: Ed. UPC Technical University of Catalonia
21. Kogge P (2011) The tops in flops. IEEE Spectr 49–54
22. U.S Environmental Protection Agency (2006) Report to congress on server and datacenter energy efficiency public law. http://hightech.lbl.gov/documents/data_centers/epa-datacenters.pdf
23. Greenpeace (2011) Greenpeace "likes" facebook's new datacenter, but wants a greener friendship. http://www.greenpeace.org/international/en/press/releases/Greenpeace-likes-Face-books-newdatacentre-but-wants-a-greener-friendship
24. Kovar J (2011) Data center power consumption grows less than expected: report. www.crn.com/news/data-center/231400014/data-center-power-consumption-growsless-than-expected-report.htm?pgno=2
25. Miller R (2011) Google's energy story: high efficiency, huge scale. http://www.datacenterknowledge.com/archives/2011/09/08/googles-energy-story-high-efficiency-huge-scale
26. Armbrust M et al (2010) A view of cloud computing. Commun ACM 53(4):50–58
27. Buyya R (2009) Market-oriented cloud computing: vision, hype, and reality of delivering computing as the 5th utility. In: Proceedings of international symposium on cluster computing and the grid
28. Barroso LA, Hölzle U (2007) The case for energy-proportional computing. IEEE Comput 40(12):33–37
29. Barroso LA, Holzle U (2009) The datacenter as a computer: an introduction to the design of warehouse- scale machines, 2nd edn. Morgan and Claypool Publishers, San Rafael
30. Wu CM, Chang RS, Chan HY (2014) A green energy-efficient scheduling algorithm using the DVFS technique for cloud datacenters. Futur Gener Comput Syst 37:141–147
31. de Carvalho OA Junior, Bruschi SM, Santana RHC, Santana MJ (2016) Green cloud meta-scheduling a flexible and automatic approach. J Grid Comput 14:109–126
32. Alzamil I, Djemame K, Armstrong D, Kavanagh R (2015) Energy-aware profiling for cloud computing environments. Electron Notes Theor Comput Sci 318:91–108
33. Roy S, Gupta S (2014) The green cloud effective framework: an environment friendly approach reducing CO2 level. In: Proceedings of the 1st international conference on non-conventional energy, Kalyani, India, pp 233–236
34. Chu FS, Chen KC, Cheng CM (2011) Toward green cloud computing. In: Proceedings of the 5th international conference on ubiquitous information management and communication, Seoul, Korea
35. Ge Y, Zhang Y, Qiu Q, Lu YH (2012) A game theoretic resource allocation for overall energy minimization in mobile cloud computing system. In: Proceedings of the 2012 ACM/IEEE international symposium on low power electronics and design, Redondo Beach, CA, USA, pp 279–284
36. Horri A, Dastghaibyfard G (2015) A novel cost based model for energy consumption in cloud computing. Sci World J
37. Gavaskar S, Anisha A, Renit C, Shiney TS (2016) Mobile apps for green cloud computing performance measure. In: Proceedings of the international conference on energy efficient technologies for sustainability (ICEETS), Nagercoil, India, pp 865–869
38. Diouani S, Medromi H (2019) An adaptive autonomic framework for optimizing energy consumption in the cloud data centers. Int J Intell Eng Syst 12(4)

A Review: Recent Trends in Green Computing

Shrddha Sagar and Nilanjana Pradhan

Abstract In today's world, Green Computing is one of the most attention seeking domain. In Green Computing architectures of system and software plays an important part in the systems for telecommunication and computing. With the increase in use of internet Green Computing is needed for cooling and higher rate of power. Green Computing is implemented for securing our environment and main attention is on the virtualization, power management, telecommunication and material recycling. For the adverse effect on global environment, we have to improve the working habits of computer and business users. Due to these types of issues many scholars have taken number of actions for reducing the usage of power on computer. In this chapter we have discussed about green computing and the algorithms for green computing. Authors have also identifies the problem in this domain.

1 Introduction

Green-Technology includes broad range of areas that is from latest energy generation approaches to the thorough knowledge of enhanced materials which are used in one daily routine. The main aim of green technology is to minimize the environmental impact of the process of industries and innovative technologies which are induced by the growing population on the earth [1]. Earth will not be viable enough for living beings due to huge disposing of toxic waste which is huge in amount and rate [2]. High levels of carbon dioxide (CO_2) emission are dangerous and can cause health problems. As computing becomes increasingly pervasive, energy consumption due to computing keeps increasing. Green computing is emerging as a critical information communication technology to reverse the trend. For maintaining overall comput-

S. Sagar (✉)
School of Computing Science and Engineering, Galgotias University, Greater Noida, India
e-mail: sagarshraddha@gmail.com

N. Pradhan
School of Computing Science and Engineering, Greater Noida, India
e-mail: nilanjana.pradhan@galgotiasuniversity.edu.in

B. Balusamy et al. (eds.), *Green Computing in Smart Cities: Simulation and Techniques*,
Green Energy and Technology, https://doi.org/10.1007/978-3-030-48141-4_2

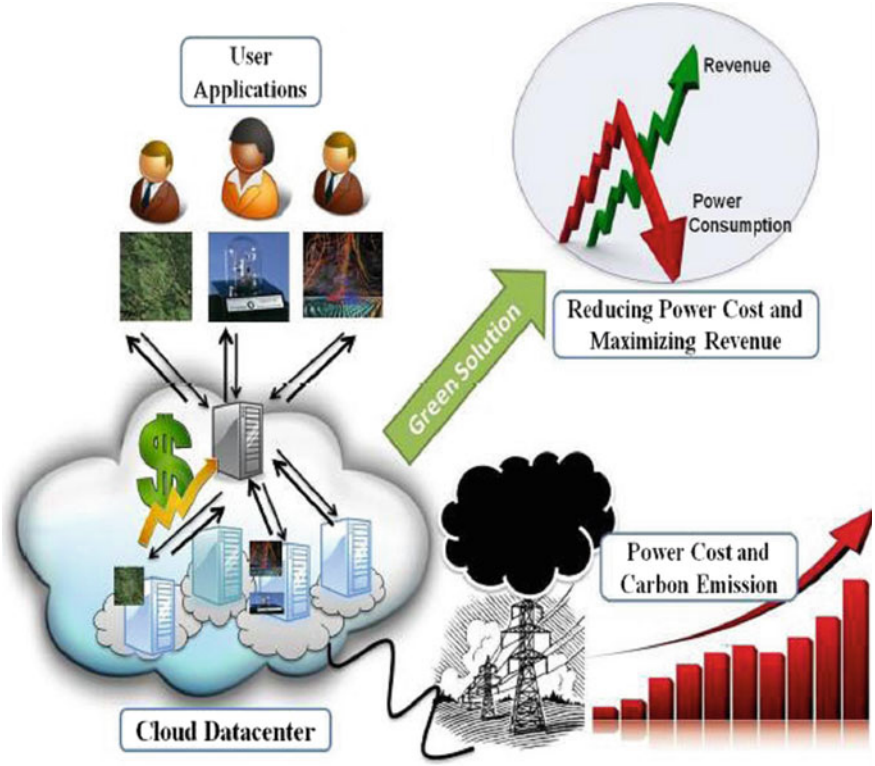


Fig. 1 A typical illustration of green computing

ing performance green computing uses computing resources which are environment friendly [3]. Companies in the computer industry are interested in green computing because it saves energy and expenditure cost. In Fig. 1 green computing is shown which includes the elements as user applications, cloud datacenter, power cost and carbon emission and reducing power cost and maximizing revenue [4]. Green computing and green chemistry are much similar on following parameters like reduction of usage of hazardous materials and increasing efficiency of energy in the entire product lifecycle. Green computing is the movement towards more environmentally sustainable computing. It seeks to conserve the energy and reduce the e-waste. It is important for all classes of computing systems, from handheld mobile devices to data centre facilities, which are heavy consumers of energy [5, 6]. Many governmental agencies and non-profit organizations have implemented standards and regulations that encourage green computing. Some countries have launched a number of "paperless" initiatives with the aim of reducing the use of paper in offices [7].

2 Defining Green Computing

Green computing is one of the important application of environmental science which allows economical solutions that are possible for conserving natural resources and environment. Major components of green computing like designing, manufacturing or usage and disposal of computers and its sources more efficiently, so that there is minimum affect on the environment. The main aim of green computing is managing of power and energy efficiency along with preferred environment friendly hardware and software devices and usage of recyclable material for increasing the life of product. Electricity bill is reduced with usage of green computing and provide peace to the mind. Now a days star management approaches and technologies are used for the reduction of energy consumption waste [8].

For study and practice virtually green computing (also known as environmental sustainable computing) is used for efficient and effective computing which have minimum or no effect on the environment. Number of facts are there for achieving green computing like designing, manufacturing, usage and disposal of components of computers which also include hardware and software parts also [9].

Following mentioned below points are steps for designing of green computing are as [9]:

- Green usage minimize the consumption of energy for computers and information systems and also use them in an environmental friendly manner.
- Green disposal includes reuse of old computers and recycling rejected computers more efficiently along with electronic devices.
- Green design consist of designing sound components (like computers, servers, cooling equipment, and data centres) which more energy efficient and have environment friendly.
- Green manufacturing includes development of those electronic components, computers and other related subsystems which have minimum affect on the environment.

Thorough use of computing and IT resources more efficiently is the main practice in green computing. Protection of the environment and saving of energy cost is one of the most important responsibility of human being in today's world. For sustainability of computing and information technology green computing and green information technology are used for the analysis [10]. The requirement of green computing is for reduction of use of hazardous devices, increase the efficiency of energy and for the promotion of the reusability of computing devices and information technology waste. Green computing is the only way through which constructive policies for future. It consists of sustainability in environment, commercialization of energy efficiency, and total cost estimation of disposal and recycling of computing and IT devices. The main aim of study and practice is the efficient use of computing resources [11]. Consolidation and cloud computing are the main parameters of green information technology [12] (Fig. 2).

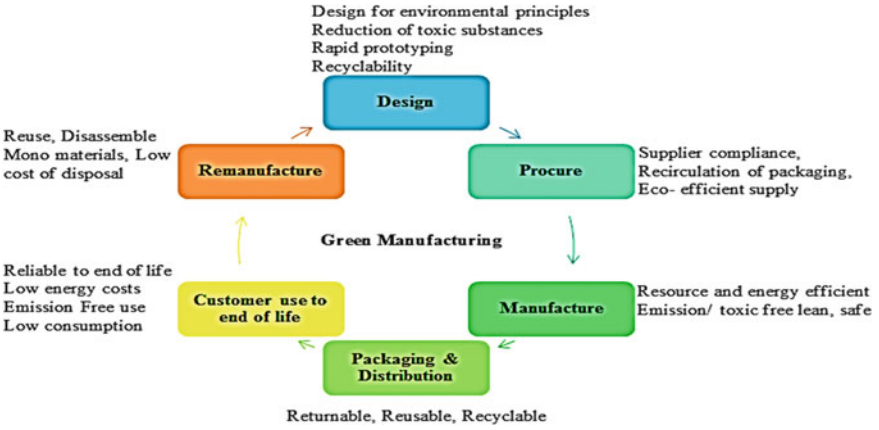


Fig. 2 Cycle of green manufacturing

3 Purpose of Green Computing

Environmental change and an Earth-wide temperature boost are seen by numerous individuals as the two most testing issues confronting the Earth. Green IT and specifically, green figuring, are two different ways the data and correspondences innovation network is attempting to address those issues. With the unstable development of Internet-empowered distributed computing and superior processing focuses, IT's vitality utilization and supportability effects are relied upon to keep climbing great into what's to come. Endeavors are in progress in both industry and the scholarly community, be that as it may, to address it (Fig. 3).

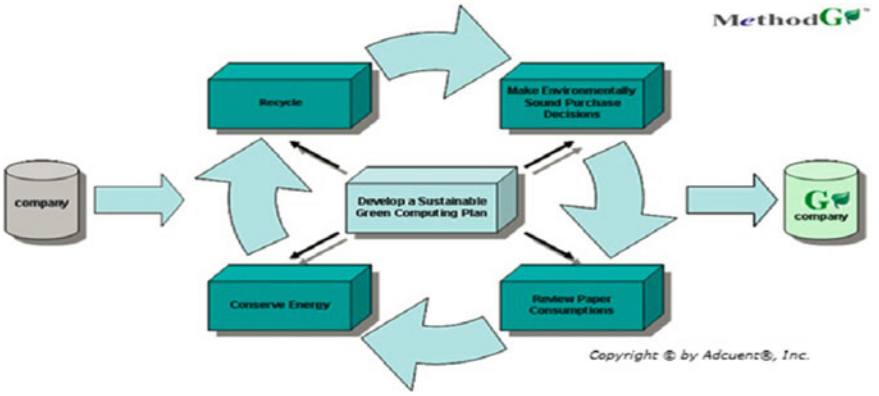


Fig. 3 Implementation of green computing

As the requirement for computing and transmission of data is increasing day by day, servers, systems, and server will expend increasingly more vitality. For instance, IT assets in the US currently expend more than 1.5% of absolute power utilization. Power utilization of US server farms in 2006 was 1.5% of the all out vitality devoured and at an expense of more than US $4.5 billion.

Today, the green correspondences idea centers chiefly around creating vitality proficient correspondence procedures for networking of systems. Three fundamental methodologies are proposed for power the board in networking systems like doing less amount of work, lessen working pace, and switching off those components which are not in use. Doing less work means advancing procedures with the goal that the framework executes less tasks and therefore utilizes less vitality. Diminishing activity speed could anticipate repetitive asset use from the crisscrossed speed of sub-forms. At last, closing down inactive networking system parts and connections can clearly lessen vitality dissemination. The all out vitality utilization by servers, PCs, screens, information correspondence prerequisites and cooling frameworks for server farms is relentlessly expanding. This expansion in vitality utilization brings about expanded ozone harming substance outflows. Every PC being used produces about a huge amount of carbon dioxide consistently. As vitality emergency develops and the assets drain, we have to genuinely consider rolling out generous improvements in our way of life for vitality preservation. Green registering is one method for managing the vitality emergency. It is conceivable to lessen carbon emanations, spare vitality and secure the earth all in all with this methodology. Green computing is the act of utilizing PCs and related innovation in a naturally capable way. It goes for drastically changing the manner in which we approach processing, utilizing the electronic gadgets and following severe vitality protection rules, in order to limit the harm caused to nature by PCs. This action isn't simply constrained to sparing power yet additionally adopts an all encompassing strategy towards condition agreeable utilization of PCs. Conceiving creative and condition cognizant procedures for vitality age is likewise one of its angles [13]. As per analysts of Green Computing following are very common difficulties that Green computing is confronting today [14]:

- Equipment control thickness/Power and cooling limits.
- Increase in vitality necessities for Data Centers and developing vitality cost.
- Control on expanding prerequisites of warmth expelling hardware, which builds as a result of an expansion in all out power utilization by IT kinds of gear.
- Equipment Life cycle the executives—Cradle to Grave.
- Disposal of Electronic Wastes.

4 Methodologies to Green Computing for Smart Cities

A Smart City, or insightful city, is a city fit for improving its residents' life quality, offering an enduring open door for social, financial and social development in a solid, protected, animating and dynamic condition [15]. A Smart City is a city that assurances:

- Monetary aggressively (smart economy), development, venture, financial picture and brands soul, efficiency, work showcase adaptability, worldwide reconciliation, change limit;
- Preparing and social cooperation of natives (brilliant individuals), capability level, long haul preparing, social and ethnic majority, adaptability, imagination, cosmopolitanism and mental opening, interest to open life;
- Organization working and administrations (smart governance), interest to delusional procedures, open and social administrations, straightforward government movement, political methodologies and viewpoints;
- Accessibility of data and correspondence advancements and current and supportable transportation frameworks (smart portability), accessible locally, accessible universally, accessibility of IT foundations, feasible, imaginative and safe transportation frameworks;
- High ecological quality (smart environment), the appeal of characteristic conditions, pollution, environment security, practical administration of assets;
- Life, culture, well being and security quality (smart living), social structures, well being conditions, singular security, homes quality, instructive structures, touristic appeal, social attachment.

5 Smart Power Grid

A savvy grid is a system that connects power organizations to a variety of intellectual gadgets that monitors power utilization inside homes and organizations [16]. According to the current consumption of energy levels smart grid controls the fluctuations. Utilizing this data, green programming applications can advance its conduct likewise. For reduction in wastage of energy proper utilization of energy consumption in accordance to availability of energy resources. In the event that brilliant urban communities use control from smart power frameworks [17], at that point the whole control utilization of the city can be changed in accordance with the power supply so phenomenal power disappointments won't happen.

6 Green Cloud

Green cloud is a stylish articulation that implies the potential environmental favorable circumstances that information advancement (IT) organizations passed on over the Internet can offer society. The term joins the words green—which means environmentally neighborly—and cloud, the regular picture for the Internet and the contracted name for a kind of organization movement model known as cloud computing. According to the statistical survey done by Pike Research, the wide-spread reception of cloud computing could provoke a potential 38% decline in generally speaking server farm use on vitality utilization by 2020 [18]. The hold assets would be in a

general sense achieved by cementing server homesteads and enhancing power use effectiveness (PUE), improving reusing tries, cutting down carbon and gas releases and constraining water usage in cooling the remainder of the data centers.

Because of a lot of a data centers' energy utilization bolster information storage, the Storage Networking Industry Association (SNIA) has advanced new innovations and structures which backing to spare energy. Progress in SAS drive advances, robotized information duplication, stockpiling virtualization and capacity intermingling diminish the measure of physical stockpiling a data center requires, which helps decline its carbon impression and lower operating expenditures (OPEX) and capital expenditures (CAPEX). Since the shading green is additionally connected with paper cash, the term green cloud is now and then used to depict the cost-effectiveness of a cloud computing administration [19].

Green cloud computing can enable a supplier to slice expenses and market to ecologically cognizant clients. In any case, cloud suppliers must adjust the publicity encompassing the green and corporate social duty activities with their definitive necessity exceptionally accessible and solid cloud administrations for their clients. The idea of "becoming environmentally green" is picking up force over all businesses and cloud computing is no special case. A few clients need to diminish their ecological impression and are going to cloud suppliers that offer green cloud computing and energy efficient data centers.

A few open cloud suppliers, including IBM and HP, have reported different green server farm activities. eBay as of late uncovered designs to develop data centers which are controlled by energy component innovation instead of the national power grid. Interxion, a Netherlands-based bearer impartial data center and oversaw specialist co-op secures over half of its capacity through sustainable power sources over its 28 data centers in 11 nations. Its data centers influence hydroelectric power, among other vitality sources, and exploit the "free cooling" that the cold Scandinavian air gives, as indicated by Lex Coors, vice president of data centers innovation and building for Interxion [18].

Depending on the location of the cloud provider, various renewable energy sources might be available, including the wind, hydroelectric or solar energy. Cloud providers in France and the U.K. may soon be relying on wind farms. More energy efficient is a data centre greener are the servers. The renewable energy source is not available to every cloud provider, but anyone can build a more energy-efficient data center, starting with server hardware, said Amy DeCarlo, principal analyst of security and data centre services at Current Analysis. Vendors are now building servers that can run at high temperatures, which lower cooling costs. Cloud providers should consider partnering with these vendors to cut down on energy consumption and costs in their data centres. Cloud providers need to take a look at their legacy equipment and decide if their servers are as energy-efficient as possible. Small cloud providers looking to reduce their footprint can consider location facilities with other cloud providers which will result in a significant cost-savings opportunity in addition to a smaller environmental footprint.

Sustainable methods to power or cool data centres must be carefully implemented. For instance, local environment can have a negative impact if water is used to cool a

data centre. In the Netherlands, we can drill up to 300 feet down for water for cooling power, but we can't simply pump hot water back in the ground for the towns, other data centres use ocean water for cooling, but pumping hot water back into the ocean can be deadly to sea life. Cloud providers need to give that water time to cool before returning it to the ocean. No one is thinking hundreds of years down the line, and even these sustainable energy sources can make an impact on the environment.

Everything in moderation is important especially when it comes to green cloud computing, research director for Pike Research, a consulting firm for global clean technology markets. Customers need a dependable and available cloud environment. Despite how "green" a cloud provider may be, customers still value reliable cloud services over everything else. Green credentials will be a strong requirement for data centre businesses going forward, but data centre managers need to be assured that they will have the same level of reliability they've always had. While cloud providers should consider renewable resources, having a backup strategy in place is necessary as green cloud computing can be idealistic, the cloud providers must strike a balance between offering more energy-efficient, socially responsible practices and upholding their services.

7 Green Computing Algorithms

Green registering is the eco-friendly innovation for the environmental friendly computers and usage of their assets. Green computing is additionally characterized as the way that lessens their natural effect on study of structuring, building, and assembling, utilizing and discarding registering devices. The server farm incorporates every one of the parts of vitality use in an effective way from the IT hardware to the HVAC (Heating, ventilation and cooling) equipment of genuine development of the labs and offices. Green computing idea is presented in 1992, by the Environmental Protection Agency (EPA) in the Energy Star Program. Numerous IT organizations are attempting to concoct the vitality effective figuring gadgets for lessening the wastages and improving the reuse methods in the formation of computerized devices. Green Computing, is also known as green improvement, is the earth reliable utilization of PCs and related assets. Such practices intertwine the execution of imperatives proficient centrally preparing units (CPUs), servers and peripherals and what's increasingly diminished asset use and genuine move of electronic waste (e-waste).

Energy utilization is like manner essential in PC frameworks, similar to both cost and accessibility. Power costs power an impressive strain on the money related arrangement of data and figuring centres. Google engineers, keeping up a considerable number of servers, advised that if control usage continues creating, control costs can without a lot of a stretch overpower hardware costs by a tremendous edge. In-office circumstances, PCs and screens speak to the most shocking vitality use in the wake of lighting. Power dissipating is in like manner important stress in minimal, battery worked gadgets that have multiplied rapidly starting late. All of us have experienced the event that the battery of our workstation or mobile phone is depleted.

The issue is much progressively authentic in free, appropriated, for instance, sensor frameworks where the charging of batteries is problematic or incomprehensible. Finally, vitality dissipating causes warm issues. Most of the vitality eaten up by a system is changed over into warm, realizing wear and reduced reliability of types of equipment.

8 Algorithms and System for Power and Efficiency

Slack Reduction Algorithm (SRA) assignments with slack are executed at a minor repeat. It changes the activity repetitions of the focal points and execution of a social occasion of assignments (in which various thick direct factor-based math estimations can be rotted) with an altogether various approach to managing save imperativeness.

Slack Reduction Algorithm (SRA) assignments with slack are executed at a minor recurrence. It changes the activity recurrence of the centres and execution of a gathering of assignments (in which numerous thick direct variable based math calculations can be decayed) with an altogether different way to deal with spare vitality. A power-mindful simulator system, responsible for booking the execution of undertakings to processor centres, is utilized to assess the execution advantages of these power-control strategies for two reference calculations for the LU factorization, a key activity for the arrangement of straight frameworks of conditions. The outcomes from this method are balanced by a vitality mindful test system, which is responsible for scheduling/mapping the execution of these undertakings to the centres, utilizing dynamic recurrence voltage scaling included by current innovation. The Slack Method This segment presents another productive heuristic, called the Slack Technique, for static distribution of hard constant errands. The Slack Strategy has two objectives: First, the development of any practical task, and second, to restrain the utilization of assets. In spite of the fact that for the most part concentrating on the primary, the subsequent task is probably going to relate to a sensible satisfaction of the goal to limit assets use. The Slack Strategy is partitioned into two sub-steps named Graph Reduction and CP-Mapping. Amid the Diagram Decrease diverse exchanges (= sets of errands with a similar period) are dealt with independently. This is attractive in multi-period frameworks since it stays away from thorough investigation of all assignment initiations amid the minimum basic numerous (LCM) of the period lengths. The sizes of the charts are diminished by the Graph Decrease 1 “step utilizing the basic way bunching, and after that by the Graph Decrease 2” step misusing slack qualities. Slack qualities (i.e. the measure of time an undertaking can be postponed without missing its due date) are utilized to all slack intervals with different assignments. The outcome is a more minimized diagram with ensured timing properties (called the lessened critical-path (CP)). Because of its smaller size this chart can more effectively than the first assignment diagram.

The Hughes–Hartog Algorithm

The Hughes–Hartog algorithm is an ideal stacking calculation which accomplishes the arrangement by including one piece at an opportunity to the channel requiring the littlest extra capacity to build its rate. Though this system can be utilized to fathom the two information rate and edge augmentation, the calculation requires an escalated measure of arranging and joins gradually in functional DMT situations. A down to earth discrete multitone handset stacking calculation endeavours to boost the subchannel SNR's as opposed to the edge and again depends on adjusting. Though this is an alternate rule for stacking, the subsequent portion ought to be to a great degree close if not indistinguishable. Another stacking calculation for discrete multitone transmission indicates change of in general SNR contrasted with A handy discrete multitone handset stacking calculation and additionally some decrease in intricacy [19]. A handy discrete multitone handset stacking calculation utilizes an unassuming measure of arranging to subtract or include bits each one in turn, which might be costly if the underlying piece of the calculation is too a long way from the objective rate. The general unpredictability of the calculation is overwhelmed via pursuits and augmentations; however the activity tally will ordinarily be on indistinguishable request from the edge calculation. It is for discrete multitone regulation. Utilizing effective query table pursuits and a Lagrange-multiplier separation look, this calculation combines quicker to the ideal arrangement than existing systems and can supplant the utilization of imperfect strategies in view of its low computational multifaceted nature. Sadiku et al. [3] (iii) due to algorithm At the point when just the CPU energy is viewed as due algorithm accomplishes higher energy sparing over the non-DVS planning and has much lower multifaceted nature contrasted with the current algorithm upset. At the point when the framework energy (CPU energy + gadget energy) is viewed as the duSYS and duSYS PC calculations utilize a mix of ideal speed setting and constrained seizure. For the situation when the CPU power and gadget control are similar, duSYS and duSYS PC accomplish extensive energy investment funds contrasted with the CPU-energy productive calculation due and over the non-DVS booking calculation. In the event that the gadget control is vast contrasted with the CPU control, at that point DVS conspire does not result in most minimal energy. Presently if the gadgets in framework work at various voltage/recurrence levels, the gadget power can be separated into the dynamic part which is versatile and the static part which isn't adaptable. While this would change the framework level energy bend, the convexity property would at present hold, and there would at present be an ideal scaling factor. Different unique assignment planning calculations are considered to decide the speed setting of both the CPU and the gadget for least framework level energy utilization.

Computation and Transmission Rate Based Algorithm (CTRB) keeping in mind the end goal to understand the advanced biological communities and the green IT innovations; it is hard to decrease the aggregate power utilization of PCs and systems. The EPCLB calculation is utilized to choose one of servers with the goal that the aggregate power utilization of the servers can be diminished for general kinds of uses. In the EPCLB calculation, a server whose TPCL is least is chosen for another

demand in an arrangement of servers. The TPCL demonstrates how much electric power a server needs to devour to perform up all the calculation and transmission forms at time. In this manner, in the EPCLB calculation, a load balancer needs to gather current status and ascertain the TPCL of each server to choose a server for a demand each time the heap balancer gets another demand. Here, if the quantity of customers simultaneously performed is expanded, the calculation and correspondence overheads to gauge the TPCL of servers are expanded on a load balancer. Likewise, the status of every server may be changed amid the estimation procedure because of the correspondence delay between a load balancer and servers. Henceforth, in the EPCLB calculation, it is hard to accurately appraise the TPCL of servers and the load balancer may be bottleneck of the framework in genuine conditions. The CTRB calculation is utilized to choose a server in an arrangement of servers so the aggregate power utilization of servers and the overhead of a load balancer can be lessened. In the CTRB calculation, a server in an arrangement of servers is chosen for another demand without thinking about the TPCL of servers. Thus, a load balancer does not have to gather the current status of each server in a server set search time the load balancer gets another demand from a customer. As the outcome, the overhead of a load balancer to choose a server for each demand can be lessened.

9 Applications of Strategies

The varieties of the SaaS model happen the manner in which applications and software systems which are disseminated and utilized. Various organizations are changing to SaaS clouds to limit their IT foundation cost. Accordingly, it has turned out to be obligatory to address the efficiency of energy where productivity is at application level itself. Be that as it may, this layer has gotten next to no consideration since numerous applications are as of now been utilized and the vast majority of the new applications are generally redesigned adaptation of or created utilizing recently actualized instruments. SaaS suppliers should focus on sending programming on right sort of foundation which can execute the product most productively to accomplish energy effectiveness at application level. This advances the examination and investigation of exchange off among execution and energy utilization because of execution of programming on various stages and equipment. Moreover, the energy utilization at the compiler level and code level ought to be considered by programming engineers in the plan of their future application executions utilizing different energy effective methods proposed by researchers.

For computing with cloud through mobile application is Mobile Cloud Computing (MCC) is developing interest of cell phone the interest for quick calculation is likewise developing. Mobile cloud calculation of addresses tends to the serious handling and capacity interest for constant and very good quality applications. MCC alludes to a framework where the two information storage and the information processing occur outside of the mobile devices. MCC move the computing power and the information storage endlessly from mobile phones into the cloud mobile cloud

applications move the computing power and the information storing ceaselessly from mobile phones into the cloud. MCC has three segments Mobile gadget, Wireless communication channel and cloud. Mobile phones have asset imperative as far as battery power, memory, handling power and have multivariate hardware, operating system and input/output interface. During our thorough study we have featured that energy related issues ought to be talked about and considered as ahead of schedule as conceivable in the advancement of an application makes the application more energy efficient and costs with respect to energy utilization can be limited. We have to investigate more chances to lessen carbon impressions in the cloud condition; assessing the cloud's capacity to spare energy through both innovation and procedure related changes.

The devices of mobile, Wireless correspondence channel and cloud. Devices of mobile have asset requirement as far as battery control, memory, processing power and have multivariate devices, operating system and input/output interface. In this examination we featured that the energy related issues ought to be talked about and considered as ahead of schedule as conceivable in the advancement of an application makes the application more energy proficient and costs with respect to energy utilization can be limited. We have to investigate more chances to lessen carbon impressions in the cloud condition; assessing the cloud's capacity to spare energy through both innovation and procedure related changes. The normal software development life cycle has a fundamental task to carry out in building productive programming applications in a deliberate way.

10 Energy-Saving Techniques

In order to limit the power utilization of the cloud the following strategies are used:

1. The process by which cloud-based foundation enables running of individual physical server to run on various images of operating system simultaneously is known to be resource virtualization in energy consumption domain. Energy efficiency is achieved by means of virtualization of server as it reduces the energy consumption of physical server and hence empowers the agent of union by means of its green advantages.
2. In order to run outstanding tasks at hand, which lessens server farm space and the possible e-waste impression by improving resource efficiencies. Less physical hardware connected, a server at data center will devour less power from energy effectiveness viewpoint. Maximizing Consolidation and software mechanization is require to boost energy efficiencies as virtualization alone is not sufficient. To quickly arrangement, moving, and scaling outstanding tasks at hand, cloud-put together framework which is dependent on the mechanization programming. Together with the correct aptitudes, operational and design guidelines, mechanization enables to capitalize on the cloud-based architecture venture by the IT experts by elevating the points of confinement of conventional union and propor-

tions of its usage. Efficient Behavior and management of life-cycle is encouraged by the compensation of pay as-you-go nature of cloud-based architecture urges clients to just devour their requirement and that's it. Since clients can expend foundation assets just when they require it and "turn off" these resources with set lapse time will result in the improvement of the executives joined with self administration. In show, the pay per-use and self-administration abilities of cloud-based foundation increases energy and resources efficiencies all the while, since clients possibly expand the registering resources they require when they need it.

3. Multi-tenancy, Delivering Efficiencies of scale to profit numerous associations or specialty units multi-tenancy permits various associations (public cloud) or a wide range of specialty units inside a similar association (private cloud) to profit by a typical cloud-based architecture. By joining request designs crosswise over numerous associations and specialty units, the pinnacles and troughs of figuring necessities smooth out. Joined with computerization, the proportion among pinnacle and normal burdens decreases, which diminishes the requirement for additional foundation. The outcome: huge efficiencies and economies of scale in energy use and architecture resources. In the event that cloud suppliers are really going to situate their administrations as green, they should put resources into sustainable power sources [19]. Actually even the most energy proficient data center can have a noteworthy carbon impression since they are commonly getting 70% of their power from ozone depleting substance emanating petroleum products, similar to coal. Preferably, brought together cloud data centers would be controlled by inexhaustible wellsprings of vitality, similar to wind, solar based, or hydroelectricity. Until this point in time, in any case, cloud suppliers have organized different factors in planning and finding their data centers, including the expense of land, cost of intensity, property charges, information security guidelines, and access to control, transmission capacity, local skills, and clients.
4. In order to cool transistors and numerous chips direct supply of electricity is used for the operation for switching devices contained in it and it result in reducing the CPU power dissipation. This energy is dissipated in the surroundings. Processors of different mobile devices, embedded system consume less power than the processor of palmtop, netbook, notebook, desktop, laptop, so they dissipate less energy in surrounding. Free cooling can be adopted to reduce this power dissipation. The clock can be activated and deactivated by advance clock gating clock gater which is a hardware switch. The clock must be turned off when logic block is not performing any task and it must be activated only when the logic block is doing some work. Dynamic power dissipation can be reduced in globally asynchronous and locally synchronous circuits as it is very popular and it has been used in many synchronous circuits.
5. By Reducing CPU Power Dissipation Processor consumes electrical energy through charging (direct supply) for its activity, for the exchanging gadgets contained in it, for cooling of transistors and various chips. It disseminates this energy in environment. Processor scatters warms however the processors of various mobile devices, embedded system devour less power than the processor of palmtop, netbook, scratch pad, work area, PC, so they disseminate less energy

in encompassing [19]. By receiving free cooling this power dispersal can be decreased. Utilizing Advance Clock Gating Clock gayer is an equipment switch that is answerable for enacting and deactivating the clock. The clock of a logical block should be actuated just when the logical block is doing some work and clock must be killed when logical block isn't playing out any undertaking. This strategy is prominent and it has been utilized in numerous synchronous circuits yet it can likewise be utilized in all around non-concurrent locally synchronous circuits for diminishing unique power scattering.

11 Green Software

In a large portion of the cases, the purpose behind building up energy effective programming and frameworks is to accomplish a more drawn out battery life or to lessen costs. What's more, moving to the environmental piece of manageability, there is the possibility to diminish vitality and asset utilization to help. An early introduction on how programming impacts the existence cycle of the hardware by requiring an ever increasing number of assets is surrendered. The purported "Programming Bloat" signifies the impact that the accessibility of all the more dominant equipment sooner rather than later loosens up programming engineers' endeavors to create exceptionally effective code. This is because of the reality, that new hardware is rapidly accessible and reasonable and will ideally overcompensate wasteful code. Thus, equipment is supplanted by new hardware before its valuable lifetime closes. A procedure to gauge and steadily improve the sup-portability of software projects. It is fitting to actualize economical perspectives consistently, partitioned into the accompanying stages: Assessment Phase, Reflection Phase, and Goal Improvement Phase. So as to make the distinctive supportability issues reasonable, he called attention to properties of a quality model that are additionally created in later work. These perspectives are likewise incorporated into the Quality Model for Green and Sustainable Software. Investigated the meaning of Green and Sustainable Software Engineering and talked about potential outcomes and advantages of green programming. As one of the outcomes, they asserted progressively effective calculations will set aside less effort to execute and along these lines in general help support-ability. Moreover, they displayed techniques to create programming in a practical manner and contrasted these with customary strategies. In light of the existence cycle of software, Taina proposed measurements and a technique to ascertain the carbon impression of programming [18]. To do as such, he broke down the effects of every product advancement stage for a nonexclusive venture. The subsequent carbon impression is for the most part affected by the advancement stage, yet in addition by the manner in which how it is conveyed and how it will be utilized by the clients. The fundamental issue with respect to the figuring is that information is required, which is regularly not accessible (Fig. 4).

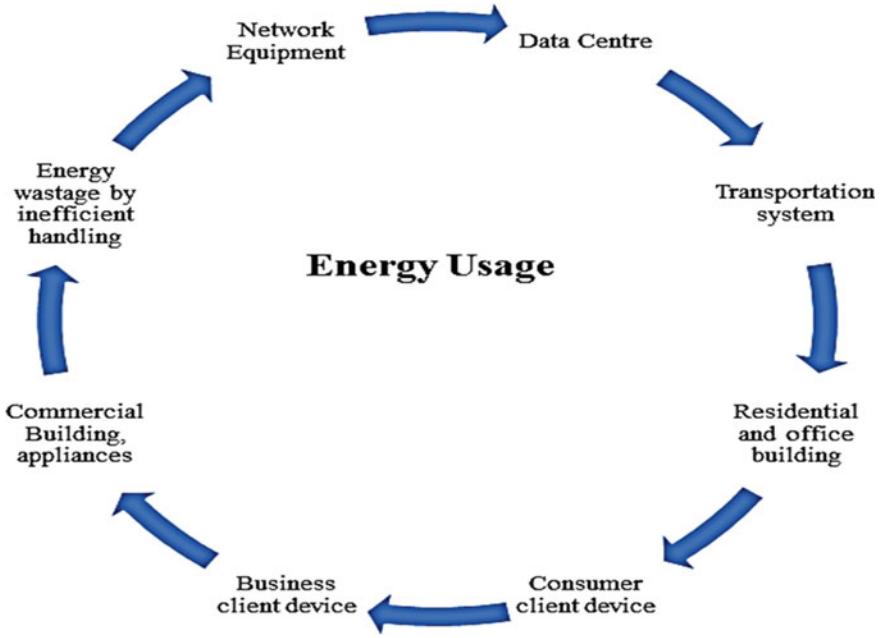


Fig. 4 Model of cloud efficiency

12 Conclusion

Green computing is an innovation for ecological well disposed and financially savvy utilization of intensity and creation. Through different algorithmic endeavours, it has been made to lessen control utilization in all aspects of PC. Low utilization of power will contribute to Green computing.

References

1. Lakshmi SVSS, Sarwani ISL, Tuveera MN (2012) A study on green computing: the future computing and eco-friendly technology. Int J Eng Res Appl (IJERA) 2(4):1282–1285
2. Chow WS, Chen Y (2009) Intended belief and actual behavior in green computing in Hong Kong. J Comput Inf Syst 50(2):136–141
3. Sadiku MNO, Ampah NK, Musa SM (2018) Green computing: a primer. J Sci Eng Res 5(4):247–251
4. Vikram S (2015) Green computing. In: Proceedings of the international conference on green computing and internet of things, pp 767–772
5. Green computing. Wikipedia, the free encyclopedia. https://en.wikipedia.org/wiki/Green_computing
6. Saha B (2014) Green computing. Int J Comput Trends Technol 14(2):46–50

7. Aljaberi MA, Khan SN, Muammar S (2016) Green computing implementation factors: UAE case study. In: 5th international conference on electronic devices, systems and applications (ICEDSA)
8. Singh M, Singh AS (2016) Green computing. Int J Adv Res Comput Sci 7(6)
9. Gokhale A, Sharma D (2014) Green computing: an eco- friendly approach toward computing. J Indian Res 2(2):152–157
10. Harbla A, Dimri P, Negi D, Chauhan SY (2013) Green computing research challenges: a review. Int J Adv Res Comput Sci Softw Eng 3(10):1–13
11. Murugesan S (2008) Harnessing green IT: principles and practices. IT Prof (IEEE) 10(1):24–33
12. McGee MK (2007) Data center energy consumption has doubled since 2000. In: Information-Week 1–5
13. Patra C, Nath A (2014) Green computing - new paradigm of energy efficiency and e-waste minimization - a pilot study on current trends. Int J Adv Res Comput Sci Manag Stud 2(11)
14. Wang D (2008) Meeting green computing challenges. In: 10th electronics packaging technology conference, pp 121–126
15. Smart Cities Council (2015) Smart cities readiness guide. Smart Cities Council, Reston
16. Gareth M, New Sci Mag. http://www.newscientist.com/special/smart-grids-need-smart-attitudes
17. Amin SM, Wollenberg BF (2005) Toward a smart grid. IEEE Power Energy Mag 3 (5):34–41
18. Kern E, Dick M, Naumann S, Guldner A, Johann T (2013). Green software and green software engineering - definitions, measurements, and quality aspects
19. Pooja RK (2013) Applications of green cloud computing in energy efficiency and environmental sustainability. IOSR J Comput Eng (IOSR-JCE) 25–33

Green Computing and Internet of Things for Smart Cities: Technologies, Challenges, and Implementation

Nurul I Sarkar and Sonia Gul

Abstract Green computing as well as Internet of Things (IoT) are becoming attractive technologies for building smart cities. Statistics has shown that the use of Information and Communication (ICT) devices will increase 41.6 billion by the year 2023(2019). While there are numerous applications and benefits of using IoT enable devices, studies have shown that the potential number and intensity of serious environmental issues including high consumption of energy, emission of carbon and other electronic waste. To deal with the adverse effects of such huge usage of ICT devices, the research community has started exploring the area of Green IoT and Networking much more exhaustedly. Fortunately, technologies like IoT can be used with green networking to reduce electronic waste and relatively use of less power/energy for future applications and in return help in achieving better results for our ecosystem. This chapter provides a survey of green computing and IoT for smart cities highlighting the importance and real-world implementation challenges.

1 Introduction

In recent years, the development of IoT has experienced a dramatic and rapid growth along with increasingly extensive use of smart devices and applications. There have been many billion devices or things already connected via the Internet and will be increasing in future as well [23]. Moreover, as per latest studies of International Data Corporation (IDC) this number has increased to 41.6 billion IoT connected devices in 2023(2019). Therefore, from the aspect of the environment, to generate enough electricity to support this increasing number of devices or other infrastructure of network may also lead to a great emission of Carbon Dioxide. Muhammad Ismail [10] provided a data which showed that the industry of telecommunication provides

N. I. Sarkar · S. Gul (✉)
Auckland University of Technology, Auckland, New Zealand
e-mail: sonia.gul@aut.ac.nz

N. I. Sarkar
e-mail: nurul.sarkar@aut.ac.nz

B. Balusamy et al. (eds.), *Green Computing in Smart Cities: Simulation and Techniques*,
Green Energy and Technology, https://doi.org/10.1007/978-3-030-48141-4_3

two percent Carbon Dioxide emissions of the global emissions in 2016. Ha-Vu Tran [29] predicted the overall Carbon Dioxide footprint of Information and communication Technology (ICT), such as, IoT devices, Cell phones and wireless networking) in 2020 is three times more than that of 2018. The power consumption is also a big challenge for wireless network. The wireless networks consumes much higher amount of power than that of wired networks; this results in the dissipation of heat and discharge of pollution from the electronic devices and power plants. From the aspect of finance and economy, some researchers have already present that the cost of energy of the whole OPEX (Operation Expenditure) ranges from approximately 18% in developed European market to thirty two percent in Indian market and for those operations which are off-the-grid may cost fifty percent of the whole OPEX in energy [10]. Finally, from the aspect of the quality of users' experience, researchers [10] indicated that more than sixty percent of mobile phones users are not pleased with the current capacity of cell phones' batteries, because the gap between the modern mobile devices batteries capacity and the user demand for power is still increasing, and the life time of the rechargeable batteries of the mobile devices is expected to be two to three years, but every year the disposition of batteries are 25000 tons which are a big waste and causes a big burden to the environment.

Therefore, to deal with these problems and issues in power using and wasting, firstly scientists and researchers tried aiming towards how to maximize the usage of existing communications system, but now they have changed the direction of their research/studies of how to produce maximum performance of a device and make that device use the minimum energy. In current industry, overproviding and redundancy are two good characteristics which can be used to boost the quality if the network and these two characteristics are widely used among the traditional network design. However, these two traits have some innate issues, or rather problems to the term used as green networking [19]. The standard station and control methods are ready for the energy saving and green communication technology to be applied to in the future. In report [19], it indicated that in Europe, this topic has already become a conspicuous with much attention on. There were some projects in FP7 (7th Framework Programs, 2007–2013) including EARTH, OPERA-Net, ECONET and TREND (a network of excellence). Those projects are used for energy-saving communications and networking. Also, EIT ICT Lab (European institute of Innovation and Technology) has created a concept which is called Smart Energy Systems and Green ICT (Information and Communication Technology) (2015).

Keeping in view the above stated energy and Carbon dioxide estimates, the fast development and increasing expansion of IoT technology is expected to provide a lot of benefits but also a series of serious environmental problems. These problems may include but not limited to excessive energy consumption, electronic waste produce, carbon emission and climatic variation. In order to keep the equilibrium between environmental issues and IoT advancements, the concept of green computing or green IT is necessary to be presented and considered. Researchers has now changed

the direction of their studies towards how do we make the development of IoT greener and more environment-friendly? The goal of this chapter is to identify some directions to answer this question. For this let us start with some base knowledge about IoT.

2 Internet of Things

The term "Internet of Things" (IoT) refers to a worldwide network of uniquely identifiable interconnected smart objects or things that transmit data automatically without any human interaction [3, 28]. The motivation of IoT is to create an interconnected world where intelligent devices, objects and web-based systems are automatically linked and communicate with each other through the Internet, so that users' quality of lives can be improved by technology. In the IoT paradigm, a collection of intelligent devices, appliances, vehicles and other smart objects are embedded with sensing and actuation capabilities. These things are connected to a global networked infrastructure. They communicate and interact with each other, acquire and exchange data, in order to realize automation and intelligence [21]. Hence, the main characteristics of IoT are sensing, actuation and communication.

2.1 IoT Architecture

There have been a large number of researches and studies on the architecture of IoT, and so far IoT architecture has not been reached an agreement [18]. The paper written by Zhong, Zhu, and Huang [9] has presented a very typical three-layer architecture of IoT which is widely acknowledged. Figure 1 shows IoT architecture containing three layers namely, perception layer, network layer and application layer.

(i) Perception layer
Perception layer is the bottom layer in this three-layer IoT architecture. In the perception layer, data and information is collected from physical objects, environments, human, biology, etc. by using different types of perception devices and tools, involving various sensors and transmitters. After the data collection process, the collected data is processed and packaged preliminary in perception layer and gets ready to go to the upper layer.

(ii) Network layer
Network layer is also called transmission layer and it is placed in the middle of the IoT architecture. The task and responsibility of network layer is to transfer the data which is collected by the perception layer to the upper layer (application layer) through various networks. Enabling networking technologies are such as Bluetooth, Radio-frequency identification (RFID), Near-field communication (NFC), Wi-Fi, Zigbee, Ethernet, mobile communication, satellite communication.

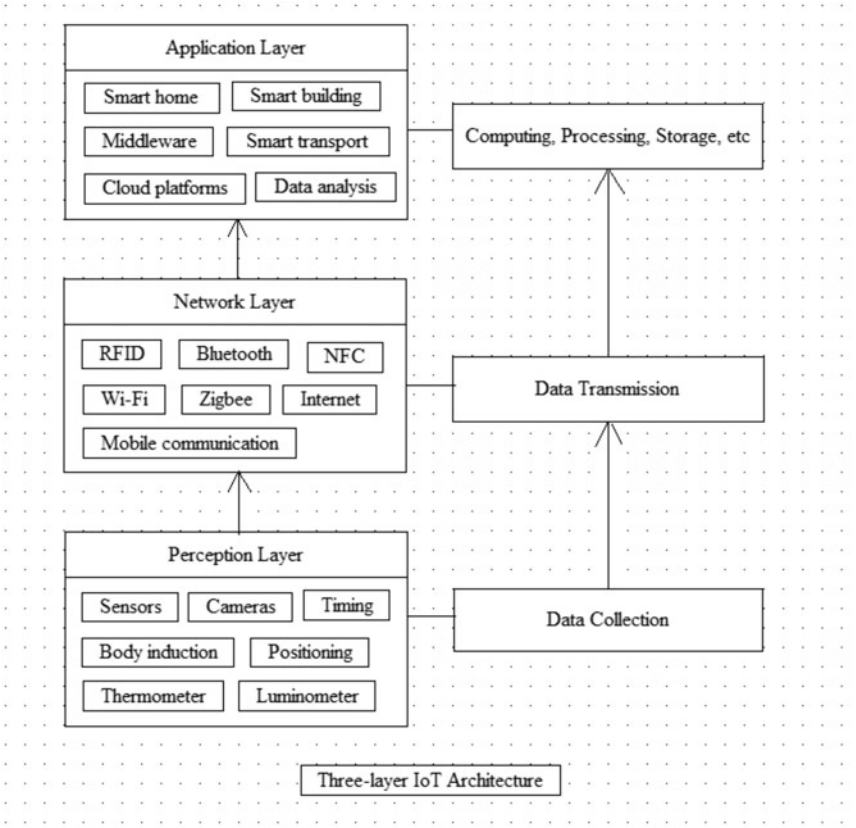


Fig. 1 Architecture of a typical IoT

(iii) Application layer
Application layer is placed in the top of three-layer architecture of IoT and it processes and computes data from lower two layer (perception layer and network layer) in order to realize the various IoT applications. Application layer can be regarded as the interface between IoT technology and clients.

3 Environmental Challenges in IoT Usage

The increasingly accelerated development of the Internet of Things (IoT) has also led to some tough issues and challenges, such as real-time requirements, redundancy, reliability and security issues [5]. But one of the chief problems is about the environment and sustainability during using IoT technologies. Environment issues mainly include three major parts: energy consumption, carbon emission and electronic waste.

3.1 Energy Consumption

There are a lot of reasons for energy consumption of the IoT. For example, the intelligent devices need power and energy to perform sensing, processing, computing, monitoring and communication in IoT tasks. The data centres behind IoT applications also need to consume a lot of energy. However, an extensive number of researches have already shown that the communications among devices for data transmission tasks result in the most energy consumption. In particular, the wireless connection technologies consume much more energy than wired connections [7]. In Decker's article, he has presented that 3G networks consume 15 times more energy than wired networks, and 4G networks use 23 times more energy than wired networks. However, wireless access networks are very indispensable and essential for the IoT, there is no doubt about it.

3.2 Carbon Emission

The rapid development and wide use of IoT technologies and intelligent devices has led to the increasingly massive energy consumption, simultaneously, is producing large amounts of carbon emissions. According to the statistics from the SMARTer2030 website [26], by the year 2015, there are 20% of the totally global carbon emissions influenced by the ICT industry. The carbon footprint of ICT industry has experienced a dramatic increase from 6 megatons of CO_2 in 2012 to 30 megatons of CO_2 in 2015. The increasing carbon emission leads to serious climatic variation issues. Hence, how to deal with carbon emission caused by IT field is another environmental challenge.

3.3 Electronic Waste

There are more and more ICT devices to be manufactured and used, in which case, large amounts electronic waste is produced. According to the Fig. 2, the Statista website has done the statistics, and it shows that the amount of electronic waste generated all over the world has rapidly and sharply increased from 33.8 million tons in 2010 to 49.8 million tons in 2018.

4 Green Computing

In this section we discuss the concept of Green Computing as a solution to our above environmental hazards. Then we present approaches to implement Green Computing firstly from the Green IoT perspective i.e., realizing green computing into three

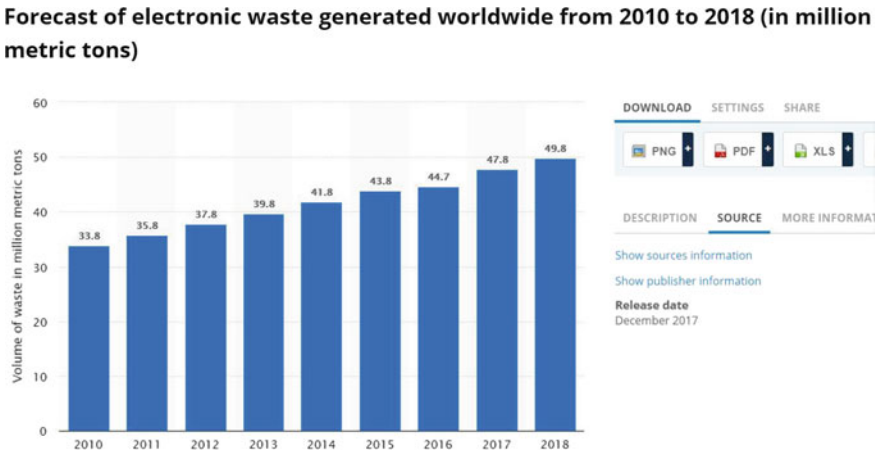


Fig. 2 Forecast of electronic waste—from Statista website [27]

categories according to IoT architecture i.e., physical devices, network connectivity and application design. Secondly we discuss the Green Computing implementation from system point of view.

