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Application of Green Computing at Nigerian Tertiary Institutions

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Abstract: *Green computing (also called green technology) is the use of computers and other computing devices/equipment in energy-efficient and eco-friendly ways to conserve energy and reduce climatic change to its barest minimum. The frequent use of various computing devices such as desktop computers, mainframe computers, data centres, and other electronic gadgets at tertiary institutions by a very large number of both staff and students result in energy being dissipated at regular intervals which may lead to climatic change and global warming that are hazardous to human health. Warmer temperatures over time can change weather patterns and disrupt the usual balance of nature thereby posing many health risks to human beings and all other forms of life on earth. In this work, object-oriented analysis and design technology (OOADM) and unified modelling language (UML) tools were employed to develop a template for the application of green computing at Nigerian tertiary institutions. The two UML tools used: use-case and activity diagrams, show the various actors involved in the usage of green computing at tertiary institutions and the sequential steps required by each of the actors in using the green computing in his/her domain, respectively. The template well adopted by all the tertiary institutions and other establishments in Nigeria will help to conserve energy and reduce climatic change drastically, thereby creating a healthy environment.*

Keywords: *Green computing, climatic change, computing devices, Nigerian tertiary institutions, object-oriented analysis and design technology*

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1.0 Introduction

The rising energy consumption, global warming, and e-waste have necessitated the consideration of green computing by government agencies and private companies as a positive contribution toward sustainable development. According to *Albert (2021),* green computing is the environmentally responsible and eco-friendly use of computers and their resources. It also defined green computing as the practice of environmentally responsible and effective use of computing resources while maintaining economic viability and enlightening its performance in an eco-friendly way *(Falade, et al., 2019).* Similarly, *Shalabh et al., (2013)* view green computing as an emerging practice that aims to reduce the carbon footprint generated by information technology, systems business, and related industries. In the same vein, *Piotr (2015)* also noted that green computing refers to the efficient use of resources in computing/ IT infrastructures and reducing hazardous environmental wastes caused by computer resources nearing their life span. Hence, green computing can be seen as a sustainable approach to designing, manufacturing, disposing and using computer resources such as monitors and system units.

Computers are made of poisonous materials such as Lead, Chromium, Cadmium and Mercury *(Shameema et al.,2017).* When computers are buried in landfill, they can seep harmful chemicals into waterways and the environment; and if burnt, would lead to the release of toxic contaminants into the air we breathe. Computers consume energy, and very few literatures has been written on the practical solutions to the environmental disasters of millions of obsolete computers hitting landfill sites around the world. Computers can also be harmful to our health because toxic chemicals that ooze out from them are absorbed by our human body through the lungs. Emissions from computer monitors pose a serious health risk, especially to those with long hours of exposure. On yearly basis, 20 – 50 million tonnes of electronic waste are generated *(Mei-chun et al., 2022*). These e-wastes end up in landfills in China, India, Pakistan, Ghana, and Nigeria. These wastes constitute a great negative impact on the environment due to the dangerous chemicals such as beryllium, cadmium, lead, and mercury that make up some of the electronic components of the computer. These toxic elements emit harmful elements called toxins into the atmosphere which in turn leads to environmental degradation.

In developing nations like Nigeria, electronic waste is increasing by the day. It has been significantly attributed to the devastating effect of air pollution, underground water contamination and human health problems in the country. Electronic waste contains gold, silver and copper, people in developing countries attempt to extract these materials by burning the substance which releases hazardous smoke into the air and creates poor air quality with so much pollution. Toxins from the air and computing devices reach the groundwater or drinking water which poses a huge health risk.

In developing countries, children and adults acquire diseases due to the existence of electronic waste which causes skin cancer, lung cancer, brain damage, kidney disease and abortion. Computers also cause unnecessary waste of paper by printing files and emails, most office waste is made out of paper. People who use computers don't normally turn them off which wastes a large amount of electricity that could have been potentially saved and reduced the amount of electricity produced by burning fossil fuels.

