FRAMEWORK FOR CAPABILITY MATURITY OF IT PRODUCT LIFECYCLE

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ABSTRACT

Many researchers have addressed the impact of ICT as the cause of global warming, climate change, and sustainability. This has encouraged further research in the area of Green IT as well as many sustainable frameworks of Capability Maturity such as SICT, IT CMF and the ITIL Maturity Model. In line with this drive, there is a need to search for a sustainable framework of Capability Maturity for the lifecycle of IT products. This paper proposes a sustainable framework of Capability Maturity for IT product lifecycles by providing IT users (consumer or organization) with a concrete guideline for practicing Green IT in the various levels of capability maturity. The product lifecycle includes Procurement, Usage, and Reuse/Disposal phases. IT and lab managers in the Faculty of Computing, UTM, will be involved in the framework verification. The framework verification will be conducted by using the card-sorting technique and interviews.

Keywords: ICT, Green IT, Capability Maturity Level, IT Product Lifecycle

1. INTRODUCTION

In the last few decades, Information and Communication Technology (ICT) has featured prominently in transforming business practices and redefined our social existence. With the help of technologies such as the Internet, sophisticated mobile phones, advanced telecommunication, and sophisticated information system applications, economies and businesses are rapidly transforming into e-economies and e-businesses. ICT provides automotive, informative, and transformation capabilities for economies to change and create economic opportunities. However, ICT industries contribute to global warming by producing CO2 emissions about 2% [1]. Although its CO2 emissions may not match those produced by the aviation industry for example, Molla and Cooper explained that CO2 emissions from ICT industries are increasing in line with the rapid expansion of the industry and that every phase of the lifecycle of an IT product has an environmental impact.

Capability Maturity is regarded as a potential solution offering benefits internally and cross enterprise because it provides a comprehensive growing of business processes. In each maturity level, the business processes have predefined objectives, goals, and processes. The targeted goal in each process area is the measurement indicator in each level [2]. Given the optimization of processes offered by the Capability Maturity Model, many frameworks have been developed for different industries such as the Sustainable Information Communication Technology-Capability Maturity Framework (SICT-CMF), Information Technology Capability Maturity Framework (IT-CMF), Maturity Model for Implementing Information Technology Infrastructure Library (ITIL), and Generic Maturity Model for COBIT. These frameworks measure how well IT processes are managed.

Overall, the aforementioned frameworks aim to achieve a measure of sustainability. To this end, the study of the lifecycle of IT products is also important. The lifecycle of IT products consists of designing, manufacturing and facilitating, packaging and transportation, usage, reuse, and disposal [3]. Some of these phases are handled by the manufacturer, while others by the organization or consumer. Consumers can be organizations that procure, use, reuse, or dispose of IT products rather than being involved in the design and production of IT hardware. For sustainable and cost-effective
practices within an organization, it is important to study how each phase of an IT product lifecycle pertaining to the consumer are managed. Such a study will contribute towards stabilizing the maturity of the organization’s processes and its implementation.

This paper proposes a framework of Capability Maturity for the lifecycle of IT products by providing IT users (consumer or organization) with a concrete guideline for practicing Green IT into levels of capability maturity with the product lifecycle phases; procurement, usage, and reuse/disposal.

The remainder of this paper is structured as follows: Section 2 discusses the theoretical background, Section 3 explains the methodology adopted by this paper, the results and discussion of the paper are then discussed in Section 4, while Section 5 concludes the paper.

2. THEORETICAL BACKGROUND

A. Green IT definition

Over the past decade, green computing has received much attention due to the rapid growth of internet-based business computing, called “cloud computing”. In this context, issues have arisen concerning the energy costs associated with cloud computing. Since there is a direct relation between energy consumption and carbon emission, a desire to decrease both has led to the emergence of green computing or green IT labels. However, there are many definitions of Green IT. Watson el al., defined “Green IT” as “The study and practice of using computing resources efficiently” [4]. He pointed out that green IT takes into account the triple bottom line of people, planet, and profit. Another definition is that of Mingay, namely “Optimal use of ICT for managing environmental sustainability of enterprise, its operations, products, services and resources” [5]. Mingray advocates that green IT emphasizes on strategy by aligning the goals of businesses with sustainable business processes.