4.1 The Concept of Green Computing

In order to deal with the above tough and serious environment issues, the concept of green computing has been presented and spread. Murugesan and Gangadharan [17] has defined that green computing or green IT means the sustainable, environment-aware and environment-friendly computing or IT. It is the study and practice of designing, manufacturing, using, and disposing of computers, servers, monitors, printers, storage devices, and networking and communications systems efficiently and energy-savingly with the minimal influence or no influence on the environment [1, 17].

The concept of green computing can be applied to the development of Internet of things, so that these environment issues which are caused by technology can be solved by technology as well. Malviya and Singh [16] have presented some current technologies and approaches to realize green computing in their article, such as green data center, green algorithms, virtualization and cloud computing [16]. Bianzino et al. [4] have also given four efficient solutions in their paper, including resource consolidation, resource virtualization, selective connectedness and proportional computing.

The number of wireless devices (including smart devices or IoT devices) has already increased significantly in recent years and the number is actually still increasing and technologies are developing either. Some of those applications are currently

Table 1 The comparison of power consumption of different wireless device types

Devices type	Scope of connection	Power consumption (watt)
Base stations	WMAN	300–3000
Points of access	WLAN	10
Screen-on cell phones	WMAN and WLAN	1.5
Screen-off cell phones	WMAN and WLAN	1 (approximately)
Computers	PAN and WLAN	1.78

and widely being using in our daily life, like: smart home, smart health care [13] and video streaming. In 2012 the predication [24] said that the traffic of data could increase 18 times in 5 years. And in 2016 [9] predicated that the in 2020 each person may own 6–7 internet of things devices. Thus, it is obvious that power or energy consumption can be very high in the future. It is a major challenge and concern for telecommunication, industries and scientists.

In [24], authors mentioned that the relative energy consumption of the wireless devices greatly varies depending on the type of overall network devices used in the network. The differences of the consumption of the power range from the case of screen-off mobile phones which results in extremely low values of power consumption to the base stations which gives the highest values of power consumption and more than half of the consumption is caused by machine cooling and operation of power amplifiers.

These great differences in the relative power consumption which are caused by the wireless devices and machines require different methods to reduce the power expenditure of different kinds of devices or machines. The paper [24] provided two reasons for the inefficient and unnecessary power consumption despite of the different demands of power of current devices (Table 1).

First, it gave a point of view that it is very common for infrastructure of network which is unnecessarily powered on, and even the number of users and load of traffic which is caused by them are low. Although, this practice is very commonly being used and it can guarantee high degrees of coverage and availability of service, but this practice is responsible for a great amount of power consumption which is unnecessary. The second cause of unnecessary power consumption which is also critical and intrinsic in current design of hardware. Especially in processors of hardware which is power hungry, bad design of the amplifiers of power, inefficient and poor heat dissipation which results in relying on intense cooling. Although those problems are easy to identify, but it is somehow pretty difficult to cope with them. Because it involves totally redesigning over the equipment of wireless network that requires a great time, endeavour and also the coast is huge, those problems make the redesigning work is not easy or even not practical to do. In [31] it summarized and introduced some different definitions which have already been proposed in the previous literature to estimate the efficiency of energy consumption of wireless networks from the aspects of network operators and mobile devices users. As an indispensable component of the

definition of efficiency of power consumption, researchers provided many kinds of models of throughput and power consumption for base stations and mobile terminals and gave some green solutions to both high and low traffic load.

Keeping in view the huge usage of IoT devices; In future the IoT devices can be a major portion of the wireless devices and contribute the most traffic load to the whole load of traffic of wireless network. Thus, the power that those IoT devices can consume can also be very high which results in high Carbon Dioxides emissions. Therefore, it is important to make the IoT greener. In [2] it indicated that since the green ICT technologies has been developed, thus, green IoT can be much more efficient in power consumption through using less power, emitting less hazardous substances, taking and using less resources and reducing pollution. As a consequence, it is natural that green IoT turns to preserving and protecting natural resources, keeping the technology impact on the environment to and health of human at a minimum level and reducing the cost in using power and restoring the environment of nature significantly. Thus, green IoT is a technology which basically focuses on green manufacturing, green design, green utilization and disposal [2]. In details:

1. Green use: Try to make the consumption of power computers and other information systems to the minimum level and make sure the damage to the natural environment are reduced to the minimum level either.
2. Green disposal: We should reuse the old computers and get the parts from unwanted computers and other electronic devices and machines (we can recycle them).
3. Green design: We can redesign system to make it more energy efficient for IoT components, computers, base station, servers and cooling system equipment.
4. Green use:
5. Green manufacturing: The adverse impact towards the natural environment should be controlled and restricted to a minimum level when producing electronic equipment. Also, in [2], it introduced some methods which are currently not been widely used but have potential possibility to make the natural environment become greener or rather healthier and provide very high quality of service of IoT in an environmentally sustainable manner.

4.2 Implementation of Green Computing—IoT Perspective

(i) Physical Devices

Smart objects or things mainly rely on two devices: they are sensors and actuators. Sensors include security cameras, environmental monitoring sensors, healthcare sensors, thermometers, and so on. Examples of actuators are all kinds of intelligent home appliances, such as floor sweeping robot. These sensors and actuators are equipped with different types electronic components, such as microcontrollers, CPUs, GPUs, transceivers, batteries, memories, and protocols [6]. All of these components require energy consumption.

One of the chief approaches to achieve the goal of IoT devices with energy-saving is using sleeping models on devices. Majority of modern microcontrollers can provide two different sleeping modes: shallow sleeping model and deep sleeping model [11]. Shallow sleeping model allows a quick wake-up and memory retention, while deep sleeping model takes a long period of time in sleep state and does not maintain cache. Switching IoT devices to sleeping model is much energy-saving than maintain in an active mode when devices are idle.

Another possible approach to address energy consumption issues of physical IoT devices is to reduce the weight of hardware in system-on-chip (SoC). Lim et al. [14] have presented a reduced hardware architecture of IoT healthcare sensor nodes in their research. This architecture reduces the numbers of general-purpose I/Os (GPIOs) and peripherals in a system-on-chip (SoC), but this process must be very careful in order to have no impacts on devices' performance. This design has not only reduced 20% energy consumption approximately but also saved more excessive space, so that the volume of SoC and devices could also be diminished.

(ii) Network Connectivity

Although IoT physical devices lead to a bit of energy dissipation, the major reason of for energy consumption of IoT is the transmission process. In which case, most of efforts and researches focus on the network layer of IoT, to achieve the aim of green and energy-efficient IoT. In this section, I mainly explain three valid approaches to green network connectivity: Selective Connectedness, Data Compression and various Low-power required Communication Protocols for IoT.

Selective Connectedness

Selective Connectedness mechanism is similar with sleeping model. It allows some of network equipment to go to idle or some unused edge nodes of the network to be turned off when network infrastructure is not busy. In which case, unnecessary workloads can be reduced even avoided, and much energy will be saved in the network layer [4].

Data Compression

In some situations of IoT services and applications, data are not required in real time. Hence data compression is an alternative approach to shrink the size of data, in order to reduce the network traffic [28]. In which case, not only network layer but also application layer will both reduce storage, workloads and consume lower energy.

Low-power Required Communication Protocols

As I have mentioned before in this paper, wireless connection technologies consume much more energy than wired connections. To address this problem, there are various wireless communication protocols in the IoT area with requiring low energy and low cost have been provided. ZigBee is one of the low-power protocols for short-range wireless connection. ZigBee is based on IEEE 802.15.4 standard and it provides low energy consumption, low cost, low data rate and high throughput [20]. ZigBee can be applied in all kinds of IoT systems with short distances (10–100 m), such as home or building automation.

Another similar wireless communication protocol for short-range IoT is Thread. Thread protocol is also based on IEEE 802.15.4 standard and it provides ipv6 addressing. Thread uses 6LoWPAN. In this protocol, border routers do not maintain the application layer states, so that the energy consumption of border routers can be reduced.

Wi-Fi HaLow (IEEE 802.11ah) is a new wireless networking protocol with low-power requirement and it is published in 2017. Wi-Fi HaLow can send packets under a high speed while consume low power, because it allows to predefine wake/doze periods. Comparing ZigBee and Threat, Wi-Fi HaLow protocol provides an extended range (1 km radius), so it can be applied in smart metering.

(iii) Application Design

There are some types of enabling technologies and approaches can be used in IoT application design. For example, virtualization technology allows a set of software replaces different kinds of hardware and devices. Cloud provides public resource and pay-for-use model for IoT applications. In these cases, the goal of green IoT applications can be achieved. On the other hand, IoT technology itself can be applied and utilized to implement green computing and to address environmental issues. For example, some IoT devices and sensors are used in smart home or buildings to monitor and manage energy consumption. IoT technology can also be applied in environmental monitoring area, such as temperature measurement, air quality monitoring and so on. In addition, IoT technologies can be applied in ICT products manufacture industry and e-waste disposal industry, to improve working efficiency and reduce manual labour, cost, time and energy consumption.

4.3 Implementation of Green Computing—General Perspective

Many studies have been conducted which explores and suggests Green Computing Implementation from general perspective i.e., not binding them tightly with IoT architecture layers.

In [22] researchers suggested a technique for greener IoT which uses sensor nodes. And those nodes play important role which can be described in two different parts: 1. the nodes which work as collectors and 2. the normal types of nodes. The node which is called data-forwarding node is the neighbour node of sensors and it is chosen by the collectors of mobile data while they are running in the predesigned and predefined elliptical path. Also, the rest of the sensors in the area of sensing act as sensor nodes with standard source, except the node of data-forwarding. After the deployment of the sensor nodes, a path of the network can be revealed for the collectors of mobile data which is based on the concept of conversion of a maximum area of the wireless sensor network. In this suggested technique for greener IoT, the data collectors run

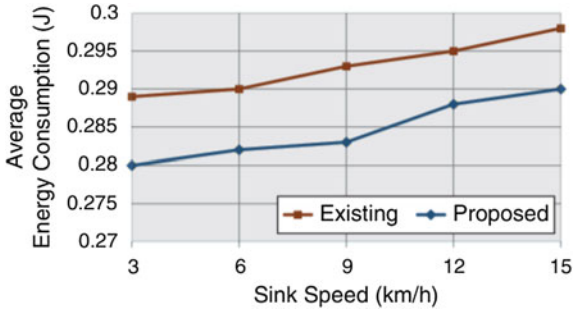


Fig. 3 The variation of the average power consumption and the data collector speed over collection of the data

in an elliptical path which is predefined and do the collection of the data from the nodes of source from nodes which is called collector nodes and make a delivery of the data to the base station of the whole network (Fig. 3).

The experiment which was carried out of this technique gave a good result over the average consumption of power of a node which is the power that is consumed averagely during the transition and reception of packets of data and control packets in a network. The consumption of power of protocols which are used for routing could be reduced the effectiveness of network could also be improved. In the experiment, the consumption of power was recorded averagely by the processes of varying the collector speed of the data which ranges from three to fifteen km per hour with increments of 3 km per hour at a constant time of simulation of 600 s. This result showed that average consumption of power of the suggested technique is less than the current data-routing technique of mobile with standard sink protocol. Also, the average consumption of power showed this technique can bring improvement over the lifetime of network.

Also, [22] provided the researchers suggested future direction of researches, the paper indicated that in the IoT, tiny sensors which are deployed to the sensing networks under the scenarios that the sensors have limited capacity of battery and replacement of battery needs effort. In such situation, the main challenge or we can the issue is how to make a better use of the limited power of the node of sensor to achieve a longer lifetime of the network. In this paper, the sensor of power constraint was the main design which was focused. Also, in this suggested routing, there were two collectors of mobile data that were utilized to collect the data from the field of sensor that was divided into two parts and they were mentioned in the previous paragraphs. Collectors of mobile data running in a rotating way on the predefined and predesign elliptical path, and their jobs were to carry out the collection of data from each sensors, send a message of signal to the forwarding neighbour nodes, make collection of the sensed data from the previous nodes, and make delivery of the data to the base station that was situated at the centre of the field of sensor. The results of the performance of the suggested technique of routing was much better with respect to the average power consumption of the control packet, the total average consumption of power, the latency of the delivery of data, and also, the relatively

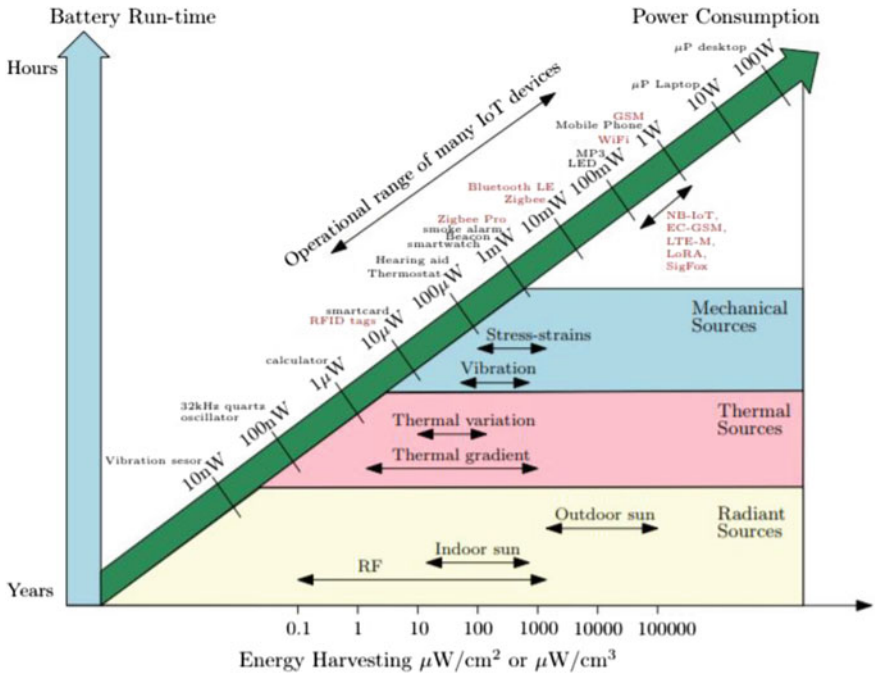


Fig. 4 The consumption of the power of different kinds of wireless devices and the different kinds of wireless techniques based on various types of sources of power

low latency of end to end. Thus, this proposed technique of routing is a good and practical solution to the problem and issue of energy-hole and it is very promising with a great potential for IoT applications (Fig. 4).

Shirvanimoghaddam et al. [25] introduced a concept of a type of IoT which is called self-powered Internet of Things. This suggested plan for the IoT uses energy harvest. The techniques of EH (energy harvest) can utilize different kinds of sources of power within the environment that surround devices in order to do a process which is called harvest to get enough power and the power will be used later by the equipment or devices of IoT for sensing, activation, and communication with the server. The paper also indicated that some traditional sources of energy like: radio frequency (RF), solar energy, energy of heat, vibration, wind, and even the body of human are only few instances of the sources of power which are available within the environment and they are used for energy harvest commonly. Also, this paper introduced that there are several different kinds of scenarios in which technologies of the EH can greatly provide enhancement over the wide performance of a system, with respect to the consumption of the power, life time of network, cost of the power and maintenance of machines or devices. Those different kinds of scenarios can be discussed by dividing them into three different categories.

1. The technologies of energy harvest is very promising and useful in some situations where machines or devices are situated or the deployment of them was made in some areas where are hard to reach. Thus, in those kinds of areas, making a massive replacement of the batteries of the nodes of sensor is nearly impossible. Also, the technology of WSN (Wireless sensor networks) have been studied and researched widely for the health monitoring of network structure. Sometimes the damage of the network may occur in space, normal buildings, bridges, and public infrastructures and they can be detected by nodes of sensor. The aim of it is to make a massive replacement over visual inspection with qualitative analysis and maintenance procedures which are based on time with a more automatic process of assessment over damage which is based on condition. The system of health monitoring of network for aeroplanes can get benefits by using techniques of WSNs and energy harvest, including the natural sources and devices like thermoelectric generators and vibration. To use piezoelectric effect and wireless charging devices as EH was also suggested by researchers to monitor and check the health and condition of tracks of railroad.
2. The technologies of energy harvest can be applied to circumstances that normal has a big requirement over a great number of devices which makes the massive and total replacement of their batteries is literally impossible or the cost can be very high. There are many examples, like: electronic shelf labelling, networks of sensor for body, massive IoT and its applications.
3. In many places there might be not enough steady or available supply of power. For example, the technology of energy harvest can be used in a farm which situates in a hard to reach area by using the technology of the energy harvest, it can support a DTN (delay tolerant network) which is combined with wireless sensors.

From the aspect of data centre. In [12] researchers suggested some future directions of researchers of green data base (due the huge amount of data may be transmitted in the near future and the rise of the cloud computing and IoT devices) which including the use of VM (virtual machines) and better control of temperature.

Another study [2] suggests that we can deploy more UAVs in order to make replacement over a significant number of IoT devices in the following areas, like: agriculture, traffic and monitoring. By those UAVs which can help people in reducing in power consumption and emission or discharge of pollution. The use and technology of UAV are environmentally beneficial which will make the green IoTs with low cost in power consumption and result in a higher efficiency.

The transmission of data from the sensor to the cloud of mobile devices can be more useful in the future. Basically, the Sensor-cloud is an integration of the wireless network between the mobile cloud and the sensors. This technology and its applications of greening IoT are very popular and promised, especially, it can save the cost of the consumption of power. An investigation and investment can be carried in green SNaaS (green social network as a service) which may enhance the efficiency the use of the power of the systems, wireless sensor network (WSN), cloud management and cloud service.

Also, in order to enhance and keep balance of power for supporting green communication between different and massive number of IoT devices, the energy harvest of radio frequency can be considered as a good solution. More researches are still needed to make the development over the design of IoT devices and equipment which can help many factories and manufacturers to make reduction of emission of Carbon Dioxides and the energy usage. Therefore, the most essential task for smart and green environmental life is to lower the consumption of power and decrease the emission of the Carbon Dioxide and discharge of other kinds of pollution.

5 Conclusion

The green computing and IoT is really important and promising technology not only towards people's normal lives but also it is very helpful to restore the health of the natural environment including the green housing effect, global warming and the rise of the sea level. In the future, the IoT devices and applications can definite be the one of the major consumers of the power, thus, by using green networking and integrate them with the IoT technology we can greatly avoid the unnecessary waste of power and enhance the performance and lifetime of the network.

In this chapter we have highlighted today' environmental issues, summarized the researcher in the areas of Internet of Things and Green Computing, and discuss various approaches to implement green IoT. Different types of methods can be applied in different layers of IoT (device, network and application). Technology is rapidly developing and leads to challenges and issues, and these problems would be fixed by technology as well. Of course, the "green" awareness is always important and should be maintained and improved.

So far how to achieve a greater equilibrium between environmental issues and IoT advancements has still a big challenge. Although there have been a lot of efforts to provide methodologies in this area, the problem remains serious. The foreseeable future trend of greening Internet of Things would focus much on creating new networking and communication protocols for wireless connection, because network layer and transmission tasks have the major influence on IoT energy consumption.

References

1. Abugabah A, Abubaker A (2018) Green computing: awareness and practices. In: 4th international conference on computer and technology applications (ICCTA)
2. Alsamhi SH, Ma O, Ansari MS, Meng Q (2018) Greening internet of things for smart every things with a green environment life: a survey and future prospects. Signal Process. arXiv:1805.00844
3. Alzafarani RA, Alyahya GA (2018) Energy efficient IoT home monitoring and automation system. In: 15th learning and technology conference (L and T)

4. Bianzino AP, Chaudet C, Rossi D, Rougier J (2012) A survey of green networking research. IEEE Commun Surv Tutor 14(1):3–20
5. Chen Y (2012) Challenges and opportunities of internet of things. In: 17th Asia and South Pacific design automation conference
6. Cho Y, Kim M, Woo S (2018) Energy efficient IoT based on wireless sensor networks. In: 20th international conference on advanced communication technology (ICACT)
7. Decker KD (2015) Why we need a speed limit for the internet. Low-Tech Mag. Accessed 14 Aug 2019. https://www.lowtechmagazine.com/2015/10/can-the-internet-run-on-renewable-energy.html
8. EIT ICT LABS (2015). Accessed 14 Aug 2019. https://www.eitdigital.eu/news-events/news/article/eit-ict-labs-becomes-eit-digital
9. Ejaz W, Anpalagan A, Imran MA, Jo M, Naeem M, Qaisar SB, Wang W (2016) Internet of things (IoT) in 5G. IEEE Wirel Commun 4:10310–10314
10. Ismail M, Serpedin E, Qaraqe KA (2016) Enabling green heterogeneous wireless network. In: The 1st international conference on green communications, computing and technologies
11. Jayakumar H, Raha A, Kim Y, Sutar S, Lee WS, Raghunathan V (2016) Energy-efficient system design for IoT devices. In: 21st Asia and South Pacific design automation conference (ASP-DAC)
12. Jin X, Zhang F, Vasilakos AV, Liu Z (2016) Green data centers: a survey, perspectives, and future directions. Distrib Parallel Clust Comput. arXiv:1805.00844
13. Kharel J, Reda HT, Shin SY (2019) Fog computing-based smart health monitoring system deploying LoRa wireless communication. IETE Tech Rev 36(1):69–82
14. Lim Y, Daas S, Hashim SJ, Sidek RM, Kamsani NA, Rokhani FZ (2015) Reduced hardware architecture for energy-efficient IoT healthcare sensor nodes. In: IEEE international circuits and systems symposium (ICSyS)
15. MacGillivray C, Reinsel D (2019) IDC report - Worldwide Global DataSphere IoT Device and Data Forecast. https://www.idc.com/getdoc.jsp?containerId=US45066919
16. Malviya P, Singh SK (2013) A study about green computing. Int J Adv Res Comput Sci Softw Eng 3(6)
17. Murugesan S, Gangadharan GR (2012) Harnessing green IT: principles and practices. Wiley, Chichester
18. Oun OA, Bloch C, Spies F (2016) Cross-platform scenario module for internet of things testing architecture internet of things. In: IoT infrastructures. Lecture notes of the institute for computer sciences, social informatics and telecommunications engineering, pp 385–395
19. Penttinen A (2011) Green networking - a literature survey. Accessed 14 May 2019. https://pdfs.semanticscholar.org/e9d2/c77e5cbacd446e38de67981bf7ac59c8e63f.pdf
20. Reda HT, Daely PT, Kharel J, Shin SY (2018) On the application of IoT: meteorological information display system based on LoRa wireless communication. IETE Tech Rev 35(3):256–265
21. Rizzardi A, Miorandi D, Sicari S, Cappiello C, Coen-Porisini A (2016) Networked smart objects: moving data processing closer to the source. In: IoT infrastructures. Lecture notes of the institute for computer sciences, social informatics and telecommunications engineering, pp 28–35
22. Roy SS, Puthal D, Sharma S, Mohanty SP, Zomaya AY (2018) Building a sustainable internet of things. IEEE Consum Electron Mag 7(2)
23. Sand B (2016) IoT testing - the big challenge why, what and how internet of things. In: IoT infrastructures. Lecture notes of the institute for computer sciences, social informatics and telecommunications engineering, pp 70–76
24. Serrano P, de la Olivia A, Patras P, Mancuso V, Banchs A (2012) Greening wireless communications: status and future directions. Comput Commun 35(14):1651–1661
25. Shirvanimoghaddam KSM, Abolhasani MM, Farhangi M, Barsari VZ, Liu H, Dohler M, Naebe M (2017) Paving the path to a green and self-powered internet of things. https://www.semanticscholar.org/paper/Paving-the-Path-to-a-Green-and-Self-Powered-of-Shirvanimoghaddam-Shirvanimoghaddam/b156d8f7eb4790fd4799455127b062230c953217

26. SMARTer2030 website (2015). Accessed 14 May 2019. http://smarter2030.gesi.org/
27. Statista (2018) Global e-waste generation forecast 2010–2018. Accessed 14 May 2019. https://www.statista.com/statistics/499891/projection-ewaste-generation-worldwide/
28. Stojkoska BR, Nikolovski Z (2017) Data compression for energy efficient IoT solutions. In: 25th telecommunication forum (TELFOR)
29. Tran H-V, Kaddoum G (2018) RF wireless power transfer: regreening future networks. IEEE Potentials 37(2):35–41
30. Zhong C, Zhu Z, Huang R (2017) Study on the IOT architecture and access technology. In: 16th international symposium on distributed computing and applications to business, engineering and science (DCABES)
31. Zhuang W, Ismail M, Serpedin E, Qaraqe K (2014) A survey on green mobile networking: from the perspectives of network operators and mobile users. IEEE Commun Surv Tutor 17(3)

Designing a Smart City: Technologies, Challenges and Solutions

Nurul I Sarkar, Lonise Sakaio Iasepi, and Sonia Gul

Abstract Most of the cities are aspiring to become a so-called smart city worldwide. With the increasing urbanization across the globe, there is an urgent need to improve various services so that citizen can easily access to important information and life support services. Thus, the introduction of information and communication technologies and other technological innovations to cities coupled with effort to empower human capital in urban areas are crucially important ensuring that people in the cities have access to valuable information. This chapter, therefore, focuses on some of the advanced technologies currently being used to develop smart cities to promote sustainable developments and quality of life for people living in cities. The chapter also highlights various challenges that current technologies often encounter, and the solutions to overcome these challenges to build smart cities.

1 Introduction

Along the years, more and more people are migrating to urban environments. 55% of world's population are residing in cities and is expected to escalate to 68% by 2050 [15]. With this in the picture, more challenges are likely to occur and local governments are pushed to make innovative solutions to meet the needs of its citizens [26], thus creating sustainable developments and a safer and healthier environment to live in. A possible solution to these challenges is to motivate cities and transform them into smart cities with the help of Information and Communication and Technology (ICT). Even though it could help eliminate the existing risks and promote sustainable developments, more challenges could be generated at the same time and more resolutions are needed to be made and diligently implemented to solve these arising problems.

N. I. Sarkar · L. S. Iasepi · S. Gul (✉)
Auckland University of Technology, Auckland, New Zealand
e-mail: sonia.gul@aut.ac.nz

N. I. Sarkar
e-mail: nurul.sarkar@aut.ac.nz

B. Balusamy et al. (eds.), *Green Computing in Smart Cities: Simulation and Techniques*,
Green Energy and Technology, https://doi.org/10.1007/978-3-030-48141-4_4

The concept of Smart Cities first was envisioned in 1993 as "Intelligent City" (Heng and Low) but through the years, it does not have a universal definition. There were various definitions within the literatures and according to Nam and Pardo [36], "A city is smart when investments in human/social capital and IT infrastructure fuel sustainable growth and enhance the quality of life, through participatory governance". This concept consists of smart citizens, smart living, smart governance, smart environment, smart infrastructure and smart mobility [26] to name some. The development and emergence of smart city requires the better "utilization of networked infrastructures to improve economic and political efficiency and enable socio, cultural and urban development" [32]. Everything existing in a smart city appears to be smart which offers significant and innovative opportunities for improving people's liveability and transformation to a higher quality of life. This confirms [32] claim that the intent of the smart city is to offer its citizens the highest possible quality of urban life as people are well informed and aware of what is happening around them as they enjoy the privilege of easy access to all the important information they ought to know.

Undeniably, the term smart city is new but frankly, several researchers had developed different definitions to understand its meaning. Therefore, it is important to understand the term smart city from the different perspectives of these researchers. Hence, Table 1 is a summary of various working definitions of smart city.

Table 1 Working definitions of smart cities. *Source* Nam and Pardo [36]

References	Definition
Giffinger and Gudrun (2010, 2018)	"A city well-performing in a forward-looking way in various characteristics, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens"
Hall (2000)	"A city that monitors and integrates conditions of all of its critical infrastructures"
Hartley (2005)	"A city connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city"
Toppeta (2010)	"A city combining ICT and Web 2.0 technology with other organizational, design and planning efforts to de-materialize and speed up bureaucratic processes and help to identify new, innovative solutions to city management complexity, in order to improve sustainability and liveability"
Washburn et al. (2010)	"The use of Smart Computing technologies to make the critical infrastructure components and services of a city-which include city administration, education, healthcare, public safety, real estate, transportation, and utilities more intelligent, interconnected, and efficient"

Interestingly, in the past years smart city has become a popular research topic with numerous researches conducted on the same, particularly investigating the different applications and technologies used, its design and implementation, management, challenges occurred and solutions to eradicate these challenges. This brings us to the core of this paper. This chapter provides some insight into the need for smart cities along with the advance technologies (both tangible and intangible) are being employed to help promote sustainable developments, what are the various challenges that could occur, and solutions to overcome these challenges in smart cities.

1.1 Why Smart Cities

Cities around the world are growing rapidly, for instance, by 2050 it's expected that two thirds the planet population will be living cities. This means that cities are growing in terms of size and population. Such growth increases the magnitude of the current issues that cities face or bring along new challenges. For example, issues such as pollution, congestion, waste management and energy needs will continue to grow [27]. The application of legacy approaches to solve such problems will not provide efficient outcomes, if it all were able to fix the core problems [26].

Taking the example of adding more lanes to overcome congestion. This has proven to be 20th century approach and, in the 21st century, is unable to provide a sustainable solution to the issue (2018). The 21st century solution to such issue would include concepts such as car sharing and Intelligent Transport Systems. Another example is the enforcement of parking spaces; is manual enforcement still a viable solution (2018)? Would using video analytics systems be a more efficient solution?

It seems that addressing city growth issues was one of the main driver behind the modern thinking and the introduction of Smart City concepts. However, according to (2018), city growth creates opportunities as well. MIT (2018) research found that 80% of wealth creation and 60% of energy consumption will be generated from cities. Population growth would also mean more innovative people are coming to the city. This would mean that Smart Cities might become a platform for innovators [8].

An interesting view of the values that Smart Cities can deliver is to concentrate on the components and requirements to convert smart city platforms from providing digital services to platforms that enable public members of the community to innovate and develop applications that are meaningful and have greater values [8].

In general Smart Cities have the potential to deliver some tangible benefits [30]:

- Citizens safety. Utilising technologies such as intelligent surveillance.
- Advanced healthcare.
- Intelligent Transport Systems (ITS) and smart mobility. Ride sharing and smart parking are such practical example.
- Energy management, such as renewable energy, and real-time energy monitoring.

2 The Role of IoTs in a Smart City

Some of the most noteworthy and important functions that IoT performs in a Smart City are discussed below.

2.1 Traffic Management

Implementation of IoT has huge potential in managing traffic signals and the traffic on roads in a Smart City. Data collected from a grid of cameras and other equipment and sensors can be used to determine the analyse the flow of traffic, congestion and jam prone streets, affected streets and roads during rush hours and duration of traffic signals in a busy street [6, 34, 35]. The data thus collected can be used to control, change and direct the signals so that the traffic flows smoothly with marked reduction in congestions and waiting time. The results of applying the technology have been outstanding in all Smart Cities around the world. For example, the city of Los Angeles has put in place a $400 million system to control and manage traffic by the use of cameras and road embedded sensors that provide real time data to a central computer system. The system controls 4500 traffic signals across the city. A 16% faster traffic and 12% lower waiting time and congestion has been attributed to the new system since its completion in 2013.

2.2 Water Supply Management

The supply and management of water resources is a traditional affair in most cities. Age old infrastructure and resources are in use for storing, pumping and supplying water to customers. This aging system is dependent heavily on manual work which makes detection of faults and defects very difficult. Utilities companies rely almost exclusively on customer complaints to register a fault. The result of this is tremendous amounts of wastage, high running and maintenance costs and delayed response to a situation.

Putting IoT to work by installing sensors that monitor pipelines and detect and report faults, register consumption and customer complaints makes water management much more effective and cheaper. The process of fault detection can become virtually error free and without manual input. With new and cheaper technology becoming readily available in the market the potential for IoT is very high in water management, especially due to the growing scarcity of the resource and governments across the globe devising conservation plans. Huge emphasis is being put on employing IoT to the cause of water management in Smart cities globally, knowing for certain that water is one of the most crucial resources for human survival and it is only going to be a scarcity due to the eminent climate change. As much as 20% of water costs can be saved in a smart city by effectively implementing IoT.

2.3 Transportation

Integrating, managing and developing transportation infrastructure and expanding network is critical for a Smart City as it has various implications towards the overall development and accessibility of resources. A Smart City that strives for a healthy and sustainable environment for its residents must focus on a well-connected, advanced and seamless public transportation [35]. This will not only make all parts of the city more accessible but also cut down the emissions and traffic congestions caused by the thousands of private vehicles taking to the streets daily. The way forward is by providing the citizens with alternative modes of transportation which are cheap, dependable and easily accessible. The Internet of Things has various tools and solutions that can help a Smart City address its transportation problems. Smart RFID enabled cards to integrate different modes of transport is one such tool that makes travel hassle free. This technology uses RFID to allow commuters to board a bus, a subway train or a tram without having to buy different tickets for each service. Buying tickets or recharging smart cards through apps and online portals eliminates the need to queue up at the counters or ticket vending machines. Online information about arrivals, frequency and stops makes it easy to find the best route and mode for the average commuter. Smart and predictive tolling systems are also being used to decongest roads by minimizing the time spent at paying tolls by reading information from the vehicle, registration plates and real time data processed in a central system. When we combine all these together, we can expect a much improved and enhanced travel experience that cuts down on costs, time and emissions. This in turn will attract more commuters to public transports and the continuous evolving nature of technology will produce the desired results for a healthy and sustainable environment for all citizens [17]. For instance, the city of Chicago in the US has already integrated the payment for its transportation services through the use of Ventra Card. Commuters can seamlessly use the card for travelling by CTA, Pace and Metra services, thereby no longer needing to buy different tickets.

2.4 Energy Efficiency

With the continuing influx of the global population to cities the need to generate and sustain the supply of energy is more than ever before. It is believed that by 2030 more than 60% of the world's population will be concentrated in cities driven mainly by the influx patterns in Asia, Africa and Latin America [24]. The population surge has made it absolutely critical for cities the world over to think of new ways to generate and conserve energy to sustain their development and provide citizens, businesses and governance authorities with uninterrupted supply of electricity. The use of energy is of the most vital importance in the smooth operation of a smart city, given the fact that it relies extensively on sophisticated tools, equipment and networks in an Internet of Things setting.

Use of traditional non-renewable sources of electricity does not provide Smart Cities with a sustainable solution to the energy problem. These resources are depleting thick and fast and need large and costly infrastructure to produce, not to mention the cost of manpower involved in the production process. Add to this the cost of emissions and the carbon footprint; it makes the need to look for alternative and possibly sustainable resources extremely crucial not only to counter the current situation but also for the future generations' energy requirements [15]. Let us look at some of the ways in which the IoT can help solve the energy dilemma of Smart Cities:

Optimizing consumption of energy is important for reducing the carbon footprint and emissions coming from cities. Cities today are the primary contributors to all emissions measured globally. A 2016 report in International Renewable Energy Agency states that cities consume 65% of the total power output and contribute to nearly 70% of all manmade carbon emissions [24]. Employing IoT has helped many Smart Cities with substantially reducing the consumption of energy and the related costs including carbon emissions. The working model of IoT is complex and requires advance technology integrated with the production of energy. A wide network of smart and communicating meters that accurately measure the consumption, load, demand, supply quality and other vital customer information [15]. The information thus generated is then used by producers and suppliers to determine the individual requirement of every consumer on the grid. Energy sensors, smart lighting solutions and smart devices and appliances are also vital in generating information about energy consumption patterns in an office or home. This information is used for optimum energy supply according to varying demands of such establishments.

Use of small and locally maintained power grids is making communities and Smart Cities self-reliant in energy production from renewable resources. A substantial fall in the cost of procuring equipment and technology such as windmills and solar PV panels is providing the much-needed boost that Smart Cities were looking for. Energy produced from these resources is most relevant to the objective of providing healthy and sustainable alternatives to polluting plants of traditional energy production. Embedded sensors are used to collect and communicate data regarding the production and individual consumptions within these micro-grids. The IoT enables optimized distribution of power to homes, businesses and industries by interpreting the data derived from sensors and smart devices [24].

New developments and research in enabling buildings to provide data on energy consumption aims at making them learn the patterns and decide the requirement based on variables such as lighting, heating, cooling, humidity and number of occupants at different points of time through the use of wireless sensors. The compiled data is then used to make the building learn how to optimize and adjust the power supply so that the requirements are met while effectively reducing the consumption. Many companies are developing this concept and it should be in widespread use in a couple of years from now [24].

2.5 Improving Public Safety

In ever-growing, evolving and fast paced cities the problem of public safety is as relevant as it can be. Huge population in cities translates into huge arena for criminals who thrive in densely populated surroundings. IoT in collaboration with the local governing authorities can provide solution to this menace that has the potential to hinder the growth and development of cities. The solutions that IoT offers are highlighted below.

Real time monitoring of the city by installing and connecting cameras, sound and video recording devices and specific sensors to a central system which alerts the police and other related departments of crimes taking place with pinpoint location and identification, thereby enabling them to take prompt action. Even if the criminals could not be caught in the act, the quick action will ensure that they get identified faster and caught without inflicting further damage to the society.

IoT enables the seamless exchange of data among different departments and sections of the police and law enforcing agencies, thereby empowering the concerned officials with faster decision making and quick action when a situation arises. This ensures the timely response to citizens in emergency situations.

The police can take preventive action to safeguard the citizens by using information generated over time and real time data of places where the crime rates are high. This data can also be helpful in detecting the areas and localities where patrolling should be increased or more police presence is required.

2.6 Wireless Sensor Networks

Wireless Sensor Networks (WSNs) can be defined as a network of nodes connected together with features to sense and control the environment [31] as shown in Fig. 1. This technology uses wireless communication but not wired communication. They are an absolutely vital component of the information collection process in a smart system.

The network of wireless sensors installed throughout the system and its elements collects important information making adjustments and adapting to the specific environment. The necessary data is collected and segregated by the sensors taking into account the variables that affect a specific outcome in any given situation or location. The sensor network is often regarded as the first layer of a smart city concept [10].

2.7 Functions of WSN in a Smart City

Transportation and Mobility: With the constant population growth and number of private and public vehicles taking to the roads, the need for managing and controlling

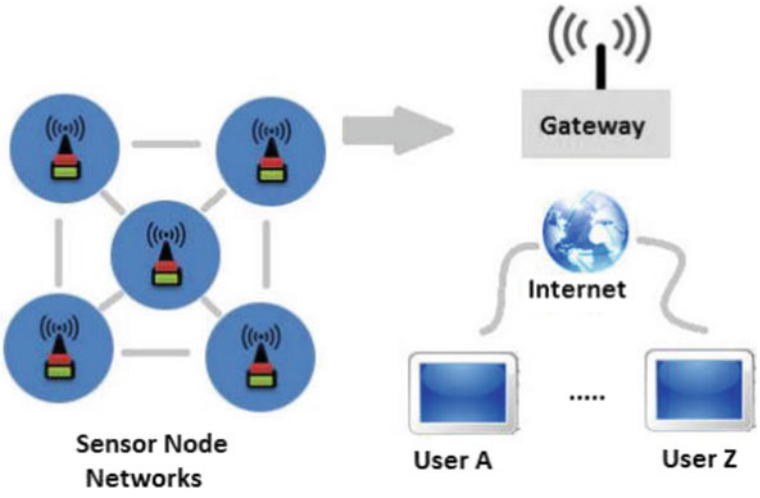


Fig. 1 Illustration of wireless sensor network

the transportation system in a city is quite apparent. Daily gridlocks and congestion on the streets have huge negative impact on the productivity of the city's workforce. The delay caused by the slow movement of traffic generates waste and emissions from the idling vehicles and increases the time required to travel to work. Smart Cities have incorporated sensor-based traffic and mobility analysis and control systems to minimize such losses efficiently [16, 35]. Real time data is transmitted from the road embedded sensors to the central monitoring and control system, clearly notifying the traffic situation in any given location and point of time. The control system can use this information to control the traffic signals and direct the flow of vehicles to reduce congestions and gridlocks. The use of predictive maps and real time navigation on mobile devices also helps the cause by collecting information of the movement and flow of traffic. This information is processed, and suggestions are sent on the devices to help drivers to find alternative routes to avoid snarls. The optimized use of sensors can produce great results in solving traffic problems of the city thereby cutting gas costs, carbon emissions and other wastage such as idling time of vehicles.

Electricity management: Smart and intuitive sensors are used in the production, storage and supply of electricity. These sensors are highly capable and intelligent, providing accurate information about the consumption, demand, supply, faults and defects and usage patterns of the city as well as individual consumers. Advance technology in sensory devices means faster and more adaptive response to any situation that may occur on the production plants and the supply system which in turn optimizes the use of resources that are in use. Real time data provided by these sensors helps in identifying and determining the quantity of electricity that needs to be produced and supplied in exact figures, thus reducing wastage considerably [20, 34]. The overall effect of optimization and implementation of sensors in energy management results in accurate, intuitive and predictive delivery to the end user. The

reduction in wastage and reckless production is crucial also for the environment as it puts a lot of technological inputs in place in reducing emissions and pollution caused by the traditional production of electricity.

Environment Monitoring: Rapid urbanization resulting from population influx to the cities has put them into a environmental crisis situation. The more the resources are used the more evident its impact on the environment becomes. For instance, the need for transportation in cities is growing by the count of the day, leading to more vehicles- public or private on the roads. This growth in the number of vehicles has direct bearings on the environment in terms of emissions and stress on the resources to keep them in motion. Gas consumption for transportation has been going up in cities over the decades. This rising consumption directly affects the environment by releasing huge amounts of carbon emissions and other micro pollutants in the air. The quality of air and water has seriously deteriorated because as a direct effect of this. The end result is the decrease in productivity of the residents due to poor environmental conditions. Now, the smart sensors when put into work help monitor and collect data about the quality of air, water and other elements that make up the environment of the city. Sensors such as weather mapping tools are of great use in predicting the change in weather conditions and any imminent warning situation. Outdoor sensors are also used to monitor the pollution and impact on the environment. This gives a chance for the city authorities to devise plans and techniques to keep the pollution at the minimum level possible [35].

3 Challenges to Build Smart Cities

This section will discuss the challenges around building Smart City environments including strategic, platform and technological challenges. The subsequent sections will present the current solutions and technology platforms that might address those challenges. Building a Smart City has many challenges and perhaps defining what a Smart City means for citizens and what problems it's going to solve for them is among the most underestimated yet most significant challenges. For example, [26] argued that the citizens of Barcelona did not participate in defining nor understood the concept of Smart City. This would imply that the citizens of Barcelona did not effectively realised the values of living in a Smart City. Another non-technological challenge is the transformation of the Smart City strategies into tangible projects driving the change and delivering specific outcomes [12]. Every city must have a vision, strategic themes and goals when introducing Smart City initiative. Defining the strategy for a Smart City implementation requires composite coordination among large number of stakeholders, departments, businesses, and services [26] making the agreement on such strategy even harder. Linking the Smart City projects back to the strategic objectives is essential to determine the validity and viability of such projects (2018). In order to achieve this linkage between the strategy and the objectives, represented in projects, the city must follow a methodical approach to bridge this gap.

3.1 Security

With the collection of personal data that is vital in providing IoT and WSN based solutions for Smart Cities, the concern of data breach is very real. When personal and privileged information goes into the public domain chances of illegal use and theft become very high [33]. There are numerous instances where the information stored on the servers have been attacked by online hackers. This stolen data can be used to gain access to bank accounts, personal and private information, social security and everything that is on the database [14, 23].

Security in general is concerned about Confidentiality, Integrity and Availability. This is no different to Smart Cities security, whereby weak security measures will result in malicious activities, data integrity issues, invasion of privacy, services interruption and many more problems [30]. Such risks have direct impact on all stakeholders including citizens, government institutions and businesses. Al Dairi and Tawalbeh [7] categorises security issues into infrastructure security and data privacy, which is a similar categorisation to what [30] has proposed. Infrastructure is prone to many security threats. For example, because the Smart City has to rely on connectivity between devices such as wireless connections, such connections can suffer from Denial of Service (DoS) attacks causing Availability issues [7]. Cerrudo [18] presented a comprehensive summary of infrastructure related security problems, we will mention few of them: (1) lack of security testing (2) lack of security measures in the software and IoT devices produced by different vendors (3) weak encryption management specially around poor encryption keys generation and management, which is a big issue in an environment that relies on wireless connections as in Smart Cities (4) poor patch management practices, which is mainly linked to the difficulties around testing patches in non-production environments and slowness in releasing patches by vendors (5) relying on old outdated systems—such as using an out of support operating system to run the backend of a building management system. Simple vulnerabilities might have severe impact on the daily life of citizens in a Smart City if security is not managed properly; for example, a vulnerability in a smart parking management system that shows available parking locations in the city, might cause a chaos by sabotaging the system to show that most of the on-street parking areas are available while they are packed during rush hours.

The other aspect to security issues is data privacy. One of the main aspect to this matter is data ownership: if data is owned by private companies, then security and privacy is less of a concern to private company (for example, they might sell the data to 3rd parties), however, if the data is owned by government entities, then such organisations are more concerned about personal information privacy and security. For instance, many Smart Cities would rely on cloud solutions to collect and store data from different sources including sensors, IoT devices, and cameras and so on. In such case the questions would be: (1) does the city trust the vendor hosting the data and what are the parameters to asses such trust? (2) how the authentication and authorization to access the data would be handled? [9].

3.2 Accountability

The governing bodies that compile and store the data generated from IoTs and WSN sometime fail in providing accountability to the citizens by not showing how the data is being used to deliver a better quality of life for the residents. The data can be confusing sometimes which results in determining the use of a particular set of information, which is the root cause of this problem.

Managing data: In a Smart City environment, there is a tremendous amount of data from different sources and different types that would require real-time collection and processing, storage, aggregation, analysis, access and security [30]. There are many sources for the data, including sensors, mobile apps, and different types of software where sensors are the main source of data. As per [11] sensors produced 1,250 billion GB of data worldwide in 2010.

Sensor data on the other hand have the following aspects: high velocity, high variability, and high volume [44], hence the need for a platforms and technology with characteristics necessary to address such aspects. In addition to those data needs, managing and analysing the collected data in way that is easy to represent and provide value for decision makers and other consumers, is probably the main element of concern [44].

3.3 Connectivity Requirements

Networking infrastructure plays a big role in Smart City environment. It provides the connectivity required among different components of the Smart City. The network infrastructure has to be reliable, available, efficient and secure [29, 30].

Moreover, despite the advancement in networking technologies in general and their ability to provide very long ranges and high throughputs (such as WiMAX and LTE), such technologies cannot necessary address all the connectivity requirements due to their high power consumption needs [30]. It's also worth noting that different Smart City applications have different networking and communication needs, and [29] provided a summary of such applications and their communication requirements. For instance, Intelligent Transport Systems are less constrained to power consumption than UAV systems. Such difference in networking requirements entails that there no one size fits all solution to address these requirements and that a structural approach is needed to provision the right infrastructure.

3.4 Interoperability

This challenge can take different aspects at different layers of the Smart City architecture. For instance, at infrastructure layer this issue could relate to the lack of standard or open protocols to support interoperability and communication among

different types and manufacturers of IoT devices [31, 43]. On the other hand, at higher layers where applications are to interact with IoT devices, there is a lack of standardisation in terms of interfacing with IoT devices [43]. For instance, application developers will need to create interfaces that integrate with IoT product specific APIs, leading to silos and complex architectures.

3.5 Open Data

Many cities are embracing the concept of Open Data, which means free open access to data collected by government. A Smart City is a source for large amount of data collected from different sources. The challenges faced by cities in terms of providing open access to data are mainly around security, privacy, data formats, data management and data access [30].

3.6 Costs

It cannot be denied that the implementation of new technology is a costly affair and requires large amounts of investment in procurement and development of supporting infrastructure. The burden of the impending cost has to be ultimately borne by the residents who can be reluctant towards this cause [42]. Security and privacy are another concerning challenges that are actively researched.

4 Solutions

Technology has played a major role in industries like healthcare, education, retail, and agriculture and will surely do the same with Smart Cities. According to Pablo and colleagues [38], technology is the backbone of an Intelligent City. Therefore, discussed below are different technologies that could help in the management and functioning of a Smart City. Discussions also covered the challenges and solutions faced by these advance and innovative technologies in their integration and application in smart cities.

4.1 Information Communication and Technology (ICT)

Basically, there are two methods when talking about smart cities–the technology driven method (TDM) and the human driven method (HDM)[32]. The TDM claims that “smart cities are networked places where deploying ICTs into each activity in

the city would improve standards of life" [32]. This approach claims that the use of ICTs by societies introduce opportunities for them to actively participate in their active roles and take matter into considerations. However, ICTs cannot do this by itself i.e. achieving the quality of life desired by variety of people, therefore human capital must be enhanced as well as other forms of skill development among the citizenry [37]. Thus, the HDM approach empowers urban citizens with the capacity and innovative skills needed to actively participate in the mainstream and better utilization of technologies in cities thereby taking advantage of manpower to solve major problems and create common goods for urban citizens.

In fact, there is recognition amongst practitioners and scholars that ICT alone cannot effectively ensure the sustainable development and firm establishment of smart cities. This is because "human capital remains crucial for inventing and advancing usage of technology in cities and, therefore, investments in human capital are essential for smart cities to foster the capabilities of citizens" [32]. Hence, it is evident that the diligence combination and simultaneous implementation of TDM such as Information and Communication Technologies (ICTs) and HDM such as human capital skill empowerment are crucially important in ensuring the effective application of ICTs' initiatives in smart cities [32].

4.2 Internet of Things (IoT)

Internet of things is as known as a Machine-to-Machine (M2M) is a concept that encompasses every device and appliance that can connect to the internet. In Fig. 2, it shows how IoT is connecting every devices, sensors, software and electronics which enables connectivity to collect and exchange data.

It is an umbrella term used for all devices that have the capability to record, register and transfer data over the internet. Such devices can be as small as a sensor embedded in an athlete's shoes to monitor performance and as big as a server that holds millions of information and data in a digital format [23]. With the advancement in technology and growing use of the internet, the IoT is becoming an integral part of our daily life. Growing reliance on technology, especially the internet has resulted in companies jumping on this bandwagon and developing products that are capable of generating and transferring data over a network. In essence every tool using the internet falls under the premise of IoT [38].

The main implication of IoT is in the generation, recording and storage of digital data for various purposes with minimum human effort and involvement, making it error free. It also makes the data readily available at the fingertips, thus saving the user a lot of time and effort [39].

The sheer number of devices with advance technological features and the scope of data that they generate on a daily basis make IoT an integral part of the process of transforming any city into a Smart City. A smart city relies heavily on the data and information about its citizens, which are of great use in formulating, devising and

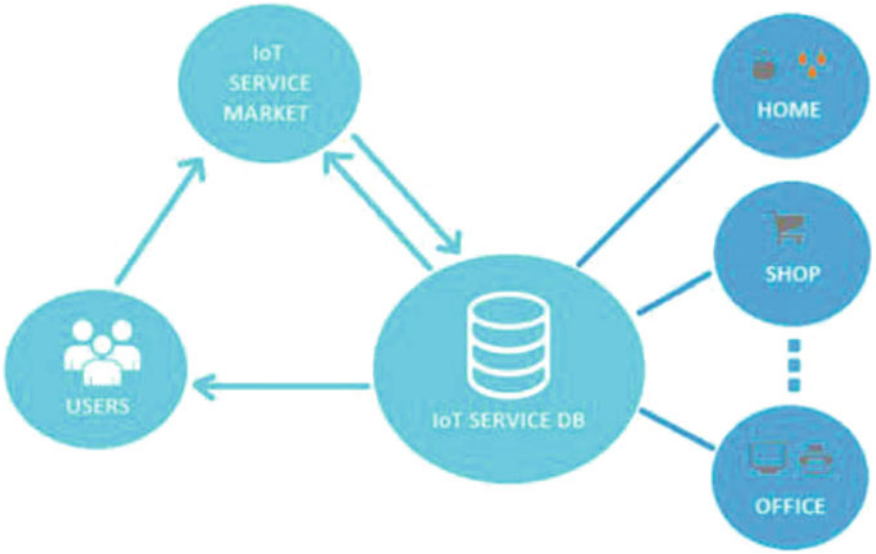


Fig. 2 Internet of things (*Source* [31])

executing plans and delivering the best solutions to the inherent problems within its limits. Here, IoT plays a very crucial part by providing individual data, combining and integrating data with that of the city's population and creating useful information in the database [31]. It is of vital importance that the devices are interconnected and can exchange data among themselves. The smart devices, in order to effectively cut costs and reduce waste and time, need to communicate and make decisions on their own and provide smart solutions to problems in a smart city environment.

