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Trends in Green Computing Paradigms towards Environment, Eco Friendly Technology and Future Sustainable Kenya

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Abstract – Computing has led to an increase in energy consumption, global warming and e-waste. The environmental impact of computing is alarming, hence the dire need for green initiatives by governments and organizations towards sustainable future. There are various approaches and assumptions of green IT solutions and energy efficient practices in computing. In the paper carries out a systematic study on several strategies and developments in context to the ICT sustainability as a future asset of growth for modern Kenya with special emphasize on the technologies and practices (economic, social, environmental) for creating eco-friendly technology. The paper also highlights trends in green computing paradigms that are used in Kenya for sustainability of the environment. This is achieved by identifying the state of the art technologies and establishing its impact on environmental sustainability using desktop review shall be used on a global perspective.

I. INTRODUCTION

Green computing is the use of ICT equipment responsibly [1]. According to [2], Green Computing refers to the art of utilizing computing resources in an efficient and eco-friendly, sustainable manner. The term Green Computing emanated from the Energy Star Programme initiated by the U.S. Environmental Protection Agency, in the year 1992 with similar efforts experienced in Europe and Asia later on. This was an initiative tailored to design ICT equipment and electronic devices with less energy consumption [1]. According to [3], Green computing terminology was comprehensively used to cover ICT, data communication, and telecommunication equipment as well as the connectivity devices. The phenomena include the implementation of technology fit for operational excellence in terms of efficiency and effectiveness of energy systems and adequate mechanism for disposal of electronic waste. As a result, the key tenets of Green computing revolves around economic viability, social responsibility, and environmental impact. The industrial sector contributes directly to pollution, with IT industries adversely affecting environmental pollution caused by consumption of power and inefficient use of hardware devices. The world has experienced numerous technological advancements over the last two decades hence, the dire need for government, commercial organizations and even individuals in society to explore the reasons and ultimate solution to the effect on the environment [3]. According to the Green Report Tool [4], there are two of the most popular metrics that can measure the green effect of an existing data center. These are Power Usage Effectiveness (PUE) and Data Center Efficiency (DCE). It breaks down resources consumption by type such as servers, network, storage equipment, or other and are in-verse to each other as stipulated in the Green Report Tool of 2009.The computer network is a connection of nodes that form the Internet when intergrated. The nodes are connected together by the various technologies. According to [18], there are three key phases of the evolution of information and communication technology considered necessary for greening effect. Computers in the 1990s were used by end users mainly for purposes of connecting to technology to access information. Later on the new technologies were used by end user for

connecting through technology to bring together end users. Today users can now connect within the technology in merely virtual world. This practice allows for a more advanced collabo-ration of users and creation of tailor-made content [5] where users can exist virtually. The study carried out on the Kenyan case [6] established that the level of green ICT readiness is lower in developing economies Kenya included. It also established that there was a significant relationship between ICT personnel variables and green ICT preparedness dimensions. This study is anchored on all these dimensions.

II. METHODOLOGY

This is accomplished by content analysis design that involve collecting data from existing sources. These include academic articles, journals, papers, books and publications. This is because it is a low cost technique and time friendly as compared to field research whose main cost involved is enormous. It is very effective, cheap, and quick and most of the basic information is fetched and used as benchmark in the research process.

III. NEED FOR GREEN COMPUTING

A survey on several companies shows a report on 'How dirty is our data', about the energy demands of the data centers, and the sources from which energy comes from (Table 1). The Data centers to house the explosion of virtual information currently consume 1.5-2% of all glob-al electricity, this is growing at a rate of 12% a year [7]. Where: 1-Clean energy index, 2-Coal, 3-Transparency, 4-Infrastructure siting, and 5-Mitigation strategy.

Table 1: Energy demands on data Centre's from different companies (Adapted from [6]).

COMPANY	1 In %	2 In %	3	4	5
Amazon	26.8	26.8	F	D	D
Apple	6.7	64.5	C	F	C
Facebook	13.8	63.2	D	F	D
Google	36.4	34.7	F	C	B
HP	9.9	49.4	C	D	C
IBM	10.9	51.6	C	C	B
Microsoft	26	34.1	C	C	C
Twitter	21	42.6	F	F	F
Yahoo	66.9	18.3	D	B	C

This is a clear indication of the dire need for greener practice towards a sustainability future.