B. Green IT Initiators

As a means to measure the presence of green IT practices, certain guidelines for best practices among businesses, customers, and manufacturers have been proposed. These guidelines are the result of the experience of those who initiated green IT practices. This research has adapted elements of best practice guidelines to develop the Capability Maturity framework for the lifecycle of IT products. Table 1 show the list of green IT initiators who have introduce supplier, manufacturer and end user to practice and use IT device efficiency.

<table>
<thead>
<tr>
<th>Green IT Initiator</th>
<th>Establishd Year</th>
<th>Objectives</th>
<th>Products/Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Star</td>
<td>1992</td>
<td>Help organization to save money and reduce GHG emission by having IT device with good energy efficiency practice.</td>
<td>Computer and monitors</td>
</tr>
<tr>
<td>The Swedish Organization TCO</td>
<td>1992</td>
<td>Environmental, social and economic are considered in the process of manufacturing, using and recycling IT products</td>
<td></td>
</tr>
<tr>
<td>Green Electronics Council (GEC)</td>
<td>2005</td>
<td>Aims to consider the electronics and sustainability issues and finding the constructive paths for the issue.</td>
<td>EPEAT</td>
</tr>
</tbody>
</table>

C. Capability Maturity Model

Thousand of organization applied CMM model to improve software processes by reducing expended resources in billions of U.S dollars [6]. As a result, many sustainable Green IT frameworks are developed based on the on CMM model such as SICT, CMF-IT, ITIL Maturity level, and COBIT Greneric Maturity Model. The CMM model is developed by the “Software Engineering Institute or SEI” [7]. It can be a tool for many organizations to use in different ways based on their organizational goals. CMM capability levels are used to help an organization identify issues, achieve improvement, and generate feedback to the organization [8]. Each CM level has process growth that is well defined. It helps organization to stabilize the processes in the organization. Each CM level is predefined by process area [2]. In CM levels, each level is measured by goals
achievements that are applied to a predefined set of process area [2, 6, 7, 8, 9].

- Level 5 Optimizing: Focuses on the continuous improvement of business process and product sustainable to sustain and improve green implementation.
- Level 4 Advanced: Focuses on the benefits from green implementation such as the source of income of the organization.
- Level 3 Average: Organizations are implementing green practices.
- Level 2 Basic: Organizations are aware of environmental sustainability and initiate green IT implementation.
- Level 1 Very Low: Organizations do not have a strategy and operational plan to implement green IT.

D. Green IT Product Lifecycle

Green product lifecycles are developed to help achieve sustainable product manufacturing, use, and disposal. Xin and Ziao pointed out that in the development of green products, the focus is on product lifecycle [10]. They stated that the main idea of a green product is to reuse or recycle materials as far as possible and recycle or reuse the waste to create new products.

There are 5 phases of the green product lifecycle, which include; design, manufacture and facilities, packaging and transportation, usage, and reuse or disposal [3,11]. Designing, manufacturing, packaging and transportation are related to the manufacturer, whereas procurement, usage, and reuse or disposal relate to the consumer.

Green Procurement — The meaning of green procurement is the process of buying a product and/or service that has less impact on environment. It concerns about environmental issues and the impact on human life by purchasing a product and service that has high quality with competitive prices. From 2000, the government sectors began developing procurement regulation as guideline and require business and public sector to consider the environmental issue during procuring electronic device. This regulation is to encourage business and public sector to reduce rather than disposal after single use.

Green IT Usage — Green IT usage is the level of green IT product usage and its impact on the environment. During IT usage phase, many devices consume significant amounts of energy. This increases a device’s carbon footprint. To help choose the most energy efficient devices to reduce the energy consumption, the user can use the Energy Star rating system. Energy Star attempts to optimize power usage of electronic devices through a number of tools.