4.3 Installing High Security Systems

To prevent data from being stolen and misused the authorities must install highly advanced and multi-level security system [40]. This may include advance firewalls, access control and regulation and latest server technologies. Making the database secure is of the prime importance to achieve the end result of delivering the quality of services as planned. Many tools including hardware and software are available today that can help in minimizing the chances of data theft thereby making it safe for storage.

4.4 Proper Planning

The governing authorities must chart out detailed plans as to how and where the data will be used and announce them to the public to maintain transparency in data usage. Each piece of information must be acknowledged to the residents so that they know where their information is going and how it will affect them. Proper counting and segregation will make the data distinguishable and it will be much easier to assign accounts and usage for relevant purposes. Multiple available systems can be implemented to determine the source and destination of data generated by the IoT and WSN, which will ensure trust and high accountability on part of the authorities.

4.5 Optimizing Technology

Optimum and carefully planned use of technology can greatly reduce the costs for smart cities [42]. It needs to be accurately determined that what are the focus areas for development that need immediate attention. Working on a priority basis will give time to implement one technology at a time thereby effecting remarkable cost savings. The technology and systems also need to be taken full advantage of so that there are no procedural wastages. Other systems can be added once the current process has taken full effect. This also makes shortcomings easily identifiable, thus providing scope for improvements and adjustments.

5 Big Data in Smart City

Like ICTs, the use and better utilization of big data in cities is a genuine characteristic of a smart city [19, 22]. Big data can be defined as "large and complex sets of data that represent digital traces of human activities". Traditionally, large amount of data related to urban living around the globe from things such as energy infrastructure, energy using residents, stakeholders etc has been gathered. The use and easy accessibility of these data create technology for making life easier for smart cities populations, companies, new comers as well as local governments [19]. Prime examples of the better utilization of big data in smart cities were demonstrated and evident in San Francisco and Rio de Janeiro governments where they used big data to analyse crime records which offer better security services and other data from implemented sensors and cameras for addressing the need of cities citizens like safety, energy efficiency and weather to name some.

However, the challenge to smart cities is that data in cities nowadays have risen greatly and thus the move to data-based smart city transformation is not easy [22]. For instance, there are challenges in getting information from these available data for smart cities such as managing the data quality, integrating different data, addressing

privacy issues, understanding the needs of citizens, visitors, and employee, enhancing geographic information delivery method and designing smart city services. The above-mentioned challenges suggest that big data use for smart cities certainly require various types of expertise, including knowledge of citizens, city administration, data management, data analytics, law, and service design. Hence, better management and organization of the growing quantities of data and various types of big data in modern cities will surely enable urban planners to transform data into useful information vital in delivering urban support services for the benefit of citizens, visitors, local government and companies in smart cities. Most importantly, the desire for smart cities to have improved and increased productive services can be seen through analysing data for a better understanding. This enables better decision making thereby raising the quality and standard of living in such environments [25].

6 LiDAR Technology in Smart Cities

According to [25], "light detecting and ranging (LiDAR) is a technology that provides accurate elevation-based information, which can be used for interior building level analysis and the analysis of large geographical areas, such as municipalities or regional jurisdictions." LiDAR technology is crucially important as it provides critical information about hydrological modelling and flood prone areas in the city, potential production of clean energy such as solar energy in certain areas of the city and the linkage of building heights with emergency plans. Additionally, "LiDAR data provides a highly detailed record of the built urban environment and can provide support in the planning and assessment of climate change resilience activities" [25]. Hence, this technology has been used to address climate change challenges in smart cities and to archive the ultimate objective of smart cities which is to become climate change resilient cities. For instance, in the city of Toronto in Canada, challenges such as improving water drainage on roads, production of solar energy to minimize greenhouse gas emissions and creating advanced evacuation plans were being effectively addressed with the LiDAR technology. This implies that the LiDAR technology has been very effective and of great assistance to relevant city authorities and governments in their continuous effort to address climate change challenges and minimizing the negative consequences of climate change related hazards in smart cities.

Like other technology, the use and application of LiDAR technology in smart cities is also challenging. For instance, the implementation of LiDAR technology needs data collection programs and succeeding data processing activities given the high density and large scale of modern cities [25]. The challenge therefore is the huge costs associated with the facilitation and implementation of these data collection and creation programs. Most importantly is the challenge to avoid errors during the data collection and creation processes to ensure correct and truthful information are being collected and made available which are vital for decision making in response to climate change challenges. Solutions for these challenges are to secure funding from

relevant stakeholders and strengthening partnership with them to meet the cost of facilitating these massive data collection and creation processes. The data collection and creation process should be able to produce information on population changes and materials within the city which generate reliable data driven decision making for the benefit of urban people.

Smart management and policy in smart cities

Typically, a city is considered as a smart city when it has a "comprehensive commitment to innovation in technology, management and policy" [36]. This infers that the emergence and successes of smart city technology are truly attributed to smart management and policy. This is because the integration and adoption of advance technology in smart city would only be fruitful with the strategic implementation of smart management and policy. In fact, recent studies have shown that the successful integration of technology and other innovations into smart city certainly require or necessitate smart management and policy [32, 36]. These studies reviewed the wide range of government projects, technology innovation and urban innovation in smart cities and found out from the experiences of the execution of these government projects, technology and urban innovations that a smart city is truly an innovation in management and policy.

The evidence also reveals that the failure in managing high risk technological problems in smart cities leads to absolute failure in technology driven public sector projects [36]. For instance, "85% of IT projects fail because of the challenges by non-technical aspects of innovation in large part–policy, organization, and management related risks" [36]. The most common reasons include; "poor planning, weak business case, lack of top management support, lack of leadership, lack of professional skills, misalignment between organizational goals and project objectives, vulnerability to policy swings, too much technology-driven enthusiasm, and political hyper-activism [36]." Nam and Pardo [36] also assert that these non-technological side of smart city is truly regarded as innovation which is substantially related to technology considering that the successful integration and application of advance technology in smart city has largely influenced by these non-technological factors. This confirms Fernandez and Rainey (2006) argument that the emergence of smart city is a result of the application of intelligence to city management. In short, it is evident that smart management and policy is an integral characteristic of smart cities which certainly has a profound impact on the successful integration and execution of modern technological innovations in smart cities.

7 Conclusion

The construction and emergence of smart cities will bring about a higher quality of life to urban population through easy access to the various ICT's innovations and better utilization of big data, IoT and Wireless Sensor Networks (WSN), LiDAR technology in smart cities as well as the benefits resulted from digital interconnectivity. However, the introduction of these advance ICTs related technologies also brings about its

unique challenges such as costs, maintenance, the need to protect individual privacy and participation, and access issues. Most importantly, it is also vital to maximize the benefits being shared by smart cities, citizens, visitors, local governments and companies as a result of their active participation and use of the various technological innovations being introduced in smart cities.

References

1. (2018) Beyond smart cities. Programs for professionals, MIT professional education. Accessed 17 May 2019. https://professional.mit.edu/programs/short-programs/beyond-smartcities
2. (2018) Global e-waste generation forecast 2010-2018. Statista. Accessed 14 May 2019. https://www.statista.com/statistics/499891/projection-ewaste-generation-worldwide/
3. (2017) IoT for water utilities. Accessed 17 May 2019. https://www.ibm.com/blogs/internet-of-things/iotfor-water-utilities
4. (2018) The problem with applying 20th century solutions to 21st century problems. Accessed 17 May 2019. https://www.lynda.com/Data-Sciencetutorials/problem-applying-20th-centurysolutions-21st-century-problems/571620/624404-4.html
5. (2018) World urbanization prospects: the 2018 revision. United Nations Population Division. New York. Accessed 17 May 2019. https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html
6. Al-Shammari BKJ, Al-Aboody N, Al-Raweshidy HS (2018) IoT traffic management and integration in the QoS supported network. IEEE Int Things J 5(1): 352–370. Muhammad Ismail ESaKQ (2016) Enabling green heterogeneous wireless network. In: The first international conference on green communications, computing and technologies
7. Al Dairi A, Tawalbeh L (2017) Cyber security attacks on smart cities and associated mobile technologies. Procedia Comput Sci 109:1086–1091
8. Apolinarski W, Iqbal U, Parreira J (2014) The GAMBAS middleware and SDK for smart city applications. In: IEEE International conference on pervasive computing and communication (PERCOM) workshops
9. Atlam H, Alenezi A, Alharthi A, Walters R, Wills G (2017) Integration of cloud computing with internet of things: challenges and open issues. In: IEEE international conference on internet of things (iThings) and IEEE green computing and communications (GreenCom) and IEEE cyber, physical and social computing (CPSCom) and IEEE smart data (SmartData)
10. Basic Z, Jogun T, Majic I (2018) Integrated sensor systems for smart cities. Portal Croat Sci Prof J 25(1):277–284
11. Baraniuk RG (2011) More is less: signal processing and the data deluge. Science 331(6018):717–719
12. Bastidas V, Bezbradica M, Helfert M (2017) Cities as enterprises: a comparison of smart city frameworks based on enterprise architecture requirements. In: International conference on smart cities
13. Bianzino AP, Chaudet C, Rossi D, Rougier J (2012) A survey of green networking research. IEEE Commun Surv Tutor 14(1):3–20
14. Braun T, Fung BCM, Iqbal F, Shah B (2018) Security and privacy challenges in smart cities. Sustain Cities Soc 39:499–507
15. Brundu FG et al (2017) IoT software infrastructure for energy management and simulation in smart cities. IEEE Trans Ind Inf 13(2):832–840
16. Cassandras CG (2017) Automating mobility in smart cities. Ann Rev Control 44:1–8
17. Caywood M (2018) How IoT enabled infrastructure will revolutionize public transit. Accessed 17 May 2019. https://www.iotevolutionworld.com/smart-transport/articles/438023-how-iot-enabled-infrastructurewill-revolutionize-public-transit.htm

18. Cerrudo C (2015) An emerging US (and World) threat: cities wide open to cyber attacks. Accessed 17 May 2019. https://ioactive.com/pdfs/IOActive_HackingCitiesPaper_CesarCerrudo.pdf
19. Chiehyeon L et al (2017) Smart cities with big data: reference models, challenges, and considerations. Cities 48:86–99
20. Chinmaya M et al (2017) Energy management in smart cities based on internet of things: peak demand reduction and energy savings. Sensors 17(12):1–21
21. Cosner S, Ramaglia F (2018) Smart city solutions: applications that power connectivity. Public Management. June 2018
22. Dwevedi R, Krishna V, Kumar A (2018) Environment and big data: role in smart cities of India. Resources 7(4):1–10
23. Eckhoff D, Wagner I (2018) Privacy in the smart city-applications, technologies, challenges, and solutions. IEEE Commun Surv Tutor 20(1):489–516
24. Fuilherade P (2017) Smart cities to boost energy efficiency. Accessed 17 May 2019. http://www.smartbuildingsmagazine.com/features/smart-cities-to-boost-energy-efficiency
25. Garnett R, Adams M (2018) LiDAR-A technology to assist with smart cities and climate change resilience: a case study in an urban metropolis. Int J GeoInf 7(5):1–13
26. G-Hernandez M (2018) Building a smart city: lessons from barcelona. Commun ACM 61(4):50–57
27. Hanes D, Salgueiro G, Grossetete P, Barton R, Henry J (2017) IoT fundamentals: networking technologies, protocols, and use cases for the internet of things. Cisco Press, Indianapolis
28. Heng TM, Low L (1993) The intelligent city: Singapore achieving the next lap. Technol Anal Strateg Manag 5(2):187–202
29. Jawhar I, Mohamed N, Al-Jaroodi J (2017) Networking and communication for smart city systems. In: IEEE SmartWorld, ubiquitous intelligence and computing, advanced and trusted computed, scalable computing and communications, cloud and big data computing, internet of people and smart city innovation
30. Khatoun R, Zeadally S (2016) Smart cities: concepts, architectures, research opportunities. Commun ACM 59(8):46–57
31. Kocakulak M, Butun I (2017) An overview of wireless sensor networks towards internet of things. In: 2017 IEEE 7th annual computing and communication workshop and conference (CCWC)
32. Kummitha RKR, Crutzen N (2017) How do we understand smart cities? an evolutionary perspective. Cities 67:43–52
33. Lacinak M, Ristvej J (2017) Smart city, safety and security. Procedia Eng 192:522–527
34. Li Z, Shahidehpour M (2017) Deployment of cybersecurity for managing traffic efficiency and safety in smart cities. Electr J 30(4):52–61
35. Masek P et al (2016) A harmonized perspective on transportation management in smart cities: the novel IoT-driven environment for road traffic modeling. Sensors 16(11):1–23
36. Nam T, Pardo T (2011) Smart city as urban innovation: focusing on management, policy, and context. In: Proceedings of the 5th international conference on theory and practice of electronic governance
37. Neirotti P et al (2014) Current trends in smart city initiatives: some stylized facts. Cities 38:25–36
38. Pablo C et al (2018) Tendencies of technologies and platforms in smart cities: a state-of-the art review. Wirel Commun Mobile Comput 2018:1–17
39. Park E et al (2018) The role of internet of things (IoT) in smart cities: technology road map oriented approaches. Sustainability 10(5):1–13
40. Popescul D, Radu LD (2016) Data security in smart cities: challenges and solutions. Inf Econ 20(1):29–38
41. Santana E, Chaves A, Gerosa M, Kon F, Milojicic D (2017) Software platforms for smart cities. ACM Comput Surv 50(6):1–37
42. Silva BN et al (2018) Towards sustainable smart cities: a review of trends, architectures, components, and open challenges in smart cities. Sustain Cities Soc 38:697–713

43. Soursos S, Zarko I, Zwickl P, Gojmerac I, Bianchi G, Carrozzo G (2016) Towards the cross-domain interoperability of IoT platforms. In: European conference on networks and communications (EuCNC)
44. Wu C, Birch D, Silva D, Lee C, Tsinalis O, Guo Y (2014) Concinnity: a generic platform for big sensor data applications. IEEE Cloud Comput 1(2):42–50

Better Transmission of Information Focused on Green Computing Through Data Transmission Channels in Cloud Environments with Rayleigh Fading

Reinaldo Padilha Franca, Yuzo Iano, Ana Carolina Borges Monteiro, and Rangel Arthur

Abstract Cloud services have become very popular in recent years, where sharing, transmitting and storing data has been one of the great needs of today. In the last years, concepts and developed methodologies of cloud computing systems have been improved. And considering the current situation of the planet, the concepts of economic development are increasingly linked to sustainability, where Information Technology also has a significant impact on the environment, either by the high demand in energy consumption or by the manufacture of parts and components. Being critical for any Green IT project to begin with the decision of a platform with greater efficiency, to further reduce energy consumption without interfering in productivity, generating sustainability. In this way, the present study aims to develop the method of data transmission based on discrete event concepts, named CBEDE (by the acronym), its experiments were matched in the MATLAB software simulation environment, where the memory consumption of the proposed methodology was evaluated. Therefore, the CBEDE methodology presents great potential for intermediate users and computer systems, ensuring speed, low memory consumption, and reliability. Being the differential of this research, the use of discrete events applied in the physical layer of a transmission medium, the bit itself, being this to low-level of abstraction, the results show better computational performance related to memory utilization related to the compression of the information, showing an improvement reaching up to 115.28%.

1 Introduction

Green computing is not just that idea that some have to try to minimize only the impact of global warming, because such concept has a connotation of how to work what we produce in computing in the matter of devices, hardware, so that they can

R. P. Franca (✉) · Y. Iano · A. C. B. Monteiro · R. Arthur
School of Electrical and Computer Engineering (FEEC),
State University of Campinas (Unicamp), Campinas-SP, Brazil
e-mail: padilha@decom.fee.unicamp.br

B. Balusamy et al. (eds.), *Green Computing in Smart Cities: Simulation and Techniques*,
Green Energy and Technology, https://doi.org/10.1007/978-3-030-48141-4_5

be reused and recycled easily. One of the earliest initiatives toward green computing in the United States was the voluntary labeling program known as the Energy Star, conceived by the Environmental Protection Agency (EPA), in the year of 1992, with the intention of to promote energy efficiency in hardware of all kinds. The Energy Star label became a common sight, especially in notebook computers and displays, which later led to similar programs being adopted in Europe and Asia. Having the green computing focused primarily on reducing the environmental impact of IT hardware by improving energy efficiency, reducing the use of harmful chemicals in computing devices, and promoting reuse and recycling [1, 2].

Green computing would be more an expression applied to a concern of companies regarding the environment and the sustainability of the company itself, having a more economic character. It is a very broad concern with this type of material so that, to the extent possible, it is the least toxic material used for the construction of hardware. Like other human activities, IT (information technology) causes impacts on the environment, both by the demand for electrical energy and by the materials used in the fabrication of the hardware, which in this context, there are companies that adopt Green IT actions supporting the businesses and other companies that offer similar solutions [2, 3].

With the aim of producing products that consume less energy, avoid the use of heavy metals and the use of chemical and toxic components, besides increasing the quantity of recyclable materials in the manufacture of the products, Green Computing aims to attain economic viability and improve the way computing devices are used, that is, when companies manufacture, use, and dispose of computers, servers, and other hardware in environmentally friendly ways. Practices are focused on reducing energy consumption and disposing of equipment in responsible ways, where most computers and hardware require special handling and disposable as they contain toxic substances that can contaminate soil and water if left in landfills, or pollute the air if incinerated, for example [1, 4].

Certain parts such as aluminum, iron, copper, and plastics may also be removed from the computers and hardware for reuse. Being aware of the environmentally responsible and eco-friendly use of computers and their resources. In broader terms, as an example the use of processors with more than one core in this type of architecture, provides a more intelligent use of the resource for the processing, being related also the study of designing, engineering, manufacturing, using and disposing of computing devices in a way that reduces their environmental impact [5].

Many IT manufacturers and vendors are continuously investing in designing energy-efficient computing devices, for example providing a machine with a more robust processing, and in that case, it will probably have a smarter use of that energy consumption of the machine itself. This could indicate a concern with this issue of green computing, which also leads us to the idea of reducing the use of dangerous materials and encouraging the recyclability of digital devices, that is, Green Computing is also known as green information technology IT [2, 5, 6].

The most classic example of news and related disclosure is that of the famous datacenters, which are places where companies store data. The datacenter ends up being a great environment with machines that already consume a level of energy,

and need a very large cooling level, making the energy consumption bigger. What you are looking for, in some big business moves that work with hardware, is to try to produce hardware that dispenses and requires less energy. From there, to be able to have proper use of that energy, generating less heat and contributing to this issue of green computing, such practices include the implementation of energy-efficient central processing units (CPUs), servers and peripherals as well as reduced resource consumption and proper disposal of electronic waste (e-waste), that is, a computing that does not require so much of the environment and that does not "pollute" so much [7, 8].

In view of the reality of the disadvantages of IT resources, Green IT arises, aiming to eradicate or reduce the damages caused by IT resources to the environment while maintaining its advantages, with applicability both in the level of production of these resources, the which have a better adaptation to the context that is being computerized and how best to manage these resources [2, 4, 8].

Based on this, the present chapter aims to develop a model of information transmission based on discrete event concepts for transmission channels in the cloud environments. This methodology aims to increase the speed in sending and receiving data between cloud computing systems and computers, improving the economy and better use of computational resources, consuming less computational memory during this process. Next, we will discuss the concepts of methodologies that contribute to the development of the CBEDE methodology (Coding of Bits for Entities by means of Discrete Events).

2 Cloud Computing

Green computing or green IT can be defined as the efficient use of energy for computing resources, in this way the market for cloud computing services has expended quickly during the past few years, offering compelling alternative to traditional data center operations, becoming increasingly prevalent in the business world. Cloud computing is a set of services, that is nothing more than the concept that is to deport on remote servers data processing traditionally located on local servers or on the desktop of the user. Thus, the client or organization no longer has to manage its computer room or infrastructure that is supported by a service provider [5, 9].

Cloud computing can be used as a reuse of resources, that is, when it becomes necessary to expand, there is no need to buy more infrastructure as this increases carbon emissions and electricity consumption to cool servers. In this case, all expansion to the cloud can be carried out using pre-cast resources, channeling the company's energy use for other purposes, and not requiring refrigeration components, thereby reducing the emission of harmful gases. So saving the environment and saving money that would be spent to accomplish such an expansion [10].

Cloud computing is a metaphor used by IT services companies for the delivery of computing requirements as a service to a heterogeneous community of end-recipients, being the Virtualized Computing Platform, of scalable use of computing

resources. Cloud computing is the usefulness of the offer oriented IT services to users worldwide, enabling hosting of applications from consumer, scientific and business domains. In this context, the cloud can be green. Indeed, considering the example of a small business with 15 employees or less in need of computers and the Internet to work, is certainly more interesting for this structure to select a messaging solution "in the cloud" rather than to acquire a dedicated server, the licenses that go with it and its maintenance. Virtualization is a foundational technology for deploying cloud-based infrastructure allowing a single physical server to run multiple operating systems concurrently. As an enabler of consolidation, server virtualization reduces the total physical footprint, which has inherent green benefits [10, 11].

What brings us to resource-efficiency perspective, less equipment is needed to run workloads, which proactively reduces data center space and the eventual e-waste footprint. Also related to an energy efficiency perspective, with less physical equipment plugged in, the data center will consume less electricity, resulting both in green benefits. Combined with the right skills and operational and architectural standards practiced today, automation allows IT professionals to make the most of their cloud-based infrastructure investment by pushing the limits of traditional consolidation and utilization ratios, which generates savings [11].

The higher these ratios are, the less physical infrastructure is needed, which in turn maximizes the energy and resource efficiencies from server virtualization, which also multitenancy allows many different organizations (public cloud) or many different business units within the same organization cloud) to benefit from a common cloud-based infrastructure. And combining demand patterns across many organizations and business units, the peaks and troughs of compute requirements flatten out. What combined with automation, the ratio between peak and average loads is smaller, generating even more green benefits, which in turn reduces the need for extra infrastructure. The result in turn is massive efficiencies and economies of scale in energy use and infrastructure resources [12].

Reducing carbon emissions from hundreds of tons by large US companies and around the world can be somewhat counteracted by cloud computing, which can help users avoid direct capital investments in infrastructure; improve time-to-market, since a new server can be created and placed online in minutes; Provide greater flexibility because in the cloud companies can pay for the use of extra capacity only when they need it; avoid the continued maintenance of excess capacity needed to handle peaks; and improve automation that helps you cope with process efficiencies [13].

So it is important to be aware of the fact that cloud computing consists of replacing workloads with cloud computing, or developing new workloads in a cloud-native environment, can help an IT organization directly contribute to energy-efficiency and sustainability goals, This technology can be applied to the use of data storage, networking, operating systems, and software applications. Where the increased use of cloud computing could have a positive environmental change and helping to reduce the IT industry's massive carbon emissions [14].

To reduce carbon emissions and cost, we also need to reduce energy consumption in data centers, where there are models of ecological cloud computing using different techniques to cope with the high impact of the cloud on the environment. Being that

green IT is the design, manufacture, use and disposal of computers, servers and other resources efficiently and effectively with minimal impact to the environment. This can be achieved by redesigning the network infrastructure by reducing the number of servers, switches and cables, and by using different power consumption schemes. There are new technologies that work behind cloud computing to reduce the power consumption of data centers, making cloud computing flexible and reliable. Some of these technologies deal with virtualization, scheduling, resource allocation and routing, as a result of the growth of cloud computing energy consumption decreasing terawatt hours around the world, thus making it increasingly necessary to develop new energy efficient data center that will lower the carbon footprint of clients who use it for cloud computing [15].

Cloud computing can have a positive effect on the environment, addressing this assertion is that each organization that has adopted cloud-based software has reduced its energy consumption, carbon emissions and IT resources. It can be even more efficient with distributed Internet-based cloud computing to provide all kinds of services to users via the network, such as storage, processing, resource sharing, software. The contribution of cloud to online economy has been incredible over the last few years, looking at cloud benefits in a broad perspective, it is obvious to determine that because of cloud computing today the online economy has become so dominant, causing people to save more resources. With more and more organizations going digital, huge amount of resource consumption has been prevented [16].

Cloud computing also allows your employees to work from home, allowing you to access the cloud from any corner of the world and consequently getting work from home. This means they do not have to drive to their jobs, which saves fuel and reduces carbon emissions. With employees working at home, fewer electronic devices decrease, which reduces the use of machines and power. If there is a reduction of computers and servers, there is also the reduction of refrigeration appliances, reducing the electricity used and the carbon emission [17].

We do not have anymore to drive our cars to obtain products when at a click we can order these online being delivered by our postal service. Due to the online economy, the rise of physical stores/offices has also decreased, reducing the demand on heating and lighting. In the same way, we do not have to travel nationally and globally to meet other when mobile and internet technologies have prevented physical travel, like Skype, for example. These are expensive and consume vast amounts of energy, moving to the cloud users access large data storage centers globally, that in reality consumes large volumes of power lower when offset against if every office or household had one [16]. Migrating to cloud computing may be the best way to reuse resources. The need for expansion can be converted into investment in the cloud and change the cost scenario of the company, acquiring ready or pre-molded resources that meet the need for expansion and thus stop acquiring new equipment and cooling systems, reducing the emission of gases harmful to the environment [18].

3 Green Computing

Green computing, or eco-technologies, the purpose of which is to create environmentally oriented computer technology, in which use of hazardous materials is reduced; maximizes efficiency; reduced power consumption; increases the service life of the product; there are opportunities for repair and improvement; having the main advantage of green IT brings to the business the energy saving, which helps reduce costs and free up investments to other strategic areas, contributing to its success [19].

Using computer and other ICT devices with greater efficiency and in an environmentally responsible way to reduce power and environmental waste while maintaining or improving overall performance. The concept of green IT is an expression that has been used by the technology sector to incorporate concern for the environment and sustainability, which, despite recent discussions on the subject, deal predominantly with efficient energy consumption, This can be broadened, including an environmentally sustainable approach to procurement of energy efficient ICT devices with a clear, consistent set of performance, their sensible use, reducing or eliminating environmentally sensitive materials, designing for longevity and disposal of used or unwanted electronic equipment in a convenient and environmentally responsible manner [20].

Green computing refers to environmentally sustainable computing, and it is important to evaluate other aspects such as the impact of the productive chain, the use and reuse of natural resources, equipment recycling, final waste disposal, as well as the use of architectures and processes that allow a greater useful life for the technology infrastructures, with main objective focused on save power and save environment, practical measures like manufacturing of energy efficient computing systems, change of mode of use of the systems towards saving energy (less power consumption means less burning of fossil fuels that is less green house gases to atmosphere). (The requirement of environment friendly technology for disposal and recycling—waste to wealth concept). In addition to structurally improving the company, these measures also contribute to the development of a collective environmental awareness among its different teams, which leads to a sustainability resulting in a sincere concern of all, helping to implement new sustainable measures and achieve better results [1].

In simple words, green computing is the practice of reducing environmental footprints of technology by efficiently using the resources. Broadly, and to promote green computing concepts at all possible levels, the following four approaches should be employed, which includes [20]:

- Green use, that is, using resources in such a way that reduces the use of hazardous materials, and minimizing the electricity consumption of computers and their peripheral devices and using them in an eco-friendly manner;
- Green Design, on the issue of designing objects and services that comply with the environment, such as energy-efficient computers, servers, printers, projectors and other digital devices;

- Green Disposal, i.e. recycling e-waste with no or little impact on the environment, repurposing existing equipment or appropriately disposing of, or recycling, unwanted electronic equipment;
- Green Manufacturing, which relates to the discovery and development of new products that reduces or eliminates the use or generation of hazardous substances in manufacturing, minimizing waste during the manufacturing of computers and other subsystems to reduce the environmental impact of these activities.

Many IT manufacturers and vendors are continuously investing in designing energy-efficient computing devices, reducing the use of dangerous materials and encouraging the recyclability of digital devices. Impact heavily on cost savings, being one of the major reasons why green IT has taken off among large organizations. Spending reductions on equipment, energy, and even tax breaks and other financial incentives make green computing that much more practical and attractive for companies to adopt. Regulations established to address climate change have forced businesses to change their ways and become environmentally friendly [21].

As a result, new economic opportunities exist, companies can enter the market and grow revenue and job growth by supplying or servicing energy efficient equipment, or developing green technology. The application of green computing in an organization can be applied starting from a Tactical approach, which does not modify the IT infrastructure or the internal policies, only incorporates measures of containment of excessive electrical expenses. Examples are the use of automatic monitoring of available energy in the equipment, the shutdown of the same at times of non-use, the use of fluorescent lamps and the optimization of room temperature. These measures are simple to implement and do not generate additional costs for companies [21–23].

It is also possible to start in a **Strategic approach**, where they are examples, the creation of a new infrastructure in the electrical network aiming at its greater efficiency and computational systems of lower electrical consumption (including new internal policies and measures of control of its discards). Besides the concern with the retention of electric expenses, the marketing generated by the measures adopted by the brand is also taken into account [21–23].

A **Deeper approach**, broader approach than the first two can be included, incorporating the structural design and implementation of a technology park aiming at maximizing performance with the least electric expense; this includes cooling, lighting and equipment design projects on site based on the first two previous structures (which requires a much higher cost than the first two) [21–23].

With the growing expansion of TI Verde, small and medium-sized companies started adopting such measures in the quest for sustainability with economic and environmental gains, previously followed only by large companies and corporations. The concept of Green IT also grows in society even if unconsciously, since environmental concern is a recurring subject in everyone's everyday life [20].

4 Green ICT

For most people, Green ICT is about reducing the impact of ICT on the environment, reducing the energy use of computers, servers and data centers, minimizing the negative impacts and maximize the positive impacts, used in the field as an enabler for new environmental-friendly technologies, to make other processes more efficient and thus reduce their impacts, to dematerialize atoms to bits avoiding the use of (rare) materials. It all depends on how ICT is used, in the end it means to an end, mighting even considering the whole life cycle of ICT equipment and look at the rare material use or think, develop awareness, about e-waste and recycling [24].

An example of such a thinking is the e-waste gold recycling, by using gold reclaimed from used electronics, reducing its demand for mining of gold ore, resulting in a decrease in associated environmental impacts from gold mining, such gold recovered can be used in motherboards, laptops and tablets again, being able to reduce the cost of gold from several dollars per product to a few cents per product, or even low-power communications for the Internet of Things, low power consumption improves data economics without compromising spatial coverage [12, 17, 22].

Sustainability of communication technologies is one of the main aims of today, is associated with aspect of economic, environmental, and social impact of organizations, words themselves "Information Technology" sound weightless and futuristic, perhaps leading us to misconception the IT itself is inherently efficient and green. As everything we do, however, it has an environmental impact, a lot more significant one than most people realizing, and building awareness of this is the first step to reducing that impact (service suppliers, administration, academia, enterprises etc) [12, 17, 22].

Green IT is to be taken into account in the sustainability, the environmental impacts come in much the same way the impacts from any equipment, manufacture, use and disposal, goes on to address how the use of smart technology could make many other processes more efficient. The term "Green" usually means energy efficient and environmentally friendly and sustainable means planning and investing in the technology infrastructure that serves the needs of today as well as the needs of today, while conserving resources and saving money, which moves the economy toward that thought [12, 17].

The field of "green technology" encompasses a continuously evolving group of methods and materials, from techniques for generating energy to non-toxic cleaning products, in the field of energy perhaps the most urgent issue for Green technology, this includes the development of alternative fuels, new means of generating energy and energy efficience. Currently there is Green nanotechnology, involving the manipulation of materials at the scale of the nanometer, or even one billionth of a meter. Scientists believe that mastery of this subject is forthcoming that will transform the way that everything in the world is manufactured, that is, is the application of green chemistry and green engineering principles to this field [25].

Green ICT is what manufacturers, specialists, analysts and providers call all ICT solutions that save energy, including hardware, software and services, its contribution

to global CO2 emissions as already mentioned, furthermore, the ICT sector depends on the extraction of essential and valuable metals, in which they condiz at the other end of their life cycles, vast quantities of ICTs become highly specialized waste that includes environmentally hazardous metals like lead, mercury and cadmium, as well as toxic flame retardants and plastics. It does not mean that ICT systems can enhance business performance through complete system and enterprise integration, embracing the 'Smart Green Building' concept that saves energy, safeguards the environment as well as impacts the profitability of the organization, might include energy efficient microprocessors, efficient batteries, controllers and sensors for 'smart' products, energy efficient servers and PCs, smart grids and solar cells. In this way, the goal of Green Information and Communications Technology (ICT) is all about reducing the use of energy, carbon emissions, waste, materials and space while improving process efficiency and saving Money [19, 23].

5 Discrete Events

Discrete Events, usually called by the abbreviation DES, is an effective tool to approach a wide variety of communication issues, is based on the assumption that the state of the simulation changes at discrete-time intervals, that is, is a proper method for modeling complex environments, which have a lot of interactions between the modeled objects, is a proper method for modeling complex environments, which have a lot of interactions between the modeled objects. The discrete events are used to relate to a model that represents a system as a sequence of operations performed on entities (transactions) of certain types such as data packets, bits, among others [26].

The discrete events are derived from the results of actions taken in a system, and can be classified as an occurrence responsible for the change in the state of the system in which they act, and may be of all kinds, where they are generally capable of producing state changes at random intervals of time, generating data and consequently the information. The universe of actions that provide events is subjective and depends on the ability of the modeler to abstract the events which the system is being modeled. These entities are discrete in a discrete event simulation, where this technique has been used to model concepts with a high level of abstraction, ranging from the exchange of emails on a server to transmission of data packets between devices connected in a network, i.e., the entire extent of a communication system [26, 27].

The Fig. 1 shows the relation of events over time, with respect to being generated along it, also illustrated that each event (t0, t1, t2 …tn) is related to some respective point in time. In this way, the diversity of applications that the discrete events technique provides, showing its importance in several areas of knowledge, as well as in engineering (area of the proposal of this chapter), was remarkable, being able to apply it in a telecommunication system, more specifically in the transmission of data in a channel [28].

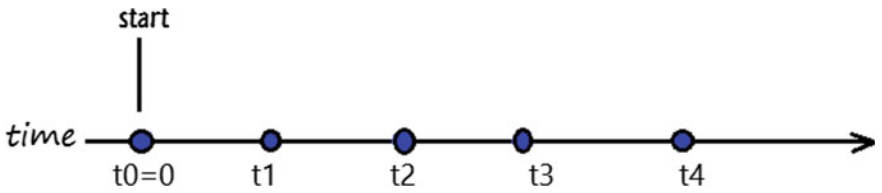


Fig. 1 Events × Time

5.1 Entities

Entities are defined as discrete items of interest in a discrete event simulation, however, the meaning of an entity depends on what is modeled, and the type of system used. This relation occurs because the presence of certain attributes may be able to affect the way events are treated or cause changes the entity flows through the process, being important to emphasize that the concepts entities and events are different. Events are instantaneous discrete incidents that can change a state variable, an output, and/or an occurrence from another event. In its turn, an entity is somewhat dependent on what is modeled and the type of system, thus the characteristic of a discrete event indicates that something (eg, an accident, an earthquake, a fault, a control, a person, a heartbeat, or any other desirable concept within a system) occurred, that is, an event is a conceptual notation that denotes a state change in a system [29].

5.2 AWGN Channel

The communication channel is the medium responsible for providing the physical connection between transmitters and receivers in a communication system, whether it is the wire or for a logical connection in a multiplexed medium, or even the radio channel in telecommunications networks and computers. Transporting data typically in two types of media: physical (twisted pair and fiber optic cable) and electromagnetic (microwave, satellite, radio, and infrared) [30]. A widely used model applicable to a large set of physical channels is the Additive White Gaussian Noise (AWGN) channel model, and such a model has the characteristic of introducing a statistically modeled noise, such as a white Gaussian additive process, into the transmitted signals. However, even the existence of disturbances as well as the noise in the channel (free space/atmosphere) can have multiple causes, modeled on such existent imperfections, naturally by the channel AWGN, being one of them the thermal noise by the virtue of the movement of the electrons in the electronic circuit used for transmission and in turn, in the reception of this signal [30].

5.3 DPSK and PSK

Differential Phase Shift Keying (DPSK) is a modulation scheme that facilitates non-coherent demodulation, however, PSK (Phase Shift Keying) modulation generally requires only a coherent demodulation. This coherent demodulation is related to the carrier, which is modulated to obtain the signal in the passband, this signal is then reproduced at the receiver and subsequently used for demodulation in the passband. When the same carrier frequency is used, the noisy demodulated signal is generated, resulting in a laborious process for the receiver to generate the received carrier [29].

Already in DPSK modulation, there is the modification of the transmissions allowing that each transmitted signal depends on the previous one. In this way, the demodulation of this signal is dependent on the signal received in the previous time period, and can be used as the local carrier. Such equality leads to the cancellation of the signals, allowing their demodulation, in a simpler and more effective way. Accordingly, the phase of that modulated signal is shifted relative to the phase of the previous signal [29, 31].

In DBPSK (Differential Binary Phase Shift Keying) modulation, the signal can be differentiated by encoding the data by similarity or by the difference of the symbols in relation to the previous signal, determined by the presence of bit 1 and bit 0, what eliminates phase ambiguity and the need for phase acquisition and tracking, resulting in reduced energy consumption, thus the non-coherent way is used to solve the coherent reference signal at the receiver and thus the input binary sequence is first differentially encoded and then modulated. Where in his demodulation, there is no need to know the initial state of the bit, simplifying synchronization [29, 31].

This modulation scheme is widely used in wireless LAN, as well as in most of the adaptive modulation technique adopted in cellular communication, CDMA, WiMAX (16d, 16e), WLAN 11a, 11b, 11g, 11n, Satellite, DVB, etc., due to the difference of 180 degrees between two constellation points, withstand the severe amount of channel conditions or channel fading. These modulations are used by most of the cellular towers for long distance communication or transmission of the data, and their demodulator requires only two decisions in order to recover the original binary information [29].

5.4 Rayleigh Fading

The wireless mobile channel refers to wireless communication and devices that are based on radio frequencies, where the communication path is mobile at both ends, being the channel modeled by a random attenuation (fading) of the transmitted signal, followed by additive noise. Such channel is susceptible to several types of impediments such as multipath, fading, shadowing, noise, among other interferences, where these deficiencies can cause huge degradation in system performance. These variations are classified into two types large-scale variations and small-scale variations [32].

Variations in the received signal are only noticed when observed on a large scale, that is, when the signals travel long distances or long periods of time, so this type of variation is called large scale, thus, the increment or decrement of the distance between the base unit and the mobile unit is called the long term. The variation is determined by loss in the course, being directly related to the distance and the frequency of its propagation, presenting linear variation, expressed in dB (decibels), having main effects of large scale fading are signal power losses in free space and obstruction signal shadowing, being the latter affects the signal, mainly due to the presence of irregularities in land, buildings, vehicles and the presence of trees during the course; and small-scale variations are also called short-term and fast-fading. Such variations can be observed at distances of few wavelengths [32, 33].

In cases where there is no line of sight, the behavior of fast fading is best represented by the Rayleigh distribution, being an ideal model for large urban centers, these areas have a large extension of buildings. Because the number of buildings is a quantity that is indirectly proportional to the quality of the signal transmission, because the larger the number of buildings, the greater the number of physical barriers to signal propagation, which leads to a decrease in the quality of information transmission. The distributions described above are used to describe the level of the received signal, which in turn can be affected by three factors: (1) a fading channel, (2) depending on its temporal variation, (3) and/or the amplitude of its individual multipath components. They are propagated through space, where they suffer interferences such as reflection, dispersion, attenuation, etc. Thus, for this type of transmission, efficient modulation of carrier frequency data is required [32–34].

6 Methodology

The development of this methodology was performed in a computer with hardware configuration being an Intel Core i3 processor, containing two processing cores, Intel Hyper-Threading Technology, and 4GB RAM. To provide enhancements in cloud environments, the present study implements a model CBEDE applied to a communication system, and advanced modulation format DBPSK (Differential Binary Phase Shift Keying) and with Rayleigh fading, in a simulation environment, the Simulink simulation environment of the MATLAB software, improving the transmission of data, through a pre-coding process of bits applying discrete events in the signal before of the modulation process.

The experiments were conducted through the Simulink tool, from Matlab (2014a). This simulation environment was chosen because it is already consolidated in the scientific medium, having a development and simulation environment already tested and validated. DBPSK modulation was chosen in this study, because are considered the most robust of modulation schemes in terms of noise immunity, is less immune to the interference, allowing the highest level of distortion in the signal being still successfully demodulated.

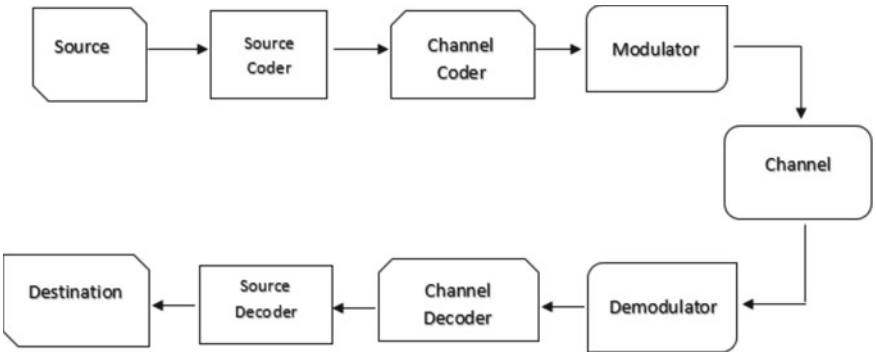


Fig. 2 Traditional model of a telecommunication system

Table 1 Parameters channel models DBPSK Rayleigh

Parameter	Value
Sample time	1 s
Simulation time	10000 s
Eb/N0	0 a 30 dB
Symbol period	1 s
Input signal power	1 W
Initial seed in the generator	37
Initial seed on the channel	**67**

Four libraries were used: (1) Communications System, which is designed to design, simulate and analyze systems, being able to model dynamic communication systems; (2) the DSP System™ that is capable of designing and simulating systems with signal processing; (3) Simulink, which is a block diagram environment for multi-domain simulation, capable of supporting system-level projects for the modeling and simulation of telecommunication systems, and (4) the library SimEvents®, which is classified as a discrete event simulation mechanism and components to develop systems models oriented to specific events. In this way, the proposed methodology is based on the development of an AWGN hybrid channel, characterized by the introduction of the discrete event technique in the bit generation process, focusing on both bits 1 and 0.

In the proposed model, Fig. 2, the signals corresponding to bits 0 and 1 will be generated and modulated with the advanced modulation format DBPSK, which will use the phase shift, coming from the modulation format itself. It will then proceed to an AWGN channel according to the parameters shown in Table 1. The signal will then be demodulated to perform the Bit Error Rate (BER) calculation of the channel. The values obtained for BER will be sent to the Matlab workspace, for equality verification and generation of the signal BER graph.

The modeling according to the proposal implemented with discrete events is similar to the one presented previously, differentiating that in this model by the addition of discrete events in the pre-coding phase. The proposed bit precoding was

Fig. 3 Proposed bit precoding

implemented through the discrete event methodology. Bit processing is understood as the discrete event methodology in the step of generating signal bits (information) to make it more appropriate for a specific application.

The event-based signal is a signal susceptible to treatment by the SimEvents library, and posteriorly passed by conversion to the specific format required for manipulation by the Simulink library. Both time-based signals and event-based signals were in the time domain. This treatment had an emphasis on bits 1 and 0, which were generated as a discrete entity and followed the parameters as presented in Table 1. Then, Entity Sink® represents the end of the modeling of discrete events by SimEvents library. This tool is responsible for marking the specific point in which Entity Sink will be located, where later the event-based signal conversion will be performed for a time-based signal. This time-based signal was converted to a specific type that followed the desired output data parameter, an integer, the bit. By means of the RealWorld Value (RWV) function, the actual value of the input signal was preserved. Then a rounding was performed with the floor function. This function is responsible for rounding the values to the nearest smallest integer.

Also used to a Zero-Order Hold (ZOH) which is responsible for defining sampling in a practical sense, being used for discrete samples at regular intervals [35]. The ZOH describe the effect of converting a signal to the time domain, causing its reconstruction and maintaining each sample value for a specific time interval. The treatment logic on bits 1 and 0 is shown in Fig. 3.

Subsequently, the signal is modulated with the advanced modulation format DBPSK and passing through a Rayleigh fading channel, having multipath, with Jakes model having Doppler shift set at 0.01. It will also be employed a mathematical function 1/u, having importance for the modeling of mobile channels with fading and multipath. This function will be employed to track the channel time variability, where the receiver implementation usually incorporates an automatic gain control (AGC). It will then follow an AWGN channel, according to the same parameters specified in Table 01. The signal will be demodulated to evaluate the bit error rate (BER) of the channel, as shown in Fig. 4.

In the proposed model, Figs. 2 and 4, the signals corresponding to bits 0 and 1 will be generated, respecting the rule and mathematical logic shown in Fig. 5. This rule and mathematical logic with respect to PSK M-ary numbers generate randomly distributed integers in the interval [0, M−1], where M is the definition for bit representation, following the nomenclature of the MATLAB software. Figure 6 shows the respective generation of the bits by means of this logic. The models shown in Figs. 2 and 4 run with 10000 s of simulation and will respect the configuration defined according to Table 1.

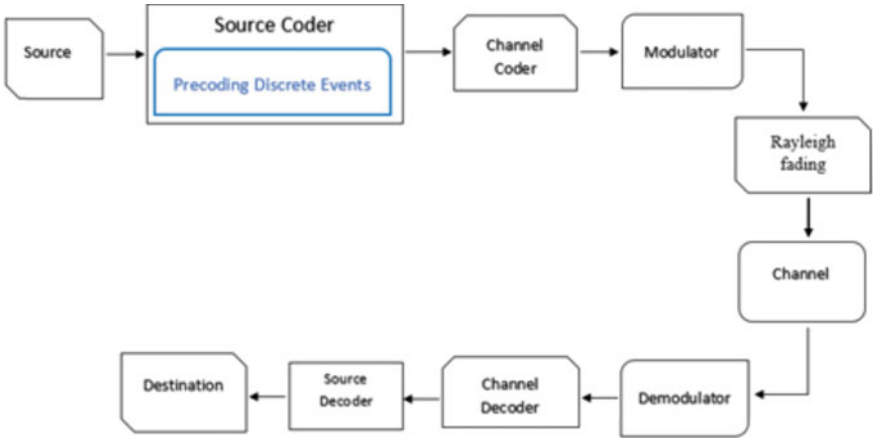
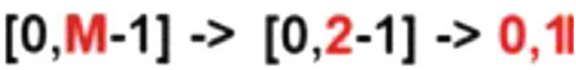


Fig. 4 Model of a telecommunication system with the proposal and Rayleigh Fading

Fig. 5 Generation M-ary numbers for bits 0 and 1



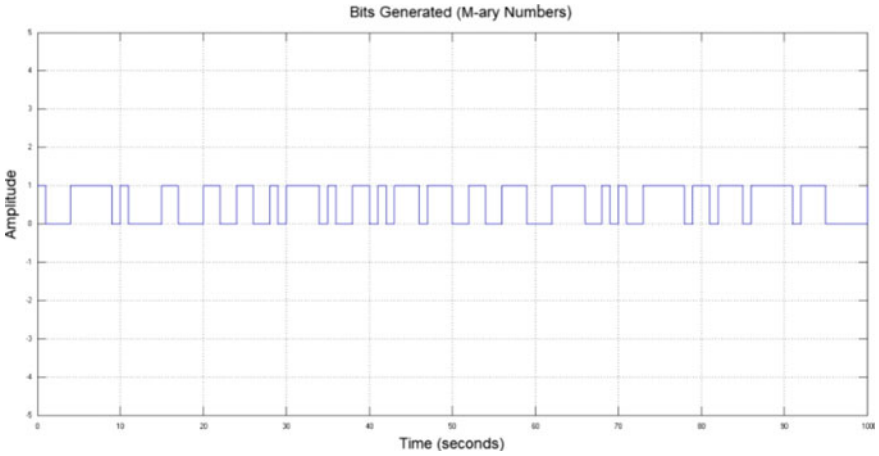


Fig. 6 Traditional model of a telecommunication system

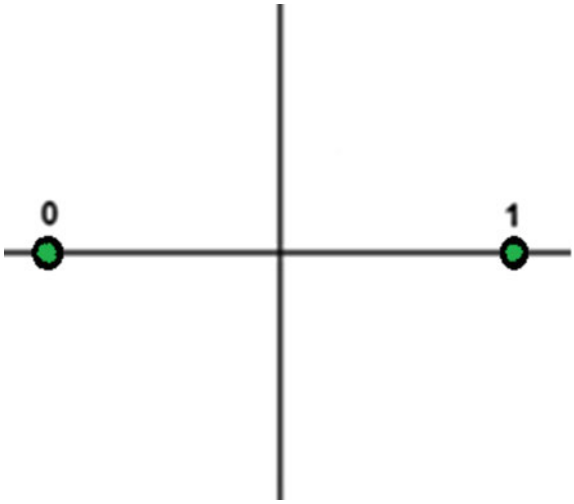


Fig. 7 Theoretical DBPSK constellation

The verification of equality of the signals is performed through the "size" and "isequal" functions of the Matlab software, as well as through the bit error rate (BER). These functions are responsible for the mathematical comparison proving that the signals have the same size and the same size. Together with the BER check, it will state that the same amount of information will be transmitted (bits) in both the proposed methodology (hybrid AWGN channel) and the conventional methodology (AWGN channel). Thus, if the signals are of the same size and size, the logical value 1 (true) is returned and the same volume of data is transmitted, indicating that the equality of the signals is true. Otherwise, the value will be 0 (false). This check will show that the submitted proposal does not add or remove information to the originally transmitted signal.

The constellation has as function to analyze both signals transmitted by the models. In the case of the DBPSK constellation, a phase represents the binary 1 and the other phase represents the binary 0. As the digital input signal changes its state, the output signal phase will be changed between two angles separated by 180° [29]. This validation methodology has as function to affirm that the proposal will not modify the amount of bits transmitted by the signal, since both signals transmitted in the conventional channel and in the channel containing the proposal of this study, will be of the same size. In Fig. 7 the DBPSK constellation diagram.

