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TOWARDS SUSTAINABLE INFORMATION SYSTEM THROUGH GREEN DESIGN

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ABSTRACT. Nowadays, many disciplines and technologies are focusing on the aspect of sustainability in the development of hardware and application. There are challenges to find useful sustainability components for the information system design in order to develop green Information System (IS). This paper proposed components of green system design for achieving IS sustainability. The components involved are people, hardware, data center and network in system design process, which are beneficial to the stakeholders that contribute to economic, social and environments aspects sustainability for future development.

Keywords: green design, information system design, sustainability

INTRODUCTION

Nowadays, most agencies have been widely using information technology (IT) to support their business process. However, they do not take into account serious responsible to protect the environment. Numerous studies have emphasized the environmental sustainability that are concerned with the main components in the agencies such as hardware and software, and many organizations wish for achieving sustainability in environment aspect (Bokolo and Noraini, 2016; Rusli et al, 2016). Green computing means the efficiency use of resources in computing and IT infrastructure which focusing on minimizing the hazardous environmental impact along with achieving economic viability and improved system performance. For example, covers alternative energy-generation, electricity consumption techniques and use of eco-friendly, recyclable materials to implementing sustainable digital services. These technologies include the green infrastructure such as energy-efficient buildings, intelligent cooling systems and renewable power resources, the multicore computing systems, energy efficient server design and solid-state storage, and green software and applications. Green computing involve initiatives, strategies and programs that directly or indirectly contribute in reducing greenhouse gas emissions, achieve sustainability and reducing the effects of global climate change. Therefore, in green computing adoption of system development consisting of analysis, design, implementation, testing and maintenance of phases which offers direct and indirect positive effects to the economy, society and environment from its development life cycle and usage which are reducing on software measures, natural resources and energy. The aim of this paper is to identify the gap and limitation in the system design process and provide components and their attributes to the IS perspective and to classify in order to define the sustain-

ability purpose in system design process for IS. We organize the content of this paper as follows: in Section 2, we discuss on the information system design activities and sustainability; in Section 3, we show the proposed components involved in the system design showing the components, its attributes and measurement description for green design. Finally, we state our conclusions and discuss about future work.

RELATED RESEARCH

The software industry is contributes high volume on the usage of computers, servers, cooling, fixed and mobile telephony, local area network (LAN), office telecommunications and printers. However, based on a report of the International Data Corporation (IDC) in 2014, there are approximately 18.5 million software developers worldwide, which do not consider software energy efficiency at all or merely consider it. In order to achieve green software it is required for identifying the energy consumption metrics related to the software perspective. These metrics is then classified in order to define the utilization purpose, the kind of measurement results, and the environment in which they are used. P. Bozzeli et al. (2013) has come out with the metrics that focused on how to measures on the related resources and which metrics are more appealing with respect to their environment. Gürbüz et al. (2016) have proposed four categories of metrics which are performance, energy, performance-energy and utilization. Chaudhary et al. (2011) proposed a step in building a green database included analyzing energy saving options for data centers. It is important to know how data management and possible solution to the problem of data center. Unhelkar (2011) considered the people as a resource of green organization known as green collar workers are associated directly or indirectly with the organizations to become a green organization. In order to identify the suitable levels of competencies of workers within the IT industry the skill framework for information age (SFIA) is used to suggest how those levels and competencies can be applied in practice. This framework consists of seven levels that component would be measure the performance of the people where it will be the skill set of the people in the organization. Drouant et al. (2014) proposed a framework for designing environment-friendly network architectures which take consideration of efficiently and optimize on resources and practices. In order to promote energy-saving innovations, a voluntary program that designed by the Environmental Protection Agency (EPA) provides consumers with objective information about the products. Sara and Imtiaz, (2013) proposed software model for sustainable software engineering which organizes into four parts such as life cycle of the product, evaluation criteria, procedure, and recommended tools for developers. The green software model is consider on how a software product effects and aid in keeping the environment and how software can monitor and utilize resources efficiently. The sustainability involves three value added to economic, social and environmental profit and consider on protection of biodiversity of ecosystem, species and genetic diversity (Serna et. al, 2007).

Information System Design

System development involves many activities in order to plan, manage and control development of an IS where includes specific deliverables and artifacts. IS includes main functions such as a collect, process, store and distribute information that involved a set of interrelated components in order to support decision making in an organization. It consists of information about people, places and things within organization or in the environment surrounding it (Valacich, and Schneider, 2010). Table 1 shows the components that consist of developing an IS such as people, hardware, software, data and telecommunication.

Table 1. Information System Component

Types	Description
People	Build and use to collect, create and distribute useful data
Hardware	Physical computer equipment such as monitor, central processing unit (CPU), keyboard
Software	Program or set of programs that tell the computer to perform certain tasks
Data	Raw material –recorded, unformatted information such as words, numbers
Telecommunication	Group of two or more computer system linked together with communication equipment