A preliminary study by *Shafinah et al., (2021)* on the cognizance of green computing concepts and practices among secondary school students, explored green computing practices awareness among the younger generation. Consequently, 94 secondary school students were gathered using a sampling technique across Selangor state. The tool used for data

collection was the questionnaire method. The data items contained in it comprised 20 items. The components of the data were about dangers involved in the use of computers and their related devices in the environment. The findings revealed that secondary school students are still unaware of the green computing concept. It was discovered that 54.35% of students may not realize that computers and communication devices could be disposed of eco-friendly manner. In addition, 61.96% of students do not realize that computer hardware can be recycled, and 75% do not have experience disposing of their computers. Surprisingly, they mostly do not practice green computing regarding reducing energy consumption. It, therefore, is proposed that students must be educated on utilizing ICT resources and practicing green computing mechanisms to boost environmental sustainability. This study differs from the present study because this study was a preliminary study that was aimed at finding out the cognizance of green computing concepts and practices among secondary school students, while the present study examined the objectives, contents, as well as evaluation procedures that may be suitable in developing green computing program for higher institutions. Both studies aimed at improving skill acquisition in the field of computing through the use of green computing.

A study to investigate the knowledge of green computing possessed by university students in Nigeria was conducted by (Shittu et al., 2016). To achieve this, a survey method was employed to carry out the study. The study involved students from three departments which include Computer Science, Engineering, and Education. The purposive sampling method was used to pull three hundred (300) respondents that volunteered to answer the questionnaire administered to gather the data for the study. Out of the three hundred questionnaires distributed, two hundred and seventy-six (276) were used for data analysis. In all, one hundred and sixty-seven (167) respondents were male, while one hundred and nine (109) were female. The instrument used for gathering data was adapted and modified before it was used. Pilot testing was adopted to determine its validity/legitimacy, and internal consistency. The originality/reliability of the instrument showed a .75 Cronbach's alpha level. The three research questions of the study were answered with descriptive statistics (percentage), a t-test and an Analysis of Variance. The study showed that the students do not possess adequate knowledge of the conscious use of computing systems. Also, the study showed no significant difference in the green computing knowledge possessed among males and females and students from engineering, education and computer science. From these findings above, the study suggested among others an aggressive campaign on green computing practices among university communities. The aim of this was to investigate the knowledge of green computing possessed by university students in Nigeria, while the present study is meant to focus on the development of green computing practices program for integration into the computer science curriculum in universities in South East, Nigeria. This study is related to the present study, in that both aim to ensure that green computing practices program is effectively adopted in Nigerian universities.

The object-oriented analysis and design technology (OOADM) as well as the unified modeling language (UML) tools were employed in developing the template for the application of green computing at Nigerian tertiary institutions. The two UML tools used in this study are:

- Use-case diagram, and
- Activity diagram

The "use-case diagram" shows the various actors involved in the usage of green computing at tertiary institutions. On the other hand, the "activity diagram" shows the

sequential steps required by each of the actors in using green computing in his/her domain.

1.1 Statement of the problem

If green computing is not adopted in society, it can lead to numerous problems such as:

(i) E-waste is a result of the indiscriminate dumping of discarded computing devices.
(ii) Climatic change and global warming can pose many health risks to human beings and all other forms of life on earth
(iii) Rampant wastage of energy that should have been well conserved for other uses

1.2 Aim and objectives of the study

This study aims to develop a template for applying green computing at Nigerian tertiary institutions to conserve energy and reduce climatic change drastically.