Reuse or Disposal — Advancements in technology often renders current technologies and devices obsolete over a period of two years. This leads to a lot of e-waste. Such waste has a significant impact on the environment. One way to reduce waste is to increase the lifespan of devices. Reusing an old computer is a great way to increase its lifespan and may be seen as better than recycling. According to Computer Aid International, reusing a computer is 20 times more effective than recycling [12]. Another way to increase the lifespan of a device is to upgrade its parts. For example, a notebook can upgrade its RAM and Hard Disk to upgrade the performance of the computer. When reuse through modification is not possible or appropriate, then donation and recycling is the next best option. Many devices can be recycled for their raw materials. As a result, many companies implement recycling programs to collect old devices for the manufacturing of new devices. In this way, 17.7% or 600 000 tons was recycled [13].

3. METHODOLOGY

The basic concepts of maturity level underlying the Capability Maturity Model and product lifecycle are relatively easy to understand. However, applying those concepts to a complete range of green IT practices in each phase of a product lifecycle that map capability maturity levels are far from straightforward. To this end, the researchers found that the card-sorting technique is an effective technique for a framework of capability maturity for the lifecycle of IT products. The researchers requested the IT and lab managers in the Faculty of Computing, UTM, who have experience in managing IT devices, to categorize the practices in each phase of a product lifecycle to a specific capability maturity level. This is followed by interviews with expert respondents for their ideas and opinions concerning how best to categorize different practices into different levels.
A. Card-Sorting Technique

The card-sorting technique is the most appropriate technique for the proposed framework. It is a useful elicitation technique employed for knowledge elicitation in many fields such as website design, software engineering, knowledge engineering, and psychology [14]. It can be implemented into two methods, namely the open and closed method [15]. The Closed Method is a method where respondents are asked to group the cards with predefined categories, whereas in the Open Method, respondents create their own categories to group the card. Most researchers suggest that the card-sorting technique is the best technique for information hierarchy or classification [16]. Respondents are free to categorize or organize the information in a way that is logical to them. The result of card-sorting can be represented to analysts in the form of a dendrogram or matrix table to analyze what information is grouped and where.

B. Preparing Cards and Categories

This research uses the Closed Method for card-sorting. The researchers provided respondents with a list of cards with predefined categories. The cards consist of the green IT practices as found in green IT initiators, and the categories are the levels of capability maturity. Figure 1 is the 14 cards in green IT procurement, Figure 2 is the 15 cards in green IT usage, Figure 3 is the 11 cards in green IT reuse/disposal, and Figure 4 is the five predefined categories or group discussed in section 2.3.

FIGURE 1: Cards of Green IT Procurement

FIGURE 2: Cards of Green IT Usage

FIGURE 3: Card of Green IT Reuse/Disposal
C. Conducting Cart-Sorting

To conduct card-sorting, the researchers selected IT and lab manager from the Faculty of Computing, UTM, as respondents. The respondents were selected based on their knowledge, IT background, and work experience as an IT or lab manager. The researchers then used the online card-sorting tool “optimalworkshop” to create the card lists and categories to facilitate ease of response. Once the card and categories were created, the URL link is provided to the respondents during card sorting. The card-sorting activity was conducted through a one-on-one session between the researchers and each respondent. The following are the steps taken in this regard:

1. To begin with, the researchers briefly explained to the respondents the main purpose of the activity, namely to categorize green IT practices into capability maturity levels called categories.
2. Respondents were provided with the URL for optimalworkshop to conduct the card-sorting activity.
3. Respondents categorized the card for the green IT practice of each IT product lifecycle into the level of capability maturity based on his experience.
4. After the respondent completed the card-sorting activity, the chosen card and categories are recorded.

Figure 5 shows the online card-sorting tool used to create the cards and categories.