IV. STATE OF ART IN GREEN COMPUTING

Green computing is considered from the Life Cycle perspective, or Organizational perspective. Manufacturing computers and their components consumes electricity, raw material chemicals, and water, that generates hazardous waste. From the life cycle perspective of IT components, the highlighted processes can reduce this harm [8] and [9]:

i. Green design: designing energy-efficient and environmentally sound components, computers, servers, cooling equipment, and datacenters;

ii.Green manufacturing: manufacturing electronic components, computers, and other associated subsystems with minimal impact on the environment;

iii.Green use: reducing the energy consumption of computers and other information systems as well as using them in an environmentally sound manner;

iv. Green disposal: refurbishing and reusing old computers and properly recycling unwanted computers and other electronic equipment The so called life cycle perspective is a process from the beginning of the life cycle of an IT component, to the end.

V. STATE OF ART IN GREEN COMPUTING

A. CLOUD COMPUTING

Cloud computing is a technology that intergrates the computing services into the data centers and eliminate it from the desktop point of view. All the computing services and software applications are offered as services on the Internet platform and cloud infrastructure [10]. The computing services and resources are hosted by internet service providers (ISPs) and the end users can access to these services via web browser [11]. It is a computing approach where services are offered to external clients using the Internet platforms. As a result, there has been a dire need to establish the effects of the cloud platform in the provision of services to end users away from the premises equipment especially the computational power, storage capability, business applications etc. Most of the vendors utilizing Cloud computing today concentrate on the cloud strategy and variations.The practice of cloud computing approach has a correlation with sustainable

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improvement. This can have economic, social and environmental benefits. The environmental practice towards cloud computing comprise of less power consumption, reduced cooling energy space and requirements [3]. The flexible nature and cost reduction in operations are the most echoed benefits accrued from the decision to implement the cloud computing strategy. According to [3], there some features of the cloud in form of an identification model towards the provision of green benefits. The model elaborates a couple of environmental factors for migrating the computing services and resources to the cloud [3] [13]. These include:

i.Virtualization and dynamic datacenters: Datacenters are dynamically maintained in line with the available demand. In addition, virtualization server technology enhances connectivity to different computing resources together for customers in a selective manner.

ii.Optimal server utilization: in most cases server equipment stays idle of 85-95%. During this time power is consumed at the same rate as the active mode. This is also enhanced by virtualization by hosting several applications on one server equipment. As result, the energy consumed is drastically reduced and the number of active equipment decreased.

iii.Thin-client technology: it is one of the energy-efficient client device technology. The technology makes it possible to reduce the amount of power consumed by the client devices. This is achieved by allowing several client terminals to share one processing server in the cloud model. Cloud computing application areas include webmail, smart shopping, e-commerce, among others.

B. GREEN CLOUD COMPUTING ARCHITECTURE

The substantial efforts to make Cloud computing energy efficient, lack a unified picture though various components of the Cloud are efficient in terms of power and performance [14]. The Cloud computing sustainability enhancement has omitted the network contribution. If the data units for transmission are quite large in a heterogeneous network, the it contributes immensely to energy consumption. As a result, it is considered greener to run applications locally than on the Cloud infrastructure [26] [14]. consequently, a lot of work done concentrated on particular component of Cloud leaving out the effect of other components, hence it may not contribute to energy efficiency [15]. The green computing awareness initiative is the Green cloud architecture that incorporates efficient energy [3]. The essence of the cloud strategy, is to avail a high-level architecture with efficient power service provision for end users and service providers. In this strategy, the service providers will experience less power consumption. The end user computing services can be pro-vided as well as saving energy consumed by the service provider. According to the Green cloud computing infra-structure [14], it demonstrates the architecture for an energy efficient service allocation in green cloud. The plat-form provided by the Green-Broker allows access to computing services sub-scribed in the public directory [3]. The Green-Offer directory on the other hand enables the cloud service providers to list their services at subsidized rates together with green hours. It is responsibility of the cloud-broker to lease out cloud services to requested users and schedule applications. It also selects the offer with regard to the end user requirements. The parameters considered for the offer include the time, price, quality and Carbon emission [3]. The purpose is to guarantee quality and minimize Carbon emission which is a key factor affecting the environment.