The specific objectives for achieving the aim are to:

(i) Design a use-case diagram using UML tools for showing the various actors involved in the usage of green computing at tertiary institutions
(ii) Draw the activity diagram that can be used by a particular actor (say lecturer) in green computing

2.0 Materials and Method

The object-oriented analysis and design technology (OOADM) and unified modelling language (UML) tools were employed in developing the template for the application of green computing at Nigerian tertiary institutions. The two UML tools used in this study are:

(i) Use-case diagram, and
(ii) Activity diagram

The "use-case diagram" shows the various actors involved in the usage of green computing at tertiary institutions. On the other hand, the "activity diagram" shows the sequential steps required by each of the actors in using green computing in his/her domain.

2.1 The Use-Case Diagram for the Proposed System

Figure 1 shows the use-case diagram for the application of green computing at Nigerian tertiary institutions. The various actors involved are: -

(i) Lecturers
(ii) Students
(iii) ICT staff
(iv) Lab attendants

The various services (or use cases) provided by the system for each of the actors are shown in the figure.

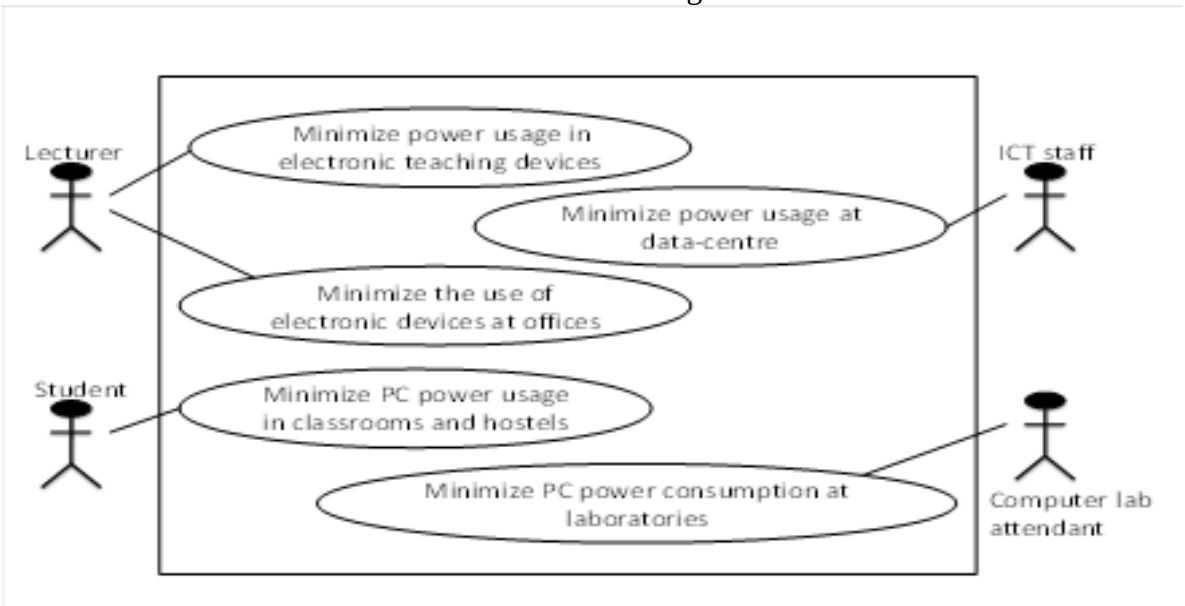

Fig. 1. The use-case diagram for the application of Green Computing

2.2 The Activity diagram for using green computing by a lecturer

Fig. 2 shows the activity diagram for a lecturer to harness green computing by "*Minimizing power usage in his/her electronic teaching devices*".