7 Results and Discussion

The research presented in this section shows an AWGN transmission channel with DBPSK modulation, being used the Simulink simulation environment of the MATLAB. The model from Fig. 8 incorporates the traditional method (left) and the pro-

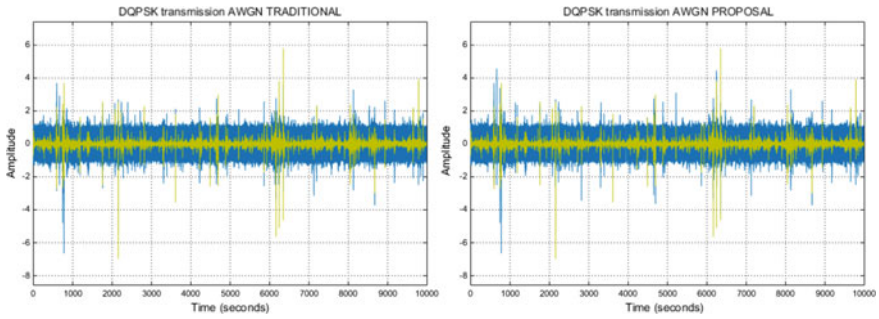


Fig. 8 Transmission flow for DBPSK Rayleigh

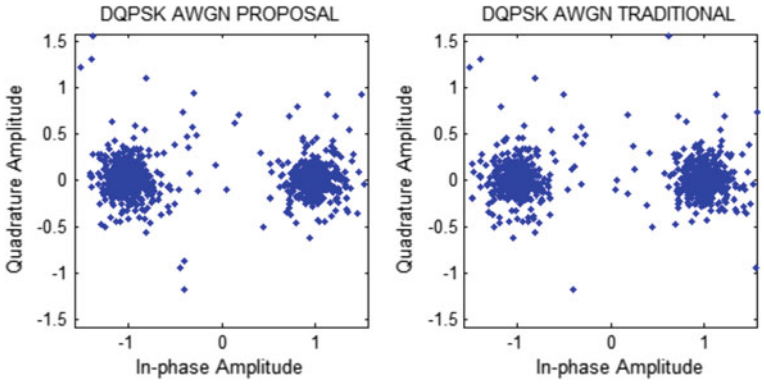


Fig. 9 Simulated DBPSK constellations Rayleigh

posed innovation of this chapter (right) is presented, showing the signal transmission flow (corresponding to bits 0 and 1), being generated and then modulated in DBPSK, passing through the channel AWGN. The Fig. 9 display the constellations for 9 dB for the proposed (left) and the traditional methods (right).

The models developed were investigated from the perspective of memory consumption evaluation. The first simulation of both models in each command is analyzed, since it is in the first simulation that the construction of the model in a virtual environment is performed from scratch, it is in it where all the variables of the model are allocated, the memory of the operating system in which the MATLAB is running is reserved for the execution of the model and the results of this model, according to the evaluation parameters are, in fact, real.

Thus, the experiments considered the memory consumption. For memory calculation, the "sldiagnostics" function will be used, where the "TotalMemory" variable will receive the sum of all the memory consumption processes used in the model, by the "Process MemUsage" parameter [36]. This parameter counting the amount of memory used in each process, throughout the simulation, returning the total in MB (megabyte). For this was used a computer with hardware configuration being

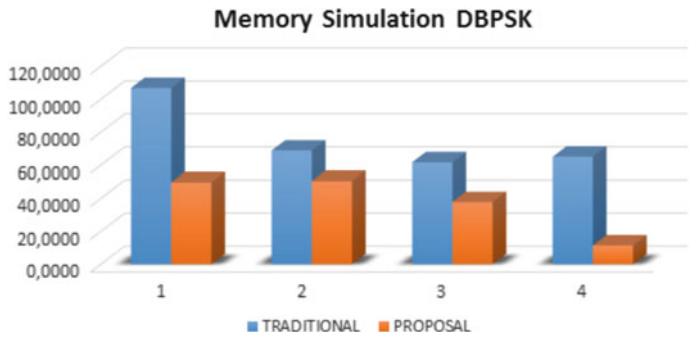


Fig. 10 First simulations (memory) model DBPSK Rayleigh

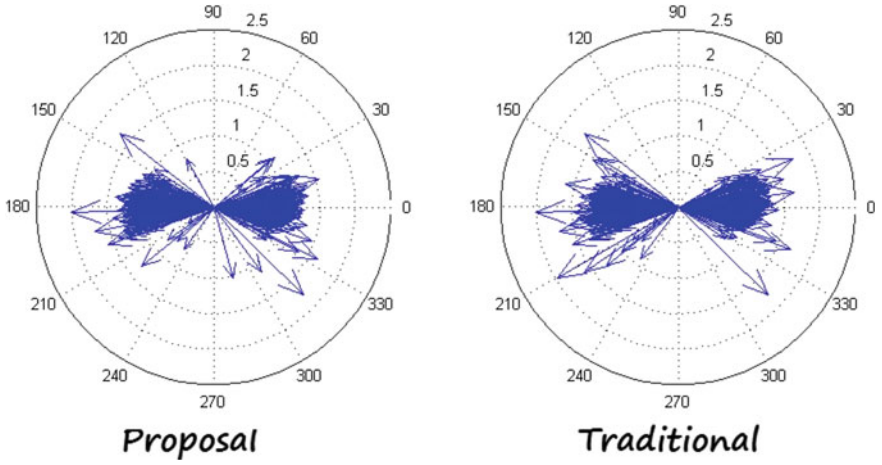


Fig. 11 DBPSK constellation Rayleigh

an Intel Core i3 processor, as previously described, because it relates the proposal to the dynamics of the real world and will affirm its efficiency and applicability.

For this, physical machines with hardware configuration were used, as previously discussed. The experiments were carried out through 4 simulations of each model developed in order to develop the analysis of this chapter, as shown in Fig. 10.

The results obtained by the "size" and "isequal" functions, the DQPSK modulation were analyzed through its constellation, by means of the "compass" function, which will display a compass graph with n arrows, and how the constellations will be PSKs, their representations of points will be radial. This feature, the graph format has a compass shape, where n is the number of elements in Z. The location of the base of each arrow will be its origin. In turn, the location of the tip of each arrow will be determined by the real and imaginary components of Z, relative to the constellation of the signal. In the same way and with the same intention will be used the diagram of the constellation.

Table 2 Amounts of memory consumption

Simulation	Traditional	Proposal
1	106.7930	49.6055
2	68.8086	50.4453
3	61.6016	37.7930
4	64.9961	11.4727

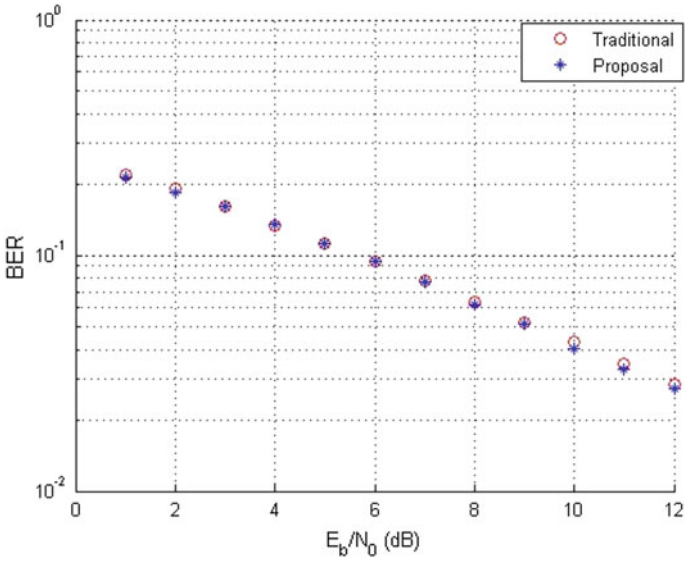


Fig. 12 BER between the models DBPSK Rayleigh

In the Fig. 11 is shown the comparative between a traditional methodology and the CBEDE methodology, both simulated with 30 dB. In this context, the traditional methodology corresponds to a channel without discrete events. As important as developing the methodology is an improvement of the transmission of a signal that shows better performance, is to make the know-how available to the academic community, as well as to contribute to the area of study of the proposal as well as the theme that this chapter deals with.

The respective amounts of memory consumption shown in Fig. 10 are found previously are in Table 2.

To analyze the relationship between the simulation methodology (proposed × traditional method), and the impact on the physical layer of the channel, scripts were made in the MATLAB for processing of the graph BER. Figure 12 display the performance of the models during transmission with noise ranging from 0 to 12 dB.

This proposal brings a new approach to signal transmission. In this case, the transmission is performed in the discrete domain with the implementation of discrete entities in the bit generation process.

In this way it is possible to increase the capacity of information transmission for communication systems, making the use of computing in the transmission of data for both end users and organizations more sustainable and less harmful. Given the above, the technique of discrete events can be applied in the treatment of bits in its generation stage, being responsible for their conversion into discrete entities, being its result the use and application in a lower level of application, which acts on the physical layer, which is already an important parameter to meet the needs of an increasingly technological world, and which requires sustainable techniques and methodologies that enhance existing technologies without the addition of new features.

Considering that speed is a key issue when choosing methodology, whether it is used by a user, companies or universities, CBEDE methodology can be seen as a great allied to green computing systems, since it increases the efficiency and the performance of the transmission of the data in a system, reduces the need for additional installations, and also collaborates and promotes increased productivity, as it works on reusing existing resources and enhancing them. Where even if the cloud has a large storage capacity, the user always cares about the time it takes to upload or download your data. For this, it is important to invest in systems that intermediate the cloud computing systems with green consciousness.

Since Cloud Computing is closely tied to Green Computing, because it transfers to the cloud saves substantial amount of energy, cloud computing consists of replacing regular servers with the virtual ones, and cloud computing can be applied to the use of data storage, networking, operating systems, and software applications. And so touching Green ICT, since its guideline for communications, networking and data processing, is about reducing the impact of ICT on the environment, reducing the energy use of computers, servers and data centers. And with the result reaching up to 115.28% in the improvement of memory of the CBEDE methodology can be employed in this process, since the amount of data of the user greater is the concern with the speed of the transmission.

Another important factor when it comes to data transmission is the memory consumption of the device, because currently, the cloud computing system is directly linked to computers and mobile phones. It is well known, the use of cell phones today is much larger than that of a computer due to its mobility. And even considering that since Green Computing corresponds, in simple terms, to the use of Information Technology with applicability of the concept of Sustainable Development, not limited only to business environments, but expanding to public, university and other organizations. Ordinary users they tend to upload documents, images, and videos for the purpose of sharing their common social network, or even save their personal files (docx, pdf, avi, jpg, among others) in their “personal cloud”. The slowness related to the speed of communication and the cloud technology implemented in the system structure used by these users, can often generate device crashes, inconvenience to the user and sometimes even loss of data, if these are in real time.

The need for methodologies that make sustainable development available should become a reality because it generates benefits such as resource savings, importance to the environment, and reflects in a sustainable return, whether a company and in that context, of greater interest on the part of investors. Thus, in order to generate greater reliability, the CBEDE methodology can also be seen as a great ally, because the experiments demonstrate lower reaching up to 115.28% memory consumption in data transmission, being better than the traditional methodologies, which do not require the use of discrete events.

8 Future Research Directions

Future work on the CBEDE methodology includes simulations with respect to performance on a wider variety of hardware and processors, with addition in testing the data transmission via mobile devices, due to its greater popularization in recent years, which also intended to conduct even more data transmission tests with cloud computing platforms with deeper orientation in green computing and related.

9 Conclusion

Being the differential of this research, the use of discrete events applied in the physical layer of a transmission medium, the bit itself, being this a low-level of abstraction, the results show better computational performance related to memory utilization related to the compression of the information, showing an improvement of 115.28%. This demonstrates that the CBEDE presented in this chapter has great potential in the improvement of the communication services potential oriented to Green Cloud Computing and Green ICT, with the possibility to improve already existing processes to increase the performance of communication response between all the devices in the system and in the green cloud environment, with respect to the flow of data will consume fewer resources and, therefore, can improve the interactions between the users, generating improvement of resources, as well as economy of the same, since it uses the same structure already available and thus resulting in sustainability. The objective of this research is in the use of discrete events being applied to the lowest level of abstraction possible within the communication system, as is done in bit generation, and as a result make the green cloud environment more productive, faster, more sustainable, and with better performance. In this way, information compression is a byproduct, since the proposal acts on the bits, having a substantial impact on the compression methods performed in higher layers within a communication system (here cited by example, format types such as HEVC, MPEG- 4 AVC/H.264, JPG, PNG, among several others), affecting all media information (data of the most varied types) that can be transmitted, resulting in a higher quality of both sending and receiving.

References

1. Porter ME, Van der Linde C (1995) Toward a new conception of the environment competitiveness relationship. J Econ Perspect 9(4):97–118
2. Brunnermeier SB, Cohen MA (2003) Determinants of environmental innovation in US manufacturing industries. J Environ Econ Manag 45(2):278–293
3. Molla A, Abareshi A (2011) Green IT adoption: a motivational perspective. In: PACIS
4. Kijpokin K (2018) Cloud computing, green computing, and green ICT. Cloud computing technologies for green enterprises, IGI Global, pp 28–50
5. Ahmad I, Ranka S (2016) Handbook of energy-aware and green computing- volume. Chapman and Hall/CRC, Boca Raton
6. Kharchenko V, Kondratenko Y, Kacprzyk J (2017) Green IT engineering: components, networks and systems implementation. Springer International Publishing, Berlin
7. Schulz G (2016) The green and virtual data center. Auerbach Publications, Boca Raton
8. Stimmel CL (2016) Big data analytics strategies for the smart grid. Auerbach Publications, Boca Raton
9. Huo R, Yu FR, Huang T, Xie R, Liu J, Leung VC, Liu Y (2016) Software defined networking, caching, and computing for green wireless networks. IEEE Commun Mag 54(11):185–193
10. Chang V (2015) A proposed cloud computing business framework. Nova Science Publisher, New York
11. Marinescu DC (2017) Cloud computing: theory and practice. Morgan Kaufmann, Burlington
12. Agarwal S, Ghosh A, Nath A (2016) Green enterprise computing approaches towards a greener IT. Int J Innov Res Adv Eng (IJIRAE)
13. Rittinghouse John W, Ransome James F (2016) Cloud computing: implementation, management, and security. CRC Press, Boca Raton
14. Garg SK, Versteeg S, Buyya R (2013) A framework for ranking of cloud computing services. Future Gener Comput Syst 29(4):1012–1023
15. Chien AA, Wolski R, Yang F (2015) Zero-carbon cloud: a volatile resource for high-performance computing. In: 2015 IEEE international conference on computer and information technology; ubiquitous computing and communications; dependable, autonomic and secure computing; pervasive intelligence and computing
16. Thakur S, Chaurasia A (2016) Towards green cloud computing: impact of carbon footprint on environment. In: 2016 6th international conference-cloud system and big data engineering (Confluence)
17. Schwab K (2017) The fourth industrial revolution. Currency
18. Schneider S, Sunyaev A (2016) Determinant factors of cloud-sourcing decisions: reflecting on the IT outsourcing literature in the era of cloud computing. J Inf Technol 31(1):1–31
19. Lee K-H, Min B (2015) Green R and D for eco-innovation and its impact on carbon emissions and firm performance. J Clean Prod 108:534–542
20. Calza F, Parmentola A, Tutore I (2017) Types of green innovations: Ways of implementation in a non-green industry. Sustainability 9(8):1–16
21. Rao T, Narayana V et al (2015) Sustainable environment friendly green computing for futuristic technologies. J Inf Sci Comput Technol 2(1):128–132
22. Asabere NY, Acakpovi A, Quaynor N (2016) Encouraging Green ICT implementation strategies in polytechnic education in Ghana. Int J Appl Inf Syst (IJAIS) 10(6):14–21
23. Frick T (2016) Designing for sustainability: a guide to building greener digital products and services. O'Reilly Media, Inc, Newton
24. Segars Albert H (2018) Seven technologies remaking the world. MIT Sloan Management Review, Executive Guide
25. Ramdhani MA et al (2017) Model of green technology adaptation in small and medium-sized tannery industry. J Eng Appl Sci 12(4):954–962
26. Brito T, Trevisan EFC, Booter RC (2011) A conceptual comparison between discrete and continuous simulation to motivate the hybrid simulation technology. In: Proceedings of the 2011 winter simulation conference, pp 3915–3927

27. Chahal K, Eldabi T (2010) A multi-perspective comparison between system dynamics and discrete event simulation. J Bus Inf Syst 6(1):4–17
28. Padilha R (2018) Proposta de Um Metodo Complementar de Compressao de Dados Por Meio da Metodologia de Eventos Discretos Aplicada Em Um Baixo Nivel de Abstracao. Dissertacao (Mestrado em Engenharia Eletrica) - Faculdade de Engenharia Eletrica e de Computacao, Universidade Estadual de Campinas. Campinas, SP - Brasil
29. Tozer EP (2012) Broadcast engineer's reference book, 1st Edn. Focal Press, Waltham
30. Rama Krishna A, Chakravarthy ASN, Sastry ASCS (2016) Variable modulation schemes for AWGN channel based device to device communication. Indian J Sci Technol 9(20)
31. Couch LW II (2013) Digital and analog communication systems, 8th edn. Prentice Hall, Upper Saddle River
32. Ling Sylvia Ong Ai et al (2017) A review on cooperative diversity techniques bypassing channel estimation 10(1):3777–3783
33. Giordano AA, Levesque AH (2015) Digital communications BER performance in AWGN (BPSK in Fading), Wiley Press, New York
34. Bhat SA, Singh A (2017) Review on effective image communication models. Aust J Basic Appl Sci 11(8):11–65
35. Dragotti PL, Vetterli M, T. Blu (2007) Sampling moments and reconstructing signals of finite rate of innovation: shannon meets strang-fix. IEEE Trans Signal Process 55(5):1741–1757
36. MATLAB and Simulink Release (2014a) The MathWorks Inc. Natick, Massachusetts, United States

Green ICT Communication, Networking and Data Processing

M. Adimoolam, A. John, N. M. Balamurugan, and T. Ananth Kumar

Abstract Green ICT is the Green Information Technology or Green computing and it is required for keeping the Harmless Green Environment even when people are using Electronic computable and storage devices for various purposes tremendously. Finally, the green computing is about reducing the energy usage in communication, networking and, data processing devices and various servers. The communication, networking and data processing devices are the major components which use high energy for its operation. So here comes the time to choose green energy efficient devices for communication, networking and data processing. The application area like video surveillance communication, clustering networks spends lots of energy to do its work. Again, to add up secure communication, it is spending considerably more energy for encryption and decryption processing. The Wireless Sensor Network (WSN) is aided with tremendous technological growth and it is widely used in many applications like Border Monitoring System (BMS), Forest Monitoring System (FMS), Ocean Monitoring System (OMS), Critical Response System (CRS), etc. Generally, in all the surveillance systems the sensor nodes capture the data and send them to the Storage Node (SN) for further processing. The foremost challenges faced by all these WSN applications are formulating Green Communication and Networking (an efficient clustering technique) to handle the group of the sensor nodes and also to ensure secured data transmission. These adverse consequences lead to the challenges which are high energy consumption, more bandwidth utilization, wastage

M. Adimoolam
Department of Computer Science and Engineering, Saveetha School of Engineering, Chennai, India

A. John (✉)
School of Computer Science, Galgotias University, Greater Noida, Uttar Pradesh, India
e-mail: johnmtech@gmail.com

N. M. Balamurugan
Department of Computer Science and Engineering, Sri Venkateswara College of Engineering, Chennai, India

T. Ananth Kumar
Department of Electronics and Communication Engineering, IFET College of Engineering, Kengarampalayam, Tamil Nadu, India

B. Balusamy et al. (eds.), *Green Computing in Smart Cities: Simulation and Techniques*,
Green Energy and Technology, https://doi.org/10.1007/978-3-030-48141-4_6

of memory in SNs and unsecured data transmission (challenge to the Green environment). The main objective of this chapter is to provide solutions to the challenges listed above thereby assuring the Green environment suitable (efficient, effective and secured) data transmission, networking and data processing in the WSN applications. This chapter includes choosing a Green energy efficient clustering technique, providing good cryptography algorithm and eliminating redundant data. There are so many clustering techniques adapted in WSN such as Low Energy Adaptive Clustering Hierarchy (LEACH), Hierarchical Clustering Control (HCC), Energy Efficient Unequal Clustering (EEUC), Power Efficient and Adaptive Clustering (PEACH), and Scalable Energy Efficient Clustering Hierarchy Protocol (SEECH) clustering techniques. The applications mainly focused are BMS and FMS to reduce the energy. The impact of the clustering parameters is studied in detail and based on this study the LEACH clustering technique is used to fulfill the needs of a good cluster. The clustering parameter values used in LEACH are: clustering type is dynamic, Cluster Head (CH) count is variable, CH selection is randomized, CH mobility is fixed and finally the CH hop distance is one hop distance. The performance of LEACH is studied. Also, it is compared with EEUC, HCC, and PEACH clustering techniques. To address the challenge of secured data transmission in the WSN the cryptographic algorithms are studied. The Private Key Cryptography algorithms such as the Data Encryption Standard (DES), Advanced Encryption Standard (AES), Rivest Cipher 4 (RC4), Triple DES and Blowfish algorithms are implemented and compared. The cryptographic algorithms are compared with the data size ranging from 20 KB to 100 KB and the experimental results show that the Blowfish algorithm takes comparatively less time for encryption and decryption processes in WSN data transmission and it is very much suitable for green computing environment. The other biggest challenge in WSN is data redundancy as the sensor node captures the video data and sends it continuously to the SN without eliminating the redundant data. This causes more energy consumption and bandwidth utilization in data transmission and may not be advisable for green environment, also more storage space is wasted in SN. The literature review shows that in most of the WSN applications the redundant data are handled only at the SN. But this chapter works a novel algorithm called, Green environment suitable Intelligent Duplicate Check Algorithm (IDCA) is proposed to make the sensor node intelligent by not transmitting the redundant data. So, the sensor node is made intelligent to identify the redundant data in the system before data transmission. To implement this proposed IDCA, the surveillance video data set is taken from different sources. The OpenCV package in python is used to execute this algorithm. Thus, this chapter provides energy efficient and secured data transmission model for WSN applications by using the LEACH clustering technique to form clustered WSN with blowfish cryptographic algorithm for secured data transmission and also making the WSN's sensor nodes intelligent with a novel IDCA.

1 Introduction About Green Energy and WSN

As newer and newer technologies come into wireless communication, there are tremendous demands on the WSN application and sometimes the consumption of energy for the activities of WSN is more. So it is necessary to find the green computing on WSN to reduce the Energy on communication, networking and data processing. WSNs consist of sensors, transmission medium, and sink node. A WSN is a kind of network in which sensors sense the environment and then the sensed data is sent to sink node through wireless transmission medium for further processing. The major applications of the WSN are the surveillance systems. The cooperative effects of such surveillance applications are sensing, tracking and alerting the networks which facilitate the tasks of monitoring, controlling and tracking activities about hostile environment. In recent decades, WSNs have been used in latent areas such as FMS for rare animal activity monitoring, OMS to monitor species activity, BMS for unauthenticated people crossing surveillance, real world navigation system, natural disaster monitoring system, and battlefield surveillance system. Such applications generate tremendous amount of data in the form of analog or digital data like images and videos. These data are being communicated over transmission lines and the same are stored in the sink node for further analysis either by automated or manual process and these processes consume more energy if we are not introduced to suitable less energy consuming mechanism and techniques.

2 Green Energy Efficient Clustering Data Transmission Model

2.1 Introduction

In real world many applications use the WSN to process the spatiotemporal data for surveillance and monitoring systems. In such an application the WSN sensors are scattered widely in geospatial environment for data collection as per the application specific needs. The important constraint in WSN is energy which could be majorly consumed for data transmission as every individual sensor node sends data to SNs or sink node. If every sensor sends directly to the sink node, then the amount of energy consumption by all sensors is directly proportional to the sum of the energy consumption for each and every sensor for data transmission alone. Such network is also called Flat WSN, which is not hierarchically organised well and also reason for much energy consumption is unorganized sensors in some orders and not clustered groups of sensors for data collection and sensors for data transmission. Now there are many clustering techniques being proposed for application specific purposes in WSN with the aim of organising sensors into clusters which are able to reduce the energy for data transmission considerably lesser than flat WSN energy usage and it makes green energy efficient mechanism.

2.2 Green Efficient Clustering Techniques

Clustering is the organizing of sensors in the network into groups of sensors or clustered sensors as region where a number of sensors is available. Then among clustered sensors one sensor is identified as CH and the remaining sensors are able to sense their surrounding and collect the data, then instead of sending data directly to sink node, it sends the data to CH. Now CH will send the received data from all sensors in that cluster region to the sink node. The advantage of this clustering technique is the energy reduction for transmission of data altogether.

The following energy efficient clustering techniques considering: CH count, CH selection, CH mobility and CH hop distance. They are Clustering Chain Multi Agent Routing (CCMAR), Energy Efficient Clustering Algorithm (EECA), EEUC, HCC, LEACH, and PEACH. Review of few works related to clustering techniques are given below.

2.2.1 Clustering Using EECA Technique

The EECA clustering technique was proposed for removing hot spot issued in WSN [1]. The cluster parameter value for this cluster technique is as follows. The clustering type is a dynamic one. The CH count is always varying. The CH selection is based on probability initially. There is no movement of CH in this clustering technique. Finally, the CH hop distance is multi hop since the number of nodes to cross to reach sink node from CH is more than one as per dynamic clustering proposal.

2.2.2 Clustering Using EEUC Technique

The EEUC clustering technique was proposed [2] for inter-cluster communication application. Another work which is used in EEUC was proposed [3] to represent Sierpinski Triangle for WSN. In both works, the energy efficiency is measured in sending data to the sink node in WSN. The values for cluster parameters in EEUC are as follows. In the EEUC the clustering type is dynamic in nature. The CH count is variable. The CH selection is proportional to the number of nodes in the networks. In EEUC there is CH mobility to gather the data from nearby sensors. So, CH's place is fixed. Finally, the CH is supposed to reach the sink node with the help of multiple nodes. So, the CH hop distance is multi Hop.

2.2.3 Clustering Using HCC Technique

The HCC clustering technique was proposed for multi Hop data communication in WSN [4]. Here the clustering type is dynamic and CH count is variable one. The CH selection is statically pre-assigned and later to select the CH again the Breadth First

Search algorithm is used. There is mobility of CH in HCC. The multiple numbers of links is employed to reach from CH to sink node. So, the CH hop distance is multi Hop in HCC.

2.2.4 Clustering Using LEACH Technique

The LEACH clustering technique is energy efficient clustering technique and widely used in the WSN's data transmission. A few of the works using the LEACH clustering technique are as follows: The LEACH clustering technique was proposed as application specific clustering technique for wireless micro-network [5]. LEACH clustering technique for cooperative WSN to attain energy efficiency was introduced [6]. Later this clustering technique was used in work organized [7] for attaining affinity propagation in WSN. The same LEACH also was introduced in the work proposed for WSN with an Improved Three-Layer Low-Energy usage for data transmission [8]. Finally, another work using this LEACH protocol was introduced for Duty Cycling for Energy Harvesting Enabled WSN [9].

The clustering parameter values for this LEACH clustering are as follows: The clustering type for LEACH is dynamic. The CH count is variable and not a fixed range. The CH selection in LEACH technique is random as per the current energy level of each sensor node in the cluster region. There is no mobility of CH node necessary as every node gets equal chance to become CH in a random manner. Finally, the very best suited parameter is called CH hop distance. In this LEACH technique the CH hop distance is one hop. That is, the number of nodes to be crossed to reach sink node from CH is one hop. The advantages of LEACH are low latency for data communication being low, extended life time of clustered WSN and easy data aggregations from CH to sink node.

2.2.5 Clustering Using PEACH Technique

The PEACH clustering technique was introduced for WSN application [10]. The PEACH clustering type is dynamic in nature. The CH count in PEACH is variable. The CH section in PEACH technique is purely probability based and every node having equal probability to become CH node. There is no CH mobility in PEACH clustering technique. The CH hop distance is multi hop to reach sink from CH node.

2.2.6 Selection of Green Energy Efficient Clustering Technique

The comparison of clustering techniques was discussed to measure the efficient green energy adapting clustering technique in [11]. Now choose a clustering technique to be adapted for establishing WSN for data transmission. Usually the clustering technique choosing for any application is always application specific. The parameters' values for all clustering techniques are discussed above. Table 1 lists the clustering technique

Table 1 Comparison parameters for clustering

Clustering techniques	Clustering type	CH count	CH selection	CH mobility	Hop distance
EECA	Dynamic	Variable	Probabilistic	No	Multi hop
EEUC	Dynamic	Variable	Proportional	Yes	Multi hop
HCC	Dynamic	Variable	Pre-Assigned	Yes	Multi hop
LEACH	Dynamic	Variable	Random	No	1 hop
PEACH	Dynamic	Variable	Probabilistic	No	Multi hop

parameter values. Here proposed architecture for application specific with 500-m distance from any sensor node to sink node. The CH hop distance best suited is just one and which is directly proportional to reduced energy utilization for sending data from any CH node to sink node (Table 1).

So, the best green energy efficient clustering technique is LEACH technique. Now parameter values are as follows. The clustering type is dynamic. The CH count is variable. The CH selection is random one and indirectly gives chance for any sensor node to become CH at any time interval. Obviously, there is no need of movement in CH. Now LEACH clustering technique is introduced as clustering technique for WSN.

2.3 Green Energy Adapting Model Architecture for WSN

Figure 1 shows the overall green energy adaptable architecture for data transmission from every sensor to sink node. This architecture diagram consists of NO, MN and group of sensors with CH namely CH1, CH2, and CH3. The functionality of NO is sending Query to MN with certain time interval or the NO will cross check to find if the data collected by particular sensor is genuine or not. The functionality of MN is to receive the data from every CHi and store in memory. The other functionality of MN is to process the query received from NO occasionally. The functionality of CHi is to collect the data from its cluster region area sensors and send it further to MN to store and process data.

The explanation for the proposed green energy adaptable architecture's working mechanism as follows: The clustered field sensor collects the data with time interval as showed in Fig. 1 and send the data to CHi. The remaining all other sensors in the same CHi region also collect and send the data to CHi. Other CHi region's sensors also do the same activity. Now, the MN receives the entire CHi's data through communication medium and stores in the memory space.

The NO at any time of interval sends a query to MN. For example, the NO query will be "send the data at time 't1' captured by sensor s1 of CH1". Then the MN processes this query and tries to send the result to NO. Once the NO has received

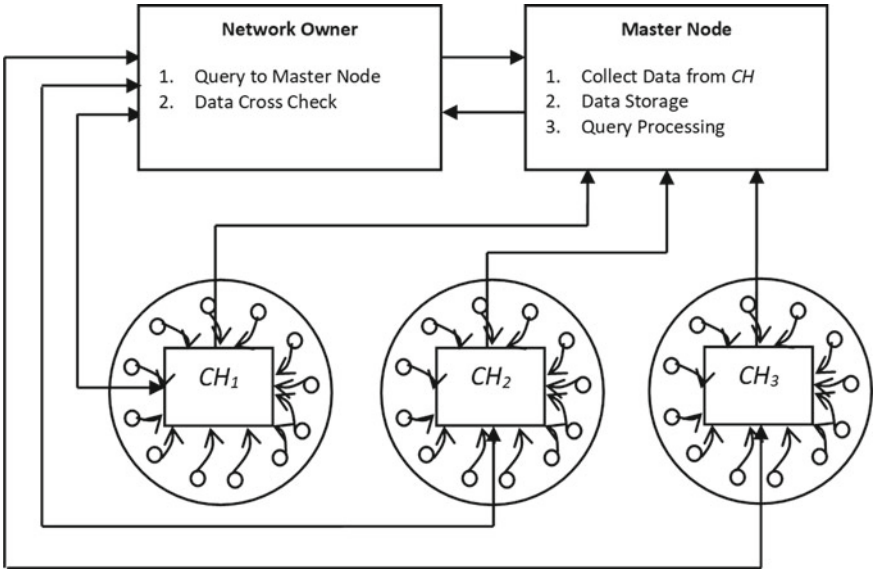


Fig. 1 LEACH based WSN's model architecture for green environment

the result for a query sent, the NO will analyse the result. If the NO suspects that the result is compromised, then NO sends a request to respective sensor node directly and asks it to send back the previously captured data.

Note that this cross check will be only possible whenever the query to MN by NO is just previous time slot data say t1 if the current time slot is t2. In that case every sensor has stored t1 time slot data temporarily. So, in this situation the CH1's sensor say s1 will send back the t1 data to NO. Now the NO checks both MN's result at t1 data with direct requested data from s1 being compared. If both are not the same, the NO suspects that either s1 sensor node is malicious or MN is malicious. If both the data are the same data, then the NO concludes that s1 as well as MN are genuine components. This working mechanism is illustrated in Fig. 1 with proper flow over communication lines.

2.3.1 LEACH Working Mechanism

The CH selection is based on LEACH clustering technique (Algorithm 2.1). The LEACH clustering technique is basically self organizing and self adaptive in nature to form CH. The LEACH clustering technique is used to select CH among groups of sensors in the region. The selection mechanism to find CH is as follows.

Algorithm 6.1: LEACH clustering technique

Parameters: G - group of nodes that has not been the CHs in last round.
p - desired percentage of CH.
r - current rounds.
n - one of the nodes of G.

1. each node of G generates a random number between 0 and 1.
2. for each $n \in G$, compute threshold $t(n) = \frac{p}{1-p*r\%\frac{1}{p}}$
3. if (random number of node $n < t(n)$ of n), then n becomes CH.
4. else n is non-CH node.

In LEACH clustering technique setup state, the parameters such as G, p, and r are initialized using Algorithm 6.1. Algorithm 6.1 choose a node to say 'n ∈ G' and computes the threshold value using formula t(n). Then it compares the random number of n with currently calculated t(n). If the random number of n is less than the t(n), then n becomes CH. Else n become a non-CH node. In current round, if a node is selected as CH from the G then selected node will be removed from the G. This algorithm is repeated for the number of rounds to select the CH till the energy of network goes down.

2.3.2 CH Formation

Figure 2 shows how the CH is formed using LEACH protocol and further communication to MN. Usually the LEACH clustering technique will work in two states called set-up state and steady state. In set-up state the LEACH protocol selects any nodes from G say n is chosen as CH, then it never has the chance to become CH node again.

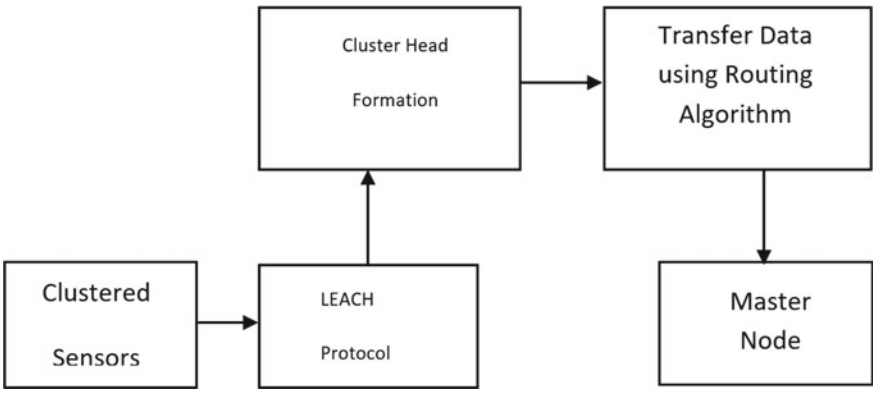


Fig. 2 CH formation and flow of data to MN

In the steady state the chosen CH tries to gather data which are collected from sensor nodes of that region. Here the all nodes of particular cluster region send the data to CH using TDMA technique. Now the CH uses the Frequency Division Multiple Access (FDMA) to send the CH collected data to MN, since in this set-up many CHs are formed in different regions. So, every CH supposes to access the common wireless Ethernet and it is limited to 11 Mbps. The number of clusters will be supported for 11 Mbps, wireless Ethernet is directly proportional to the data packet size.

3 An Energy Efficient Secured Data Transmission Model for WSN

3.1 Introduction

Nowadays, WSNs are used for many sensitive monitoring and surveillance systems. The activities of such system are that the sensors sense the data and if the WSN uses the clustering technique, then the data will be sent to CH of that cluster region. Again, the CH further transmits the data to sink node. If the WSN is just flat network, then every sensor directly sends the sensed data to sink node. In both cases the following issues exist. When sensors introduced in WSN, the NO does not authenticate the sensor before joining WSN. So, there will be situation such that the malicious nodes can join the WSN and sense the data and try to leak the data to malicious people. Like that the NO of WSN is used to assign two or three MNs or sink nodes to store all sensors' sensed data in the storage memory. So, there is a chance that the malicious node becomes an MN. Then the malicious MN will act as an authenticated MN and it will send the entire sensor collected data of particular region cluster to malicious people. On other hand, the WSN data transmission has many flaws and using them the attacker tries to tap the data in illegal ways. Because of these issues the NO may not attain the intended activities in their WSN.

The solution for this issue is the introduction of authentication mechanism into the WSN. Whenever a sensor joins the cluster region in WSN, the sensor identity must be authenticated and like that a MN is also authenticated. The sensed data is encrypted and then sent over WSN's transmission medium. So, the encrypted data is not prone to flaws and attacker to gain the access in illegitimate manner.

3.2 Secure Access Control and Security Algorithm

The secure data access is the approach where the intended user is authenticated before accessing the data needed from the SN. The energy efficient security algorithm is used to send and receive the secured data with encryption and decryption respectively.

Usually the private key cryptography algorithms are more energy efficient than the public key cryptography algorithms. The access control mechanism can be achieved by setting the security policy for the user to access the data.

3.2.1 Secure Data Access Approach

The crypto based access control and role-based access control are the types of secured data access approaches and are successfully applied in many data access control applications. The data access control is essential part of the secured data access. A different work has been introduced for data access control and log management. The work related to RBAC was introduced for access control [12]. The crypto based access control was introduced to access the data secretly in common databases [13]. Another work related to crypto based access control was introduced for user role-based cloud storage data access [14].

Log management is an inevitable component in secured data service as further investigation to evaluate the past data access activity. The secure log management was introduced for database pattern service [15]. Later the log maintenance and its activities related work was proposed for secure log as service in the cloud storage and role-based user's data access [16]. In [11] the various secure cryptography algorithms were discussed to compare the encryption time for data transmitted over WSN.

3.2.2 Access Control and Log Management Mechanism

To provide the secure access control mechanism and secure log management mechanism, the following model architecture shown in Fig. 3 will be used for any application for controlling the data access securely.

Figure 3 consists of three components. The first component is the user and types of user are owner and ordinary user. The second component is the Crypto and Role Based Access Control (CRBAC). The third component is data and its log. The working mechanism of this model is that the user either owner or ordinary user can access the data with their role. For accessing the data, any user can send the request to access control component. CRBAC will authenticate the user based on user's credential and role permission. It will grant permission to access data. Then the same user further sends the data access request to data component and the data component further grants permission to the user if user is valid since it checks if the user is directly requesting or the same user has before requested for the CRBAC permission and data component will start to maintain the log of this user activities if granted permission. In this secure access control and log management if illegitimate users try to access the data, the authentication will be denied either in CRBAC or in spatiotemporal data component.

Table 2 summarizes the user activities in secure access control mechanism. These activities are represented by communication like 1–4 which is shown in Fig. 3.

The highlight of this architecture to access control mechanism is secured by CRBAC and the log is maintained in two places with different logs. The first log is

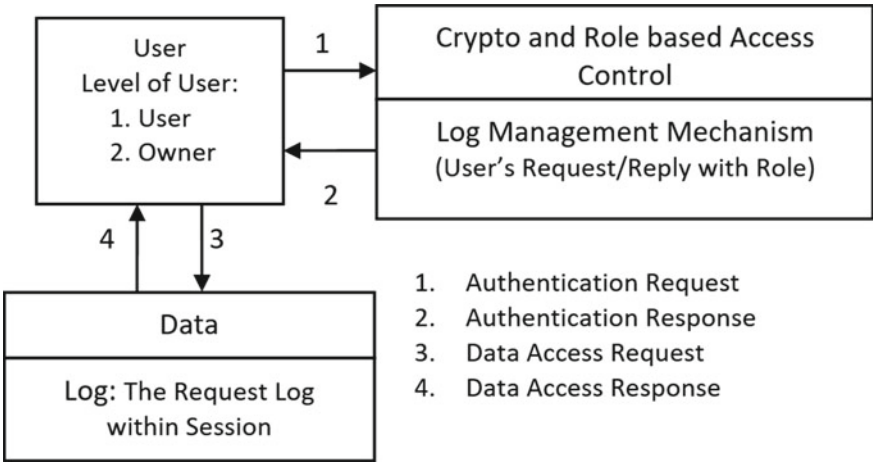


Fig. 3 Secure access control and log management

Table 2 Access control and log activities

Communication line	Description
1. Authentication request	The user/owner sends request to CRBAC authority to get permission to access spatiotemporal data
2. Authentication response	The CRBAC authority verifies user's credential information and allows or denies the request and also maintains log
3. Data access request	Once CRBAC authority grants persimmon with reply message, the user sends request message to spatiotemporal data
4. Data access response	The spatiotemporal data allows the user to access the data and this event is maintained as log along with detailed session information

user request log in CRBAC to allow or deny the user. The second log in spatiotemporal data access component which maintains log about the data of the user is accessing.

3.2.3 The Comparative Study on Cryptography Algorithms to Identify Green Energy Adaptable Algorithm

Various security cryptography algorithms were discussed for security practices [17] and RC4 algorithm was discussed [18]. These cryptography algorithms were used in encryption and decryption functions for secure transmission of data from source node. So choosing the cryptography algorithm is generally of green energy adaptable consumption for encryption and decryption processes and more time consumption

Table 3 Comparison of private key cryptography algorithms

Algorithm	Structure	Key size (in bits)	No. of rounds
AES	Substitution permutation network	128, 192, 256	10, 12, 14
DES	Balanced feistel network	56	16
Triple DES	Feistel network	112,168	48
Blowfish	Feistel network	32–448	16
RC4	Unbalanced feistel network	80	32

for cracking the algorithm. Since the network is the WSN and each node having limited energy, energy consumption is also a factor to choose the green energy adaptable cryptography algorithm for encrypting the data at sensor nodes and the energy consumption is directly proportional to the time consumption of encryption and decryption processes. Table 3 lists various private key cryptography algorithms types such as AES, DES, Triple DES, Blowfish and RC4 along with their structure, key size and number of round details.

The mathematical structure used in AES is substitution and permutation concepts and key size is always different. For example, if the key size is 128 bits, then the number of times the substitution and permutation is performed for 10 rounds. If the key size is 192, then the substitution and permutation is performed for 12 rounds and for key size 256 the substitution and permutation is performed for 14 rounds. In DES the balanced feistel network is applied and key size is 56 bits always constant and the number of rounds repeating the feistel network is 16 times. The triple DES again the mathematical function of DES is used 3 times of encryption followed by decryption and again follows encryption in order and either encryption or decryption, the number round is always again 16 each so total number of rounds is 48. The mathematical structure used in RC4 is a kind of feistel network called the unbalanced feistel network. The key size in RC4 is 80 bits and the number of rounds the feistel network repeated for 32 times. The mathematical structure used in Blowfish algorithm is again feistel network. The key size in Blowfish algorithm varies from 32 bits to 448 bits and the feistel network is repeated for 16 times.

The computation and working time complexity are more in Triple DES algorithm than in RC4 algorithm. The RC4 uses more time for computation and working of mathematical round than AES. The AES time complexity is more than DES and finally the Blowfish algorithm consumes less time than DES algorithm [19].

3.3 *Green Energy Adaptable Secure Model Architecture for Hostile WSN*

Figure 4 shows the secure green energy adaptable model architecture for hostile WSN's environment. The architecture components are Network Owner (NO), Master Node (MN), Authenticator and clustered sensors. In this chapter the security authentication and encryption mechanism alone is discussed. The functionality of NO is to send the secure query to the MN to access any sensor data which is stored in MN. If the NO suspects that MN is sending the false data reply, then it will authenticate the same data with sensor that had sensed it. The functionality of MN is to receive the query from NO and respond to the query using stored encrypted data.

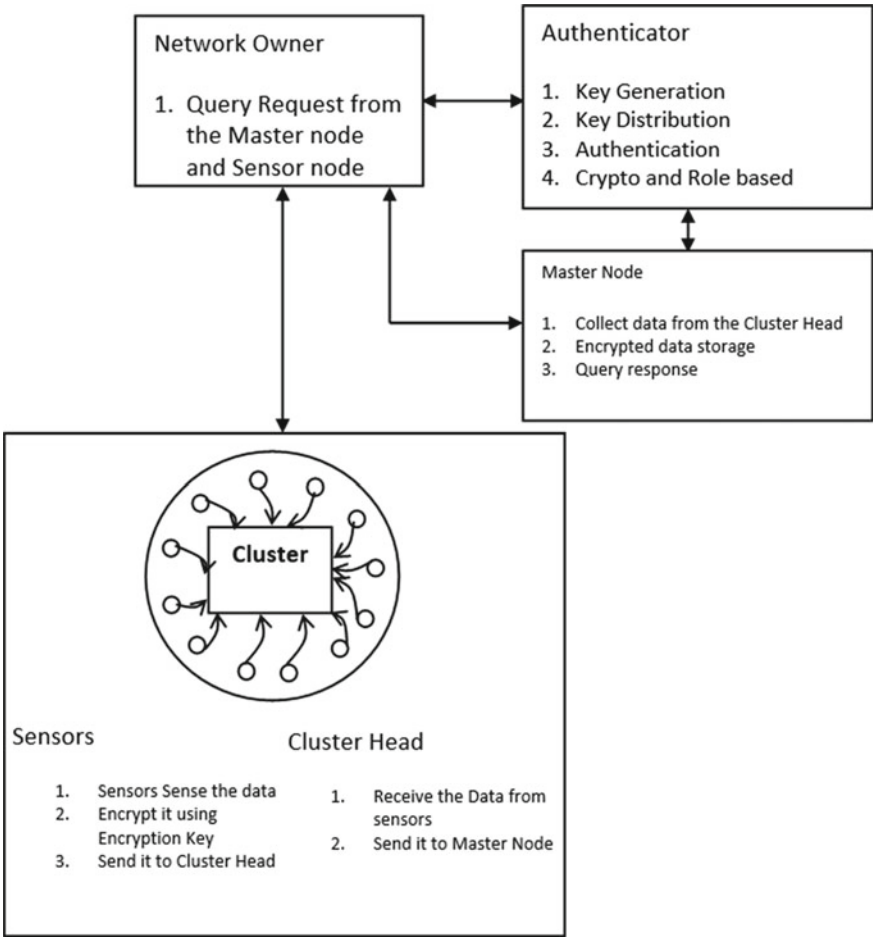


Fig. 4 Green energy adapting secure model architecture for WSN

The other functionality of MN is to store the encrypted data sent by the CH. The authenticator component functionality is as follows: The authenticator, one of the functionalities is key generation and it will generate the keys using pseudo random generator algorithm. The second functionality of authenticator is distribution of keys to sensor nodes and MNs. For every 10 min it will send new keys. The third functionality of authenticator is to authenticate every sensor node and MNs if they come as new nodes to WSN. Finally, the authenticator is also serving the CRBAC to users. The last component is clustered sensor nodes with CH formation.

The working mechanism of this model architecture is as follows: Initially, the Authenticator gives the encryption keys also called decryption keys to all sensors with time interval of 10 min time. The security algorithm used for encryption and decryption is Blowfish Cryptography algorithm. The sensor senses the data for each time epochs and encrypts the data and sends to the CH. The CH further sends the encrypted data to the MN. The sensor also stores the current epoch data up to next time interval. For example, if the sensor senses for the current 1 min, then the same data will be there up to the next minute. Now the MN will receive the data in the encrypted format and store with sensor id and time at which the sensor sent the data. The authenticator will keep each time interval keys of all sensors in database for the NO decryption process. Now let us consider that the NO sends the query to MN. The query is as follows.

"Send the data sensed by Sensor s1 at CH1 at time epoch t1."

Now the MN receives this query and sends the request to the authenticator as follows.

"Send the decryption key k1 assigned for s1 of CH1 at t1."

Now the authenticator retrieves the key k1 from database and sends it to MN. The MN after receiving the respective decryption key k1 for NO encrypted data query request, it now sends the query response as encrypted data along with key k1 to NO. Now the NO decrypts the data sensed by sensor s1 of CH1 at time epoch t1 and sees the data. If the NO suspects that data might not be authenticated data, MN might alter the data. Then NO sends the request to respective sensor s1 that sends the data captured at previous epoch at time t1. The sensor s1 now sends the encrypted data at time t1 to NO. Since the NO has its respective decryption key k1 so it will decrypt the data received from the sensor s1 and cross check with the query response from MN. If both are matching, then the data is correct and if not matching, then the data is altered by MN. The NO now sends the request to the Authenticator that authenticates the MN namely mn1. Finally, the authenticator authenticates the mn1 using the mn1 identity and checks whether it is previously authenticated MN or malicious MN. The NO also requests the authenticator to find if some sensor s_i is authenticated one or not.

Equations (1), (2), and (3) are used as the mathematical model for energy efficient secure data transmission and they are Encryption, Encryption time and speed respectively.

$$Encryption = Enc_X(Data, Key) \tag{1}$$

where, Enc_X is the type of security algorithm, $Data$ is size of data used in bytes and Key is key data in bytes.

$$Enc_{Time} = \frac{Data_{size}}{Speed} \tag{2}$$

$$Speed = \frac{Cycles_{persecond}}{Cycles_{perbyte}} \tag{3}$$

where, Enc_Time is the encryption time measured in seconds, $Data_size$ is data size and speed is ratio between cycles per seconds to the cycles per bytes.

3.3.1 Working Mechanism of Blowfish Algorithm

The Blowfish algorithm has comparatively less time consumption for encryption and decryption and more time is needed for malicious users to crack it and it is best suitable algorithm for green energy adaption. So that is the sturdy for introducing the Blowfish algorithm for WSN secure data transmission. The blowfish algorithm was introduced by [17, 20]. Let us consider the Blowfish algorithm's working mechanism. The Blowfish algorithm uses the 64 bits data and it uses the feistel network for 16 round functions and a round function is shown in Fig. 5. The single round function consists of key whitening, applying S-box, EXOR with F function and swapping of output. The algorithm consists of key expansion and data encryption. The key expansion is the use of the key size of 32 bits to 448 bits and it is expanded into several sub-key arrays. The sub-key array consists of 18 P arrays and each P array is 32-bit sub-keys. This key expansion also has four 32 bits S-Box and has 256 entries.

The data encryption uses the 64 bits data and it divides the 64 bits into 32 bits halves each. Then it is applied to Feistel network and finally gets 64 bits output. The actual round function in this algorithm divides the 32 bits data of each halve. The divided 32 bits is further divided into 8 bits. This each 8 bits set is put inside the S-box and produces the 32 bits as output. The 4 S-box produced output further performs addition followed by XOR and following the addition again and finally produces 32 bits as output as shown in Fig. 5.

3.3.2 Advantage of Blowfish Algorithm

The reason for choosing the Blowfish algorithm for data encryption and decryption is that complex task of encryption is done in less time than by the other private key cryptography algorithms. The following factors are advantages of Blowfish algorithm: fast, compact, simple and secure. The factor fast is that it uses only less clock cycle of 32 bits microprocessor for a byte data processing. This Blowfish algorithm can be run for less than 5 KB memory size. The Blowfish algorithm is very simple as it performs addition followed by XOR operation and then finally lookup table

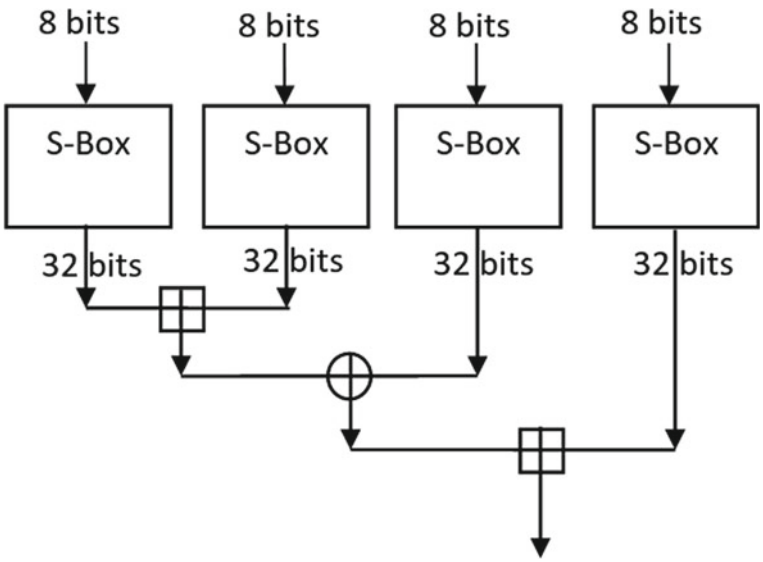


Fig. 5 Round function of Blowfish algorithm

as each round function. Whereas in the case of other block cipher like AES, Triple DES, and DES use more complex mathematical operations. And finally, it is more secured than the other algorithms since the key size varies from 32 bits to 448 bits.