4. RESULTS AND DISCUSSION

All the respondents completed the card-sorting activity. Each session took 30 to 40 minutes. The
results were displayed in a matrix table to illustrate the similar and different cards that have been sort into the categories. Figure 6, 7 and 8 are the matrix table as analyzed by optimalworkshop.

Percentages are represented from the highest and lowest similarity of card grouping. 100% means all respondents categorized the same card into the same group, where 67% means that most respondents grouped the same card into the same group, and 33% represented that few respondents grouped the same card into the same group.

In the matrix result, when all respondents sort the cards into the same group, the researchers will save those cards in that particular group. In other cases when some cards are sorted into different groups, in the case of the majority grouping, those cards will be saved in that group. When there is no majority for a single group, the researchers conducted interview session with each respondent to obtain their ideas and opinions on their chosen grouping.

According to the matrix results, Cards number P6 and P9 had equal percentages, meaning there was no majority grouping. Card number P6 is:

“P6: Purchase of IT product that is upgradable, reusable, recyclable and reducible.”

The result of card number P6 is; one respondent sorted into Level 3, another respondent sorted into Level 4 and the last person sorted into Level 5. During the interview session, the first respondent who sorted P6 into Level 3 mentioned that:

“This card should be sorted into Level 3 because the card pertains to the practice of green IT procurement by purchasing an IT product that can be upgradable, reusable…. which is in line with the definition of Level 3.”
green practice and execute it for future improvement.”

When researcher asked the second respondent to sort this card into another level, he remarked: “As the concept of this card reflects the performance and the future improvement, this card can be sorted into Level 3.”

The last respondent who sorted the card into Level 5 mentioned: “This card is addressing the practice of green IT procurement and that will be for future improvement, so it should be in Level 5.”

From the result of the interviews, P6 should be sorted into Level 3 as agreed to by both respondent one and two.

The result of P9 is one respondent sorted it into Level 2, another respondent into Level 4, and the last into Level 5. Card P9: “P9: use of multiple green criteria to select and evaluate IT products for advance green procurement”
During the interview session, the first respondent who sorted the card P9 into Level 2 did so:

“Because multiple green criteria should be performed in Level 2”

The second respondent who sorted it into Level 4 explained:

“Because it is multiple criteria, it can be done based on the green procurement plan to improve for advance green procurement practices.”

The last respondent who sorted it into level 5 said:

“Because this card is more on the alignment for effective improvement for future practices.”

Upon review, P9 should not be in Level 2 since this level is concerned only with awareness, nor should it be in Level 5 because it is not the continuous improvement based on historical data. P9 should be sorted into Level 4 since it mentions that the organization should have a plan and evaluate it for advance practices. This is the aggregation of the second respondent’s idea.

Table 2 are the finalized framework after the card-sorting activity and interviews.

**TABLE 2: Green IT procurement with Capability Maturity Level**

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1: Initial</td>
<td>Do not have procurement plan (Skulmoski, 2001; Curry and Donnellan, 2012; Kerinia, 1997; Jacobs and Trienekens, 2002; Roger and Glen, 2009; and Curley, 2011)</td>
</tr>
<tr>
<td>Level 2: Basic</td>
<td>Aware environmental concern in IT product procurement (EPEAT, EPA, FEC, Energy Star)</td>
</tr>
<tr>
<td>Level 3: Intermediate</td>
<td>• Calculate Total Cost of Ownership (EPA) • Perform IT product benchmarking on environmental criteria (EPA) • Purchase IT product that has:</td>
</tr>
</tbody>
</table>
− Energy efficiency (FEC, Energy Star, EPEAT)
− Environmental certificate such as EcoLogoM, Green Seal, ENERGY STAR® and EPEAT® (EPEAT, EPA, FEC, Energy Star)
− Multifunction device better than a single function device (image equipment) (EPEAT, EPA)
− Duplex function (image equipment) (EPEAT, EPA)
− Network base better than local device (image equipment) (EPA)
− Take back option (FEC, EPA)