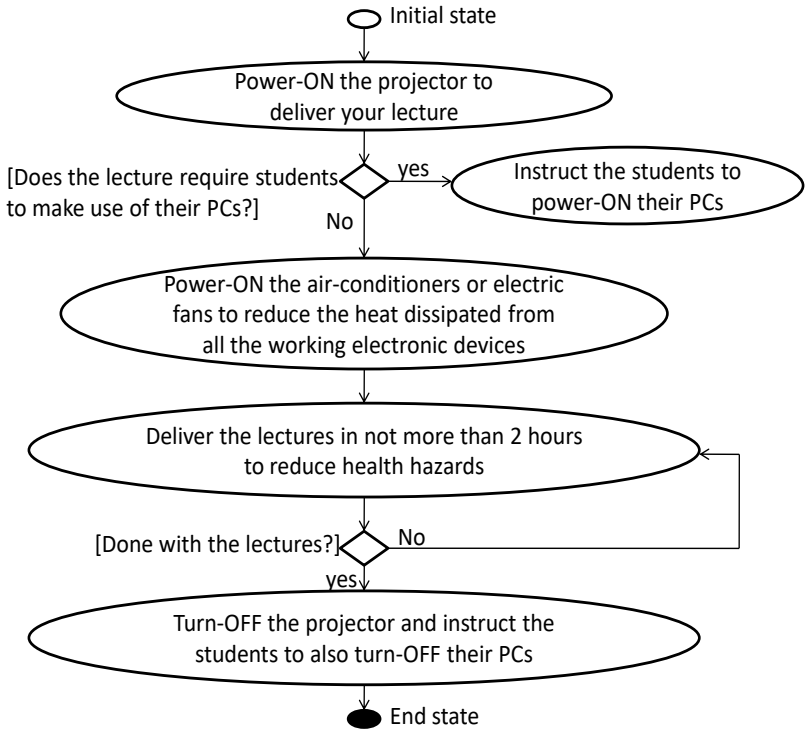

Fig. 2. Activity diagram for the use-case called Minimize power usage in electronic teaching devices.

3.0 Results and Discussion

When a lecturer teaches with a projector, the wattage of a projector lies in the range 150-800 watts per hour. This implies that the heat generated by it increases with time. For instance, in 2 hours the total wattage consumed by a projector lies in the range (150x2 – 800x2) = (300 – 1,600 watts). Similarly, the wattage of a laptop computer lies in the range 50-120 watts per hour. Thus, if each student in a class size of about 100 students uses a laptop for 2 hours of lecture, the total wattage consumed lies in the range (50x100 – 120x100) = (5,000 –12,000 watts). The addition of the minimum wattage for a projector to the minimum wattage of all the laptops in use, we have 300 + 5,000 = 5,300 watts. The maximum wattage for both the projector and the laptops sum up to 13,600 watts. We can see that the quantity of heat dissipated for just 2 hours of lecture is indeed high.

This implies that if proper ventilation is not provided in the class, the room temperature will be high which is very hazardous to human health. Again, if the students do not turn of their PCs, the idle wattage usage for a single PC is about 50 watts. And this implies that the total wattage consumed by 100 idle PCs in 2 hours = 5,000 watts. It is therefore very imperative for students to always turn off their laptops when not in use in order not to make the room temperature of the classroom dangerous to human health. A similar rule of thumb applies to the other key

actors of green computing at tertiary institutions, as earlier shown in Fig 1.

4.0 Conclusion

The present study led to the following conclusions:

i. Green computing (also called green technology) involves the use of computers and other computing devices/equipment in an energy-efficient way to conserve energy and reduce climatic change to its bearest minimum.

ii. The frequent use of various computing devices such as desktop computers, mainframes, data centres, and other electronic gadgets at tertiary institutions by a very large number of both staff and students result in energy being dissipated at regular intervals which may lead to climatic change and global warming that are hazardous to human health.

iii. The application of green computing practices in our tertiary institutions would lead to a more eco-friendly environment.

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Consent for publication

Not Applicable

Availability of data and materials

The publisher has the right to make the data public.

Competing interest

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Authors Contributions

Nnaemeka Emeka Ogbene, Hyacinth Chibueze Inyiama, Frank Ekene Ozioko, Nnamdi Johnson Ezeora, Agbo Chibuike George and Asogwa Tochukwu Chijindu contrinuted equally **to the work.**