3.3.3 Secured Data Access

The authentication is the process of authorizing the intended users and allowing them to access the system and its data. In Fig. 4 the authenticator component is handling the authentication for users and for its nodes like sensor nodes and MN. The pseudo random algorithm is able to generate key along with Blowfish algorithm and distribute encryption key to every sensor node. Later, the authenticator validates the NO, if the NO wants to access the data from the MN. The NO is provided with CRBAC permission after the authentication of the NO is successful. Here the authenticator is checking the role of the NO using the credential information of NO in a secure manner. So, this CRBAC ensures that forgery or impersonation of the NO is validated and access permission is always denied. On the other hand, the authenticator also validates the sensor nodes and MNs while newly joining the WSN.

4 Green Energy Efficient Data Communication Model for Intelligent Surveillance System

4.1 Introduction

In the past decades the surveillance systems were used in limited applications such as temperature monitoring and humidity monitoring etc. These application sensors sense the scalar data. These scalar data are reported to the sink node. The sink node further investigates the scalar data manually. The manual process might be inefficient and delayed response. This process might not be supported in today's world and much automation oriented and digital data capturing surveillance systems evolved as the technology has grown with respect to WSN.

The surveillance system applications are nurtured for identifying activities of remote places in WSN. These surveillance systems are sending the data either in form of scalar data such as temperature, wind and humidity or video data. As there is technology improvement in WSN and introduction of IoT, many surveillance systems are very suitable for capturing video and image data and further sending to SNs over wireless transmission. These remotely sensed video data is investigated by analysing if the activities are regular or any suspect is there. The surveillance systems like FMS and BMS are used to capture the video data by video sensors and using the wireless communication and the video data are sent to SNs. For these processes the following facts are true. Fact one is that the video sensors consume considerable energy for capturing video data. Fact two is that all the captured data are sent to SNs through wireless medium and for this activity again considerable energy is consumed. The third fact is that in the SN the amount of memory is used to store all the received video data.

To enhance the WSN's based surveillance system all these three factors become challenges to reduce the energy usage for capturing the video data and transmitting the video data over wireless transmission and also to reduce memory space for storage and make these activities to adapt in green energy environment. Here we propose the redundancy elimination algorithm in surveillance system camera sensors. The aim of this algorithm is that when every video sensor while capturing the video and storing in current buffer of one-minute video in the fields, it will compare the current buffer video with previous time slot video which is in previous buffer. If both current buffer and previous buffer videos of time slots are the same, then the currently captured one minute is same as previous time slot one-minute video (i.e. duplicate video capturing occurs) and the respective sensor doesn't need to transmit the current buffer video again over transmission line. If the sensor is not sending the duplicate data again in current time slot, then the data is not transmitted over wireless communication so the energy used for transmission is saved, the network bandwidth is also saved and the storage space needed to store such duplicate data is also saved. These three facts such as energy for transmission, network bandwidth utilization for transmission and storage space for storage are unnecessary and avoided when the duplicate video checking algorithm is introduced in WSN's surveillance system. Finally, the life time

of this WSN's based surveillance system is also extended with the same energy and space capacity for application such as BMS and FMS.

4.2 Collision Free Data Communication

In the distributed video surveillance, data communication is very important approach for monitoring the distributed and remotely placed sensors' data. The technique for video data communication is that there is a coordinator sensor node which receives the captured data from all sensor nodes and in turn sends the video data to the SN. So, this approach must introduce a collision free communication. A bit map protocol was discussed for collision free data communication using contention slot in wireless technique [21].

Figure 6 shows the bit map protocol for collision free data communication using contention slot. The contention slots are reserved for eight sensor nodes named from node 0 to node 7. Among the eight sensor nodes if the sensor nodes have data to send, then it must place a single bit with value as "1" in respective slot. From the above Fig. 1 the sensor node 1, sensor node 3 and sensor node 7 have reserved the slot with bit map information. Now the sensor nodes 1, 3 and 7 alone utilize the entire bandwidth of wireless communication and send the data without any collision. The same Fig. 6 also illustrates that sensor nodes 1 and 5 alone are in contention slot in second time interval and for third time interval the senor node 2 alone is in contention slot.

The bandwidth efficiency of the eight sensor nodes connected wireless communication is measured as the ratio between the actual number of sensor nodes sending the data and the total number of sensor nodes connected to the communication line. This efficiency will be calculated using Eq. (4).

$$E = \frac{d}{N} \tag{4}$$

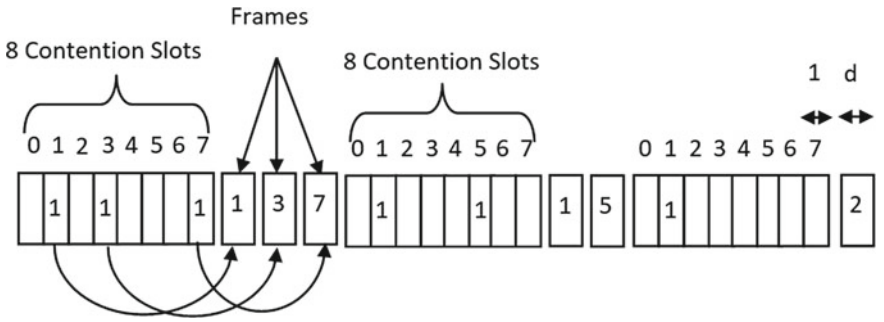


Fig. 6 Bit Map protocol

where, E is the bandwidth efficiency of wireless communication. d is the number of sensor nodes sending the data, and N is the total number of sensor nodes in the wireless communication. Consider N = 8 and for first time interval contention slot has only 3 sensor nodes (sensor nodes 1, 3, 7) sending the data then the bandwidth efficiency is 3/8 *100 = 37.5%.

4.3 Duplicate Video Identification for Green Energy Adaptation

The social network applications and video surveillance monitoring systems mostly use image, audio and video data and must store in the memory of systems. But unfortunately, many users are being able to store the same data in the memory of such system without noticing it. So, there is a need of introducing the duplicate video check methodologies in such an application to adapt green energy. The advantage of checking duplicate video data is to enormously reduce the storage space and this is the one issue in social networks as well as in video surveillance systems. The purpose of video processing applications is monitoring the behaviour of people in the traffic signal system, automation of fraudulent activities in finance systems, the duplicate video forensic systems for copyrights ownership authentications, the big data related duplicate video checking in social network and border security automations. Finally, the green energy data processing is achieved with help of introducing green energy adaptable duplicate video check algorithm.

4.4 Duplicate Video Check Methods Comparison to Find Green Energy Adapting Method

The hash-based technique was proposed for duplicate video check [22]. In this technique the video frames are applied with hashing technique to convert the entire video into hash in frame level and the hash value indices are produced for all the frames. The comparison is made for two videos and every frame index of two videos are checked. If both video frame indices are the same, then both videos are the same. The applications of this hash-based methodologies are the video forensic and video codec used in Motion Joint Photographic Expert Group.

The video sequence matching with duplicate using increment similarity update algorithm was proposed for duplicate video check [23]. The comparison is made on two videos in frame level. This methodology is able to measure the performance parameters like execution time, memory consumption and accuracy of two stored videos in web video data set. The format used in this methodology for video is H.264 of MP4 with querying facilities to measure the precise parameters. The advantage

Table 4 Duplicate video checking techniques to identify green energy adaptation

S.No.	Applications	Purposes	Demerits/limitations
1	The video forensic	To analyze the originality of video	Hash based technique consumes more time
2	The online storage for web video access	To store efficiently huge collection of video data	More memory is needed
3	The social media video storage	To enhance the social data clarity	Complex graph for visual information
4	The copyright infringement for video production	To find the ownership of video production	Dynamic programming usually takes more time complexity

and motivation of this methodology is to check the duplicate video in online web video storage data set.

The coding frame with near duplicate video checking using the graph based similar video grouping was proposed to check the duplicate video [24]. The specialty of this methodology is that the visual information of the two videos is correlated using the joint video frame coding. The main application of this methodology is used in social media video storage.

The copyright protection for video is challenging task as many cases of impersonation are happening in digital data access. The dynamic programming with m-pattern was proposed for near video duplication [25]. The methodology measures the average precision and the normal cost for detection and it also calculates the re-rank of video retrieval. This methodology is mainly used in copyright ownership protection of video data. Table 4 lists the various works related to duplicate video checking and their applications, purposes and limitations.

4.5 Camera Sensors in Surveillance System

The camera sensors are used in many applications for sensing data in digital format and send it to SNs. The applications are monitoring day to day activities of human being like abnormal behaviours in traffic signal, country borders and fraudulent activities of human in finance related applications. The other camera sensor applications include rare animal movement monitoring.

4.5.1 Comparison of Video Surveillance Systems

The intelligent sensor with dual camera with 360-degree data work was proposed for general surveillance related applications [26]. The technique used for this work is the zooming capability-based image capturing with Omni-directional and this technique of working mechanism also enriches multiple targets.

The multi-view face recognition using sensor assistance was proposed for video surveillance [27]. This work is able to use low energy and overwhelming computation to detect face accurately. For this work the energy efficient sensor is used as assistance to identify and recognize the face. The technique is called a novel face recognition algorithm which is used to recognize the face over multi-view face images and this technique is more efficient than the Computer Vision Library algorithm. The applications of this work are the finance related currency-oriented transaction and mobile payment users monitoring system.

The surveillance system on real-time traffic was discussed for vehicle classification surveillance [28]. The multi-view traffic visual sensors data are used to classify the vehicles into buses, trucks and cars. The methodology used for classification of vehicle very accurately is deep learning with neural networks on visual sensor captured data. The balanced sampling and data augmentation process is performed on visual sensor captured data to predict the object identification accurately. The other important task is the parameter learning on augmented data to further identify objects on traffic visual data. The classification of vehicle is the best suited application.

Heterogeneous information merging and scaling the intelligent video sensor in large quality was proposed for the surveillance system [29]. The event driven visualization mechanism is used for large scale intelligent video surveillance as multimodal information. This work is to sensitively alert the owner after analyzing the sensed video spontaneously. This video camera sensor scores the rank that considers the semantic object features and event urgency on visual data. The application of this event driven video surveillance system is generally used in border security monitoring and any general sensitive alert systems.

Automated moving object identification was proposed for video surveillance system [30]. The sensor captured data is analyzed for identifying moving objects. The video is analyzed using image processing to identify the objects. The pre-image objects are stored in the sensor buffer as trained data set and these images are compared with currently capturing video data using image analysis. The sensors used in this work are infrared motion sensor, vibration sensor and acoustic sensor as scalar and multimedia sensors. This work is applicable to the general-purpose multimedia surveillance system to detect moving object identification. Table 2 lists the various camera sensor-based video surveillance system applications, purposes, and demerits (Table 5).

Table 5 Different video surveillance applications to use green energy

S.No.	Applications	Purposes	Demerits
1	General surveillance	The panoramic scene analysis	Rotation of 360 leads to fade image
2	Mobile payment	The face recognition	Only 15% Accuracy
3	Real time traffic monitoring	The classification of vehicle	Accuracy is limited as unbalanced data set
4	Large scale general surveillance monitoring	The heterogeneity data and data merging	Merging of sensed data might measure inaccuracy
5	The moving object classification	The classification of automated moving object identification	Power consumption is high

4.6 Video Data Transmission in WSN

The WSN video transmission applications are widely used for remotely monitor system like forest fire monitoring system, border security system and habitat monitoring system etc. Let us discuss the works related to data transmission techniques in WSN.

The cluster chain mobile agent routing using LEACH clustering technique was proposed for mobile network [31]. The methodology used in this work is the data aggregate and the reduction of the energy in aggregate data transmission. This leads to efficient energy utilization achieved for the sensor collected data to be aggregated and sent to SN.

The video streaming transmission is carried out for surveillance system in WSN. The factors considered for such transmission are video transmission energy, end to end delay, number of frames transmitted per second and bandwidth utilization. The one work related to high quality video transmission using Open System Interconnection layers responsibility was proposed for video data transmission [32]. The functionalities like compression of application layer and routing protocol of Network Layer and Transport Layer Transmission type are responsible to achieve high quality video transmission in WSN. The network used for this work is Wireless LAN.

The energy efficient and Quality of Service (QoS) based video transmission in WSN was proposed for video data transmission [33]. The energy consumption of video transmission and network life time of video streaming are analyzed in WSN. The Wireless Multimedia Sensor Network framework is introduced to achieve QoS video transmission.

The different MAC protocols are analyzed to measure the performance parameters and this work was proposed [34]. The performance parameters measured in this work are throughput, latency in transmission and packet delivery ratio. All these parameters are checked with different network types such as IEEE 802.11, Lightweight MAC, Berkeley MAC, CSMA/CA and IEEE 802.15.4 (Zigbee). All these performance parameters are out performed for the network type IEEE 802.11.

4.7 Green Energy Support Model Architecture for Surveillance System

The video surveillance system application uses the energy for capturing the video data and the energy for transmitting the data [35]. In the receiving sink node, the video data is stored in memory. For these activities the challenges are to reduce the energy for transmission and to reduce the memory space for storage to meet green energy adaptable environment. If these challenges are overcome, then the life time of such a surveillance system in WSN will be extended considerably. Figure 2 shows the model architecture for the intelligent surveillance camera sensor. The components of this architecture consist of the Intelligent Camera Sensor (ICS), contention slots and SN. The camera sensor is able to sense the environment and has two buffers (Fig. 7).

One buffer is called Previous Buffer (PB) and is able to store the previous time slot 1-min video and the other buffer is called Current Buffer (CB) and is able to store the current time slot one-minute video. Then all camera sensors are able to place their videos in respective contention slots. The contention slots bandwidth is 11 Mbps and each contention slot capacity is 990 Kbps. The last component is called SN and this node is able to receive the video which is transmitted in the contention slots.

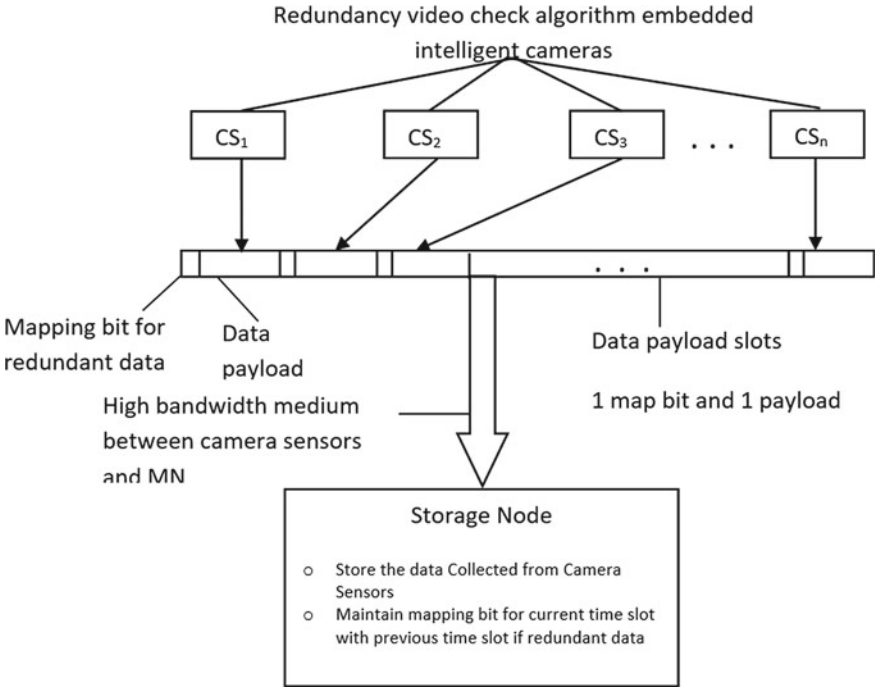


Fig. 7 Intelligent surveillance system's model architecture for green energy usage

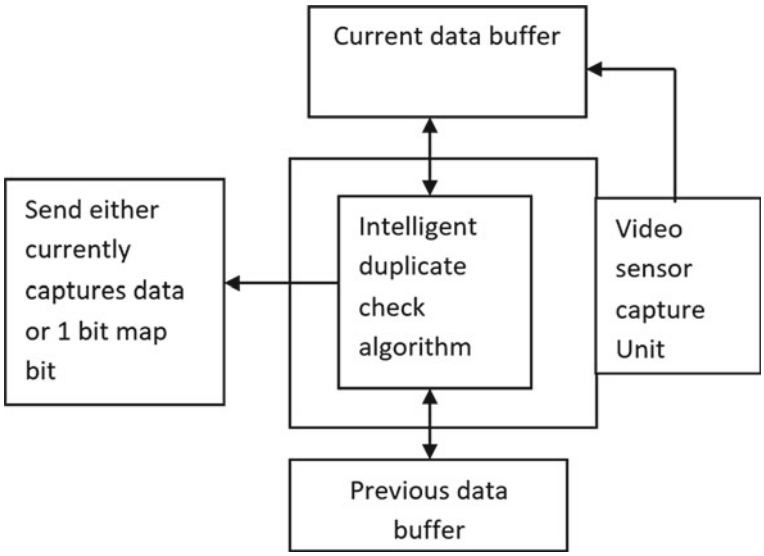


Fig. 8 ICS's video capturing mechanism

4.7.1 Green Energy Usable ICS Working Mechanism

The green energy usable ICS is the camera component and this sensor is able to store two minutes video in two buffers. The PB is the buffer and it stores the previous time slot (t−1) one-minute video. The CB is the buffer and it stores the current time slot (t) one-minute video. Figure 3 illustrates the ICS video sensor working mechanism. The ICS has the special algorithm called green energy based IDCA. This IDCA is embedded inside the ICS. This algorithm compares the PB and CB buffers videos frame by frame. If both the videos are same, then the ICS only sends the '1' as one-bit information to contention slot. Otherwise this ICS will send the actual CB buffered video to contention slot. The specification of video capturing for this ICS is as follows. The resolution of video is Quarter Common Intermediate Format (QCIF) 176 × 144 and each pixel of 8 bits size. The frame rate of video is 5 Frames per Second (FPS) (Fig. 8).

4.7.2 Payload Slots and Data Transmission for Green Energy Communication and Networking

The payload slots or contention slots reserve 8 sub bands channel and each sub band channel or bandwidth is assigned to one ICS. The total number of cameras is 8. This contention slots are able to receive the video data from ICS if the current time slot of ICS is different from the previous time slot data or else the contention slot receives 1-bit information. Figure 4 illustrates the working mechanism of contention

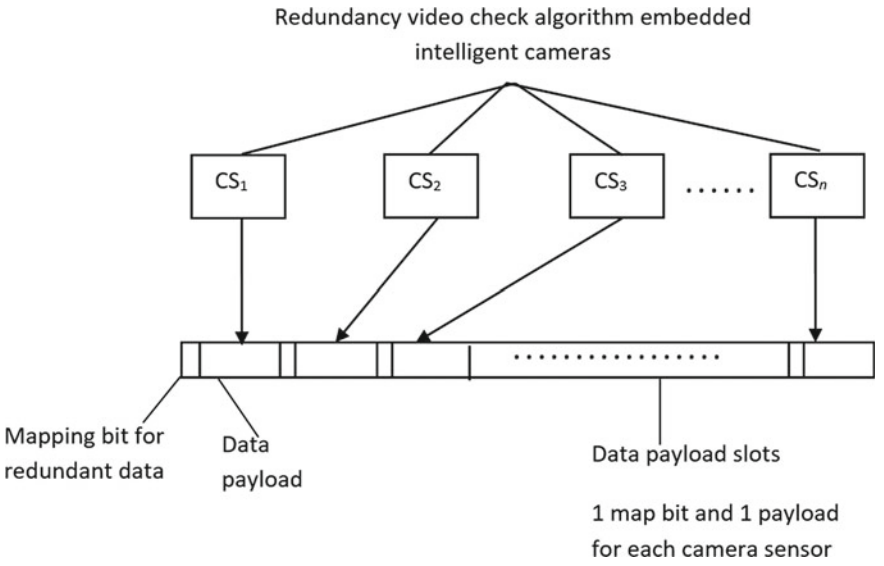


Fig. 9 Contention data slot's payload

slots. The other side of contention slots is connected with SN. The advantage of this contention slot is that this slot avoids the collision of different ICS data. The sub band data transmission rate is 990 Kbps and the entire contention slots bandwidth is 11Mpbs of Wireless LAN (IEEE 802.11) (Fig. 9).

The other advantage of this contention slots concept is as follows. Let us consider every one minute the green energy usable ICS's sending the CB video over contention slots; then the bandwidth efficiency is 100%. The reason is that there is no duplicate data captured in current time slot as compared to previous time slot. Otherwise the bandwidth efficiency is less than 100% based on how many ICSs are sending the 1-bit information. In this work if the efficiency is less than 100%, then the contention slots is not sending duplicate data from any of ICSs. Equation (5) calculates the Necessary Efficiency, NE.

$$E = \frac{TS}{TB} \tag{5}$$

where, TS is the Total number of ICS Sensor's Bandwidth used for sending the unique data from each ICS, and TB is the total sub band channel bandwidth reserved for ICS. Here if the Necessary Efficiency is less than 100%, then there is considerably some number of ICS's capturing the duplicate data.

4.7.3 Green Energy Adaptable Intelligent Duplicate Video Check

The IDCA is able to compare the PB's and CB's video data of each one minute. This algorithm compares the one-minute data of both PB and CB using frame by frame. The number of frames in one-minute video is 300 frames. This algorithm is embedded inside ICS so if it compares all the 300 frames of both videos, then it will take considerable amount of energy for comparison itself. This IDCA works as per Algorithm 6.2.

Algorithm 6.2: A novel green energy adapting IDCA

Input: PB video data at *t-1* time with 300 frames.
CB video data at *t* time with 300 frames
PB video frame sequence: $PB(A_i(t-1)) = a_1, a_2, a_3, ..., a_{299}, a_{300}$
CB video frame sequence: $CB(B_i(t-1)) = b_1, b_2, b_3, ..., b_{299}, b_{300}$
n - one of the nodes of G.
Call: Duplicate video check function *dvc()*
Compare A_i and B_i: $dvc(A_i, B_i)$
for i = 1 to 300
while$(CB(A_i(t))!empty)$
if$((a_1 == b_1)$ && $(a_6 == b_6)$ && ... && $(a_{291} == b_{291})$ && $(a_{296} == b_{296}))$ then
Both videos are same $(A_i(t-1) == B_i(t))$
Discard CB video: $CB(B_i(t)) = 0$
Send (1bit mapping bit)
else
Both videos are different $(A_i(t-1) \neq B_i(t))$
Replace
Replace $PB(A_i(t-1) = CB(B_i(t))$
Send $CB(B_i(t))$

The Algorithm 6.2 compares every second's first frame of both buffered videos alone to reduce energy for frame comparison. For example, the number of frames in one-minute video is 300 frames. Each second number of frames is 5. The first frame of seconds are 1st frame, 6th frame, 11th frame, ., ., ., 296th frame and it is described as a_1 to a_{300} for PB video frames and b_1 to b_{300} for CB video frames. Now this algorithm checks if $(a_1 = b_1)$, $(a_6 = b_6)$ and up to $(a_{296} = b_{296})$.

4.7.4 Advantage of the Green Energy Adapting Model Architecture

In general, the WSN based surveillance system is one in which the video sensors are able to capture the video and send it over wireless communication medium. The energy used for transmission and bandwidth utilization is always constant and the storage space required is also constant and it meets the green energy data communication and data processing. All the three issues are overcome by introducing ICS with green energy adapting IDCA. This algorithm is able to reduce the energy for sending video data if the current time slot data is the same as previous time slot data. For example, let us consider 10-min video surveillance. If initial 5 min video data is

different from every one-minute data of 5 min, then 50% energy is used for initial 5 min video transmission. Later if remaining 5 min for which all 6th min to 10th min are the same as 5th min video data, then the ICS need not send the video data of 6th min to 10th min; then this ICS is able to reduce the 50% of energy, 50% of bandwidth utilization and reduces 50% of the storage space needed for storage.

The IDCA duplicate video data elimination algorithm has been working with compression technique for frame transmission. There are three different video compression techniques available and generally named as picture types or frame types. These picture types are I-frame (Intra-coded picture), P-frame (Predicted picture) and B-frame (Bidirectional predicted picture).

- I-frame are the least compressible one and don't require other video frames to decode.
- P-frame generally use data from previous frames to decompress and they are more compressible one than I-frame.
- B-frame can use both previous and forward frames for data reference to compress the data. B-frame gets the highest amount of data compression.

For the experiment, the video data were taken from surveillance video with 5FPS. The aim of the experiment was to send the original data after eliminating duplicate video frames. The picture type more suitable for IDCA algorithm is P-frame to find duplicate video frame. The reason is as follows. The P-frame type is able to hold only the changes in the previous frame with current frame. The ultimate need of experiment is to reduce the energy for video data transmission with IDCA algorithm. Since the applications taken for the experiment results were FMS and BMS. In FMS, video frames consist of stationary forest backgrounds and animal movements. To compare the video frames, IDCA algorithm to check the moving objects in the frames. The advantage of P-frame type is reduced space requirement for frame comparison as it is not storing the unchanging background pixels. So IDCA algorithm incorporated the P-frame type as data compression technique in each packet. The P-frame type compression technique is also suitable for BMS video surveillance data since the border of the field is stationary field area and enemy penetration is movable object. As a result, using the P-frame compression the IDCA algorithm eliminates the duplicate video frame efficiently.

5 Conclusion

In this chapter work, three modules were carried out to meet green ICT communication, networking and data processing. The first work was identifying and applying the appropriate green energy adapting clustering technique in WSN for applications like BMS and FMS for green energy communication and networking. The novel green energy adapting energy efficient data transmission model architecture was proposed to provide the solution for the first module. The LEACH clustering technique was

identified as the best green energy adapting clustering technique for the proposed architecture.

The second module discussed in this chapter is the identification of green energy efficient encryption and decryption security algorithm for WSN's data transmission for green ICT communication and data processing. The solution proposed for this module is Blowfish private key cryptography oriented secured data transmission and the green energy efficient and green energy based secured data transmission model architecture is proposed. In this green energy adapting architecture the sensors were provided with Blowfish encryption key with every 10 min interval of time. The sensed data from the sensors were encrypted using encryption key and then the data were transmitted to MN for storage in the clustered based WSN. The stored encrypted data were readily available to the access permission through query and response process.

The third module discussed in this chapter was the green energy based intelligent surveillance system in WSN based video data transmission for green ICT communication and data processing. The solution for this module is the introduction of novel green energy based duplicate video check algorithm to eliminate redundant video before video data transmission for surveillance-based applications in the WSN. The novel green energy adapting redundancy free video data transmission model architecture was proposed to eliminate the duplicate video data. Thus, the Green ICT Communication, networking and Data processing are discussed for WSN based Data Communication and data processing applications.

References

1. Muni Venkateswarlu K, Kandasamy A, Chandrasekaran K (2016) An energy-efficient clustering algorithm for edge-based wireless sensor networks. Procedia Comput Sci 89:7–16
2. Li C, Ye M, Chen G, Wu J (2005) An energy efficient unequal clustering mechanism for wireless sensor networks. In: IEEE international conference on mobile adhoc and sensor systems conference, Washington, USA, pp 604–611
3. Guiloufi ABF, Nasri N, Kachouri A (2016) An energy-efficient unequal clustering algorithm using sierpinski triangle for WSNs. Wirel Pers Commun 88(3):449–465
4. Banerjee S, Khuller S (2001) A clustering scheme for hierarchical control in multi-hop wireless networks. In: Proceedings of twentieth annual joint conference of the IEEE computer and communications societies, vol 2, pp 1028–1037
5. Heinzelman WB, Chandrakasan AP, Balakrishnan H (2002) An application-specific protocol architecture for wireless microsensor networks. IEEE Trans Wirel Commun 1(4):660–669
6. Asaduzzaman, Kong HY (2010) Energy efficient cooperative LEACH protocol for wireless sensor networks. J Commun Netw 12(4):358–365
7. Sohn I, Lee J-H, Lee SH (2016) Low energy adaptive clustering hierarchy using affinity propagation for wireless sensor networks. IEEE Commun Lett 20(3):558–561
8. Lee J-S, Kao T-Y (2016) An improved three layer low energy adaptive clustering hierarchy for wireless sensor networks. IEEE Int Things J 3(6):951–958
9. Bahbahani MS, Alsusa E (2018) A cooperative clustering protocol with duty cycling for energy harvesting enabled wireless sensor networks. IEEE Trans Wirel Commun 17(1):1–11
10. Yi S, Heo J, Cho Y, Hong J (2007) PEACH: power efficient and adaptive clustering hierarchy protocol for wireless sensor networks. Comput Commun 30(14):2842–2852

11. Adimoolam M, Sugumaran M, Rajesh RS (2018) A novel efficient clustering and secure data transmission model for spatiotemporal data in WSN. Int J Pure Appl Math 118(8):117–125
12. Kirkpatrick MS, Ghinita G, Bertino E (2012) Privacy-preserving enforcement of spatially aware RBAC. IEEE Trans Dependable Secur Comput 9(5):627–640
13. Upmanyu M, Namboodiri AM, Srinathan K, Jawahar CV (2010) Blind authentication: a secure crypto-biometric verification protocol. IEEE Trans Inf Forensics Secur 5(2):255–268
14. Kim J, Nepal S (2016) A cryptographically enforced access control with a flexible user revocation on untrusted cloud storage. Springer J Data Sci Eng 1(3):149–160
15. Ding X, Yang Y, Deng RH (2011) Database access pattern protection without full-shuffles. IEEE Trans Inf Forensics Secur 6(1):189–201
16. Ray I, Belyaev K, Strizhov M, Mulamba D, Rajaram M (2013) Secure logging as a service - delegating log management to the cloud. IEEE Syst J 7(2):323–334
17. William S (2013) Cryptography and network security principles and practice, 6th edn. Pearson Education, India
18. Mousa A, Hamad A (2006) Evaluation of the RC4 algorithm for data encryption. Int J Comput Sci Appl 3(2):44–56
19. Adimoolam M, Sugumaran M, Rajesh RS (2018) Efficient encryption algorithm for video data storage. Int J Inf Comput Sci 5(10):41–49
20. Bruce S (2008) Applied cryptography: protocols, algorithms, and source code in C, 2nd edn. Wiley, New York, pp 461–465
21. Tanenbaum AS, Wetherall DJ (2011) Computer networks, 5th edn. Prentice Hall, Upper Saddle River
22. Andy S, Haikal A (2017) Simple duplicate frame detection of MJPEG codec for video forensic. In: International conferences on information technology, information systems and electrical engineering, pp 321–324
23. Chiu C-Y, Tsai T-H, Liou Y-C, Han G-W, Chang H-S (2014) Near-duplicate subsequence matching between the continuous stream and large video dataset. IEEE Trans Multimed 16(7):1952–1962
24. Wang H, Tian T, Ma M, Jun W (2017) Joint compression of near-duplicate videos. IEEE Trans Multimed 19(5):908–920
25. Chou C-L, Chen H-T, Lee S-Y (2015) Pattern-based near-duplicate video retrieval and localization on web-scale videos. IEEE Trans Multimed 17(3):382–395
26. Scotti G, Marcenaro L, Coelho C, Selvaggi F, Regazzoni CS (2005) Dual camera intelligent sensor for high definition 360° surveillance. IEEE Proc Vis Image Signal Process 152(2):250–257
27. Weitao X, Shen Y, Bergmann N, Wen H (2017) Sensor-assisted multi-view face recognition system on smart glass. IEEE Trans Mobile Comput 17(1):197–210
28. Liu W, Zhang M, Luo Z, Cai Y (2017) An ensemble deep learning method for vehicle type classification on visual traffic surveillance sensors. IEEE Access 5:24417–24425
29. Fan C-T, Wang Y-K, Huang C-R (2017) Heterogeneous information fusion and visualization for a large-scale intelligent video surveillance system. IEEE Trans Syst Man Cybern Syst 47(4):1–12
30. Civelek M, Yazici A (2017) Automated moving object classification in wireless multimedia sensor networks. IEEE Sens J 17(4):1116–1131
31. Sasirekha S, Swamynathan S (2017) Cluster-chain mobile agent routing algorithm for efficient data aggregation in wireless sensor network. J Commun Netw 19(4):392–401
32. Aghdasi HS, Abbaspour M, Moghadam ME, Samei Y (2008) An energy-efficient and high-quality video transmission architecture in wireless video-based sensor networks. Open Access Sens 8(8):4529–4559

33. Dien MEE, Youssif AAA, Ghalwash AZ (2016) Energy efficient and QoS aware framework for video transmission over wireless sensor networks. Wirel Sens Netw Sci Res 8(3):25–36
34. Maulidin M, Mahmuddin M, Kamarudin LM (2016) Evaluation of video transmission of Mac protocols in wireless sensor network. J Telecommun Electr Comput Eng 8(10):189–192
35. Adimoolam M, Sugumaran M, Rajesh RS (2018) A novel efficient redundancy free data communication model for intelligent surveillance system in WSN. J Adv Res Dyn Control Syst 10(3):743–754

Smart Education Using Mobile Green Cloud Enabled Platform and Services

S. Jerald Nirmal Kumar, K. Anandhan, N. Suresh Kumar, and D. Damodharan

Abstract The education system passed multiple mile stones: from the traditional education, digital education and the introduction of smart education in the cloud, which provides easy access and promotes green IT. Nowadays the form of learning changes dramatically, such as conventional learning to smart learning to offer an all-encompassing understanding of how to use today's innovation to fully set them up for a rapidly changing world where versatility is important. Students are given various tools and techniques for acquiring knowledge from anywhere and at any time. One of these possible tools are the three blended flavours of significant technologies, namely the Mobile Green-Cloud Computing. Through cloud computing, the operating system focuses mainly on less carbon emissions and sustainable development not just for fostering the green IT advancement but also to reduce the energy consumption and the green house gas emissions. The migration from the conventional learning approach to the Mobile Green-Cloud Computing Learning system therefore allows, among other things, efficient use of resources, reduction of physical books and hardware components (i.e. reduction in energy consumption).

S. Jerald Nirmal Kumar (✉) · K. Anandhan · N. Suresh Kumar · D. Damodharan
Galgotias University, Greater Noida, India
e-mail: Jerald.kumar@galgotiasuniversity.edu.in

K. Anandhan
e-mail: anandhan.k@galgotiasuniversity.edu.in

N. Suresh Kumar
e-mail: sureshkumar@galgotiasuniversity.edu.in

D. Damodharan
e-mail: damodharan@galgotiasuniversity.edu.in

B. Balusamy et al. (eds.), *Green Computing in Smart Cities: Simulation and Techniques*,
Green Energy and Technology, https://doi.org/10.1007/978-3-030-48141-4_7

1 Introduction

1.1 In This Day and Age

The Education has no restrictions and accomplished from encounters around us. A formal way of defining the education can be, "The Education is the way toward obtaining or giving precise guidance, predominantly in schools and universities". The learning is auspicious strength for Knowledge and skills. To understand the way in which we deal with education today and a decade before is completely different. There are two perception in which a student get the education in his life.

(1) Teacher Centric
(2) Student Centric

In this day and age, a revolution has occurred after the year 2015. The Teacher centric approach is transformed into Student approach today after the introduction Outcome Based Education (OBE) [1].

1.2 Revolution on Technology

The educational data is now made available to a student like bread and butter with cutting edge technologies. There are various tools and techniques are offered to the students to acquire knowledge from anywhere, anytime and anyone. This is possible with three blended flavor of significant technologies i.e., Mobile Green-Cloud Computing.

1.2.1 Search Engine

The World Wide Web (WWW) is inevitable in this world today. The Internet has reached every corner of the world in a drastic manner. The artistic way to handle this growth is to enhance our skill periodically. The one who can handle the Google Search can play gimmicks in learning towards the trending technologies. Google is the entry gate for most of the internet users for past two decades. The Google Search is best resource locator comparatively with all the other search engines in the market. There are more Google products available to support the students for their education a lot. Recently introduced, Google Co-Lab, Google Cloud [2] were used to deploy student projects in the Machine Learning and Data Science domain.

Baseline for every student today is avoid Physical books to E-Book learning. The E-Book is available in eminent way to handle in all the platform such as Computer, Laptop, Tablet, Mobile, watch, etc. The Audio E-Books is another helpful resource for learner to engage in learning for long time in their playlist.

1.2.2 Outstanding Storage

The notebooks are usually used to take notes are transformed into digital notebooks today. There are thousands are website can able to store your diversity of notes in an organized way online easily. Writing all the important key points in a note and months later there are chances to miss the snippets. The greatest solution to all this issue is taking notes online and accessing anywhere and anytime by any platform like mobile or Tab (Fig. 1).

1.2.3 Mobile and Gadgets

The Digital gadgets are trending nowadays learn and produce data in fast manner. The Computer and Laptop are used by all the students in this day and age to manage all their work in an organized way. The learning has evolved in controlling machines, gadgets and communicate among them to complete task. The Computer was best solution to work for long time in one place.

The Laptop has the greatest capability of flexibility to take anywhere. An efficient device to share and use for presentation. Mobile has set it benchmark from the year 2000 until now. The feature of mobile has taken a diverse path to learn and record a data. Take a picture of important note and share among the friends with the help of the internet. This process uses all the technology, what we are discussing from the beginning—Mobile Green Cloud Computing.

1.2.4 Instructor—Information and Communications Technology (ICT) Tools

An instructor is handling large numbers of ICT tools today to make the education reachable to students rapidly. The Power point Presentation, E-Books, Video Lectures, Online Quiz, Assignment, Mini Projects, Flip Classes, Online Videos and much more. All the above techniques is managed by Mobile Green-Cloud computing. All the teachers mandatorily need to use Mobile, Green and Cloud Computing in analysis of tracking the performance and growth of a student skill. The outcomes of each courses taught can measured will this technologies in an efficient manner.

Fig. 1 Cloud storage solutions

The instructor play a major role in what and how to be educated. The structure need to be framed, for all the topics. The technology is open to live demo many topic can be executed in simulation online and offline. This will enhance the understanding of the topics. The main objective to avail all the tools effectually to upgrade our knowledge every so often. The education nowadays served with Knowledge, skill and attitude by their curriculum.

1.3 Mobile Green—Cloud Computing Era

The trending innovations are gradually receiving a situation to help the understudy to realize, what is required to a student, how it can be acquired easily. The following are the various technologies being adopted in the past 2 years.

- Cloud Computing Tools
  - **Cloud Volumes ONTAP**—data access and management across hybrid and multicloud environments.
  - **File Cloud**—Comprehensive file-sharing, backup, and sync solution.
  - **Up Safe**—Highly secure cloud backup
- Green Computing Tools
  - **Smart Board**—by Promethean, iboard, BoardShare, etc.,
  - **E-Books**—in Portable Document Format.
- Mobile Computing Tools
  - **Hands-on Dictionary**
  - **Learning Apps**—Coursera, Solo Learn, Udemy, Wikipedia, BYJU'S, LinkedIn Learning, etc.,

2 Literature Survey

Amol Kale et al. [3] has stated the significance of the cloud storage and implementation of cloud technology in the education system. Indicated the advantages of cloud over, personalized learning, performance and user friendly in education system.

Lovedeep Saini et al. [4] presented a new heading to utilize cloud which is highly exceedingly versatile and makes virtualized resources that can be made accessible to end-users will have a significant impact on the educational environment such as online assignment, receiving materials from teachers, quiz, updated time table, receiving examination venue and so on.

In terms of sample groups, both Melhuish and Falloon [5] and Clark and Luckin [6] report that published papers show a ipads usage and class room structures devices,

followed by M-learning with computing devices ipads, mobiles, etc. M-educate systems are higher level study's increase. Oddly an only some study in equally meta-analyses be interrelated through the employ of m-learning starting the professors otherwise teachers' position.

Relating to the learning contexts of m-education studies, Pynoo et al. [7] information are register as soon as persons contexts are exposed, familiar knowledge contexts are major, followed by prescribed contexts and a grouping equally. This outcome be regular by means of results reported by other authors, namely by Ifenthaler [8].

Al-Zahrani and Laxman et al. [9], in this publication talk about the position and significance of mobile devices and social media applications in current learning and the updated techniques and benefited discussed on this paper and so on.

Kavitha suryawanshi et al. discussed about green information and green technology approach towards minimizing carbon footprint. She was done survey for finding critical success factor and analyzing green ICT in education [10].

Hudiarto et al. proposed the innovative balanced scorecard for determine green IT in higher education institution. This balanced scorecard (BSC) can calculate themselves and implement the initiates provide by the top level institution [11].

Raza et al. proposed an innovative of teaching users to easy understand how the power consumption impacts the "greenness" of any technology, believing it to be an essential step toward reducing wasteful energy consumption. Efforts to educate the young generation through educational programmes in schools and universities are already under way in the U.S., Hong Kong, India, parts of Europe, and the U.K. (Murugesan, 2013) [12].

Amol Kale et al. has stated the significance of the cloud storage and implementation of cloud technology in the education system. Indicated the advantages of cloud over, personalized learning, performance and user friendly in education system.

Lovedeep Saini et al. presented a new heading to utilize cloud which is highly exceedingly versatile and makes virtualized resources that can be made accessible to end-users will have a significant impact on the educational environment such as online assignment, receiving materials from teachers, quiz, updated time table, receiving examination venue and so on.

Zhi-Ting Zhu et al. discussed about the improvement of new advances, empowers students to adapt all the more successfully, productively, and serenely. Smart education a concept that describes learning in digital age, has gained increased attention.

Xiao Nie presented the concept of smart campus and also differentiated the digital versus smart education. He analyze the function by raising the model of framework of smart in cloud computing.

3 Mobile Computing

The present world can give more important to Technologies in various fields especially Education, medical, financial banking and corporate, etc.

In our education system, one of contribution is always using new technologies. It can perform the most important role and deliberated the important techniques to instruct colleges and schools. An instruction established a technical lab to use the students in order to communicate and assignment with instructors. Similarly, many instructors routinely use mobile technology in their classrooms and lab for assessments and documents transferring data to students.

Other then remote Technology gadgets are rottenly utilizing people like banking, open society, schools are joining the improvement. Gadgets, for example, Mobile phones and Mobiles App's, iPods, iPads, MP3 players [5], and tablets are being utilized over the world for instructive purposes. Students are already using these devices in their everyday lives; applying technologies in the classroom can make better learning and more motivating the knowledge.

Zeal-time sharing the study materials, reports, assignments, assessments all the data can transfer mode making so hard, instantly can go with soft technologies and mobile computing is an only solution reduce the difficulty and utilizing those devices for educational purposes, because it is very handy and access the information anywhere in need.

Students who, when looked with trouble or snag in their regular day's existences, discover the appropriate response without delay (through mobile technology); teachers must use innovation to apply this "request to know" normal for advanced locals in the homeroom. Nowadays that tablet PCs and other compact preparing devices are less difficult for instructive frameworks and associations of higher creation sense. They are routinely merged into an informative situation. Uneven figuring development is particularly profitable for visual, sound-related and verbal understudies since it might be successfully done again to suit the different habits by which understudies become comfortable homeroom [7] activities and review information taught to them by instructors.

1. At first, the trainer must be ready to use the advanced technologies skill to integrate without break into their organization. It is the ways to be in suggest taking classes [6] and convening a position to establish, solving the problem with innovation.
2. Coursework has been supposed to depart earlier period essentially seeing introductions or slides and give pre-administration educators chances to utilize innovation in manners that takes reflection into dynamic commitment.
3. Mobile registering innovation is individuals from the scholarly network who approach assets for example guides made in-house, face to face helps and a customary address arrangement, Conversations on Digital Pedagogy that enables staff to build up an arrangement to effectively coordinate innovation into their educational programs. The Center technique equally features is successfully utilized for innovation, then help to replacement education in the advanced teaching and learning to set from side to side its primary appearance on web recording.

3.1 Features of Mobile Computing

Adaptable innovation has established important for outside regular study halls. For understudies considering subjects example, science, agribusiness and medication utilizing a portable information accumulation framework including tablet PCs and cell phones empower them to effectively record that field for educational purposes [6].

- **Transportability:** Information could be gathered from for all intents and purposes of any area and put away for afterward recovery.
- **Adaptability:** Methods of information gathering could be changed so as to customize an understudy's learning knowledge.
- **Improved processor proficiency:** Students would be tested to learn and utilize versatile information gathering advances, which would upgrade understudies' PC education.
- **The simplicity of progress:** The mobile framework could be effectively changed and redesigned as required, instead of paper-based information accumulation shapes that are tedious and less well disposed to nature.

3.2 Enhanced Learning

The trainer can give good technical and moral support to trainees for developing ways and identifying the problem who faced then technically resolve the defects [13].

- **Unsigned membership:** Students are not able to ask and accepting the resources may well suggest questions to the trainer or react to trainers question not including others in the classroom knowledge. This would make available an opportunity for the "dumb questions" students are regularly too fearful to ask.
- **Common analysis:** Submitting coursework or practice training might be looking closely reviewed with shared controlled software.
- **Conception design:** complex concepts could understand easy if it visually illustrates are using graphics or else animation videos that might be played in complete or measured motion as well. Students would able to interrelate through the picture to examination their understanding the models has creature and presented.
- **Facts gathering:** Prepared with a suitable device possibly will use in technical teaching room and view statistics data collected works.
- **Learning game:** Cluster parts of exercises are planned to support or determine concepts that may exist one is used to control the learner part noticed in a participative manner. Large screen video based question and answer puzzle gaming with member monitoring would create sure that all category members obtain a possibility to be occupied.

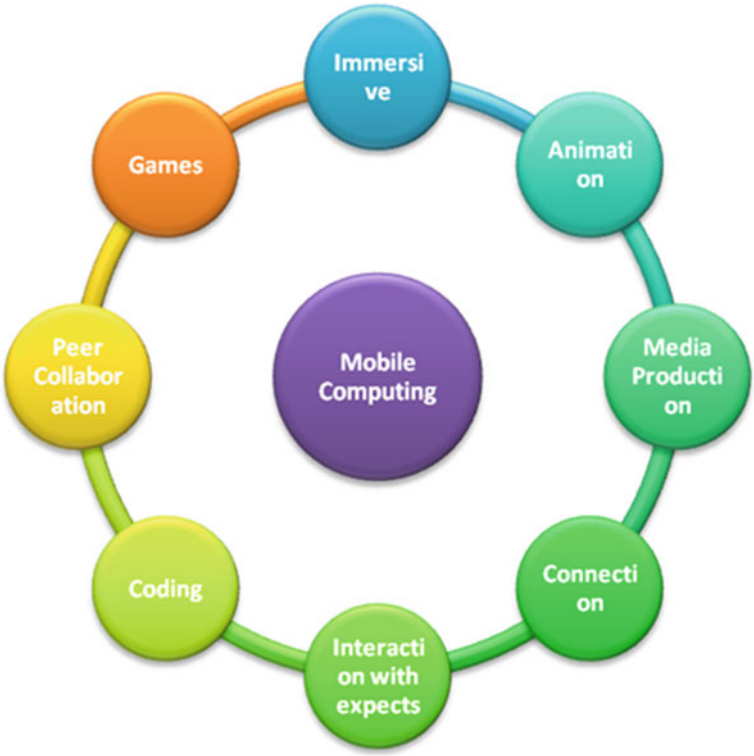


Fig. 2 Excellent ways to education techniques and create your classroom

- **Enhanced and fitness response:** Current quiz and evaluation should be award direct comment for the period of beginning attainment. Total computing is a way to undertake the tools and apply practical training that might be working to enlarge the quantity of response (Fig. 2).

3.3 Enhanced Learning

E-content and E-supplemental

Handhelds give a fit stage to e-content and additional reading circulation. A feature we can go updated technique Digital Rights organizations speak to patent issues. The guide can able to sifted also saw at various dimensions since synopsis to factor. Content be able to be completely referred inside the content to the different facilities also online assets. For sight-weakened, the content to-discourse interpretation should permit devices to peruse so anyone might hear to the understudy.

E-category membership and monitor
A smaller device with special PC Indent's may possible to be utilized and measure participation on an unbiased foundation. Understudy support just as understudy time on an assignment could be precisely followed.

Incorporating smart education in mobile computing
On purpose of increasing devices and interfacing user eco-friendly system-wide discussion and planning training for use of educational technologies given by all training and create offers (Pre-service) teachers.

Advanced learning and Administrator of Technical educator training
Software and hardware oriented jobs expert to increases for all lecturer levels in faculties and listening carefully to apply the recent tools and mobile computing technologies. In the direction of pre-service educator culture in a similar way to teachers resolve to exist predictable toward carrying their students learning [14].

Principles and practiced
Based on the updated skills and trending standards education is developing rules following by the services, students, job seekers guided all over programs. Preplanned for professional improvement on education and other supporting education like a training center, gaming maintains technology as the advanced field for micro credentialing.

Professor Trainer Support
Finding the rights opportunities to support educational intuition create more sustainable professionals and technical culture opportunity through teacher preparation instructors and pre-service teachers [15]. Continue updating on live educational skills and strategy to organize the way in a place to adviser pre-service trainers inside their classrooms.

States and District Schools
Employment with near and other than location based on technical support to make nonstop opportunities for their seekers and trainers to employ through luxury representative skills use to carry scholar wisdom.

3.4 Significant in M-Education

With the appropriation of several latest innovations, it is at the same time some difficulties also there organized. Remote handhelds are the same. Key issues include:

Handheld Device
As instructors who educate in work areas like computer laboratories, coordinating PCs interested in guidance has been a check and analysis. It has no eagerness to think coordinating devices resolve the existing one and less difficult. In numerous PC labs, teachers have grappled with keeping up understudy consideration [8]. Understudies regularly sit close to the support the group of students so it can peruse individual

communicate like mail, search the Internet, make amusements, or talking live with her companions. The device condition will be the same.

As talked about before, programming accessibility is the main problem. The writing has appeared there are a few study hall tests in progress in which scholastic programming applications and programming frameworks are being investigated.

At last, there is a significant electronic swindling. Smaller e-device with remote correspondence ability creates radiating responses to schoolmates very simple. As instructors have discovered, the present number crunchers with infrared correspondence regularly must be restricted from the homeroom or testing focus to abstain from swindling. Without sufficient shields, they can easily convey a message like answers swapping and copying.

Likely the greatest obstacle to an acknowledgment of handhelds is essential, instructive conveyance stage is a similar obstacle for teachers have looked in moving training substance nearby Internet—protected innovation privileges. As document-oriented patent laws are adjusted there complex period because computerized rights, the executives programming tends to copyright encroachment, a substance will in the long run move to the handheld.

Similarly, as with any device, fitting use is basic in protecting the prosperity of those in closeness to the instrumented client. Numerous school grounds forbid the survey of obscene sites on free PCs, as this might be considered hostile to understudies sitting close-by in the lab.

At last studies are a shift on the topic of through their handhelds, portability will "extend schemes security assets toward the most remote spans of the world". The risk of versatile interlopers turns into a genuine concern. Without sufficient security, remote handheld systems become an obvious objective for PC infections, stolen "associate" time, or individual fraud.

Numerous issues have examined in M-Education by the researcher and learning network even though it's become mandatory in day to day leaning activity, the issues had overcome when it consolidates with the cloud, and to it's become progressively green.

4 Green Computing in Education

4.1 Introduction

Now a days the learning way of method change dramatically, such as traditional learning to smart learning for giving all-encompassing figuring out how to understudies utilizing present-day innovation to completely set them up for a quickly changing reality where versatility is essential. It is not only a change in the delivery of education, but it is also much more than that of inspiring the learners.

A Computer is most important significant tool for everybody in education, business, personal, banking sector, and government, etc. Without computer no work

should be possible. So the maximum usage of computer must be ideal. Computer should not to be utilized superfluously. In spite of whether the client does not turn off the computer, they should power off the CPU and all peripherals during the all-inclusive times of latency. A person should know how to utilize the machine by reusing them contrasting to arrange them as wastage. The Students and faculty must use wide range of study materials should to be used as e-material on internet or digital format content. Accordingly, all such data should be required to be arranged into every all person to keep up eco-cordiality [16].