• Purchase IT product that is:
  − Upgradable, reusable, recycling, reducible (FEC, EPA, EPEAT)
  − Reduce, reuse and recyclable of packaging (FEC, EPEAT, EPA)

**Level 4: Advanced**

• Managed and aligned procurement processes and process improvements that integrated with environmental criteria (Jacobs and Trienekens, 2002)
• Use multiple criteria to select and evaluate IT product before purchasing

**Level 5: Optimized**

• Fine-tune and optimize green procurement process on a continuous and structured basis (Jacobs and Trienekens, 2002)
• Perform sophisticated procurement portfolio analysis to analyze and evaluate the procurement practices for future plan development (Curley, 2011)
• Predict the future based on procurement historical data (Curley, 2011)
• Integrate green policy into procurement year plan automatically (Curley, 2011)
• Develop Portfolio Management for procurement process to aggregate all procurement practices to provide regularly report status and impact to management committee board (Curley, 2011; Jacobs and Trienekens, 2002)
• Evaluate the effectiveness and efficiency of green procurement practices (Curley, 2011)

**TABLE 3: Green IT usage with Capability Maturity Level**

<table>
<thead>
<tr>
<th>Level 1: Initial</th>
<th>Do not have IT equipment usage plan (Skulmoski, 2001; Curry and Donnellan, 2012; Kerinia, 1997; Jacobs and Trienekens, 2002; Roger and Glen, 2009; and Curley, 2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2: Basic</td>
<td>Develop initial energy consumption plan (Skulmoski, 2001; Curry and Donnellan, 2012; Kerinia, 1997; Jacobs and Trienekens, 2002; Roger and Glen, 2009; and Martin Curley, 2011)</td>
</tr>
<tr>
<td></td>
<td>Aware about environmental concern on IT equipment usage (EPEAT, EPA, FEC, Energy Star)</td>
</tr>
<tr>
<td>Level 3: Intermediate</td>
<td>Provide staff training on green IT usage(PEATE, Mrugesan and Gangadharan 2012)</td>
</tr>
<tr>
<td></td>
<td>Encourage staff to turn off/power down electronic equipment at the end of each workday and/or over weekends and holidays (EPA, Energy Star EPEAT)</td>
</tr>
<tr>
<td></td>
<td><strong>Encourage staff to reduce energy consumption by:</strong></td>
</tr>
<tr>
<td></td>
<td>− Reducing the brightness of the monitor (Ashok and Sateesh, 2012)</td>
</tr>
<tr>
<td></td>
<td>− Switching off the monitor when inactive (Energy Star, EPEAT, Mrugesan and Gangadharan 2012; Ashok and Sateesh, 2012)</td>
</tr>
<tr>
<td></td>
<td>− Closing the application that is not in use (Ashok and Sateesh, 2012)</td>
</tr>
<tr>
<td></td>
<td>− Stopping the background process (Ashok and Sateesh, 2012, Mrugesan and Gangadharan 2012)</td>
</tr>
<tr>
<td></td>
<td>− Reducing the number of tasks (Ashok and Sateesh, 2012)</td>
</tr>
<tr>
<td></td>
<td>− Minimizing number of application at start up (Ashok and Sateesh, 2012)</td>
</tr>
<tr>
<td></td>
<td>− Switching off the hard dish when it is not in use (Energy Star, Ashok and Sateesh, 2012)</td>
</tr>
<tr>
<td></td>
<td>− Using standby and hibernate (Energy Star, Ashok and Sateesh, 2012; Mrugesan and Gangadharan 2012)</td>
</tr>
<tr>
<td></td>
<td>Minimize local and maximize network device for image equipment (EPA, EPEAT, Energy Star)</td>
</tr>
<tr>
<td></td>
<td>Set duplex as default to encourage staff to reduce the resource image equipment such as ink and paper (EPA, EPEAT, Energy Star)</td>
</tr>
<tr>
<td></td>
<td>Encourage staff to reduce resource usage for image equipment such as reduction in color printing, graphic, line space and size (EPA, EPEAT, Energy Star)</td>
</tr>
<tr>
<td>Level 4: Advanced</td>
<td>Develop Portfolio Management for IT product usage process to aggregate all usage practices to provide regularly report status and impact to management committee board (Curley, 2011; Jacobs and Trienekens, 2002)</td>
</tr>
</tbody>
</table>
Evaluate the effectiveness and efficiency of green IT product usage practices (Curley, 2011)