Source: Valacich, and Schneider, 2010

Currently organization are more concern about sustainability development in more serious sense of reducing the direct environmental impacts of IS use while improving productivity, reduce costs and increase profitability. However, practices by the practitioner showed in poor environmental results in types of waste, energy inefficiency, noise, friction, and the emission. Hence, poor environmental practices could be improved with the implementation and diffusion of green and sustainable practices in their business processes. Energy efficiency in hardware and data centers continues to receive a great deal of research, given the potential to decrease emissions and lessen energy costs. Recycling of computer hardware, network infrastructure and electronic waste is also a necessity for enterprises to implement a sustainable practice. In order to increase the total environmental value, green IS can therefore minimize the total cost of technology usage in supporting business's sustainability initiatives, examples of such initiatives include the deployment of analytical tools and IS that support dynamic routing of automobiles to reduce energy consumption, the execution of emission management systems and the supplanting of carbon emitting business practices through videoconferencing and other online collaborative facilities. In diffusing and implementing green IS practice organisations are committed to reduce the concentration of harmful substances, saving the use of natural resources, creating a safe working environment to make their products and service compliant with applicable laws and regulations. Green IS focuses mainly on environmental sustainability all over the IT lifecycle, and aim to enable and transform entire organisations toward environmental sustainability hub. Green IS also presents a fundamental solution to organizational environmental degradation (Gholami, et al, 2013). But currently practitioners are faced with various issues when implementing and diffusing sustainable practices in their organisation, such as insufficient information to provide support on how to implement green practices. Sara and Imtiaz, (2013) stated three design decision guidelines in order to achieve environmental sustainable in the design phase. Firstly, programmer should write efficient algorithms, design of codes and data structures based on the application, programming language, and the architecture of the hardware. Secondly, sub-systems should refer to the functions which determined in the analysis phase and designed to be efficient functionality thus producing an efficient algorithm and a less number of program lines in the implementation phase. Lastly, the organization implements reuse for developing an application in terms of energy efficiency. Software developers should choose the most suitable programming style to the application such as aspect oriented for an application with many exceptions during run time.

THE COMPONENTS OF SUSTANABILITY FOR INFORMATION SYSTEM DESIGN

Design is one of the processes of implementing system solutions to one or more sets of problems which occur after the completion of planning and analysis phases in software development process. Basic design principles are enable the system developer to navigate the design process and design problems are merely opportunities for creative design solutions. Therefore, there is a need of design for sustainability in order to reduce the environmental impact of a product during its manufacture, use and disposal, or reuse. Information designers and product designers have to work together to create the next generation of sustainability products. In this project, green design components are mapped into four components of information systems which are hardware, data center, people and network. These components and their sub-category measured in term of performance and energy. The relationship between the components and their attributes is shown detail in Table 2, Table 3, Table 4 and Table 5.

In system design, people should have high level knowledge, skills and experience in terms of the attributes as mentioned in Table 2 (i.e. system design, network design and database design etc.) to attain green design.

Table 2. People Component and Its Attributes

Components	Attributes	Measurements Description
People	Systems design	Level of skills and competencies on software design
	Network design	
	Database design	
	User experience design	
	Business modeling	
	Methods and tools	
	Sustainability assessment	
	Data analysis	
	Hardware design	
	Storage management	
	Learning design and development	
	Performance management	
	Quality standard	

While hardware component, focus on the saving energy of power electricity in term of the attributes as mentioned in Table 3 (i.e. power supply, available power saving features and power factor etc.) to attain green design.

Table 3. Hardware Component and Its Attributes

Components	Attributes	Measurements Description
Hardware	Power Supply	Practices on saving energy of power electricity
	Available Power Saving Features	
	Enabled Power saving Features	
	Power supply Efficiency	
	Power Factor	

	Idle Power Draw	(yes/no)
	Full Load Testing	
	Full Power Load	

For data center component to attain green design, it should focus on saving energy of power electricity in term of the attributes as mentioned in Table 4 (i.e. lower power processors, high efficiency power supplies, power management features etc.).

Table 4. Data Centre Components and Its Attributes

Components	Attributes	Measurements Description
Data Centre	Lower power processors	Practices on saving energy of power electricity (average unit)
	High efficiency power supplies	
	Power management features	
	Blade servers	
	Server virtualization	
	415v AC power distribution	
	Cooling best practices	
	Variable capacity cooling: variable speed fan drives	
	Supplemental cooling	
	Monitoring and optimization: cooling units synchronized	

Finally, for network component, it should focus on saving energy of power electricity in term of the attributes as mentioned in Table 5 (i.e. use the waste as resources, diversity and cooperate to fully use the habitat, gather and use energy efficiency etc.) to attain green design.

Table 5. Network Components and Its Attributes

Components	Attributes	Measurements Description
Network	Use the waste as a resources	Practices on saving energy of power electricity (yes/no)
	Diversify and cooperate to fully use the habitat	
	Gather and use energy efficiently	
	Optimize rather maximize	
	Use materials sparingly	
	Don't foul their nest	
	Don't draw down resources	
	Remain in balance with biosphere	
	Run on information	
	Shop locally	

Source: adapted by Drouant et al. (2014)

However, it is hard to fulfill all the attributes for all the components in the system design. Companies might need to trade-off between the components based on the system objectives.

Furthermore, small companies might have limitations of the resources (e.g., human skills and hardware) that also can delay the process in achieving the green design.

CONCLUSION

The existing efforts proposed by the previous researchers are more focus on green IS rather than green or sustainability for the components (i.e., people, data centre, hardware, and network) perspective which are essential in an IS development. Therefore, a need to determine green design of information system to assist the customers and developers to build a IS which is concerns on economic and environmental aspects of sustainability in their business operations. Furthermore, the green IS may generate more profit in delivering their products through minimizing the total cost of technology usage in supporting business's sustainability initiatives. Besides that, green IS is more convincing in fulfilling the economic, social and environments aspects for future development. These components and metrics are also beneficial for the end users, software's owner and other stakeholders in software design process. When defining the design for the system, the developer usually focuses on the "identifying" the components and their relationships, based on a customer's requirements and it will perform based on the organization objectives. Future work will involve proving the proposed components for IT practitioners to refer to as a standard when designing green IS in their organizations.

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