4.2 Green Computing in Institutions

Including Green Computing into the school core curriculum: To prepare school students for the encourage efforts in Science, Technology and Engineering, Art and Design, and Mathematics education the following steps will be taken:

a. The child age 6 onwards, computational idea (the thought processes involved in formulating problems and solutions in ways that computers can effectively execute) will be included into the school core curriculum. The basic foundation skill in the digital age and it can be successfully taught with well-made paper worksheets.

b. In future all the students are use the connected personal computing devices and the affordability by 2023. The school core curriculum will give confidence about digital literacy using these personal devices as well as existing digital infrastructure (PC laboratories, innovative laboratories etc.).

c. In primary and secondary school will offer elective subject on programming and other recent trends activities to all the young children.

In now days the world, computing is not at all atmosphere eco-friendly. It is the correct time that the green computing will need to be change. For a fresh new start, companies or businesses should be increasingly keen to make energy and cost savings in the face of rising electricity prices. Computing has a big area of human activities where real environmental savings need to be made implementing straightforward practical measures with existing hardware. The institutions or individuals should have more knowledge about the software usage to determine carbon emissions output from their computer use. Many people does not aware about what is mean by standby or sleep mode, the power can be saved more compare to shutting down a desktop computer are not properly turn it off.

The institutions can award a three level of certification course, Level 1: Foundation of green IT: Principles and practices completed person certified as green IT associate (CGIA). Level 2: Implementing green IT completed person certified as green IT specialist (CGIS). Level 3: Greening an enterprise: Green IT and enterprise sustainability completed person certified as green IT professional (CGIP). The syllabus frame should design by the BOS-Board of Study team members [17].

All the institutions every semester and annually prepare the question paper and result analysis calculated and maintain by in the file (Hardcopy). The A4 sheet play a major role to print all the information, A4 sheet was made by pulp is fed

to paper machine it will remove the water content by pressing and drying. Green computing suggests that to avoid print unnecessary documents in the institutions. The alternatively an exam can conduct through online, it will save more paper as well as tree. Every institutions must have sustainability office whenever the students are free they can learn more about green computing impact in the education.

4.3 Digital Content Delivery

Smart Boards are becoming a vital role component of the entire classroom. The following reasons:

- The smart boards are an easy way of deliver the content with efficient manner. It consists of touching and marking at the board, recording, 3D animation, presentation, audio and video learners can observe the teaching using board.
- The board was connected through USB port, we have ensure the calibration must do first before start to use the board. (four point, six point, 12 point calibration)
- Every board must have own pen, using that pen we can calibrate the board for accuracy sense.
- Use it as a tool for note-taking. Students can come and write important points on the board.
- Brainstorming in the all the classroom can be entertaining with a Smart Board. The board can support multimedia files such as text, images, diagrams, videos, quiz.
- Classroom strength can be divided into different groups to start games with ease on the smart board.
- All forms of media—videos, photographs, graphs, maps, illustrations, games, etc.—can be used on the board, making it incredibly dynamic in nature. This expands the range of content that you can use for teaching or presenting new information.
- The digital screen allows entering the different style of text, images from the computer to be displayed on a board. Any data we can also be modified on the screen itself, using a pen or a highlighting tool. The software will provide more convenient for the touch screen feature allows instructor to run programs directly from the screen simply by tapping the application with her finger and even makes scrolling easy.

4.4 Methodologies and Approaches Towards Green Computing

Green Computing is an important topic in the current circumstance. Now a days it is essential that in graduation or even in school level also there must be one subject

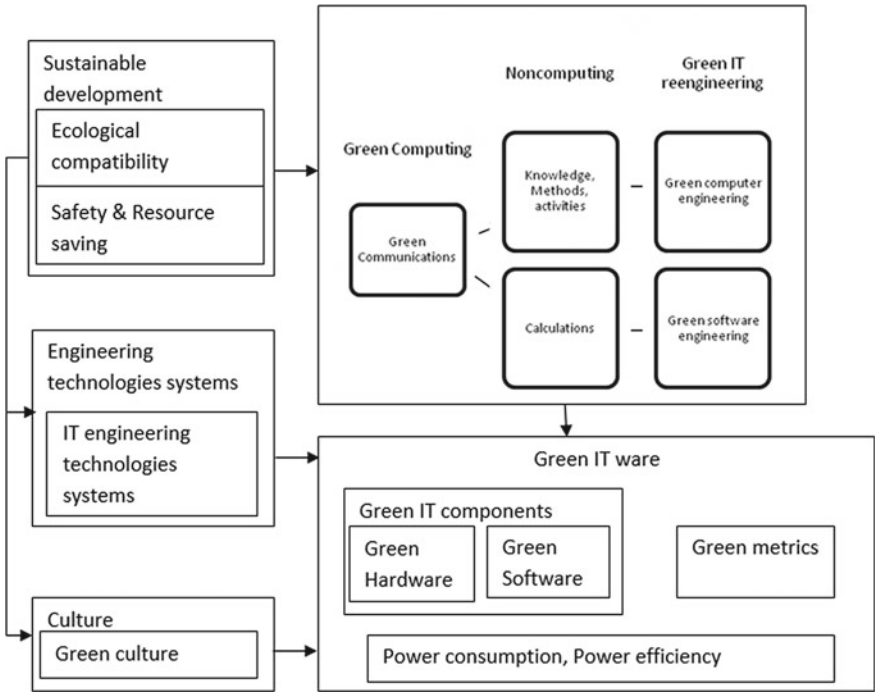


Fig. 3 Green computing components for education

called "Green Technology" to show Green IT and Green advancement. This subject is directly not only a theoretical subject of course a full application arranged subject. The understudies ought to be set up from school level what we mean by Green Technology or Green IT. The understudy should be given some endeavor on Green Computing or Green Technology. They ought to be allowed to do test how to save imperativeness [18] (Fig. 3).

4.5 To Design Green Software and the Corresponding Green Operating System (O/S)

The green computing will have a special kind of operating system (OS) in future. These operating systems mainly focus on less carbon emission and sustainable development. The institution and corporate can design, build and maintain the large networks of data. The IOT internets of things play an important role in natural environment. All the IOT components connect together such as sensors, smart energy grids, energy production and other systems.

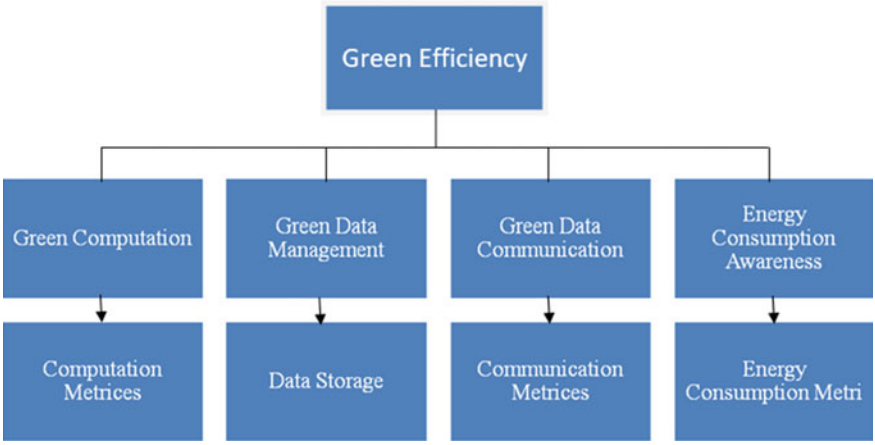


Fig. 4 Green computing efficiency

Open Source is a driven approach that is not linked to any vendor/supplier. It is widely supported by environmentally conscious proponents using fewer resources, thus being more efficient. The future operating system should be network based and it would be efficient in running network applications via Cloud Computing. Power consumption should be handled at both the levels: end user and server level. Linux operating systems is considered to be green OS as it is more environmentally friendly relative to proprietary systems. It has energy efficient power consumption mechanism. An operating system which can have full rights to control all the hardware device and memory, associated with the power savings are reduced carbon emissions.

The increasing amount of the energy consumption of today's IT solution significantly contributes to green house gas emissions. "Green Computing" or "Green IT" emphasizes on the need for reducing the environmental impacts of IT solutions by reducing their energy consumption and their green house gas emissions. ICT contributes to 8% of global energy consumption and it is expected to increase to 40% by 2030. Most of the hardware systems have significant software components. Although the software systems do not consume energy directly, they affect the hardware utilization, leading to indirect energy consumption (Fig. 4).

It is essential to engineer the software to optimize its energy consumption and a new subject called Green Software Engineering has emerged to increase energy efficiency in computer systems.

Technique for Implementing Green Computing in Management, Administration [3]**:**

- Online admission tests and publication of results
- Evaluation of exams through software
- Submission of marks, attendance, payment and other details through software
- Introduction to College/academic institute through Online Brochures

- Online filling and submission of applications and feedback
- Course details and associated staff members
- Online management of college events
- To maintain Management and administrative data through on-line using cloud computing.
- Online fees payment system

5 Smart Education Using Cloud Enabled Platform and Devices

5.1 Education in Cloud

The development of technology makes the learner more interesting than traditional learning, Smart education, an idea that portrays learning in the computerized age, has increasingly expanded consideration. The smart education which can make a society with better education and to its very trending technology that is Cloud Computing [19]. The word cloud which is used to refer the internet, On-demand we can able to access the learning data, it uses central remote servers that are virtualized to maintain application and data (Fig. 5).

5.1.1 Traditional Education

The traditional education is simply oral teaching, In this approach, students sat unobtrusively at their places and tuned in to one understudy after another present his or her exercise. He educator's essential action was relegating and tuning in to these recitations; understudies considered and remembered the assignments at home [19]. A test or oral examination may be given toward the finish of a unit, and the procedure, which was designated "task consider recitation-test", was rehashed.

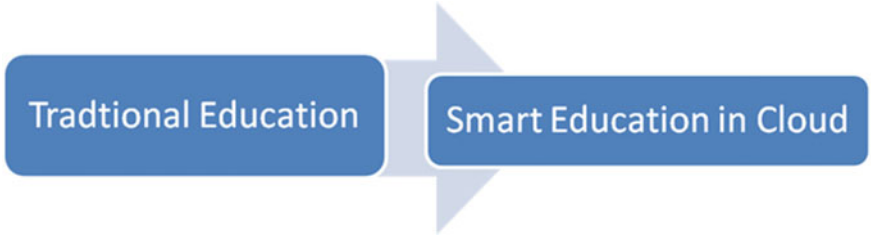


Fig. 5 Transforming education

This conventional methodology additionally demanded that all understudies be shown similar materials at a similar point; understudies that did not adapt rapidly enough flopped, as opposed to being permitted to prevail at their characteristic paces.

Demerits of Traditional Approaches

- Blackboard Teaching—Chalk dust
- Favoritism
- Communication
- Lacking students focused learning
- Lacks Emphasis on Critical Thinking
- Students dependent on teachers
- Lack of Interactive Leaning

5.1.2 Smart Education

We slowly start to move from traditional learning to smart learning for giving all-encompassing figuring out how to understudies utilizing present-day innovation to completely set them up for a quickly changing reality where versatility is essential. It is not only a change in the delivery of education, but it is also much more than that of inspiring the learners.

A smart instruction should be possible in a virtual or physical condition. It could likewise be a mixed adaptation of both. Keen training can likewise be outlined as the utilization of savvy gadgets to enlarge the learning result of customary instruction [19]. Smart training advantages guardians too. Educators can record the information of understudies with respect to their participation, examination scores, and so forth and impart the equivalent to the guardians.

The information recording techniques and specialized apparatuses together consider guardians to get engaged with the learning procedure of their kids. E-Learning is a smart education which is accessible by all types of learning community since its more interactive, and no limitations of learning. Moreover, we can avoid storing data offline. Cloud computing plays a very effective role in smart education like E-Learning and too it provides a lot of tools to the education system [20].

5.1.3 Traditional Versus Smart Approaches

5.2 Smart Education Using Cloud Platform

The "Cloud" is a blend of mechanical assets, for example, systems, servers, and applications in a typical pool where organizations and individuals can lease a progression of administrations and capacity to their particular needs [21]. It provides all types of services such as platform, software, and infrastructures to smart education. It can be

Table 1 Traditional versus smart approaches

Topic	Traditional approach	Smart approach
Person	Teacher	Student
Main objective	Rank, grades, graduation	Learning, maintenance, collection of profitable information and aptitudes
Classroom	• Grouped by age	• Based on interest or ability
	• The same content will be shared at a time	• Different groups handled at a time
		• Open classrooms
Teaching methods	• Lectures, seminar, instruction	• Creativity
	• Idle in seats	• Hands-on activities
	• Students knowledge through listening and observation	• Smart devices
		• Group activities
Materials	Textbooks, lectures, and assignments	Internet, digital library, webinar, E-learning
Subjects	Individual, independent subjects	Integrated, interdisciplinary subjects
Content	Memorization, textbook information	Analysis, evaluation, innovation, critical thinking
Relationship	Students should respect and obey teachers, narrow thinking	Both of them work together, broad thinking

rented based on the needs, it reduces the infrastructure cost for the beneficiaries and to the maintenance cost.

Cloud computing in smart education provides attractive features to the E-learners such as No more expensive textbook, Outdated learning material, Hardware, and Software required. It provides more and more diverse to all the people in the learning community. The cloud is only potent technology which can integrate all the learner community and its key to enrich the education activity through tools and applications in the cloud [22]. Understudies can work inside virtual homerooms, speaking with understudies far away, continuously, and consolidate the training of individuals from totally various foundations.

The education future is in the hands of cloud, Eventual fate of instruction is in the cloud. As per Technavio promoting research, the worldwide distributed computing market in training will see a compound yearly development rate of 26% through 2021 as teachers inside K-12 schools, universities, and colleges attempt to upgrade efficiency and improve the general learning knowledge. Moreover, 80% of the education system changed to a cloud environment so that we can save time, money, and learners can able to fetch global data [30] (Table 1).

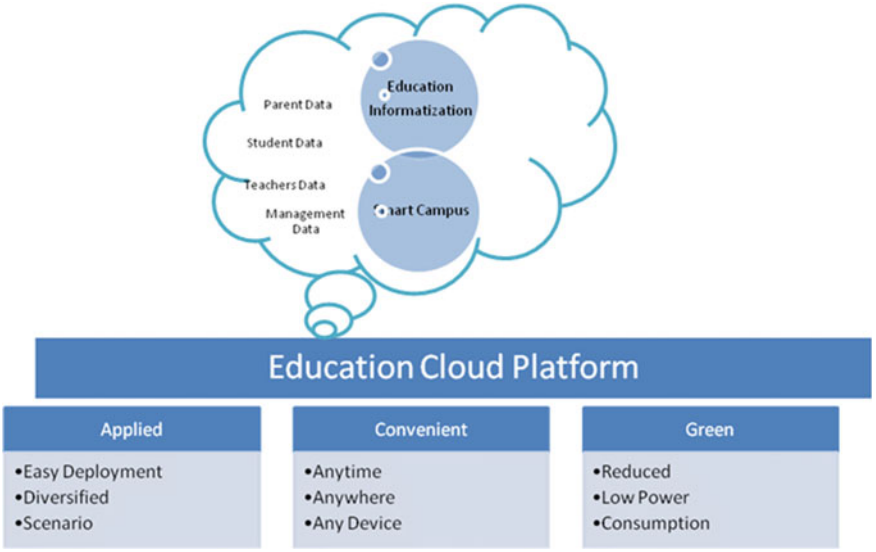


Fig. 6 Smart education in cloud

There is a big difference in traditional education and smart education, people attracted more in smart education because of their silent features, when it is used in cloud platform learners can able to get their data at anywhere in the world at any time and too there is no limitation of data access. The idea of smart learning assumes a significant job in the formation of a proficient learning condition that offers customized substance and simple adjustment to the current instruction model. It likewise gives students an advantageous correspondence condition and rich assets.

The cloud education using smart learning offers new thoughts and arrangements in accomplishing interoperability among heterogeneous assets and frameworks. Cloud learning permits the reuse of learning assets in a circulated way. It gives accessible instructive administrations in the cloud, utilizing the systems and devices that give distributed computing [23] (Fig. 6).

Advantages of using Cloud In Education

- Access to an application from anywhere and anytime.
- Support for teaching and learning.
- Compatibility in format
- Low Cost
- Secured Data
- Increase openness to students to new technologies.
- Opening to advance research.

We are utilizing distinctive administration models like IaaS, PaaS and SaaS of the cloud with various arrangement model like open, private, mixture and network

mists in our educating and learning process, among the distinctive model [24]. We are essentially center around IaaS (Infrastructure as an administration) with Private sending models. As we have proposed to utilize IaaS of cloud in our instruction condition it offers the framework that is required for educating and learning "use as you pay on" premise or once in a while with free of expense.

The private cloud models are regularly intended for a solitary association or college. Unique divisions of a college can share its administrations. It is more verified than the various models and the primary preferred position of utilizing private cloud is that is verified to explicit clients just methods it is helpful to the security motivation behind the information.

5.2.1 Education Cloud System Platform

In smart education using cloud, the education domain is linked with the cloud, thereby it maintains the data in the virtualized server, so the learning community (Learners, Researchers, academician) can fetch the data at anytime and anywhere in the world and too they can able to access any type smart tool which is used for education purpose [25]. The figure below shows the platform for smart education in the cloud (Fig. 7).

The education system crossed various milestones such as traditional education, smart education then deployment of smart education in the cloud. The aim of using the Education Cloud System Platform is for easy access and makes it green.

5.2.2 Architecture of E-Learning Cloud

E-learning platform provides the sharing, reusing learning objects and interoperability for learning community, when it is used along with cloud technology makes demand in learners, since its use virtualization we can store and access abundant data. It increases flexibility, convenience, easy accessibility, consistency and its repeatability [26]. Figure 8 shows architecture of E-learning cloud it consists of four component hardware resource layer, software resource layer, resource management layer, and service layer.

(1) Hardware resource layer: It is located at the lowest level of the cloud middleware services, the basic computing power, such as physical memory, CPU, memory layer is provided by the layer. This Emphasis is placed on the construction of infrastructure.

(2) Software resource layer: This layer mainly is combined with operating system and middleware. Because of middleware technology, a variety of software resources are integrated to provide a unified interface for software developers, then they can easily develop a lot of applications based on software resources and embed them in the cloud.

(3) Resource management layer: The layer is the Ney to achieve loose coupling of software and hardware resources. Because of the integration of virtualization

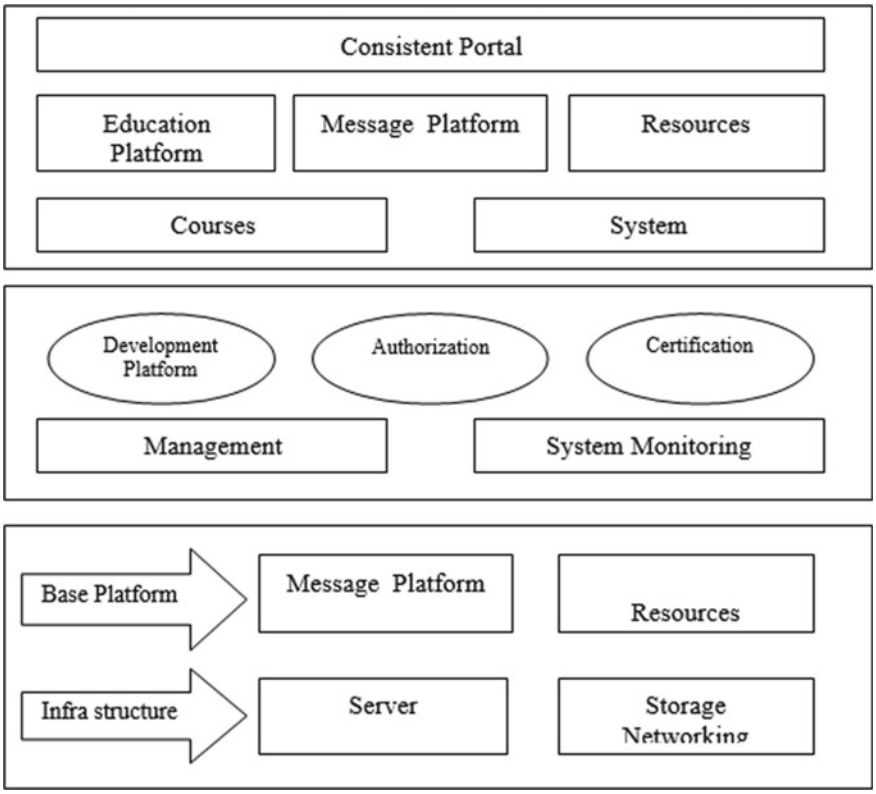


Fig. 7 Education cloud system platform

and cloud computing, scheduling strategy, free flow and distribution of software over various hardware resources can be achieved at layers 2 and 3, three substrates commonly seen.

(4) Service layer: There are three levels of services in cloud computing are SaaS (Software as a service), PaaS (Platform as a service), IaaS (Infrastructure as a service). In SaaS, cloud computing service is provided to customers.

5.2.3 Cloud Tools and Web Services for Smart Education

Training framework can be made simple with the help of cloud registering, where it furnishes everything which is been thought with procedures like a chalk writing board, classrooms. Teaching has been changed into on the web and generally proficient method for realizing, which encourages the client to take a class in an hour is a preferred position of learning utilizing innovation. Training framework requires

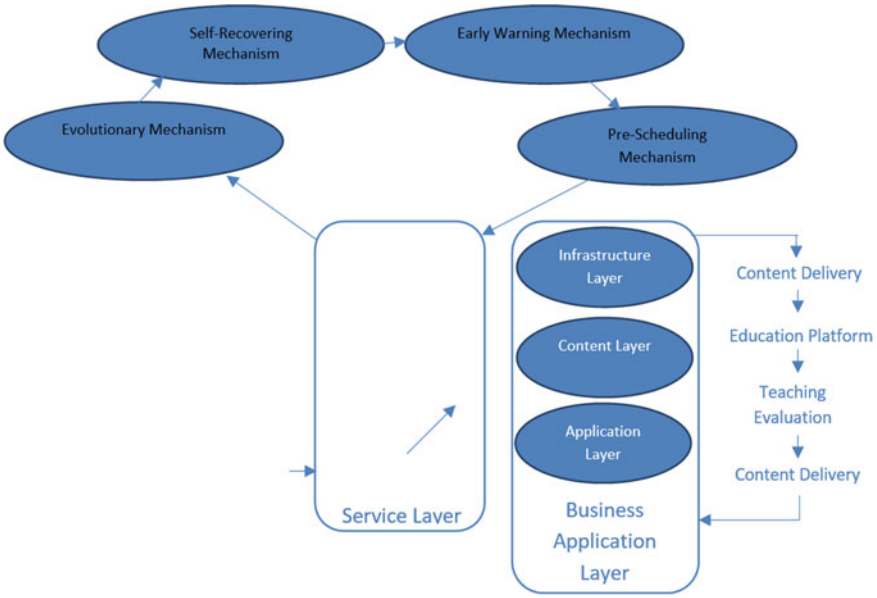


Fig. 8 Architecture of E-learning cloud

E-Learning and online arrangement for this we are in need of cloud application and tools to interact with the cloud.

The above figure shows different application tools in the cloud which can be accessed through a web browser that provides an interactive online environment. Cloud-based devices and applications are given utilizing innovation, for the most part, alluded to as distributed computing. Learners and instructors are very well indeed mindful that innovation changes and youthful students flourish in that changing universe of innovation. Cloud based apparatuses and applications bring adaptability and new conceivable outcomes for improving teaching methods just as another arrangement of difficulties in how to utilize the capability of the cloud (Fig. 9).

AWS Platform

The trending web service which is used in cloud is Amazon web services. This is the basic structure of AWS EC2, where EC2 represents Elastic Compute Cloud. EC2 enable clients to utilize virtual machines of various setups according to their requirement. It permits different design choices, mapping of individual server, different estimating alternatives, and so forth. We will examine these in detail in AWS Products section. Following is the diagrammatic portrayal of the design (Fig. 10).

Load Balancing

It is intend to hardware or software load over web servers, that improver's the productivity of the server just as the application. Following is the diagrammatic portrayal of AWS design with burden adjusting.

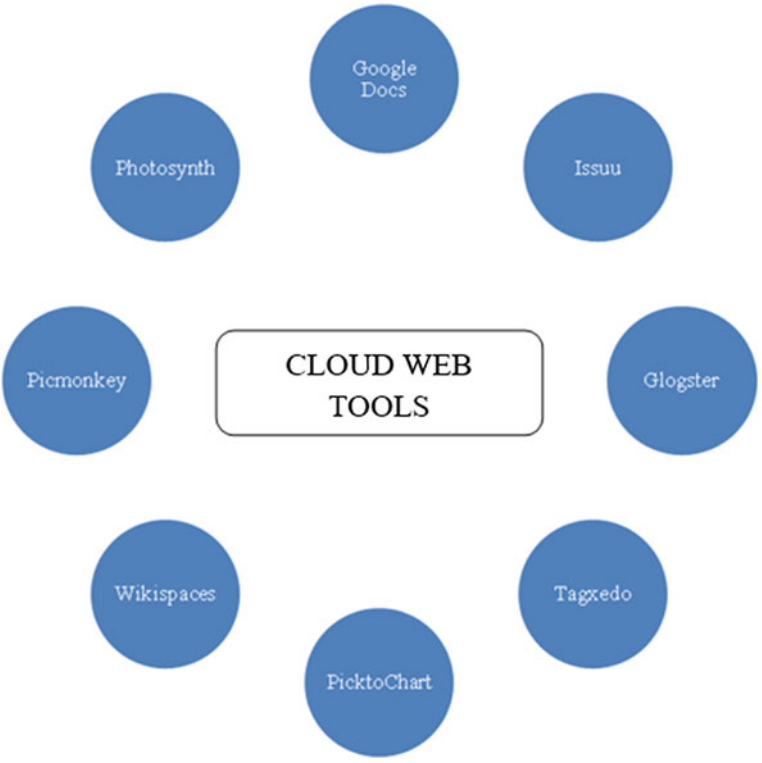


Fig. 9 Tools and application of cloud

AWS gives the Elastic Load Balancing administration, it appropriates the traffic to EC2 cases over numerous accessible sources, and dynamic expansion and expulsion of Amazon EC2 has from the heap adjusting revolution.

Elastic Load Balancing can powerfully grow and shrink the load-balancing capacity to change in accordance with traffic requests and furthermore bolster sticky sessions to address further developed steering needs.

Amazon Cloud-front

It is in charge of content delivery, for example used to deliver website. It might contain dynamic, static, and streaming content utilizing a worldwide system of edge locations. Requests for content at the client's end are consequently routed to the closest edge area, which improves the performance.

Amazon Cloud-front is streamlined to work with other Amazon Web Services, similar to Amazon S3 and Amazon EC2. It additionally works fine with any non-AWS inception server and stores the files in a similar manner.

In Amazon Web Services, there are no agreements or month to month duties. We pay just for an extent or as little substance as we convey through the service.

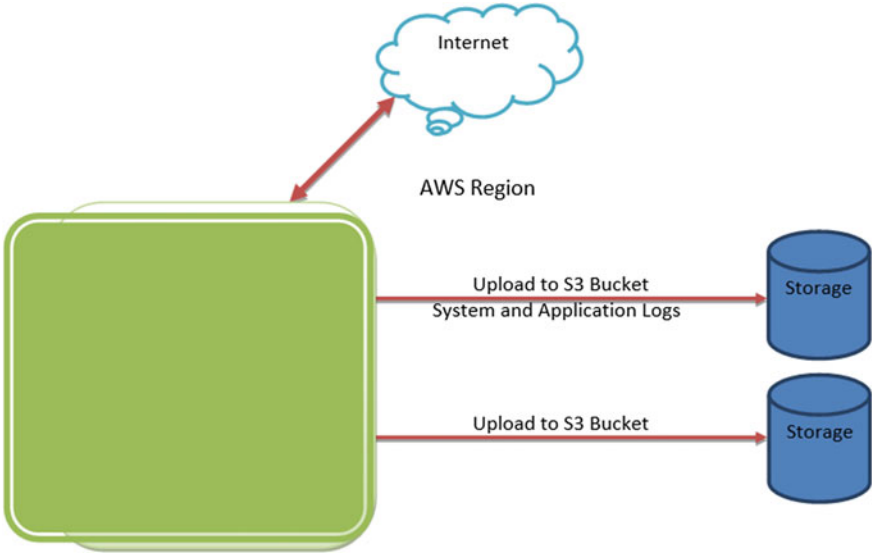


Fig. 10 AWS architecture

Elastic Load Balancer

It is utilized to spread the traffic to web servers, which improves performance. AWS gives the Elastic Load Balancing service, in which traffic is distributed to EC2 occurrences over numerous accessible zones, and dynamic expansion and expulsion of Amazon EC2 has from the heap adjusting revolution.

Flexible Load Balancing can progressively develop and recoil the load-balancing limit according to the traffic conditions.

Security Management

The component provided by EC2 is Security group, which resembles an inbound framework firewall, where we have to demonstrate the protocols, ports, and source IP ranges that are allowed to accomplish your EC2 instances.

Each EC2 objects can be allotted at least one security groups, every one of which courses the suitable traffic to each case. Security groups can be arranged utilizing explicit subnets or IP which limits access to EC2 objects.

Each EC2 model can be consigned in any event one security gathering, all of which courses the appropriate traffic to each event. Security gathering can be planned using express subnets or IP conveys which limits access to EC2 precedents.

Elastic Caches

The memory cache in the cloud is managed by web services Amazon Elastic Cache, the cache which reduces the load in services in memory management. By storing much of the utilized data it can increase performance and scalability.

The difference between AWS cloud architecture and the traditional hosting model is that AWS can dynamically scale the web application fleet on demand to handle

changes in traffic. In the traditional hosting model, traffic forecasting models are generally used to provision hosts ahead of projected traffic. In AWS, instances can be provisioned on the fly according to a set of triggers for scaling the fleet out and back in. Amazon Auto Scaling can create capacity groups of servers that can grow or shrink on demand.

The private cloud models are regularly intended for a solitary association or college. Unique divisions of a college can share its administrations. It is more verified than the various models and the primary preferred position of utilizing private cloud is that is verified to explicit clients just methods it is helpful to the security motivation behind the information.

6 Conclusion

The student started migrating from the traditional learning method to Mobile Green-Cloud Computing Learning. The Mobile is the significant resource for learning in this today era. The internet can aid further to share the data from one person to another. The data can be stored in cloud and assessed anytime, anywhere, by anyone. The projects can deployed without the need of the software's offline. In this day and age, most of the programs can run and tested online. The www.stackoverflow.com is a best website for a student share the code to community were millions of people connected, where anyone can provide solution to your error. The www.github.com is another best site for code arena. The student can store their project and share to any person to enhance their project and made available to public to reuse it.

The student have all materials in their hand using trending technologies. Now the biggest challenge is, How periodically he/she is using the resource effectively decides their growth of knowledge.

References

1. Kaliannan M, Chandran SD (2012) Empowering students through outcome-based education (OBE). Res Educ 87(1):50–63
2. Kumar M (2016) Google cloud platform: a powerful big data analytics cloud platform. Int J Res Appl Sci Eng Technol 4(11):387–392
3. Kale A, Mente R (2017) Impact of cloud computing on education system. Int J Electron Electr Comput Syst 6(11):1–6
4. Saini JL, Kaur H (2017) Role of cloud computing in education system. Int J Adv Res Comput Sci 8(4)
5. Melhuish K, Falloon G (2010) Looking to the future: M-learning with the iPad. Comput N Z Sch Learn Lead Technol 22(3):1–16
6. Clark W, Luckin R (2013) What the research says: iPads in the classroom. Accessed 17 May 2019. https://cpb-ap-se2.wpmucdn.com/global2.vic.edu.au/dist/5/48534/files/2015/08/ipads-in-the-classroom-report-lkl-v24yz4.pdf
7. Chen FH, Looi CK, Chen W (2009) Integrating technology in the classroom: a visual conceptualization of teachers' knowledge, goals, and beliefs. J Comput Assist Learn 25(5):470–488

8. Ifenthaler D, Schweinbenz V (2013) The acceptance of Tablet-PCs in classroom instruction: the teachers' perspectives. Comput Hum Behav 29(3):525–534
9. Al-Zahrani H, Laxman K (2016) A critical meta-analysis of mobile learning research in higher education. J Technol Stud 42(1)
10. Suryawanshi K, Narkhede S (2014) Green ICT at higher education institution: solution for sustenance of ICT in future. Int J Comput Appl 107(14)
11. Connolly MV (2012) The education part of green computing in higher education and beyond. In: IGI global
12. Agarwal S, Basu K, Nath A (2013) Green computing and green technology based teaching learning and administration in higher education institutions. Int J Adv Comput 3(11)
13. Vanderlinde R, van Braak J (2010) The e-capacity of primary schools: development of a conceptual model and scale construction from a school improvement perspective. Comput Educ 5(5):541–553
14. Vanderlinde R (2011) School-based ICT policy planning in a context of curriculum reform. Accessed 17 May 2019. https://s3.amazonaws.com/academia.edu.documents/3145598/PhD_Ruben_Vanderlinde.pdf
15. Rossing JP, Miller WM, Cecil AK, Stampeer SE (2012) iLearning: the future of higher education? Student perceptions on learning with mobile tablets. J Scholarsh Teach Learn 12(2):1–26
16. Murugesan S, Gangadharan GR (2012) Harnessing green it: principles and practices. Wiley Press, Hoboken, pp 1–21
17. Zhu Z-T, Yu M-H, Riezebos P (2016) A research framework of smart education. Smart Learn Environ (Springer Open Access)
18. Green technologies. http://greenevolution.ru/enc/wiki/zelenye-texnologii
19. Sanchez M, Aguilar J, Cordero J, Valdiviezo-Diaz P, Barba-Guaman L, Chamba-Eras L (2016) Cloud computing in smart educational environments: application in learning analytics as service. In: Advances in intelligent systems and computing. Springer International Publishing, Switzerland
20. Kamble A, Chavan P, Salagare A, Sharma K (2017) Cloud based ubiquitous computing for smart classroom using smart phone. Int J Eng Sci Comput 7(3)
21. G Riahi (2015) E-learning system based on cloud computing: a review. Procedia Comput Sci 62:352–359
22. Saini L et al (2017) Role of cloud computing in education system. Int J Adv Res Comput Sci 8(4)
23. A Microsoft U.S. Education white paper (2010) Cloud computing in education savings, flexibility, and choice for IT. https://campustechnology.com/whitepapers/list/microsoft_10a.aspx
24. Global cloud computing market in education sector. https://www.businesswire.com/news/home/20170815005745/en/Cloud-Computing-Market-Education-Sector---Top
25. Sankpal LJ et al (2014) Cloud computing in education system. Int J Adv Res Comput Commun Eng 3(2)
26. Nie X (2013) Constructing smart campus based on the cloud computing platform and the internet of things. In: International conference on computer science and electronics engineering
27. Pynoo B, Tondeur J, van Braak J, Duyck W, Sijnave B, Duyck P (2012) Teachers' acceptance and use of an educational portal. Comput Educ 58(4):1308–1317
28. Aaron L, Lipton T (2017) Digital distraction: shedding light on the 21st-century college classroom. J Educ Technol Syst 1–16
29. Kharchenko V, Kondratenko Y, Kacprzyk J (2014) Green IT engineering: concepts, models, complex systems architectures. Renew Green Energy (Springer)

Green ICT, Communication, Networking, and Data Processing

Sandeep K. Sharma, N. Gayathri, S. Rakesh Kumar, C. Ramesh, Abhishek Kumar, and Rajiv Kumar Modanval

Abstract The world is heading towards the information age where "data is the new gold" and with the increase in the amount of data, there is an overall increment in the resource utilization to manage, manipulate, store and transmit data. Due to the heavy demands of computing resources for the production and application of software and hardware, their disposal is an issue that leads to environmental degradation by causing environmental pollution and keep exhausting natural and energy resources. So, there's a strong need to adopt the greener and sustainable methods/resources so as to reduce the overall environmental damage due to the above-mentioned factors. This chapter, provides the different tools and techniques that can be adopted for the greener cause and sustainability of the resources in the environment.

S. K. Sharma · N. Gayathri (✉) · S. Rakesh Kumar · R. K. Modanval
Galgotias University, Greater Noida, India
e-mail: n.gayathri@galgotiasuniversity.edu.in

S. K. Sharma
e-mail: sandeepsharma097@gmail.com

S. Rakesh Kumar
e-mail: s.rakeshkumar@galgotiasuniversity.edu.in

R. K. Modanval
e-mail: gupta.rajiv0703@gmail.com

A. Kumar
Department of Computer Science, Institute of Science, Banaras Hindu University, Varanasi, India
e-mail: abhishek.maacindia@gmail.com

C. Ramesh
Bannari Amman Institute of Technology, Sathyamangalam, India
e-mail: rameshc@bitsathy.ac.in

B. Balusamy et al. (eds.), *Green Computing in Smart Cities: Simulation and Techniques*, Green Energy and Technology, https://doi.org/10.1007/978-3-030-48141-4_8

1 History

Green Computing started getting traction from the early 1990s when the U.S. Environmental Protection Agency launched "Energy Star" in 1992 to promote energy efficiency in the various electronics and computing devices [1]. In fact, the term "Green Computing" was coined shortly after the launch of the Energy Star program. One of the turning point events in favor of the Green Computing was in the year 1997 when the Kryo Protocol [2] treaty [3] was adopted so as to facilitate the endeavor of UNFCCC (United Nations Framework Convention on Climate Change) to reduce global warming by reducing the concentration of greenhouse gases in the environment. Another turning point in the history of Green Computing was the adoption of RoHS (Restrictions of Hazardous substances) [4] by the European Union in Feb 2003 which has also contributed a lot in preventing the degradation of resources. Also, the great path to sustainability was accelerated by the establishment of the Green Electronics Council in the year 2005 with its aim to deal with the issues regarding electronics and components.

2 Green ICT

Green ICT refers to Green Information and Communication Technology which is the technique of using electronic and communication devices in such a way to maximize the positive impact on the environment rather than negative impacts. The main concern of this technique is the overall efficiency of the operating equipment and finding effective solutions to build and produce computing devices that do not compromise or pollute the environment and also remain highly efficient at the same time.

According to [5], it is stated that the IT devices cause serious damage to the environment and it is majorly responsible for the Environmental problems that is faced nowadays. So, the attitude of the IT sector and the users needs to be changed so as to adopt for the greener policies and practices for the environment's shake and for our own benefits.

2.1 Aspects of Green ICT in DataCenters and Servers

2.1.1 Green Data Centers

Green Datacenters are the servers that the use power-efficient and eco-friendly techniques to facilitate the services. It uses non-primitive approaches more like newer and highly efficient technologies like Big-data to manage and process the data on the servers as they are capable of handling immense data with higher efficiency over the servers with less consumption of power.

2.1.2 Power/Energy Utilization

Power is a key component in the working of any Data Centers. With the rise in the IT sector, there's an exponential growth of data and to process such an amount of data we require high and high computing resources due to which these servers put immense loads on the power grids. So there's the great need to adopt newer technologies for the production and uses of equipment and computing devices so as to minimize the power consumption without compromising with efficiency.

2.1.3 Disposals and Management of E-Waste

Only adoption of newer methodologies won't work as the up-gradation is a continuous process. As soon as the newer and more efficient product comes in the market, so there's requirement to discard the older ones and install the newer ones, due to which the older product becomes E-waste. This E-waste contains some harmful elements like Lead, Cadmium, Beryllium, Mercury, etc. that show hazardous effects by contaminating the soil and thus groundwater, polluting the air if disposed or recycled incorrectly. According to data [6] of 2006, the United Nation estimated that the worldwide discarded e-waste was 50 million metric tons. So, the figure tells itself that there's a very urging need to opt for the proper techniques to deal with E-wastes that can be done by opting proper and standard recycling methods and by changing our mindset.

2.1.4 Reducing Carbon Emissions

Global warming is one of the greatest threats to humanity and the environment. The reason for this increment is the emission of carbon and Chlorofluorocarbons so-called CFC's and that is again due to the use of heavy machinery for cooling the datacenters and various IT plants. Green ICT can help in controlling several aspects of CO_2 emission by adopting greener and environmentally friendly methods for the application of electronic equipment. Many organizations are working towards the betterment of nature by reducing carbon footprints, Ericsson is one of the organizations working on intensive researches for the Green ICT and it is estimated that by 2030, ICT can reduce carbon emissions by 6–15% by the use of smart equipment in the IT sector [7].

2.1.5 Adaptation to Climate Change

As computing devices require a cooler environment to perform at better efficiency and it is well known that heat is the machine's enemy, so through green ICT, various smart methods are devised that can help the machines adapt to different environments and climate change to perform in a highly effective manner throughout the year. There

can also be the use of parallel computing devices that can perform operations in slots like when on is working, the other will be idle and vice versa. Also, there are smart systems that can maintain the temperature of the working environment according to the needs of server rooms or data centers.

2.1.6 Other Factors

Other factors include maximizing the server uses or its utilization that can be done by various smart scheduling and cloud technologies like load balancers so as to maximize the performance which helps in utilizing every node on a server. Also, the use of Game Theory in data centers can lead to another level by the implementation of which can make our computing more intelligent and able to adapt for the anytime demands whether in normal days or in peak days.

Figure 1 depicts the aspects of Green Data centers and servers that use the latest standards and technologies for facilitating Green ICT.

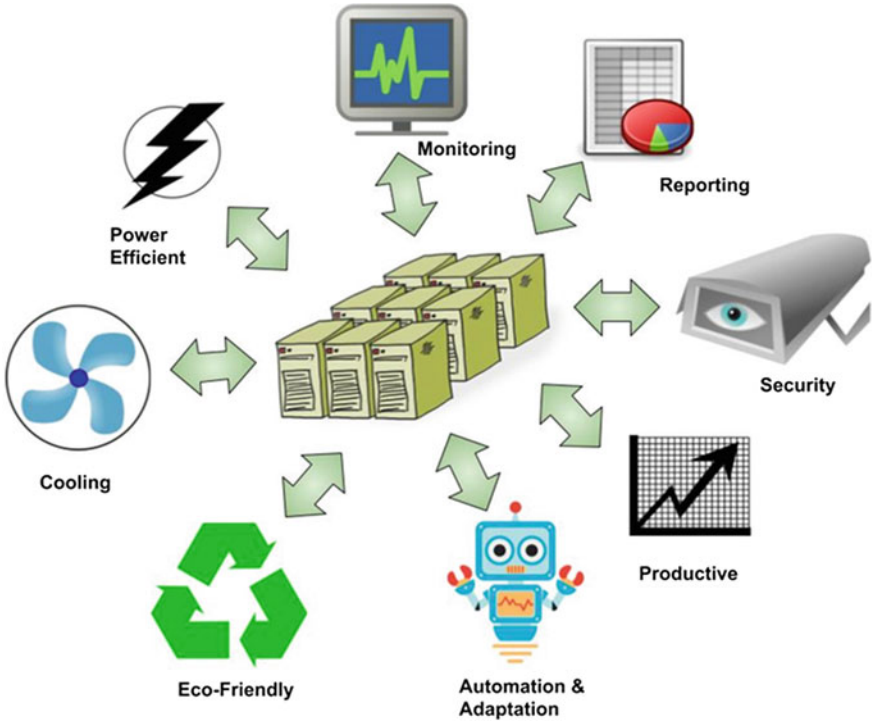


Fig. 1 Green data centers

2.2 Smart Grid System for Better Energy Management

The Grid System refers to an electric grid that is the intermediary transmission network between the electricity station and our homes and businesses. The smart grid is the technically improved version of the traditional grid system that uses digital technology allowing two-way communication between station and users, and it is sensing along the way of transmission that makes it smart.

2.3 Use of Latest Components as per Standards

Smart Grid consists of computers, automation, and the latest new technology equipment that works together to facilitate the quickly changing electric demands. Also, the use of new standards and protocols makes the system more authentic and capable enough to fulfill the demands of the masses.

Some of the protocols [8] are Application layer protocols (defines the message structure), Transport layer protocols (which provides the mechanisms for navigating through networks), Media-specific protocols(use to manage different types of media). Some standards [8] include IEEE 1815 (DNP3), IEC 61850, IEEE 2030.5 (SEP2) and OpenADR.

2.4 Replacing Less Effective and Power-Hungry Grids

The traditional grid system fails to facilitate during harsh weather conditions and mainly summers when the climate is too hot. Also in addition to that there's a huge load on the grids during summers due to the heavy usage of cooling appliances by the public that occasionally results in blackouts. Apart from that, those grid systems were power-hungry in the sense that they consume more electricity for retransmission which causes several loses in the form of heat and sound. Also, they were too huge and bulky to carry and install.

But nowadays there are smart grid systems are available that are smaller, modular and lighter and can easily adapt to the situations and act accordingly [9]. So, there's the need to replace those bulky power-hungry grids with the smart grid systems so as to improve the overall productivity and transmission of electricity.

2.5 Cloud Computing-Based Green ICT

With the exponential rise in the data, there is also a need to increase the computing power which obviously requires lots of hardware and computing devices that will need the power to perform and ultimately leads to the issues. So, best is to go for

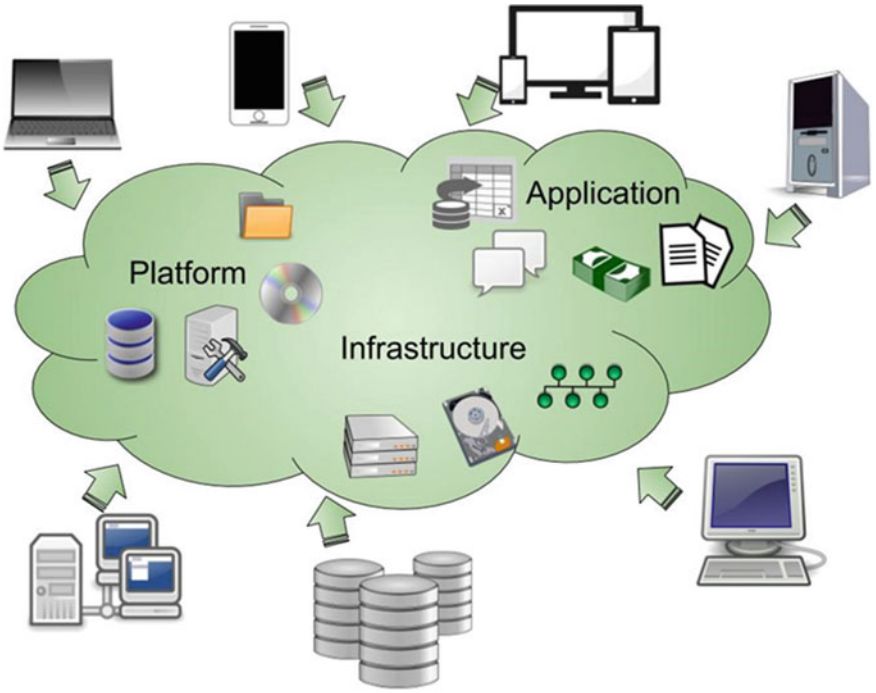


Fig. 2 Green cloud

the option where there is a centralized pool of computing hardware and resources and everyone is welcomed to use it. There comes the concept of cloud. Cloud being an evolutionary technology is capable of handling humongous data storage and data processing. It is Greener in a way that there is no requirement of any additional components but just an active internet connection and then you can enjoy effortless and seamless services provided through the cloud. It follows the concept of "pay as you go" meaning the number of resources you want, pay accordingly. It is Scalable (can scale up or down depending upon the needs), reliable, and most importantly trustworthy, the data will be safe and secure and privacy is fulfilled. There are countless applications of cloud which will be discussed in upcoming parts and it is a great technology leading towards the green ICT.

Figure 2 depicts the various aspects of the cloud that can be used to implement Green ICT.

2.6 Practicing Cloud with Google Cloud Platform

Google Cloud is one of the leading Platforms that is working towards the reduction of environmental impacts by following the latest technologies and standards for the

application of their cloud services. And It's really a great platform to start with the cloud practices. Create an account on google cloud [A1] before start practicing and everything will be done on GCP Console [A2].

Let us start by creating a simple web server on GCP: Before creating the server VM instance need to be created follow [A3] for reference. The following command can also be used to start the VM instance you just need to click on the cloud shell on the right corner of the console use:

gcloud compute instances create instance-1—zone us-central1-c
It will create the VM instance now to perform other operations you can write:
gcloud compute instances create—help
After creating a Virtual Machine open Cloud Shell (a command-line tool) from the right corner of the console then type the commands: **sudo su -**
The above command gives the root or admin access to the user then follow the commands below
apt-get update
To update our instance with all the security patches and many services
apt-get install nginx -y
Installing nginx server on the instance
ps auwx | grep nginx
To check whether the installation is done properly and now your server has started to run the server click on the external IP link displayed on the command line shell window. For the proper Hands-on experience, you can visit Qwiklabs [A4].

3 Green Communication

Green Communication is the practice of using greener and energy-efficient techniques for communication. It includes the use of standard and latest networking technologies and devices for minimizing the resources and increase the effectiveness of communication. Some of the major practices include the use of virtualization techniques, upgrading older networking and communication devices to more effective and nature-friendly devices, to increase overall efficiency by proper utilization and maintenance of resources, following the latest trends in spite of traditional for minimizing the resource usage.

3.1 Green Antennas

3.1.1 Use of Low Radiation Antennas

Antennas are one of the crucial elements of a communication system that is used for short as well as long-range communication. Based on the application, there are different types of antennas available majorly of which are Horn antenna, Disk Antenna,

Dipole, Monopole antennas, etc. Depending upon the frequency and bandwidth requirements these antennas are selected but some of the antennas are responsible for emitting a lot of radiation that pollutes the environment.

Green antennas are designed to reduce the amount of radiation radiated from the antennas by employing new standards as directed by the National Council on Radiation Protection and Measurements (NCRP) and International Commission on Radiological Protection (ICRP) [10].

3.1.2 Future Aspects of Antennas

With the continuous development in communication methods, the more and more efficient antennas are under research by engineers and scientists to make the communication better and greener by employing the latest technology for its development. Antennas becoming smaller in size day by day and the smaller antennas have become the new trend. Nowadays, scientists are developing the antennas that are 10th–100th the size of the traditional antennas available in the market nowadays and it's not very far when the ultra-small antennas will be available in the markets that will be more effective and efficient as well. Apart from these with the arrival of 3D printing, more lighter, smaller and even more powerful antennas will be printed through 3D printers [11] and engineers are working on that 5G has also started to cover the market and in the upcoming days, it will reshape the communication system that we have today.

3.1.3 Power Utilization

Power is an essential factor that governs the working of any electronic device and while studying greener approaches it becomes the vital component of our study. Depending upon the size and architecture various antennas are categorized on the basis of their power consumption, as their range is increased their power consumption increases. With the development of lighter, smaller and more effective antennas the power consumption is decreasing which is a good sign. The simple mathematical formula for power consumption by the antenna is:

Power Consumed = Input Power − Transmitted Power

As per [12] 3% of the total energy produced across the world is used by ICT's contributing 2% rise in the CO_2 level around the globe. Within ICT around 10% of the energy is consumed by radio communication of which 10% used by users and 90% used by base stations [13]. Here's the Pi chart that will give a rough idea of energy consumption by various units of base station (Fig. 3).