C.DATACENTERSUSTAINABILITY IMPROVEMENTS

For datacenter efficiency to be realized several core actions ought to be considered. The cloud green computing best practices immensely contribute to the operation of a green datacenter [3]. The environmental stability and sustainability of datacenters, depends on several practices and recommendations in key areas [16]:

i.Renewable energy: it includes sources such as solar energy, fuel cells, and wind power.

ii.Cooling technology: better cooling mechanisms have been designed to curb the demerits of the traditional ones. These includesnano-fluid technology, liquid cooling, and rack technology cooling in server systems.

iii.Building design: the optimization designs for buildings and choice of rooms housing the ICT equipment. The floor design and layout determines the air flow and circulation important to control dissipated heat during processing.

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iv.Latest power systems: utilization of ICT equipment for efficiency

D. VIRTUALIZATION AND COOLING TECHNIQUE

Virtualization and cooling technology is one of the solutions for greening the datacenters. The cooling mechanism is considered important in minimizing energy consumption [3]. Some companies use open air, water, air-conditioned systems for cooling datacenters. This is an expensive venture, unsustainable and it does not minimize the energy consumed efficiently. Secondly, virtualization approach enables several virtual machines to be executed on one physical machine. The virtual environment hides the internal working from the end user. The user is only able to access the public cloud services with-out prior knowledge of abstraction on the virtual environment. The overall energy-efficiency is realized since the power consumed on a single physical machine is drastically reduced [3]. Thirdly, encourage the concept of distributing small sized data centers across a geographical divide. This breaks the traditional notion that data centers ought to be large sized with few data requirements.

E.TELECOMMUNICATIONSRELATEDTECHNOLOES

There are several utilities that act as collaborative green spaces such as teleconferencing, video conferencing, virtual classrooms, virtual worlds, greening of professional conferences, etc. They provide availability, reliability, manageability between the communicating entities regardless of the geographical location [3]. Consequently, the related technologies reduce gas emissions, workplace space constraints, lighting cost, and heat considerations [17].

i.Teleconferencing: This technology has been of great importance towards green computing initiative. The integration of data, voice, and video in data communications and computer networking have facilitated remote working and expansion of a global market place [3].

ii.Video Conferencing: The new trends in Green computing also encompasses video conferencing. This has been possible with the skyrocketed rate of integration, portability, and miniaturization of devices. Smaller devices, such as smartphones, palmtops, and digital tablets can now be installed application software for video conferencing. These miniaturized devices exhibit less power consumptions. The video conferencing facility

iii.facilitate experimental learning, remote training, project management, e-science, meetings among others [18].

iv.Virtual Reality/Worlds: According to [28], virtual reality are systems that executes functionalities just as the physical world. The virtual experience intergrates Human Computer Interaction features such as icons and avatars. This is accomplished by replacing reality with virtual objects with the user comprehensively perceiving the environment [19]. The perception of users enhances the interaction with the real world. It helps the user to model data and visualize interaction scenarios. A virtual world is perceived as a consistent connection of objects or users made it possible by connectivity of electronic devices or nodes [20]. It is a common phenomenon in today's world with most of the population taking part in execution of functionalities for different virtual realities. For instance, the 3D virtual worlds have been commonly used in entertainment, medicine, training and professional development [21]. The communication platforms are enhanced by the use of graphical representations such as icons and avatars. The users are able to interact with data, video, and voice capabilities making it possible for instant communication. This technology saves the organization resources such as time and the associated cost of implementation. The approach has a positive impact to the environment since there is less pollution from fossil fuels due to travels.

v.Greening of Professional Conferences: the trending parameters of green computing has highly supplemented the virtual aspects in conferences [17]. Modern organizations are distributed in the whole world and as a result, most of these organizations have adopted the virtual component. This is mainly to address the concerns of members who may not travel because of logistical provisions. These may include time and financial constraints for attending conference proceedings, saving travel, hotel and meal expenses.