- Fine-tune and optimize the usage process on a continuous and structured basis (Jacobs and Trienekens, 2002)
- Perform sophisticated IT product usage portfolio analysis to analyze and evaluate the IT product usage practices for future plan development (Curley, 2011)
- Predict the future based on IT product usage historical data (Curley, 2011)
- Integrate green IT usage policy into year plan automatically (Curley, 2011)

<table>
<thead>
<tr>
<th>TABLE 4: Green IT Reuse/Disposal with Capability Maturity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 1: Initial</strong></td>
</tr>
<tr>
<td>- Do not have IT equipment reuse/disposal plan (Skulmoski, 2001; Curry and Donnellan, 2012; Kerinia, 1997; Jacobs and Trienekens, 2002; Roger and Glen, 2009; and Curley, 2011)</td>
</tr>
<tr>
<td><strong>Level 2: Basic</strong></td>
</tr>
<tr>
<td>- Plan for equipment upgrading (Skulmoski, 2001; Curry and Donnellan, 2012; Kerinia, 1997; Jacobs and Trienekens, 2002; Roger and Glen, 2009; and Martin Curley, 2011)</td>
</tr>
<tr>
<td>- Plan for IT equipment disposal and donation plan (Skulmoski, 2001; Curry and Donnellan, 2012; Kerinia, 1997; Jacobs and Trienekens, 2002; Roger and Glen, 2009; and Martin Curley, 2011)</td>
</tr>
<tr>
<td><strong>Level 3: Intermediate</strong></td>
</tr>
<tr>
<td>- Recycle through take back program (EPA, FEC)</td>
</tr>
<tr>
<td>- Reuse and upgrade part of IT equipment to increase its lifespan (Energy Star, EPA, EPEAT, Ashok and Sateesh, 2012)</td>
</tr>
<tr>
<td><strong>Level 4: Advanced</strong></td>
</tr>
<tr>
<td>- Develop Portfolio Management for reuse/disposal process to aggregate all reuse/disposal practice to provide regularly report status and impact to management committee board (Curley, 2011; Jacobs and Trienekens, 2002)</td>
</tr>
<tr>
<td>- Evaluate the effectiveness and efficiency of green reuse/disposal practices (Curley, 2011)</td>
</tr>
<tr>
<td><strong>Level 5: Optimized</strong></td>
</tr>
<tr>
<td>- Fine-tune and optimize the reuse/disposal process on a continuous and structured basis (Jacobs and Trienekens, 2002)</td>
</tr>
<tr>
<td>- Perform sophisticated reuse/disposal portfolio analysis to analyze and evaluate the reuse/disposal practices for future plan development (Curley, 2011)</td>
</tr>
<tr>
<td>- Predictive of future based on reuse/disposal historical data (Curley, 2011)</td>
</tr>
<tr>
<td>- Integrate green IT policy into reuse/disposal year plan automatically (Curley, 2011)</td>
</tr>
</tbody>
</table>

5. CONCLUSION
This paper has introduced a framework for determining capability maturity levels for IT product lifecycles. It is an archetype describing the levels and maturity stage that green IT practice go through in their lifecycle, namely IT procurement, IT usage, and IT reuse/disposal. The card-sorting technique was applied to develop the framework. Interviews were also conducted with selected respondents to examine their responses. However, this research included only IT and lab managers from the Faculty of Computing, UTM, as respondents. Further research should cover a wider variety of respondents from different fields and backgrounds to provide different views of IT product practices.

REFERENCES