3.1.4 Challenges in Wireless Sensor Networks

With the development in the wireless network and adoption of more and more advanced communication devices and methods, it becomes challenging to maintain

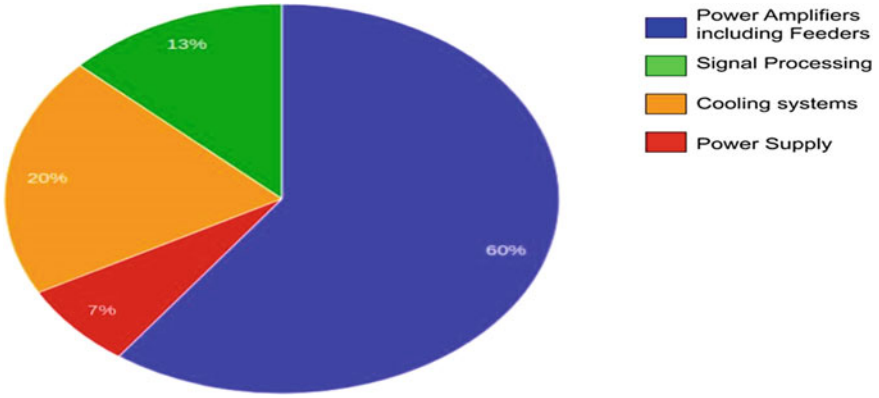


Fig. 3 Power utilization by various components of base station

the effectiveness of the network, keeping in mind the other factors that govern its working. Some of the challenges include demand for high bandwidths that arise during peak moments like in festive seasons the overall load increases on the networks thereby requiring high bandwidth to cope up. With the overall increment in the utilization of resources the power utilization also increases leading to high energy consumption, there's the problem in provisioning the QoS (Quality of service), also data processing and compression methods are somewhat challenging with the dealing of real-time data traffic become hectic in some situations which are hard to manage. Other challenges are referenced under [14].

3.2 Fiber Optic Cable Communication

Fiber-optic cable uses light to transmit the data at rates nearly equal to the speed of light, these cables are used for long-distance transmission and have higher bandwidth with immunity to interferences while signal carriage. This cable can transmit any type of media including audio, video and so on. These optical cables were invented in the 1970s and now they have revolutionized the telecommunication system. The features of this cable are what makes it different from other cables some of the features include high-speed transmission, high bandwidth, long-range communication, least communication loss due to its property of TIR (Total Internal Reflection). As there is no loss while transmission it can be seen as an effective mode of communication and can be used to promote Green ICT (Fig. 4).

The construction of Fiber Optic cable can be seen in the figure in which the inner fiber core is protected with several layers which include cladding, plastic buffer, and outer jacket. Cladding plays a key role without which TIR [15] is not possible which is the basic principle that governs the working of optical fiber.

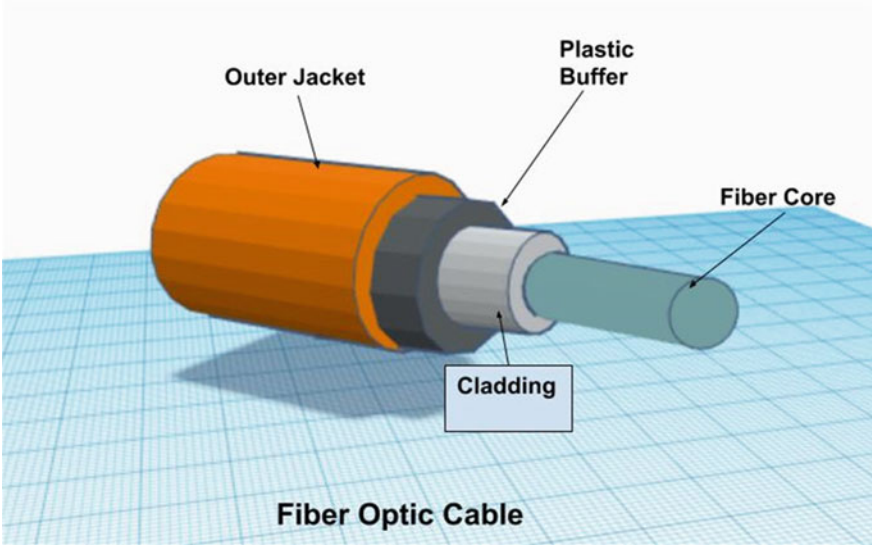


Fig. 4 Optical fiber construction

3.3 Cloud Computing-Based Communication

Cloud computing is one of the revolutionary technology that provides effective ways of communication without the need for any additional set of hardware or software we just need a device to work on with the internet connection. This practice thus minimizes the cost of communication as well as it promotes greener communication as setting up additional system will require an additional set of resources including infrastructure, platforms, power units and many more thing that is not a very good choice if we have access to services offered by various cloud service providers, one of which is the Google Cloud Platform which uses effective communication strategies to perform the task by utilizing resources as per requirement. Communication on cloud includes hosting a server on cloud and the client-server interaction, communication between the server and the APIs it is integrated with, communication via a virtual private network, intercommunication between various services in the cloud, etc. These are some of the tasks that demonstrate communication via the cloud. Due to its effectiveness, many companies are shifting their workloads on the cloud for better performance of their working entity.

3.4 Practicing Cloud with Google Cloud Platform

Google Cloud provides lots of services for effective communication, so let's look at how to use those services on GCP. Let's use VPC (Virtual Private Cloud) Network peering on the cloud to verify the private communication between two VM (Virtual Machine) Instances on the cloud. This service allows us to create a Software as a Service (SaaS) ecosystem on GCP thereby allowing private services availability across different VPC networks in an organization [16]. Create an account on google cloud [A1] before start practicing and everything will be done on GCP Console [A2]. First, create VM instance using the command:

gcloud compute instances create vm-a—zone us-central1-a—network network-a—subnet network-a-central
Create a custom network using cloud shell on the right corner of the console:
gcloud compute networks create network-a—subnet-mode custom
Now create a subnet within the VPC and specify the IP ranges:
gcloud compute networks subnets create network-a-central—network network-a—range 10.0.0.0/16—region us-central1
Enable SSH using:
gcloud compute firewall-rules create network-a-fw—network network-a—allow tcp:22,icmp Perform similar operation to set up another VM. After which ping the external IP of one VM with others using SSH and similarly with others. For Reference go through [16] and [A4] with the lab named "Using VPC Network Peering".

4 Green Networking

Green Networking referred to as the practice of adopting energy-efficient and environmental friendly networking technologies and equipment by minimizing the damage to the environment by utilizing lesser resources whenever and wherever possible. Some of the practices include Virtualizing implementation, consolidation of servers, equipment up-gradation, use of video conferencing and telecommuting for communication in spite of traveling.

Networking is the heart of ICT so it requires a lot of investment and resources however we can resource usage can be minimized without compromising with the performance by following greener methods and approaches.

4.1 Aspects of Green ICT in Network Architecture

Network architecture is the framework for organizing and designing of computer networks in terms of the effective logical design of the network, it's layout and

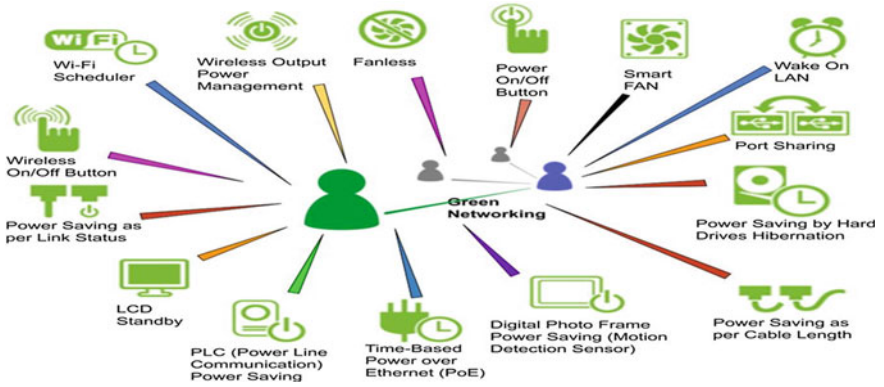


Fig. 5 Aspects of green networking

topologies, the physical or wireless connections, hardware, software, protocols, transmission media, etc. In this section, some of the greener methods that can be used to promote Green ICT without compromising the overall quality of the network is targeted. The following diagram depicts various aspects of green networking that makes networking more effective and efficient (Fig. 5).

4.1.1 Computing Equipments

Here, Computing equipment refers to the networking equipment that is used in making network architecture which includes routers, gateways, bridges, switches, hubs, repeaters, modems, wireless access points, networking cables, etc. Apart from this traditional computing equipment that is used in network architecture, some of the green equipment such as green routers [17] that are power efficient with effective packet processing and delivery and have the ability to balance the load and schedule the on/off as per usage, green switches allowing it to automatically detect the status of the link and reduce the power of the ports and the use of virtual servers in place of physical servers can play significant role in greening through networking.

4.1.2 Infrastructure

The infrastructure consists of all the resources that build up the entire network by enabling connectivity and communication across the network. It combines the networking hardware, software, and network services [18]. A lot of components and power-hungry resources are involved in building a network so, there's a need to choose effective, efficient and so-called greener components to build-up an environmental friendly network that can be build using various resources discussed so far.

4.1.3 Components Utilization

Component utilization is a common challenge across any computing devices as there are multiple components involved in any computational tasks then there arise some situations when some components remain idle. To solve this problem in operating systems there's the concept of scheduling in the same way that can implement the concept across other devices as well in which implementation of schedule based on preemption or non-preemption as per the requirement to effectively utilize the components across the device is done. In case there's some component remain idle then the auto turn-off feature can be integrated.

4.1.4 Energy Savings Techniques

The rapid increment in energy consumption by network infrastructure that puts a lot of negative impacts on the sustainability of resources that needs to be restrained. So some of the effective techniques that we can employ like to put devices in hibernate mode or switch off some parts if possible during low traffic hours, the other methods [19] includes reordering the networking equipment as per effective designs or via the use of some algorithms like a spectral algorithm [20] or clustering algorithms [21] also the use of modern technology equipment with energy-saving features and built as per standards, replacing outdated hardware and install latest software, installing programmable chips and smart thermostats for the cooling systems etc. can be of big help in support of green networking.

4.2 Cloud Computing-Based Networking

We have gone through the various applications of cloud that can help in promoting Green ICT is being discussed. It's time to practice Networking on the cloud which is the key principle of cloud computing. Various cloud services are interconnected via this and it forms the basis of cloud architecture. In GCP various Networking services are available that can be used to perform networking on Google cloud which includes: VPC network, firewall rules, load balancing, DNS, VPN, network security, etc.

To create privatenet network on GCP using cloud shell use the command:
gcloud compute networks create privatenet −subnet-mode=custom
Now to create privatesubnet-us subnet use command:
gcloud compute networks subnets create privatesubnet-us −network=privatenet −region=us-central1 −range=172.16.0.0/24
Follow command to create privatesubnet-eu subnet:
gcloud compute networks subnets create privatesubnet-eu −network=privatenet −region=europe-west1 −range=172.20.0.0/20

To check for the available VPC use the command:
gcloud compute networks list
And to list the available VPC subnet use:
gcloud compute networks subnets list −sort-by=NETWORK

For full hands-on with the networking on cloud refer [A5].

5 Green Data-Processing

Data processing is the method of carrying out operations on data by computing devices to basically retrieve, transform and classify the data. By Green Data Processing it means to use a modular approach to process data by incorporating modern power-efficient equipment and the latest software [22].

Moving towards the information age there is a rapid increase in the researched to invent something more powerful and effective that can be used to process such humongous data that is on the rise at an exponential pace. Big Data can be seen as one of the most researched technology as of now we will discuss it in upcoming sections.

5.1 Expansion of Data in IoT-Driven World

As the world is shifting toward the information age and this age coming by the increment in the data production and data usage. IoT devices are contributing to the massive production of data which is being generated in real-time by the IoT devices and sensors and with its generation the processing becomes challenging, thus there's the need to upgrade the system with greater computing and processing power. There comes the Big Data which is effective enough to manage all such problems and challenges of processing and computation and even storage.

5.2 Ecosystem of Big-Data

Big Data, the term refers to the huge collection of data and is specially designed to process or manage **Go Green by optimizing the processing power** any type of data either structured, non-structured or semi-structured. The capability of Big Data lies in its processing power and computational efficiency it possesses. It starts when the traditional system fails to manage and process a large amount of data. It has four main characteristics so-called 4V's: Volume, Variety, Velocity, and variability. From its characteristics, its applications can be said that "With Great Power comes

Great Responsibility". So it is the revolutionary technology with better operational efficiency, better speed, better resource utilization, better decision making and many more...

5.2.1 Why Big Data for Green ICT

Big Data can be seen as one of the leading technology which is capable of handling any type of data processing in an effective and energy-efficient manner that's why the role of Big Data in facing green ICT is very important. Big Data uses algorithms that are very time efficient and faster in a way to process millions or trillions of bits of data processing in no time. If we have such technology in our hands then its application becomes very high. So Big Data helps in every aspect of data from processing to storage.

Processing power is the key aspect of any IT domain. As processing requires lots and lots of resources which puts pressure on resources that are limited so to minimize the resource utilization we need to optimize the processing power so that it can take less time and relieve other resources from its burden of power consumption and computation power. So to do so it should be opt for the greener methods which include cloud, Bigdata, etc.

5.3 Cloud Computing Based Data Storing and Processing

Cloud Computing is one of the leading techs that is capable of handling any sort of computation nowadays one of which is data storage and data processing. All the big companies are now investing in maintaining the cloud and provide various services for any sort of business or startups.

For Data Storage there the term called Bucket in Cloud where we store our data. And for processing, there are numerous services based on the type of processing required one of which includes Cloud DataProc which is the GCP Service used to run the Apache-Hadoop server in very efficient way.

Let's Practice a hands-on to store data on the cloud by creating a simple cloud storage bucket. Buckets are the basic containers that hold your data in Cloud Storage.

1. Click on the hamburger menu on the left corner-up on the google cloud console (Fig. 6)
2. Now under Storage menu click on the Storage -> Browser (Fig. 7)
3. Click Create bucket (Fig. 8)
4. Now enter Bucket information and click on Continue to add another info.
5. Enter a unique name for your bucket -> choose standard -> location (as per your preference)

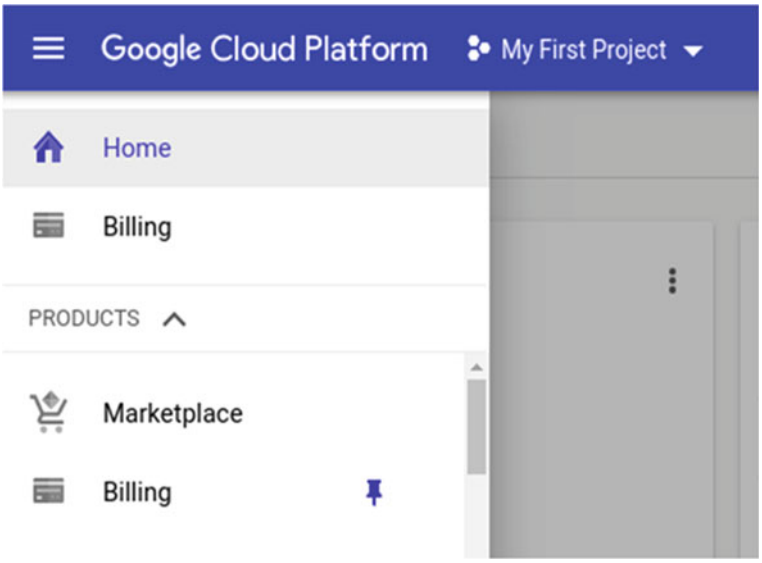


Fig. 6 Google cloud platform

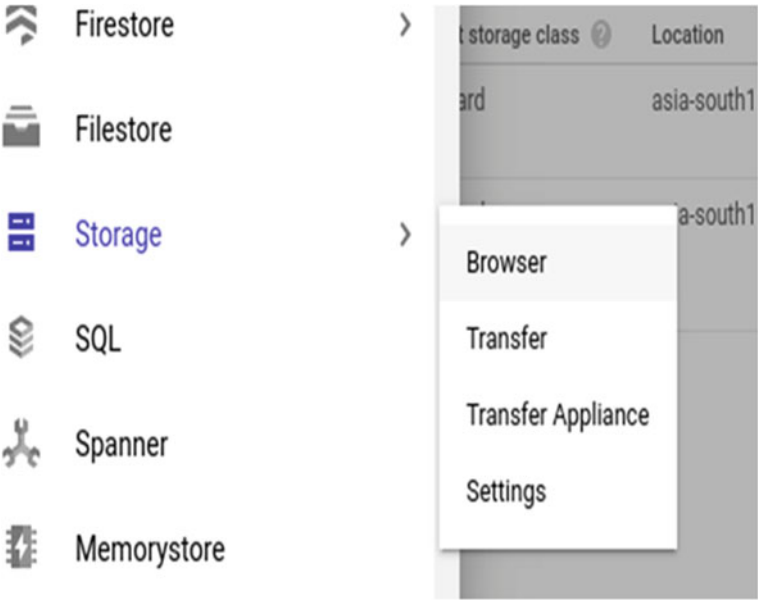


Fig. 7 Storage class

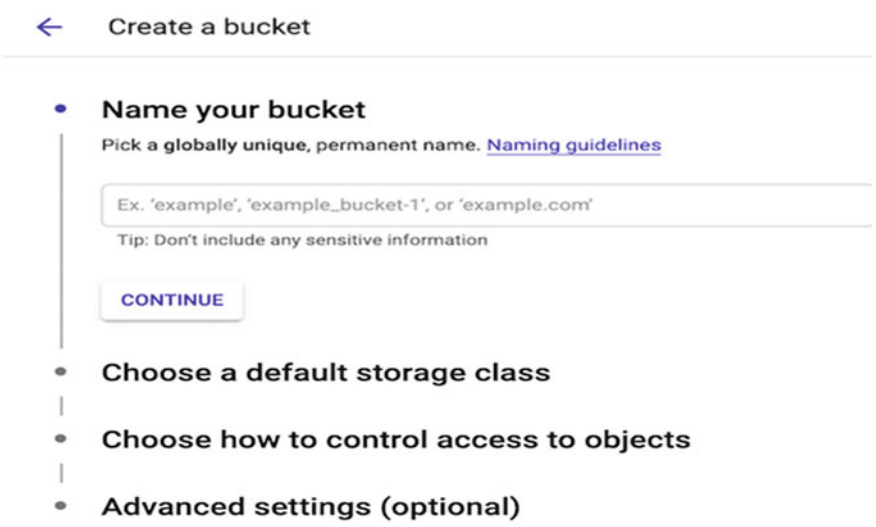


Fig. 8 Control access

6. Choose Set object-level and bucket-level permissions for the Access control model.
7. Click Create.

OK, now a storage bucket is created now to add data click on upload files to add. In case of any problem refer to this [A6]. For data Processing refer [A4], [A7] and [A8].

6 Standards in IEEE

Standards are built to maintain the overall working of any system. There are some IEEE standards that govern the working of ICT some of which are:

- IEEE P3006.8: Recommended practice by IEEE to analyze the reliability data of equipment used in commercial and industrial power systems.
- IEEE P2413: Provides a standard for architectural Framework of IoT (Internet of Things)
- IEEE P2302: Standard for Intercloud Interoperability and Federation (SIIF)
- IEEE 1636–2009: Standard for Software Interface for Maintenance Information Collection and Analysis (SIMICA) which got approved on March 2009
- IEEE 1808–2011: Guide for Collecting and Managing Transmission Line Inspection and Maintenance Data which got approved on February 2011
- IEEE 2010–2011: ISO/IEC/IEEE Systems and Software Engineering-Architecture Description got approved on December 2011.

- IEEE 2200-2012: IEEE Standard Protocol for Stream Management in Media Client Devices (Approved on June 2012)
- ITU-T Y.3600: Requirements and capabilities for cloud computing based big data (Approved July 2015).

There are a lot more other standards look [23] for reference.

7 Greening Through IT a Revolution

By revolution here means the massive change or we can say up-gradation of all sorts of ICT resources that are outdated and became very less effective either in terms of power or speed or anything. And using IT in almost every discipline to promote sustainability across resources by using its power to harness the positiveness and higher yield from all the disciplines by least impact on the environment.

IT now can be used in almost every domain and with its greener aspects it becomes a very easy and effective way to promote sustainability and green ICT. Some of the areas [23] include Large scale data analysis and management, Human-centered systems, Modeling of complex systems, Dynamic and intelligent decision making, control and management of infrastructure, Robust observation sensing, and inference and many more. We have gone through various standards as well which governs and helps in making effective products.

8 Future Aspects

The researches are at the full pace and studies are continuously going on. Soon there will be more and more effective techniques to promote greener IT in the upcoming days. The Future work will include a deeper analysis of Big Data and its optimized version with more processing power with the least power consumption. Incorporating Cloud with Big Data can be more effective and has been focused on the same. Also, there might be other more effective technology that will come based on which we will proceed further.

9 Conclusion

In this chapter, all the aspects of Green ICT from its communication, to networking, it's processing and storage is concentrated. The greener methods that can be employed to our existing resources to make it effective or to implant new standard and modular hardware and software to make our system more efficient without compromising

with its quality and our nature at the same time is focused. This chapter also provides how each of these operations can be easily done with the help of Cloud and Big data and other such sustainable approaches to maximize performance by minimizing power utilization.

References

1. Lakshmi SVSS, Sarwani ISL, Tuveera MN, A study on green computing: the future computing and ecofriendly technology. Int J Eng Res Appl (IJERA)
2. Kyotoprotocol to the United Nations Framework Convention on Climate Change. http://unfccc.int/resource/docs/convkp/kpeng.pdf. Accessed Oct 2019
3. United Nations Framework Convention on Climate Change. https://unfccc.int/resource/docs/convkp/kpeng.pdf. Accessed 8 Oct 2011
4. HP's compliance with restriction of hazardous substances (RoHS) legislation. http://www.hp.com/hpinfo/globalcitizenship/environment/pdf/leadposition.pdf. Accessed Oct 2019
5. Murugesan S (2008) Harnessing green IT: principles and practices. IT Prof 10(1):24–33
6. Blau J (2006) UN summit on e-waste: Nokia, Vodafone and others to attend UN summit on e-waste. CIO Bus Mag
7. Malmodin J, Bergmark P (2015) Exploring the effect of ICT solutions on GHG emissions in 2030. In: 29th international conference on informatics for environmental protection (EnviroInfo 2015), 3rd international conference on ICT for sustainability (ICT4S 2015), Ericsson Research, Ericsson AB Stockholm, Sweden
8. http://xanthus-consulting.com/WIEB/Discussions/377_Smart_Grid_Protocols.html. Accessed Oct 2019
9. https://phys.org/news/2012-03-power-hungry-nation-energy-grid.html. Accessed Oct 2019
10. Sinclair WK (1981) Radiation protection: the NCRP guidelines and some considerations for the future. Yale J Biol Med 54(6):471–484
11. https://www.prescouter.com/2018/01/future-antennas/. Accessed Oct 2019
12. Humar I, Ge X, Xiang L, Jo M, Chen M, Zhang J (2011) Rethinking energy efficiency models of cellular networks with embodied energy. IEEE Netw 25(2):40–49
13. Ayang A, Ngohe-Ekam P-S, Videme B, Temga J (2016) Power consumption: base stations of telecommunication in Sahel zone of Cameroon: typology based on the power consumption-model and energy savings. J Energy
14. Indu SD (2014) Wireless sensor networks: issues and challenges. Int J Comput Sci Mob Comput 3(6):681–685
15. Giallorenzi TG (1978) Optical communications research and technology: fiber optics. Proc IEEE 66(7):744–780
16. https://medium.com/petabytz/vpc-network-peering-on-google-cloud-platform-gcp-bb83a489b7a8. Accessed Oct 2019
17. Kai Y, Liu B, Lu J (2014) Green router: power-efficient router design. In: Proceedings of international conference on computer science and information technology, New Delhi, India
18. https://www.cisco.com/c/en/us/td/docs/voice_ip_comm/cucme/srnd/design/guide/cmesrnd/nstrct.html. Accessed Oct 2019
19. Habibullah KM, Rondeau E, Georges JP (2018) Reducing energy consumption of network infrastructure using spectral approach. Technology for smart futures. Springer, Berlin
20. Abbasi AA, Younis M (2007) A survey on clustering algorithms for wireless sensor networks. Comput Commun 30(14):2826–2841

21. Bandyopadhyay S, Coyle EJ (2003) An energy efficient hierarchical clustering algorithm for wireless sensor networks In: 22nd annual joint conference of the IEEE computer and communications, vol 3, pp 1713–1723
22. http://www.grupocobra.com/en/proyecto-innovacion/efecto/. Accessed Nov 2019
23. https://bigdata.ieee.org/images/files/pdf/IEEE_BDISW_2015_Kantarci_Chatzimisios_Song.pdf. Accessed Nov 2019

Impact of Green Computing in Shaping Education

Rajiv Kumar Modanval, S. Rakesh Kumar, N. Gayathri, C. Ramesh, Abhishek Kumar, and Sandeep K. Sharma

Abstract Across academic and practical fields the Green Computing has considerable significance. Saving energy consumption, reducing carbon emissions, cutting operating costs and ensuring a sustainable environment have become the top priority of today's modern world. The green computing sector is a very wide variety of research activities that have been carried out in IT and educational institutions over the last few years. In educational institutions and in IT companies, electronic devices such as computers, air conditioners, and lights consume a fixed amount of electricity as well. Savingenergy helps to cut costs and help incorporate green computing.

1 Introduction

In the last few years some educational institute, environmental organisation, IT sector and Business men think seriously about "Go Green" [1]. Today "Go Green" not just a slogan it's becomes agenda for IT industries to reduce the cost and to save the

R. K. Modanval · S. Rakesh Kumar (✉) · N. Gayathri
School of Computing Science and Engineering, Galgotias University, Greater Noida, India
e-mail: s.rakeshkumar@galgotiasuniversity.edu.in

R. K. Modanval
e-mail: gupta.rajiv0703@gmail.com

N. Gayathri
e-mail: n.gayathri@galgotiasuniversity.edu.in

C. Ramesh
Bannari Amman Institute of Technology, Sathyamangalam, India
e-mail: rameshc@bitsathy.ac.in

S. K. Sharma
Galgotias University, Greater Noida, India
e-mail: sandeepsharma097@gmail.com

A. Kumar
Chitkara University Institute of Engineering and Technology, Chitkara University, Rajpura, Punjab, India
e-mail: abhishek.kumar@chitkara.edu.in

B. Balusamy et al. (eds.), *Green Computing in Smart Cities: Simulation and Techniques*, Green Energy and Technology, https://doi.org/10.1007/978-3-030-48141-4_9

environment. Nowadays this slogan "Go Green" goes repeatedly. The posters and banners can be visualized on the sides of roads, advertisements on our television and also some video messages on our social groups to promote us "Go Green" because its has defy need in direction not only to save the environment but also to save ourselves [2]. According to figures from the National Academy of Sciences, 14 billion pounds of waste was deposited every year in the sea [3]. In addition, pollution kills 8.9 million people a year, according to a Pure Earth survey, and nearly 200 million people are exposed to lead, mercury and pesticides that cause them to experience serious health problems such as brain damage, this is the effect of pollution in our life that's there is a move towards "Go Green" [4]. "Going Green", when it comes to the environment, involves following practices that reduce the harm they do to planet Earth. In addition, the only hope left to save Earth and save the coming generation is to reduce the damage that people cause to the climate. All facts are included to improve our way of living. One myth is about "Go Green" is that it only for securing environment, but this is used to define concept of sustainable, reusable and eco-friendly products and energy. Green technology focused on the triple end of economic activity, social duty, and on the environmental impact. This varies from classical business practices focusing primarily on a computer solution's economic activity. The manufacturing companies directly harm the environment, whereas IT industries affect the environment indirectly by careless consumption of energy and disorganised used of computer and its resources.

From past few years energy consumption becomes the key challenge for IT industries globally. According to statics CO2 emission produced by the IT industries is the 2% of CO_2 emission on earth [5, 6]. The issues rises over vast amount of money spent on wasteful and needless computing, As per experts we are wasting $212.5 billion per year on energy for IT industry [7]. As a result of these concerns, some top IT companies tried to adopt green computing in his use depends on reusable energy in direction to improve his performance, reduce the cost of energy and tried to develop the product in a sustainable manner. To implement this, some top leading IT companies like Google, Yahoo, Microsoft are making their data center in various city which option of reusable energy sources like hydroelectric, solar energy and wind energy the main aim behind all things to save the environment [8].

2 Green Computing

There are many companies and people all over the world are taking advantage of computer innovation and are also take advantage of IT technology its features in day-to-day life. Technologies are changing rapidly and making our life more comfortable and work faster, but in the whole process energy consumption increasing which means the emission of carbon and harmful gases [9]. So the Green Computing have great importance in academic and practical fields. Saving energy consumption, reducing carbon emissions, reducing operating costs and ensuring a sustainable environment have become the top priority of the modern world today [10, 11].

Green computing stands for using computer and its resources in a way that ensures its sustainability, eco-friendliness and efficiency. The purpose of using green computing to reduce energy consumption, dangerous gas emission and defending environment [9]. To achieve green computing many IT companies and organization are working together. Green computing is demand of time not only to save the earth but also to save yourself.

The United State Environmental Protection Agency launches "Energy Star program" in 1992, It was a spontaneous labeling program designed for promoting energy efficient hardware product in the market after that Green Computing came into existence. An analogous program was also adopted by Europe and Asian countries as in following. It can be realized in our daily life for example whenever we go to buy any electronic product then we ask how much star It have which means how energy efficient the product is, more star means more energy saving product.

3 Need of Green Computing

Today everyone needs a computer it becomes a basic need for all. With the help of Computer works are done very easily saving our time and money but every technology has some pros and cons It also have use of computers generates a large amount of heat and it also increases the consumption of energy. Power consumption is directly proportional to the emission of carbon dioxide gas, It means if the consumption of energy increases then the emission of carbon dioxide gas also increases which has many dangerous effects on our resources and environment. Global warming is the biggest example of effect of greenhouse gases. This is because of the ignorance about the dangerous effect of using computer on our environment. Many data centers and personal computer uses a large amount of energy generated by many traditional techniques consequent is the polluted environment.

All computer related products like Personal Computer and its components, Data center and devices used for networking emit carbon dioxide in a huge amount. But the large part of carbon dioxide emitted by personal computers are not good for the environment because they are not biodegradable and the pieces and parts are rarely recyclable so it becomes a waste on the earth. So to save the earth and for reducing the bad effect of technology on environment we have to awake about this. To reduce these effects on earth, the term Green computing came into existence. There are different reasons to use green computing are mentioned below:

- Electronic devices and computers need a lot of electricity to work which have a bad impact on the environment because electricity is generated by burning coal, natural gas, nuclear and hydro power source. That have bad impact on the environment in the form of air pollution, climate change, acid rain etc.
- Many electronic devices like computers, air conditioners and so on generating a large amount of heat which causes emission of carbon dioxide gas. Global warming is the biggest example of increased carbon dioxide which increasing everyday.

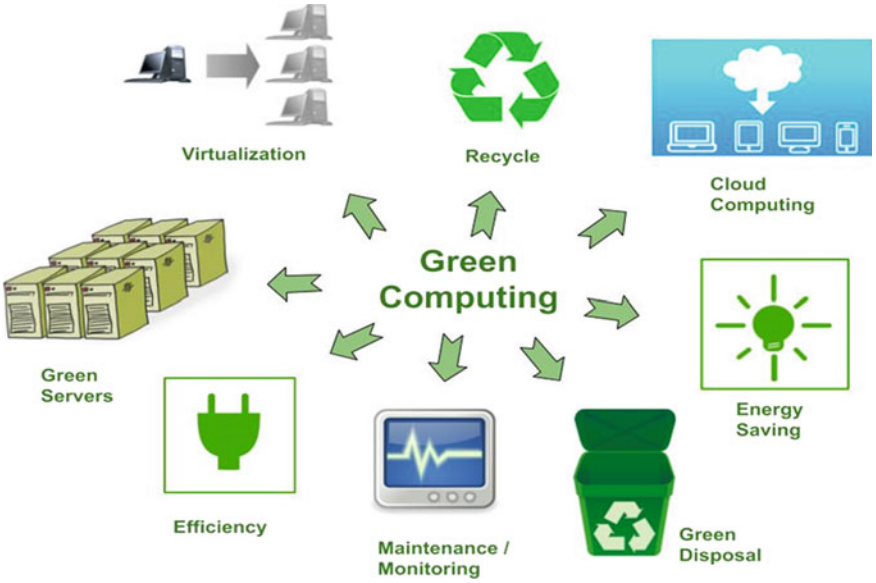


Fig. 1 Aspects of green computing

- When electronics and equipment are being disposed of, a ton of hazardous waste is created that really harms the atmosphere. It also releases into the atmosphere heavy metal such as lead (Pave), mercury (Hg), cadmium (cod).

Figure 1 depicts various aspects of green computing which have their own set of roles in promoting a sustainable environment. Aspects like virtualization, cloud computing are very effective for computing without the requirement of any additional set of hardware thereby reducing the load on the environment for the production of various hardware. Other aspects are also very important in a way to manage the power consumption and efficiency of our overall system without which there's the huge power usage and thereby putting a load on nature for power generation. Green servers comprise various new techniques which makes it highly robust and efficient with the little consumption of power. Disposal of e-waste is an intensive and risky task and should be done with utmost care misleading of which may lead to serious health problems as they consist of various toxic gases and made of harmful substances.

3.1 Areas in the IT Sector Which Have Significant Effect on Environment

IT sector affect the environment indirectly some areas of the IT sector that affects the environment directly are mentioned below:

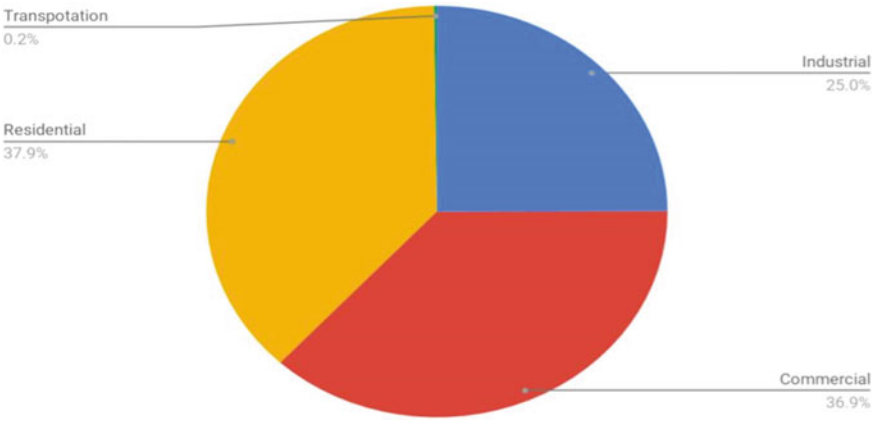


Fig. 2 Electricity consumption in Unites States by sectors (2016)

3.1.1 Pollution Due to Production of Electricity

Producing electricity is the assertive industrial source of air emissions in the today's world. The main source of emission of Greenhouse gas is Fossil fired power plants and greenhouse gases are responsible for Global warming. Renewable energy have less emission than classical energy producing technology, That's the reason why renewable energy getting more notice by the world. As mentioned below, the impacts of electricity generation on air pollution varies from technology to technology.

Figure 2 shows the consumption of electricity in The United States by different sectors. Consumption of electricity in residential use is maximum 37.9% of total consumption, and commercial consumption is 36.9%, industries consumes only 25% of total electricity consumption and transportation sector consumes on 0.2% of total electricity consumption in The United States.

A. Using Natural Gas as a Fuel

For producing electricity in power plant they burn natural gas, which generates NO (nitrogen oxides) and CO_2 (carbon dioxide) but emission is less burning oil or coal. A primary component of natural gas, methane and carbon pollution, may also be released into the air when natural gas is not fully burnt. During the whole process the emission mercury compounds and SO_2 (sulfur dioxide) are very less. If the average air emission between burning of natural gas and burning of coal is compared then it is found that burning of natural gas produces half of CO_2, one third of NO and one percent of SO_2 with compared to the burning of coal. In addition, additional pollutants are produced by the method of processing, handling and transporting natural gas to the power plant.

B. Using Coal as a Fuel

To produce electricity from coal they burned coal in power plants when coal burns it emit SO_2 (sulfur dioxide), NO (nitrogen oxide), mercury compound and CO_2 (carbon dioxide). That's the reason why coal fired boilers are need to have control devices to reduce the emissions released by burning of coal. Other pollutants are created by mining, cleaning and transporting coal to the power plant. Methane, for instance, a strong greenhouse gas contained in carbon, is often emitted during these processes in order to increase safety.

C. Using Oil as a Fuel

To generate electricity from oil, It burns at power plant produce SO_2 (sulfur dioxide), CO_2 (carbon dioxide), mercury compounds and NO (nitrogen oxide). Based on the sulfur and mercury content of the burning fuel, the volume of sulfur dioxide and mercury compounds can vary highly. However, oil wells and facilities for oil extraction are a cause of methane emissions, a potent greenhouse gas. The big engines used in oil drilling, processing, and transport processes that also generate pollutants are consuming natural gas and diesel.

D. Using Nuclear Power Plant

Nuclear power plants do not emit any harmful gases like SO_2 (sulfur dioxide), CO_2 (carbon dioxide), mercury compounds and NO (nitrogen oxide). In addition, emission of fossil fuels are linked with the mining of uranium and it's enrichment process as well as the transportation of uranium fuel to the nuclear plant (Fig. 3).

As shown in above figure 33.9% electricity is generated by burning natural gas and 29% electricity is produced by burning coal only in the United States, it means 62.9% of electricity is generated by burning natural gas and coal which have bad effect on our environment. Nuclear power plants also use to generate electricity, it produces 19.9% electricity and remaining 17.2% electricity generated using other sources like wind, solar, geothermal, hydroelectric, etc.

3.1.2 Pollution Due to Hardware Devices

IT sector uses many hardware devices like printer, computer, networking devices and machines in offices as well as in Data centers but not in an efficient manner after few when the devices not work properly they replace it with new which creates e-waste. The problem with devices is that they are neither recyclable nor reusable in future. It directly affect the environment. Figure 4 shows various E-wastes that do various sorts of pollution as they are nonbiodegradable and also some electronic components are made up of various toxic chemicals with toxic gases filled in it so there should be proper methods for treating such huge amount of e-waste being generated at a very high pace.

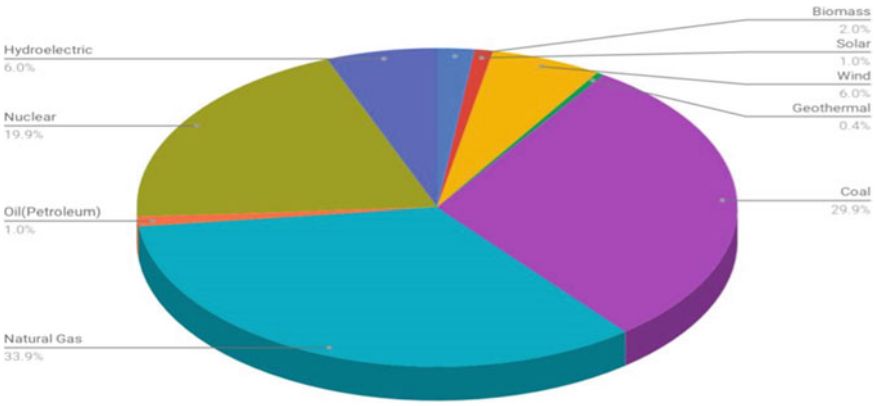


Fig. 3 Electricity generation in United State by different sources (2016)

Fig. 4 E-waste produced by Humans [12]

3.1.3 Effect of Printing on Environment

Our maximum communication and documentation are based on papers in printed format. Payment has to be done for printed papers as well as for disposing them. Both these incur huge cost. Printing's environmental impact can be important and wide-ranging. Printed books and notes are still the main source for learning in this

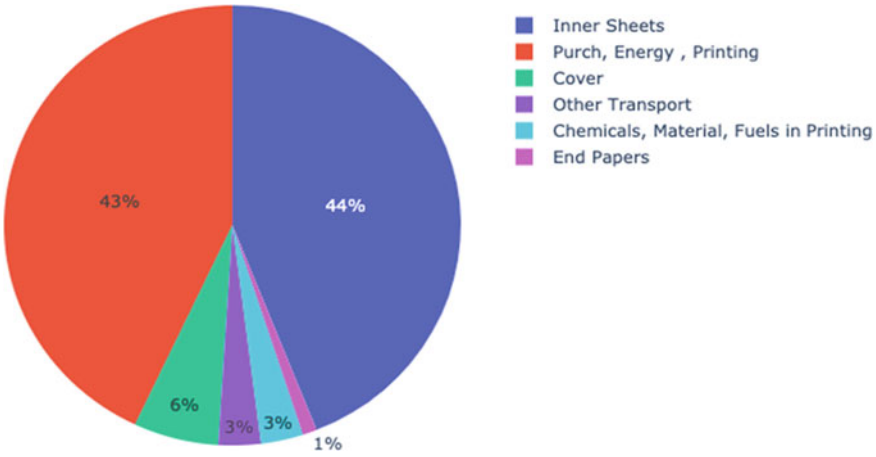


Fig. 5 Relative participates in the carbon footprint of each element of a book

age of digital world. The printing industry is top most polluting industry in the world (Fig. 5).

- The printing industry uses huge amounts of electricity at every stage for heating, printing and lighting to power equipment and at final delivery stage also.
- Many printing processes need a huge amount of water to complete. Most of the time waste water dissolved in nature without cleaning.
- The printing process produces relatively high waste grades. There are plenty of waste produced by the printing industry, from printing sheets and ink tins to pallets and packaging.
- It is known that many volatile organic compounds (VOC) come from the printing industry. The isopropyl alcohol (IPA), which is used as a damping agent, evaporates at room temperature and produces VOCs as the ink dries. VOCs are colorless, odorless gasses that harm the environment, contribute to global warming and ozone development, and are harmful for staff in the pressroom.

Pulpwood trees are harvested in large quantities to make paper and then shipped to paper mills where pulpwood fibers are processed and shaped into papers. This process is extremely energy-consuming and a major environmental danger is the infected waste water created. Therefore, the impact of deforestation remaining on the cleared land are a significant cause of concern. Land absorb carbon dioxide from the atmosphere and turn it into coal by photosynthesis, which is then deposited in the wood of trees in a process called carbon sequestration. Like Such trees are a big store for organic coal. Their elimination reduces the ability for critical processes to exist when oxygen is removed and replaced with atmospheric carbon dioxide. Figure 6 shows the steps to implement green computing in the IT industry, To implement green computing in IT sector they need to make green design of IT system, it's disposal solution, green manufacturing and its green use in way which means efficient use.

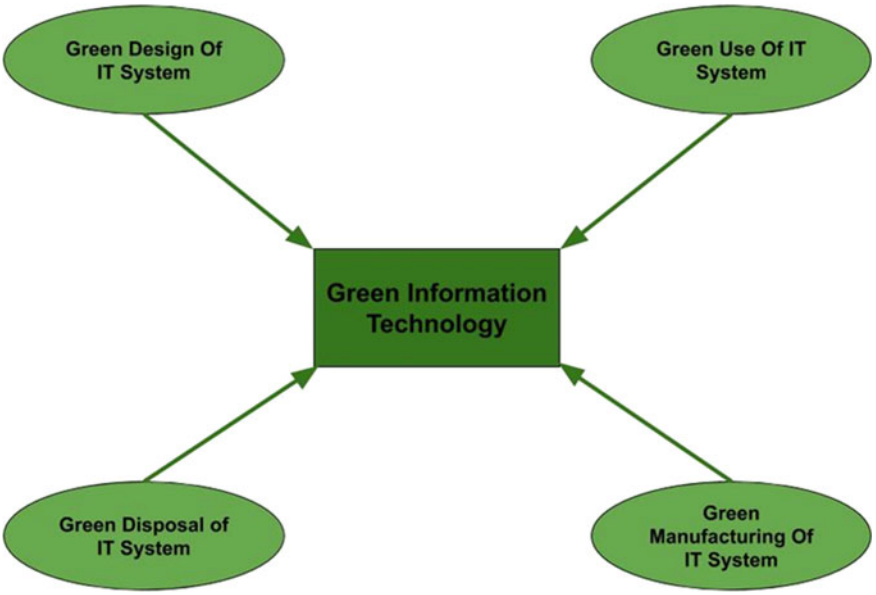


Fig. 6 Green computing

4 How Green Computing Can Change Education System

The area of green computing is very broad many research activities are going on to implement it in IT and educational institute for the last few years. The following steps would demonstrate how Green Computing in an educational institution can be successfully achieved and enforced. Individual users at home should follow easy ways to reduce energy and power usage, Some easy steps are written below:

1. Keep the Computer Shut-Down

Nowaday computer becomes the basic need of every user and most energy consuming source also, even if it is in sleep mode it consumes energy. Today personal computers are turned on and off over 40,000 times [13]. If pc's are shut down using screen shaver that will affect our pc lifespan.

2. Using Low Power Light

LED bulbs are consuming energy 75% less than the traditional bulbs and they don't have mercury so It will not affect the environment.

3. Unplug High Power Consuming Sources

Some high power consuming devices like AC, Printer, Microwave, Scanner uses accessory power even when they are off but plugged with any power source. So unplug them to reduce power consumption.

4. Use Power Strip Instead of Power Plugs

Use a power strip to shut off all electronics at once to avoid paying for this "vampire electricity". Flipping the switch on your power strip has the same impact as unplugging from the wall per time, avoiding the loss of phantom fuel.

5. Switch Off the Light

Turn off the light when you don't need.

A. Teaching and Learning with Green Computing

E-learning also known as online learning which means using many resources like communication and information technology and e-media in education. There are many online learning sourcer which bring education in the form of video, images, audio and text file also [14]. E-learning introduces books in electronic format known as e-book, electronic mail notice/instructions system which replaces the traditional way of learning and saved a huge amount of printed books and papers. E-learning decreased need of utilities for campus in the form of class room, lights and air conditioner the result of this less e-waste and heat produced by electronic devices reduced. E-learning also replaces the traditional way of classroom learning which saves a huge amount of paper waste in the form of assignments and handouts [15]. E-learning provides face to face communication through live classes, forums and chat rooms. As a consequence, students do not have to ride to their institutes, thus minimizing transport emissions. Video conferencing helps to reduce travel needed for staff faculty meeting, student institute visit for attending class and so on. Live classes allows professors to teach students with video and audio from classrooms as well as from any other location. Users can also use online conferences to have face-to-face meetings with people in remote locations from desktop or laptop computers [15].

While much of today's online learning takes place in asynchronous sessions, mobile internet and video conferencing gives teachers the opportunity to teach synchronous, live lessons over the Internet [15]. Web conferencing has made progress in learning with the advent of relatively low cost and high-speed broadband services. Web conferencing provides a platform where Face to face interaction can take place between people which helps to decrease the need of travel due to this global warming and carbon emission also reduced [16]. Electronic mails are normally used for online learning process. Instructors can receive documents and assignments in electronic format using email from students.

B. Implementing Renewable Technology in the Governance, Control and Dissemination of Information in a College

Following are the some where we can make some changes to implement Green computing:

Fig. 7 Online exam system

4.1 Virtual Entrance Assessments and Reports Released

By designing efficient software to organize online admission tests for selecting applicants, the educational institution can save huge amounts of printed/blank stationery. At the same time, institutions can publish examination results on their college website to save college staff from using too many resources to publish thousands of students results.

As shown in Fig. 7 institute can adopt an efficient software which works in real time it means, students give his exam on that software and it will reflect exam results after completing the exam. This approach helps to save a huge amount of papers and it also helps reduce a huge amount of workforce.

4.2 Using Software to Evaluate Exam

Using technology to evaluate exam It save resources which promotes Green Computing. The marks collected from the digital assessment can be fed directly into the list of the participants, removing the need to use natural resources. In many institutions, electronic evaluation systems have replaced the traditional forms of paper evaluation, thus saving the need for paper use and thus promoting green Computing.

4.3 Updation of Attendance, Marks, Other Details and Fees Payment Using Software

Administrative staff may update student records, their course of selection, attendance, marks received, points won and fees payment and due data through an easy-to-operate software system that also saves the overhead of monitoring adjustments to records while at the same time saving the costs of using natural resources. Employees are saved from manual reporting on the performance of a student, thereby saving the need for comprehensive use of paper and energy. It becomes easier to generate arrear or failed applicant lists as the program is liable for cumulative calculations. Easy and highly effective software design allows students as well as non-tech-savvy administrative staff to easily enter reports and receive unified mark sheets, analyze participation and mark disparities, and accurately measure maximum and percentages without needing to do them manually in pen and paper.

4.4 Using Online Brochures to Introduce Academic Institute

An electronic brochure that saves paper and thus protect the atmosphere can provide details about the educational institution through its website. If all the details are available Institute website then students can easily access the Information through the institute web portal at home without using any transport for travel which helps to reduce Carbon emission.

4.5 Using Online Brochures for Filling Application and Feedback Form

It is one of the most common methods for introducing Green Computing and has been implemented throughout the world in different IHEs. Many Green Computing approaches in an enterprise were built to save paper, gas, electricity, and other energy resources, and this is one of them. Filling application forms and input forms online has become the most convenient and environmentally friendly method to apply student records, and many universities have built highly developed and effective technology to do the same. Digital technology has the benefit of saving time in transportation by reducing carbon emissions and also contributing to Environmental preservation.

4.6 Maintaining Details of Staff Members and Course Details

The management team will keep track of the courses offered by the university and the related staff and teachers by digital printed soft copies that are energy efficient and easy to maintain. This allows people, whether pupils, employees or educators, to keep track of departmental adjustments quickly, avoiding the need to maintain actual documents on paper as well. In collaboration with teachers, the management staff can also design new curricula and modify existing courses and post them online to increase student exposure. It saves a lot of paper and storage, rendering environmentally friendly solutions available.

4.7 In College Event Management

There are many apps available to help synchronize and schedule university activities that are both environmentally friendly and easy to function. It is also possible to make digital graphic invites for visitors that are appealing, cost-effective and at the same time promote environmental conservation.

4.8 Making Account Department Cashless

There are many software are available in the market to manage account, adopting these software to make account department cashless and digital. Receiving academic fees in online manner removes the need to print large volumes of payment slips or other hard copy records as the software can automatically create due or pending transaction lists. This method has the additional benefit of providing protection by removing the need to wait in long queues and putting large amounts of cash at risk. It also makes it easier to accomplish the preservation of transaction data.

5 Reducing E-Waste to Implement Green Computing

Sustainability of a product is highly depends upon the life of a product or we can say it is directly proportional to the life of the product, it means long life products are more sustainable than short life product because if we use long life products then it affects the production of that product which directly reduced the number of components used to make these and e-waste. Humans prefer to always get the latest devices if it is actually needed or not. To get the latest devices many times we replaces the efficient and useful old devices which creates a huge amount of e-waste.

Fig. 8 Reduce E-waste using recycle process [17]

New devices are not always efficient and able to fulfil the user demands, so before adopting new technology/devices we have to first analyse our requirements It is a very important step to reduce e-waste. Before entering new equipment, the IT department must carefully weigh the department's requirements. If a machine or similar system is incorrect, often only one part is damaged, not the whole thing. Consult with the service providers for repairs and get the equipment fixed instead of totally refusing it. In addition, keep upgrading individual components and replacing them instead of the whole thing. If it is not possible to upgrade the equipment to meet your needs, consider reselling or donating instead of throwing it. All of these activities would help to reduce e-waste and save the environment in exchange. The problems caused by E-Waste is well known so there should be proper methods for recycling and disposal of e-waste. Figure 8 shows how recycling of e-waste can be beneficial in stepping toward a greener environment by utilizing the waste for another purpose. Like various components can be reframed or redesigned also the working components of equipment can be utilized or used for making another set of equipment.

6 Implementing Green Computing by Reducing the Use of Printing Document

Nowadays our maximum documentation and communication are based on papers in printed format. Printing paper and disposing also costs much. For learning, still printed books are being used. Yet pollution is caused by printing industry. Using e-books and e-notes for teaching and learning reduced the use of paper in this field and

also help to implement green computing in education sector. We can use electronic mails for communication and digital signature based documentation etc., these steps plays an important role to implement green computing.