F. SOLAR COMPUTING

Today, clean energy has been advocated for around the globe. Solar energy is clean, natural, cost effective, efficient and

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sustainable. The technology benchmark recognizes Taiwanese manufacturer VIA Technologies Inc., for solar technology in collaboration with Motech Industries. Ac-cording to [22], it identifies the following advantages:

i.Solar energy is a non-polluting and clean energy.

ii.Solar panels are noise free in operation, hence it is best suited in environments regarded as noise free such as, classrooms, hospitals, and shops.

iii.It incurs less costs apart from the capital cost and implementation costs hence considered free form of energy.

iv.The panels are reliable and maintenance free.

VI. TRENDS

The green computing technology trends entails the de-sign of ICT equipment, technology, and best computing practices. This is not n individual obligation but for all the plyers in the life cycle process. A sustainable (Green) environment is where mechanical systems, lighting, electrical, information and communications technology systems are designed for maximum resource efficiency and minimum environmental impact. Construction and operation of a sustainable environment includes advanced technologies and strategies, such as;

i.Optimized building footprint and data center automation

ii.Integrated cooling, power management and building control systems

iii.Waste material recycling

iv.Alternative energy technology (photovoltaic, heat pump, wind power, evaporative cooling)

v.Onsite large scale energy storage

In the past decade, several instances have been experienced where companies have cut energy costs and operational expenses by adopting green technologies. Although majority of companies claim that they are going green due to environmental concerns, cost saving is the primary objective of adopting green IT. Green technologies offer three main advantages. Firstly, reduced energy consumption that impact positively in terms of cost and the environmental. Secondly, the dissipation of less heat com-pared to typical hardware results in minimal cooling requirements. Thirdly, virtualization aids in significantly reducing the ICT equipment used in execution of operations, hence saving considerable space.The future of green computing is towards new electronic products and services with optimum efficiency and all possible options towards energy savings. The trend from the literature shows most companies are laying emphasis on moving towards eco-friendly components in computing. The use of eco-friendly sustainable components I foreseen to be the norm rather than the exception in the near future.

VII. SUGGESTIONS FOR GREEN COMPUTING IN KENYA

ICT sustainability as a future asset of growth for modern Kenya with special emphasize on the technologies and practices for creating eco-friendly technology is a collective responsibility for all the stakeholders. Overcoming these problems, several strategies are key for implementation an enforced at the policy and framework [23] level by the government, business community and all organizations as well as end users. These include:

i.The power consumptions of ICT equipment for organizations ought to be monitored. There is a correlation between the number and age of ICT equipment against power consumption and re-ten retention of energy with emphasis on individual, organizational, and datacenter ICT equipment. In this regard, hardware vendors ought to consider embedding hardware capable to run software utilities specifically designed to monitor energy levels. Once this effort is achieved, the government through Kenya Bureau of Standards can enforce it by only accepting ICT equipment that meet the minimum specification.

ii.The level of awareness on energy savings should be raised by educating all the stakeholders. Operating systems developers should also incorporate self-configuring settings for both novice and expert users.

iii.The government can use regulatory agencies that improve environmental quality. The design recyclable ICT equipment with minimal impact on environment.

iv.Green disposal annex regulating the policy on manufacturers with regard to full responsibility on the products manufactured from procurement, reuse to disposal of electronic devices.

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CONCLUSION

It is evident that most of the trends in emerging technologies today green computing included revolve around cost savings without putting into consideration environmental sustainability. The primary concern for all the stake-holders should be power management. Most of the administrators are not comfortable monitoring power usage because the main concern is performance. The administrators are more concerned with zero downtime, performance uptime, and not the power usage. This practice needs to change and power usage be measured and monitored in any implementation. This paper provides the key technologies and industry trends that are shaping the move toward green and energy efficient approaches to-wards an economic friendly and sustainability future. This research has the broader impact of achieving sustainable systems for a greener planet. The implementation of technology must be viewed within the context of the economy and environment to achieve sustainability.

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