7 Save Electricity for Green Computing/Environment

Electronic devices like computers, air conditioners and lights are consuming a fixed amount of electricity in educational institute and in IT companies also. Saving energy helps to reduce cost as well as help to implement green computing. Buying energy efficient devices having long life is the first step to step to save energy and environment. Purchase decision have long term impact with addition to his cost. To better understand this let's take an example of 19" and 17" monitor, 19" monitor uses approx double the amount of energy compared to 17" monitor. To overcome on these problems try to buy eco-friendly laptop, it uses 4 times less electricity in compare to desktop. LCD (Liquid Crystal Display) monitor uses less energy compared to CRT (Cathode Ray Tube) monitor and LED (Light Emitting Diode) more efficient than all other monitor. LED monitor and LCD monitor energy using ratio is 1:10. So replacing LCD and CRT monitor with LED monitor helps to reduce energy consumption. Electricity can be saved by shutting down our computer when it is not in use. Laptop and computers emits CO_2 gas when we use it. By enabling power saving mode on our computers we can save energy. Electronic devices consume electricity when they are connected to a power source, by disconnecting these devices from power source when it is not in use 10% electricity can be saved.

8 Institutes Implementing

In Michigan University
Michigan university has a good history in the field of research, student activity and sustainability initiatives, it wins many awards for the same [18]. Sustainable technology activities at this University include alternative transport, environmental audits and building upgrades, sustainable procurement, using renewable resources and recycling systems.

In Harvard University
The FAS Energy Reduction Program at Harvard University promotes energy preservation in all departments [15].

In Ohio University
Ohio university uses a software/system which turns down the computer when it is not in use. Using this system university saved 45% of electricity used in his campus for running computer [19].

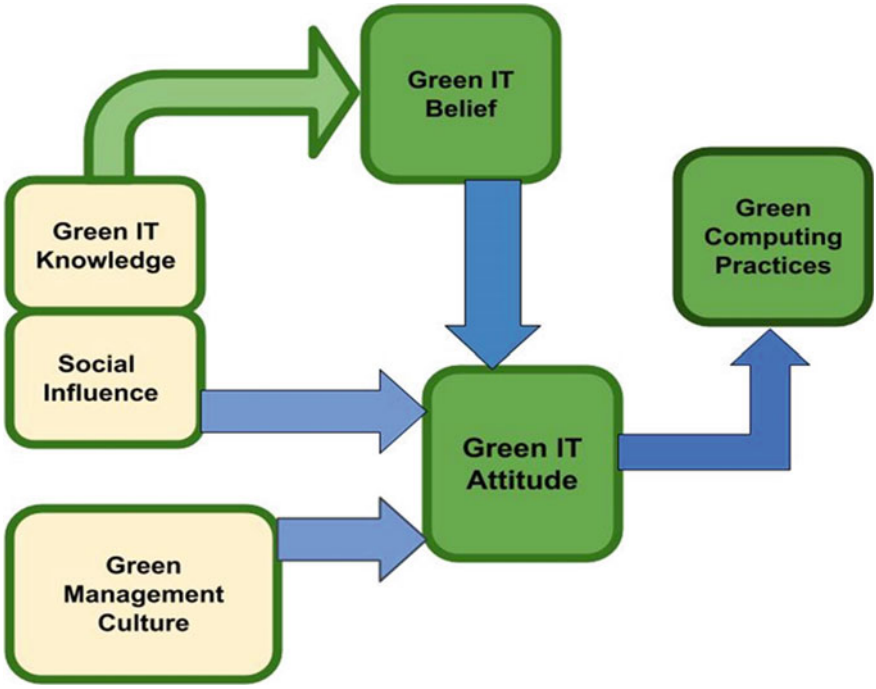


Fig. 9 Green computing practices

In Fig. 9 knowledge of green information technology (IT) leads to green IT belief and the combination of Green IT and social influence leads to Green attitude. Green attitude is nothing but it is a big step to implement Green computing practices in real life.

The list of universities are big which are really working on the field to implement green computing. Some names of universities are mentioned above with this work also which are working in the field to implement green computing in education. Many universities like Carnegie Mellon University, Pomona College, University of Florida, Yale University etc. are also working very well in this field.

9 Conclusion and Future Scope

Computer and his related devices are used in all over the world. Nowadays every person has a smartphone, they change his smartphones only for fashion, not depending on the requirement. This kind of human behaviour harms the environment very much, because by changing devices every time only to get upgraded or for show off it creates a huge amount of e-waste. In education sector every college/university

will be hi-tech in future, to achieve this they will need more computer hardware and software. So hardware and software should have to maintain some quality like optimizable, upgradable, maintainable, energy efficient etc. The good thing is that at the present time, many universities are working in the field to implement Green computing. Nevertheless, one and all in an organisation will need a larger and genuine commitment to understand the Green Computing theory in actual practice. Through the principles and recommendations outlined in this section, employees, teachers and students will begin to make small contributions towards sustainability. These small contribution helps to make energy efficient and eco-friendly system which will be good for nature as well as for us. Green Computing is needs a long term dedication to applying the principles that needs broad understanding and adequate preparation. The biggest challenge is to swell the sensitivity to green computing and make the workers in organizational management understand Green Computing's long-term benefits, both in terms of sustainability and economy. With the collaborative efforts of all institutions, the dream of an environmentally friendly, technology-enabled campus can be realized.

References

1. Agarwal S, Datta A, Nath A (2014) Impact of green computing in IT industry to make eco friendly environment. J Global Res Comput Sci 4(4)
2. Haraty RA, Bitar G (2019) Associating learning technology to sustain the environment through green mobile applications. Heliyon 5(1)
3. Pollution kills far more people than Malaria or Ebola in the developing world. https://www.fastcompany.com/3041492/pollution-kills-far-more-people-than-malaria-or-ebola-in-the-developing-world. Accessed Nov 2019
4. https://scholar.google.com/scholar_lookup?title=First. Accessed Oct 2019
5. Du Buisson W, Naidoo R (2014) Exploring factors influencing IT workers' green computing intention at a South African firm. In: Proceedings of the Southern African institute for computer scientist and information technologists annual conference
6. Molla A, Cooper V (2010) Green IT readiness: a framework and preliminary proof of concept. Australas J Inf Syst 16(2)
7. Aggarwal S, Garg M, Kumar P (2012) Green computing is smart computing-a survey. Int J Emerg Technol Adv Eng 2(2):297–303
8. Hooper A (2008) Green computing. Commun ACM 51(10):11–13
9. Singh S (2015) Green computing strategies and challenges. In: International conference on green computing and internet of things (ICGCIoT), pp 758–760
10. Mohammed MA, Muhammed DA, Abdullah JM (2015) Green computing beyond the traditional ways. Int J Multidiscip Curr Res 3
11. Ahmad TBT, Bello A, Nordin MS (2014) Exploring Malaysian University students' awareness of green computing. GSTF J Educ (JEd) 1(2)
12. Kardashian K (2018) How E-waste encourages competitors to collaborate. https://phys.org/news/2018-06-e-waste-competitors-collaborate.html. Accessed Oct 2019
13. Top 5 steps to reduce your energy consumption. https://green.harvard.edu/tools-resources/poster/top-5-steps-reduce-your-energy-consumption. Accessed Oct 2019
14. Distance education, Excelsior college student success guide. https://guide.excelsior.edu/distance-education/. Accessed Oct 2019

15. Agarwal S, Vimal A, Ghosh S, Nath A, Green computing endeavor in higher educational institutes - a noble initiative towards sustainable IT infrastructure
16. Agarwal S, Nath A, Chowdhury D (2012) Sustainable approaches and good practices in green software engineering. Int J Res Rev Comput Sci (IJRRCS) 3(1)
17. Tata Power. https://www.tatapower.com/BetterEarth.aspx. Accessed Oct 2019
18. Stuenkel MB (2009) Green IT best practices at the University of Michigan. https://er.educause.edu/articles/2009/10/green-it-best-practices-at-the-university-of-michigan. Accessed Oct 2019
19. Patrick DL, Governor L, Murray T (2008) Campus sustainability best practices - a resource for colleges and universities, prepared for the leading by example program at the Massachusetts executive office of energy and environmental affairs. https://www.mass.gov/files/documents/2016/08/ot/lbe-campus-sustain-practices.pdf. Accessed Oct 2019
20. https://www.sciencedirect.com/topics/social-sciences/academies-of-science. Accessed Oct 2019
21. Raza K, Patle VK, Arya S (2012) A review on green computing for eco-friendly and sustainable IT. J Comput Intell Electron Syst 1(1)
22. Ahmed AI (2018) Understanding the factors affecting the adoption of green computing in the Gulf Universities. Int J Adv Comput Sci Appl 9(3)
23. Kharchenko V, Illiashenko O, Phillips C, Vain J (2015) Green computing within the context of educational and research projects. In: Recent advances in computer science, 19th international conference on computers, Zakynthos, Greece
24. Agarwal S, Datta A, Nath A (2014) Impact of green computing in IT industry to make eco friendly environment 5:5–10
25. Kartiwi M, Hasan H, Gunawan TS, Husein BA (2014) Green IT attitude and behaviour in higher education institution: a gender perspective. J Appl Sci 14(7):714–718
26. Kushwaha DS, Singh VK (2013) An eco friendly approach for sustainable computing. Int J Sci Res (IJSR)
27. Agarwal S, Basu K, Nath A (2013) Green computing and green technology based teaching learning and administration in higher education institutions. Int J Adv Comput Res 3(3)
28. McWhorter R, Delello J (2015) Green computing through virtual learning environments
29. Murugesan S (2008) Harnessing green IT: principles and practices. IT Prof 10(1)
30. Pihkola H et al (2010) Carbon footprint and environmental impacts of print products from cradle to grave. Results from the leader project (Part 1). Proceedings
31. Agarwal S, Vimal A, Ghosh S, Nath A (2012) Green computing endeavor in higher educational institutes - a noble initiative towards sustainable IT infrastructure 4(5)
32. United States Environmental Protection Agency (2017) About the U.S. electricity system and its impact on the environment. Energy and the environment. https://www.epa.gov/energy/about-us-electricity-system-and-its-impact-environment. Accessed Oct 2019
33. Ojo AO, Raman M, Downe AG (2019) Toward green computing practices: a Malaysian study of green belief and attitude among information technology professionals. J Clean Prod 224:246–255

Energy Management and Monitoring Using IoT with CupCarbon Platform

A. John, T. Ananth Kumar, M. Adimoolam, and Angelin Blessy

Abstract Green computing is an Eco-Friendly usage of resources in terms of designing, displaying and manufacturing in the field of Engineering. Main purpose of green computing is reducing the environmental impact such as hazardous materials, energy efficiency during the lifetime of product and recyclability of product wastage. The main approaching fields of green computing are data center design, cloud computing, edge computing, IoT, super Computer and smart cities etc. The one of the main approaches of green computing with smart cites is collect and manage various recourses and use efficiently and effectively. In smart cities data storing, processing and using take more usage of resources are wasted. In Energy management and effectively usage is big challenging issues in recent days in the world. The Green computing with energy efficiency in a smart cities research help to improve the energy effectively. The Energy management in smart cities is tracking and monitoring the energy to use effectively in building and smart cities. In smart build and smart cities around 25–35% cost is spent to energy operations. Energy managing purpose different techniques and methodologies are introduced. Internet of things (IoT) is one of the main techniques to sense and optimize the unrelated events. In this chapter mainly concentrated integration of IoT and CupCarbon and implementation. Specially first, IoT Smart Road Network Energy management using CupCarbon is implemented with the help of Road Side Unit (RSU) and IoT protocol (MQTT). Using this implementation, we can Manage the power in the street light in road network (power optimization), Analysis the traffic in one particular and Emergency services we can take the decision. The second, Case Study with IoT Energy Management with CupCarbon in VANET environment. Finally presented various challenges and research direction for future.

A. John (✉) · T. Ananth Kumar · A. Blessy
School of Computer Science, Galgotias University, Greater Noida, Uttar Pradesh, India
e-mail: johnmtech@gmail.com

M. Adimoolam
Department of Electronics and Communication Engineering, IFET College of Engineering, Kengarampalayam, Tamil Nadu, India

B. Balusamy et al. (eds.), *Green Computing in Smart Cities: Simulation and Techniques*, Green Energy and Technology, https://doi.org/10.1007/978-3-030-48141-4_10

1 Introduction on Energy Management

Energy management system is the process of continuously saving the energy with the help of recent technologies and methodologies. The main objective of the energy management is saving the energy with the help of staff, optimization techniques, smart methods and tools. The reasons for saving the energy management system is save the energy, cost, save the environments and make the green environments without pollutions. The different procedure and methodologies are available to save the energy. Today world introduced huge number of technologies and tool are used to save the energy. For example, in business environments, smart cities, smart building, smart road and smart intelligence vehicles management systems are used recent technologies to save the energies.

The computer based aided tools are used to operate, control, monitor and optimize and regenerate and transmits the energies. Also, this computer aided tools are used to manage the energies form small home to big smart cities. So eco-friendly environments are help full to better environments. Specially in computer science green computing save the environment and reduce the environment impact from the manufacturing, designing and engineering. The various counties and organizations are motivated to save the society using technologies. In 1992 U.S. introduced Energy Star program to promote, recognize, monitor and climate control equipment and technologies to save the environments. The result is sleep more consumer electronics items are used to save the energies. The main energy optimization and computing fields are product longevity, data center design, software design and development field, materials manufacturing, cloud computing, edge computing and etc. This field and related fields consumes more energies. So smart computing devices management and tools are very important to the today environments.

Some of the main optimization technologies and tools are artificial intelligence (AI), Internet on Things (IoT) and some of the most commonly used optimization tools, namely, GenOpt, MATLAB, mode FRONTIER, Topgui, BEopt, Opt-E-Plus, CupCarbon etc. [1]. In this techniques and tools IoT is the recent emerging technologies to build the energy optimized products, make smart cities, communicate mobile devices to be connect via web in computers and monitors and control the various devices and things such as robot, home, car, blood glucose matters and other environments such as moving, non-moving objects and remote environments. Similarly, the CupCarbon [2] is the emerging framework and platform to sensing smart cities, IoT wireless technologies to optimize the energy, communicate to sensors, manage the communication nodes and communication to Android and Raspberry Pi.

The main objective of this chapters is managing the energy and monitor using IOT with the help of CupCarbon platform. And give the overview of IOT and CupCarbon, frame work, relationship between CupCarbon and IoT, Energy management and monitor using IoT and CupCarbon and finally give the brief case studies using IoT and CupCarbon.

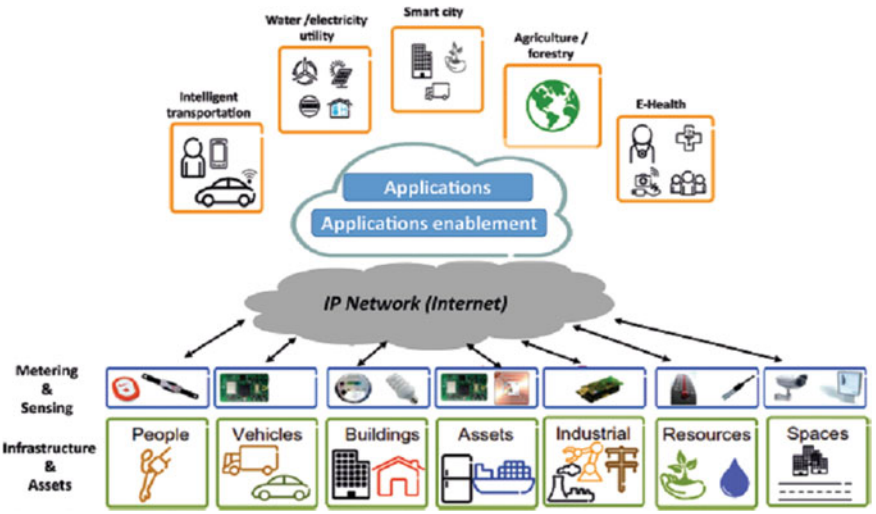


Fig. 1 Applications of IoT

1.1 Overview of IoT

IoT is the emerging technologies to sensing, gathering and networking information's. The main achievement is automation, analysis and integrations of systems. The main features of IoT are smart, connectivity and active engagement etc. The main applications are shown in the Fig. 1 [3]. The main advantages of IoTs are energy optimizations, Reduce the wastage, Technology enhancement etc.

1.2 Simulation Tools of IoT

Tools and Simulators are used to test and verify the applications of IoT. Some of the main Tools of IoT are as follows:

1. Iotify
2. MATLAB
3. NetSim
4. BevyWise IoT Simulator
5. Ansys IoT Simulator
6. IBM's Bluemix
7. CupCarbon

Iotify is a powerful IoT simulator that allows you to quickly develop IoT solutions in the cloud. This tool lets you simulate large scale IoT installations in your own virtual IoT lab.

MATLAB features an interesting IoT module that allows you develop and test smart devices, as well as collect and analyze IoT data in the cloud.

NetSim is a powerful network simulator that you can use to simulate IoT systems. You can use it to test the performance of real apps over a virtual network. If you're building a new IoT network from the ground or expand an existing one, you can use NetSim to predict how the respective network will perform. BevyWise IoT Simulator is a complex and easy to use MQTT simulation tool that allows you to simulate tens of thousands of IoT devices.

Ansys IoT Simulator IoT simulator can help you develop and test the IoT devices and networks of tomorrow. Ansys collaborated with the best IoT leaders in the world, across industries, to build this comprehensive framework for IoT engineering simulation.

IBM's Bluemix is an innovative cloud platform that allows you to sample the company's Internet of Things Platform even if you don't have a physical device using simulated data. CupCarbon is a smart city and IoT wireless sensor network (WSN) simulator. It is a new platform for 2D/3D design, visualisation and the simulation of radio propagation and interferences in IoT networks.

1.3 Outline of CupCarbon

The CupCarbon is IoT and smart cities wireless sensor networking mobility simulator. The main objective of this simulator is design, debug, visualize, monitor and validate the distributed environment data. The Set of distributed environment algorithms also used to monitor, data collection and optimization. Specially using CupCarbon create large set of environmental scenarios such as gas, Mobile, Smart cities, fire and data visualization for 2D and 3D etc. The general presentation of CupCarbon simulator is shown in Fig. 2 [4] and specialized applications of CupCarbon shown in Fig. 3 [4]. The applications of CupCarbon such as building block representations and 3D ray tracing-based radio propagations are shown in the Fig. 3a, b.

1.4 Objective of the CupCarbon

The authors Bounceur et al. [4] list of the various objective of CupCarbon are shown below. The some of the main objectives are as follows.

1. Study the wireless sensor network, deployment, mobility of wireless sensor network and usage of space and spectrum.
2. The 2D/3D visualizations in the realistic environments, simulation performance, services of multi environments etc.

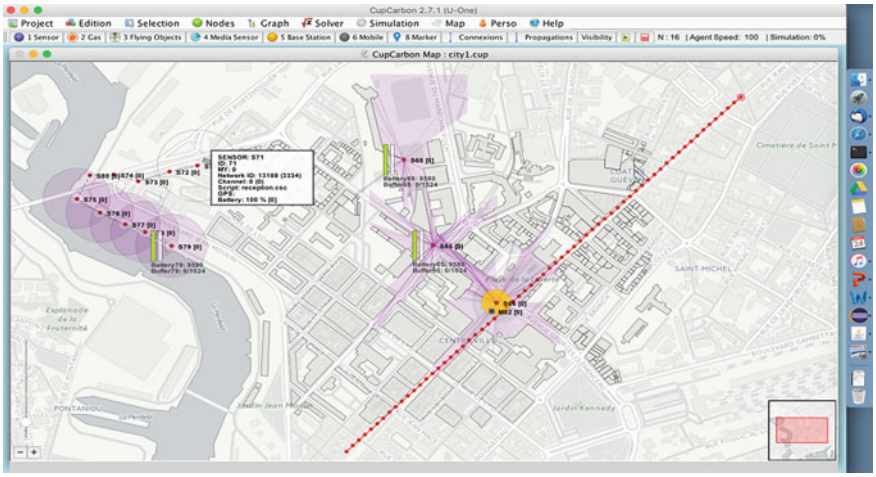


Fig. 2 General presentation of CupCarbon simulation

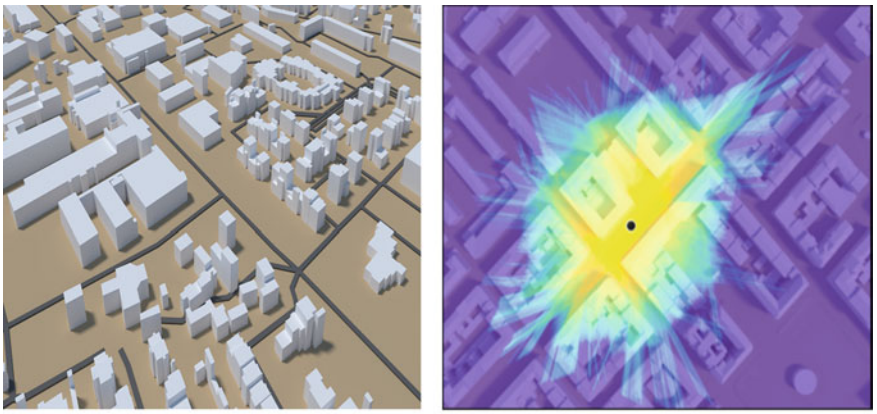


Fig. 3 Applications of CupCarbon simulation

3. The study of feasibility analysis of different environments such as communications, mobile communications, reliability of various applications development and cost estimations and energy optimizations.
4. Detect any modifying the zones in order to improve the quality of the deployment.
5. Simulation of real urban environments.
6. Visualize and simulate the various results in order to develop, validate various algorithms.
7. Monitor and analysis the distributed environments and based on the development of algorithms.

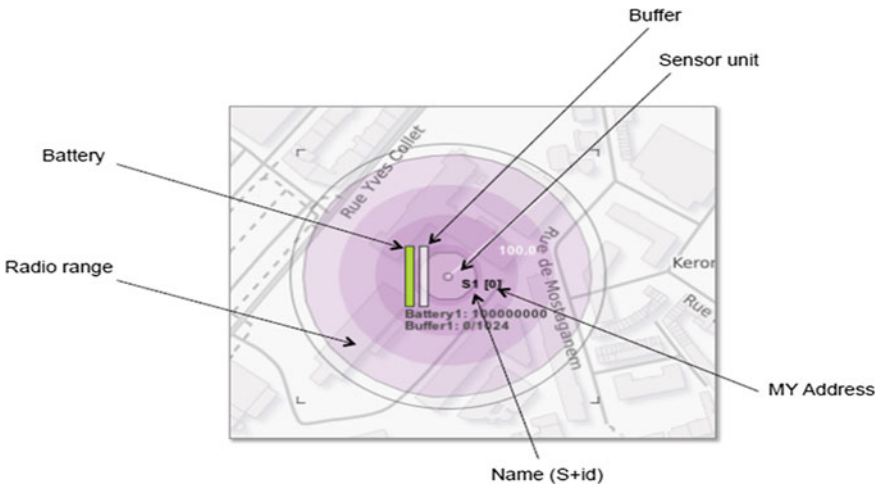


Fig. 4 Mobile sensor with CupCarbon (Bounceur et al. [4])

2 IOT and CupCarbon Platform

The CupCarbon Simulator [5, 6] tool is used to design, optimize, monitor and validate the distributed environments. In the overview of CubCarbon and IoT gives the characteristics and functionalities, application areas, comparison with existing tools are presented in the Table 1. The CupCarbon mainly used for designed to wireless sensor network. It provides two simulation parts one is design scenario with mobility and simulation of discrete events in wireless sensor network. For example, authors Bounceur et al. [4] and his presentation provided the designed mobile sensor network and, in that example, sensors are placed directly and configured by its direct command line making. A sensor specially designed for CubCarbon is called SenScript. The CubCarbon tools does not implement all the protocols. The mobile sensor node all the components, battery, sensors, Radio range and address with name are placed and configured share shown in the Fig. 4.

The huge number of protocols and tools a are used to implement the IoT concepts. The some of the main tools and comparisons are presented by the authors Lopez-Pavon et al. [7] are shown in the Table 1. The some of the comparison tools such as NS2, NS3, OMNET++, Riverbed, NC-TUNS, TOSSM and CupCarbon. The main comparison parameters are platform, graphics interface, results through graph, supported protocols, energy model and optimization etc. The most of the tools such as NS2, NS3 such as defaultly supports to the distributed environments similarly the CupCarbon default support to the distributed environments with visualization with 3D representation. The main application simulation fields of CupCarbon are represented in Fig. 5.

Table 1 Comparison of various tools with CupCarbon

Tools/Parameters	NS2	NS3	OMNET++	Riverbed	NC-TUNS	TOSSIM	CupCarbon
Platforms	FreeBSD, Linux, SunOs, Solaris, Windows, Mac OS X	Linux, OS X, freeBSD, Solaris and Windows	Windows, Unix	Windows, Unix	Linux	Windows, Linux, Cywing	Windows, Linux, Mac
Tools/Parameters	NS-2	NS-3	OMNET++	Riverbed	NC-TUNS	TOSSIM	CupCarbon
Graphical interface	Low	Medium	Medium	High	High	High	High
Results through graphs	Not acceptable	Acceptable	Acceptable	Good	Acceptable	Acceptable	Acceptable
Supported technologies and layer 2–3 protocols	TCP/IP, UDP, FTP, RTP, GPRS, Mobile IPv6, MPLS	IPv4, Pv6, 802.11a, 802.11b, 802.11g, OLSR	802.11, fair (ad hoc routing)	802.11, 802.16, UMTS, DSR, GRP, OLSR, OSPFv3, TORA	VANET, MANET, WLANS, GPRS, Real TCP/IP, UDP/IP	Low (CSMA)	Low
Energy modelling	Yes	–	No	No	–	No	Yes

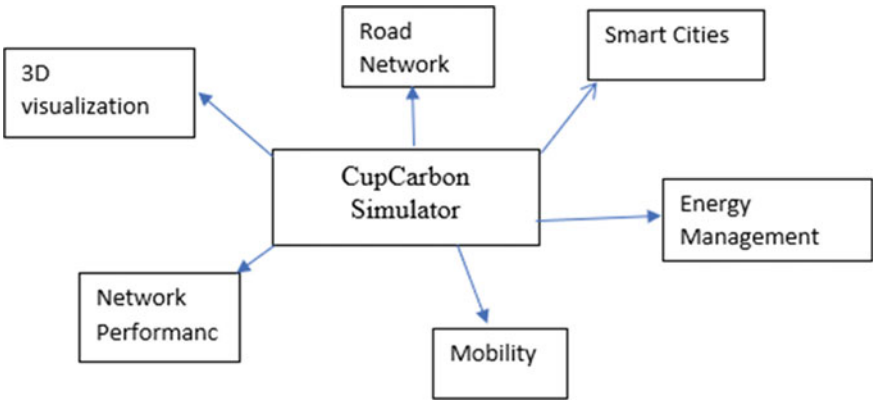


Fig. 5 Application fields of CupCarbon

2.1 Architecture of CupCarbon

The platform was designed with a modular structure to simplify replacement and customization of specific parts of the simulator. The modular structure provides two very important abilities. The first one is the simplification and the customization of the target architecture. It is easy to modify parts of the architecture, while keeping the rest unchanged. This makes the platform useful for simulating specific wireless sensor networks. The second ability is to promote multiple implementations of a given module, which allows users to switch rapidly and easily between different versions. The architecture in Fig. 6 shows the main modules of the CupCarbon simulator. They are described as follows:

- 2D/3D City model module: this module represents a digital format of a city. It contains the different informations about the buildings, roads, places, etc. It is the main part of the simulator that is first presented to the user. It allows to deploy the different sensor nodes of the network and it is used to calculate the interferences and the signal propagations.
- Mobility module: It allows to create the routes of the mobiles. A mobile can be just a device without any communicating system or it can be a sensor node or a device with a sensor node. The mobility can be fixed in advance, where the mobile follows a given trajectory. It can be determined in the script according to a given situation (e.g., detection of a target, an abnormal sensed value, etc.) which allows to perform intelligent mobility.
- Network module: This module allows to design the wireless sensor network which will be simulated.
- Communication Script module: This module represents the interpreter of the Sen-Script language used to program each node of the network. The simulator will execute the instructions of the script of each node.

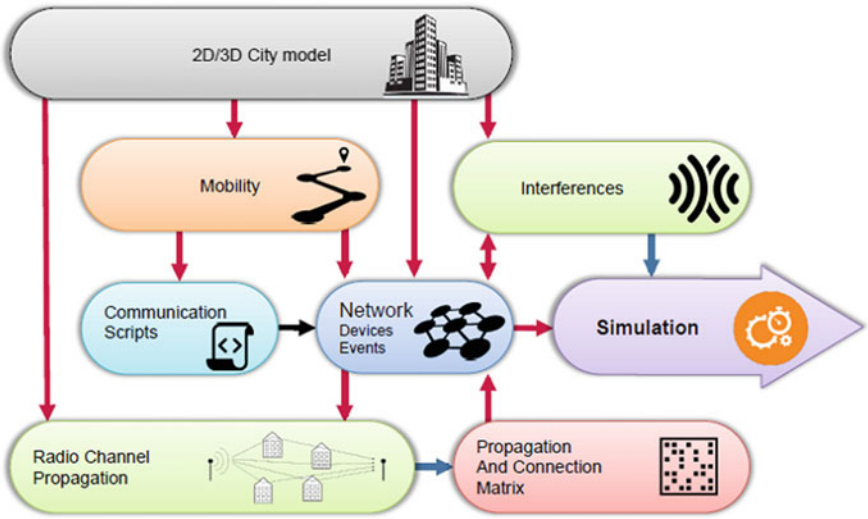


Fig. 6 Architecture of CupCarbon

- Radio Channel Propagation module: This module is used to calculate the channel attenuation and its impulse response according to each couple of nodes in the network. These data allow to determine for each couple of sensor nodes whether the level of interference or the transmitted packet is received or not. Therefore, it allows to determine whether they can communicate in the format of a matrix.
- Interference module: This module is used to determine for each sent message whether it will be received or not by the receiver. It uses the models presented above. This is where the PHY layer is implemented.
- Simulation module: This module is the kernel of the proposed architecture. It is based on discrete event simulation. The events are generated either by executing each instruction of the script of each sensor node or by a real event like mobility or a natural event like temperature, gas, etc.

2.2 Relationship Between IOT and CupCarbon

IoT devices remotely connected, controlled, monitored various objects and devices such as robot, homes, car, energy management, automation work, toys and various monitoring etc. The implementation and deployment of IoT node is very difficult because of cost, time, configuration, frequency of programming, distance implementation, location monitoring etc. Those are some main difficulties are facing while deploying time. So, needed to software to manage, configure, and monitor all the activities. So new platform used to manage all this issue. The new platform is devel-

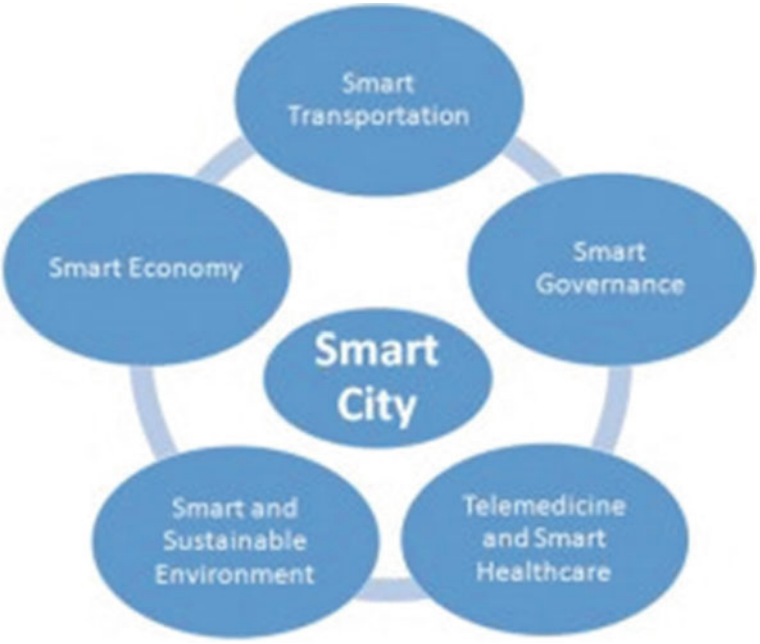


Fig. 7 Key components of smart cities

oped by CupCarbon Lab to manage all this issue. The CupCarbon platform having raspberry pi card, IoT nodes, easy way to config and manage all the activities. So, the IoT and CupCarbon activities are integrated to manage all in distributed environments. Specially CupCarbon is an open source platform for designing and simulating Smart-City and Internet of Things Wireless Sensor Networks. It is programmed in the Java language. So, using this platform in smart cities perform huge number of applications. The some of the applications of IoT and CupCarbon platform are smart energy management, Open Source Map Management, Road Network management, Energy Monitoring, location aware monitoring etc. Those are the some of main notable applications related to IoT and CupCarbon platform.

In Smart city management road network management is one of the important managements to save the energy, cost and time. Huge number of technologies are developed to manage road network with the help of IoT and other techniques. In this section IoT and CupCarbon together managed the road network management. The CupCarbon with smart cities optimization and key components of smart cities are shown in the Fig. 7.

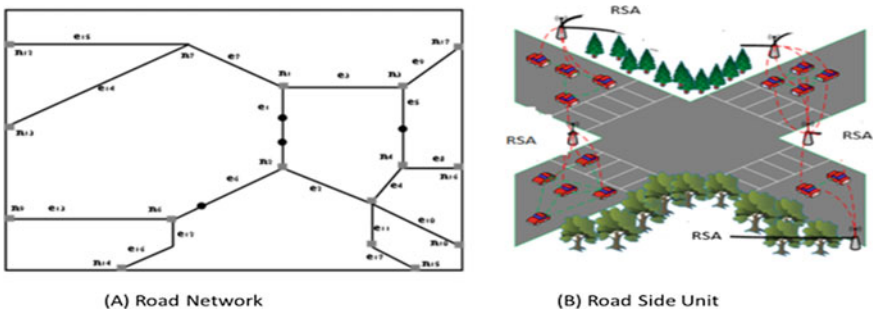


Fig. 8 Road network and RSA

2.3 IoT and Road Network Connectivity

IoT is a bridge which connects various applications to various communication devices. In IoT, there are two types of communication: human-to-machine (H2M), and machine-to-machine (M2M). H2M communication is used to measure data and relay it to remote sources by media, while M2M communication describes any technology that enables networking and exchange of information without manual help. M2M can be used for automatic applications, remote monitoring, robotics, logic services, and transportation.

In the smart cities the entire road network is represented and separated as the segments and managed by the Road Side Unit (RSU) [8]. The road representations are as follows in the Fig. 9. The network model consists of edges (e), node (n), junction (p), segments (S) and objects (O). In network graph G = e, n, the segment is represented as S_1, S_2, S_3, S_n. The junction (P) is the distance between the e_1 and e_2. Figure 8 shows the road network and RSA representation.

The operations of RSU have three parts: The first part is D with the help of Rad network the partitions are performed and its space partition method access dynamic objects data and spatial information. In this part, all the spatial information, such as main attributes <O.id, T, S, A> are stored. Here O.id is object unique identifier, T is the continuous time, S is the spatial co-ordinates, and A is the attributes of spatial information are stored in the RSU. The Road side unit to data is transferred to with the help of protocols. The following tasks are performed with the help of RSU. i. New data are inserted. ii. Updated. These two operations are performed with the help of RSU. Using these two operations and RSU continuously data is transferred to the next terminals to calculation and predictions of data.

2.3.1 Insertion

The road location and timing information <O.id, T, S, A> is inserted with the help of RSU and transferred using IoT protocols. Inserting of dynamic and static objects

is done with the help of the data is transferred with the help of M2M and MQTT protocols. O, R, e, n where the information is located in the positions, later on it is inserted to the M2M. The spatial (location) objects are inserted into the RSU which inserts location and time is accessed by RSU. The moving objects are inserted into RSU with the help of M2M, whereas the objects are inserted to M2M. After insertions of all data, objects are moved with the help of MQTT protocols.

2.3.2 Updation

The road object updations are done with the help of road side unit (RSU). Basically, spatial and temporal updations are held in RSU and then they are moved to the next RSU receiving units in the road network. The RSU is updated when the updation is changed in the road network. In the road network, the road objects and information are updated and the present data is also updated in N RSU T-Tree directly with the help of RSU. During the time of updation and retrieval, the tree performance is increased because the time complexity is reduced. The main reason of time complexity being reduced is that the partitions are used in RSU. The main updation parameters are objects (O), Object Id (O.id), Timing (T), Object Velocity (V), Position (Pos) etc. The three main parameters that are considered for temporal updating are velocity, threshold time, and object movement positions updated. The new objects are entered with the help of RSU and then transferred to transmitting RSU with the help of MQTT protocol.

2.3.3 MQTT

MQTT is a machine to machine (M2M) connectivity protocol. It is a light weight message transfer protocol. Main usage of this protocol is connection with remote places. Specially the wireless sensor and Road Side Units the data or objects are frequently transferred with the help of MQTT protocol. The main advantages of MQTT protocol is

i. Low power usage
ii. Minimize the data package
iii. Efficient information transformation from one location to another location

Using this advantage, the effectively power and data are managed with the help of MQTT protocol.

2.4 Implementation of IoT and CupCarbon in Road Network

In CupCarbon, the implementation scenario can be viewed like a Google Map with Satellite View. It can be changed to Satellite View with a single click. Using these

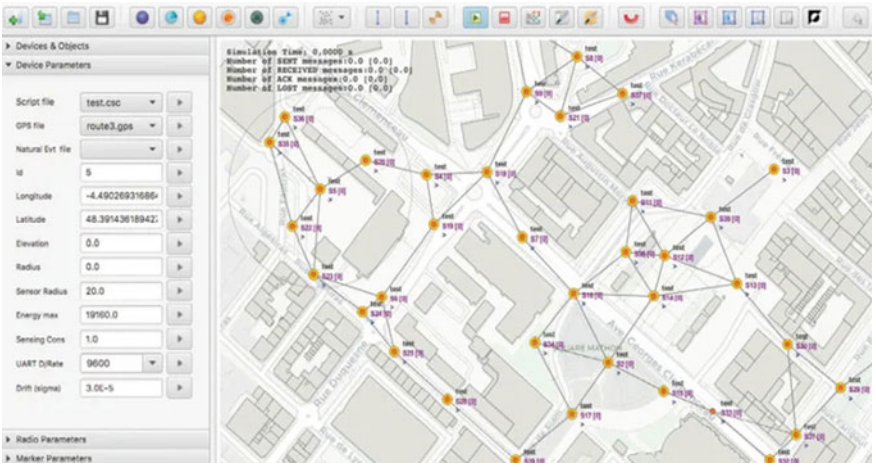


Fig. 9 Road network object representation in CupCarbon

options, the traffic, roads, towers, vehicles and even the congestion can be visualised in the simulation, for developers to get a sense of the real environment with the help of Road side unit, Protocol and data updation.

Implementing a smart Road network scenario using CupCarbon is always required to analyse the performance of the network that is to be deployed. For such scenario evaluations of a new smart road city project, key parameters like energy, power and security also need to be investigated. CupCarbon integrates the options for IoT protocol, data transmission, object movement, energy consumption and other parameters, so that researchers and engineers can view the expected effectiveness of the project. The road network connectivity with the interconnected road implementation shown in Fig. 9. The main processes of data transferring from Road side unit to CupCarbon is as follows. i. RSU device continuously collected the data. ii. The collected RSU data is transferred to main RSU. iii. Main RSU to with the help of MQTT protocol data is transferred to CupCarbon. Using this implementation in CupCarbon following decision we can make easily automatically. i. Manages the power in the street light. ii. Analysis the traffic in one particular area. iii. Emergency services we can take the decision. Beyond this applications IoT with CupCarbon easily we can perform following applications in the intelligence transportation system such, route optimization, parking, and accident prevention/detection etc.

3 Case Study: IOT Energy Management with CupCarbon

The CupCarbon is the Wireless network design simulator tool. Let us discuss the case study on smart accident management system in the traffic full road and home automa-

tion with smart home device management system. Technically speaking, CupCarbon is the best simulating tool and widely used since it has rich application interface and easy management design for any automation applications such as road accident management, home device automaton, border security system, video surveillance system and etc. The CupCarbon wireless network design tool is also user friendly tool for attaching codes for intended applications. The feature of CupCarbon like Open Street Map (OSM) helps to automate the road accident management quickly and easily and this application become IOT based Wireless Sensor Networks (WSN).

Smart Accident Response System for Indian City

In view with road accident in India, there are countless accidents have been happening now a days as population are increasing in metro capital cities like Delhi, Mumbai, Chennai, Calcutta and Bangalore. The World Health Organization (WHO) report 2018 [9] says that almost 1.35 million people have been died in road accident and in India more than 150000 people had died and it will be increased if precaution have not proposed by means of awareness about accident with general public and smart automation remedies by quick arrival of ambulance and other medical remedies at incident happened places. So adopting the smart accident response system is inevitable and also quick remedial action for now and future. The smart city's IOT based applications has been discussed in [10].

Technical Terminologies for Smart Road Accident Response System

Technically discussing, CupCarbon simulator [11] can be adopted in Indian traffic with Radio Frequency Identification (RFID) [12] and Zigbee oriented Bluetooth technology for smart personal Area Network to serve quickly and error free communication. The applications of RFID has been discussed with [13] for various smart automation applications and technical overcomes and challenges. RFID is most suitable tag can be fit in each vehicle and can be easily categories the vehicle type. Later categories of vehicle's priority will used to sort the vehicle for situation response. For example suppose an accident happened at particular place and traffic is more on the road. Then the smart system accident response system insists the on road traffic to identity and keeps the path for ambulance. This way it is highly keep way to ambulance and also it helps the ambulance to reach the hospital on time.

The Zigbee is the highly preferable technology for short distance communication among VANET Networks which could be adopted to create smart accident response system. The communication sectors like nearby traffic police, ambulance services and emergency medicine service. The Zigbee technology is working with delivering 256 Kbps data transfer and it is widely adopted for VANET. The IOT technology has been adopted in applications like smart ambulance service [14], sensitive information management system, and smart road traffic management system and so on.

VANET Architecture for Road Accident Response System

Figure 10 shows the Transport Road Architecture for VANET. The major components of VANET are Road Side Unit (RSU), Vehicle to Vehicle communication and

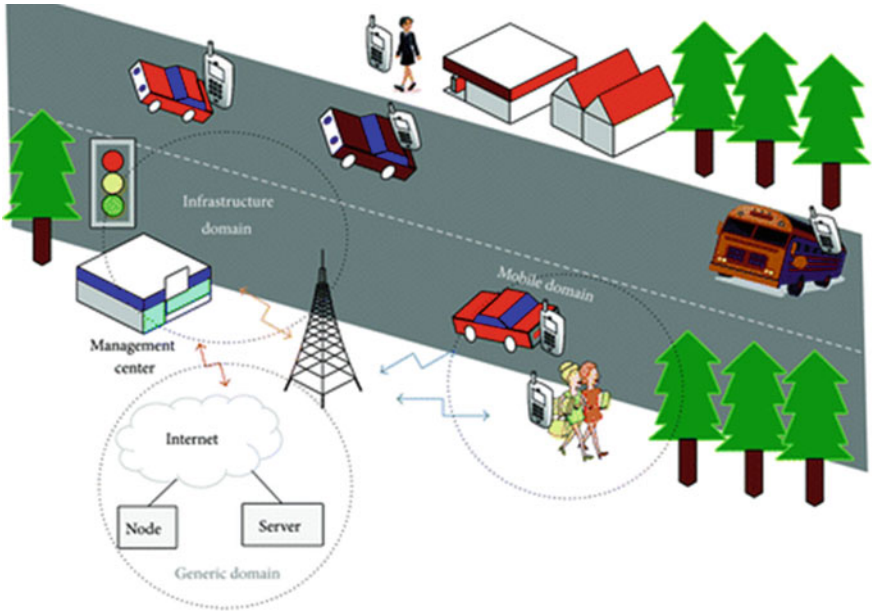


Fig. 10 VANET components

vehicle to RSU communication [15–17]. The factor influencing energy efficient communications are on board sensors, power and storage availability, dynamic topology, intermittent connectivity, mobility pattern.

On Board Sensors

In VANET on boar sensors are the major sensitive component which is able to communicate with neighbor vehicle's board sensors. It is transmitting necessary data information over wireless communication.

Power and Storage Availability

Since the nodes are dynamic with respect to other nodes. So the data transmission might be having distance issue and which leads to more power consumption. In other hand the amount of data are transmitting and receiving highly unpredictable. In that case dynamic nodes should have consistence power and storage.

Dynamic Topology

The major challenge in managing the VANET is dynamism of nodes. Vehicles are moving with respect to destination based on the other nodes (vehicles) movement. The dynamism of network is there frequently. Managing network topology is challengeable one.

Table 2 parameter specification of IOT based VANET for energy optimization

S.No.	Parameter	Specification
1	Network type	Dynamic topology
2	Communication technology	WIFI and Zigbee
3	Coverage area	1 km for each segment
4	Network communication	IoT

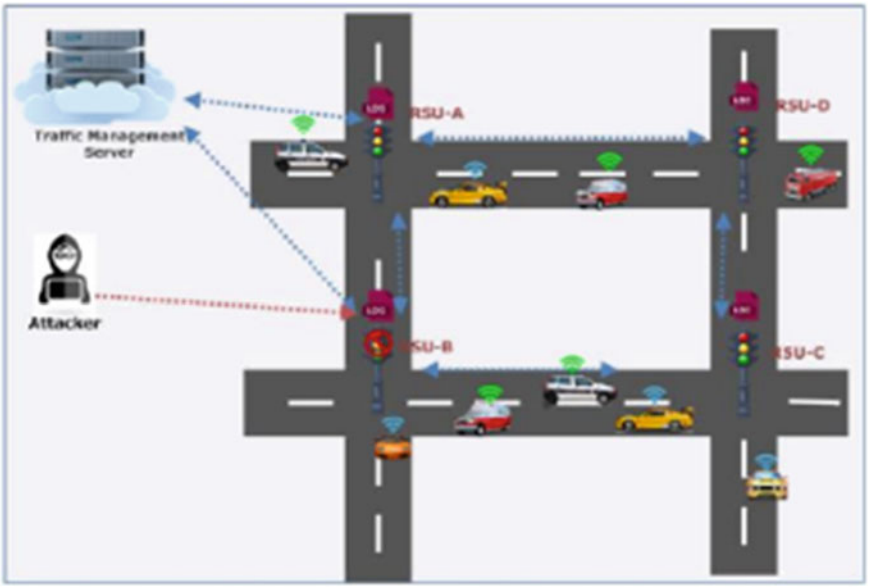


Fig. 11 VANET simulated architecture for road traffic

Intermittent Connectivity

Since the movement of nodes and its data transmission are unpredictable, and some time sudden disconnection are possible even frequently. Again disconnected data transmission must be resumed necessary then and there.

Mobility Pattern

The mobility nodes and its speed can be predictable with respect to road type, size of vehicle, road condition and so on.

Architecture of VANET Using CupCarbon

The Architecture for sample VANET network has been simulated using the CupCarbon simulator with following specification as showing in Table 2. Simulated architecture is shown in Fig. 11. Network type is chosen as dynamic topology in which the parameters intermittent connectivity and mobility pattern highly concentrated.

Smart City Initiative and Its Performance

As the smart city initiative in India, there are many cities has been developed for adopting IOT based automation like smart ambulance service, smart emergency health service and smart accident response system. There are cities like Chennai, Bangalore, Delhi, Calcutta, Raipur, Mumbai and etc. have been implementing these services by considering energy efficiency too. Recently Nagpur city has been adopting the above listed service under smart India initiative.

4 Challenges in IOT with CupCarbon

The huge number of open challenges are in IoT wit CupCarbon are list as follows.

- IoT with CupCarbon in Intelligence road network Improving traffic flow, road safety security and reducing crime response time to incidents, traveller information, public transport, Improved traffic flow, more accurate Improving the environment and information sharing from through vehicle
- IoT with CupCarbon in Intelligence in VANET accident prediction, future data prediction, Vehicle collusion prediction etc.,
- IoT with CupCarbon smart cities energy management, parking management and future data prediction in parking management, service management, information sharing from customer to customer through vehicle.
- Improve the dynamic 2D/ 3D visualizations in the realistic environments, simulation performance, services of multi environments etc.
- Improve the analysis of different environments such as communications, mobile communications, reliability of various applications development and cost estimations and energy optimizations.

5 Conclusion

Main purpose of green computing is reducing the environmental impact such as hazardous materials, energy efficiency during the lifetime of product and recyclability of product wastage. In smart cities data storing, processing and using take more usage of resources are wasted. In Energy management and effectively usage is big challenging issues in recent days in the world. The Green computing with energy efficiency in a smart cities research help to improve the energy effectively. IoT is the emerging technologies to sensing, gathering and networking information's. The main achievement is automation, analysis and integrations of systems. The main features of IoT are smart, connectivity and active engagement etc. IoT is a bridge which connects various applications to various communication devices.

In IoT, there are two types of communication: human-to-machine (H2M), and machine-to-machine (M2M) in the H2H communications huge number of tools are

used to data from one machine to another machine. The CupCarbon is IoT and smart cities wireless sensor networking mobility simulator. The main objective of this simulator is design, debug, visualize, monitor and validate the distributed environment data. Using this IoT and CupCarban more applications are interlinked and optimization also reduced. For example road network objects are linked with the help of IoT and CupCarbon so huge number of energy and other optimizations are reduced.

References

1. Bounceur A, Clavier L, Combeau P (2016) CupCarbon: a new platform for designing and simulating smart city and IoT wireless sensor networks (SCI-WSN). In: Proceedings of the international conference on internet of things and cloud computing
2. Bandyopadhyay D, Sen J (2011) Internet of things: applications and challenges in technology and standardization. Wirel Pers Commun 58(1):49–69
3. Akkurt M, Kucuk K (2018) Simulation of smart city applications based on IoT technologies with CupCarbon. In: 3rd international conference on computer science and engineering (UBMK), UK
4. Jia X, Feng Q, Fan T, Lei Q (2012) RFID technology and its applications in internet of things (IoT). In: 2nd international conference on consumer electronics, communications and networks (CECNet), pp 1282–1285
5. Ullah A (2018) IoT: applications of RFID and issues. Int J Internet Things Web Serv 3:1–5
6. Tomar R, Prateek M, Sastry GH (2016) Vehicular adhoc network (VANET) - an introduction. Int J Control Theory Appl 9(18):8883–8888
7. Liang W, Li Z, Zhang H, Wang S, Bie R, Vehicular ad hoc networks: architectures, research issues, methodologies, challenges, and trends. Int J Distrib Sens Netw 1–11
8. Kukade A, Sharma T (2015) A glance over the working methodology of VANET. Int J Adv Res Comput Commun Eng 4(12):322–326
9. Udawant O, Thombare N, Chauhan D, Hadke A, Waghole D (2017) Smart ambulance system using IoT. In: International conference on big data, IoT and data science (BID), pp 171–176
10. Bounceur A et al (2018) CupCarbon: a new platform for the design, simulation and 2D/3D visualization of radio propagation and interferences in IoT networks. In: Consumer communications and networking conference
11. Smaldone S, Han L, Shankar P, Iftode L (2008) RoadSpeak: enabling voice chat on roadways using vehicular social networks. In: Proceedings of the 1st workshop on social network systems, pp 43–48
12. Sumi L, Ranga V (2016) Sensor enabled internet of things for smart cities. In: 4th international conference on in parallel, distributed and grid computing, pp 295–300
13. Lopez-Pavon C, Sendra S, Valenzuela-Valdes JF (2018) Evaluation of CupCarbon network simulator for wireless sensor networks. Netw Protoc Algorithms 10(2)
14. Dameri R, Rosenthal Sabroux C (2014) Smart city: how to create public and economic value with high technology in urban space. Springer International Publishing, New York
15. World Health Organization (2018) Global status report on road safety. https://www.who.int/violence_injury_prevention/road_safety_status/2018/en/. Accessed 11 June 2018
16. CupCarbon User Guide (2018). http://www.cupcarbon.com/cupcarbon_ug.html. Accessed Oct 2019
17. CupCarbon network simulator. http://www.cupcarbon.com/. Accessed 11 June 2018