A GREEN IT STAR MODEL APPROACH FOR SOFTWARE DEVELOPMENT LIFE CYCLE

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ABSTRACT

Green software engineering is a principal software engineering process in the 21st century. In the Last few years there is a lot of research going on which is based on Green Information Technology and Sustainable Software Engineering. However till now there no is clear idea about how to achieve the Green and Sustainability in SDLC phases (Software Development Life Cycle) .To fill this gap this work proposes a new software model called as SDLC Energy Star Model in each phases of the life cycle of Software Engineering In this paper it is proposed to implement the star values and tried to achieve the Green and Sustainability in SDLC.

Keywords: Information and Communication Technology (ICT), Environmental protection Agency(EPA), Management Information System (MIS), Software Development Life Cycle(SDLC), Small Business Administration (SBA), Enterprise Resource Planning (ERP), Customer Relation Management (CRM), Non Function Requirements (NFR), Capability Maturity Mode (CMM).

I INTRODUCTION

Now a days creating eco friendly software and IT products are very important concepts in software and hardware industries. In both developing and developed countries the software engineers are giving more importance only for eco friendly products. [1] The objective of eco friendly principles are mainly focused on reducing carbon consumptions, hazardous wastes and saving energy. If these companies concentrate on reducing carbon consumptions, hazardous wastes and to save energy they may lose the concentration on performance quality and sustainability of the product. It is a major issue of the product based and the production based software development and hardware manufacturing companies. [1] Technology integration to eco friendly principles can induce an organization to achieve maximum performance without giving bad impact to the environment. These efforts are popularly called as Green IT. To fill this gap this paper proposed a following methodology (i.e.) In SDLC (Software Development Life Cycle) phases, requirement, design, coding, testing and implementation. This paper implement the energy star for each of the phases like electronics appliances in developing countries.

The remainder of this paper is organized as follows. In Section I introduction to the problem domain was presented. Section II gives an overview of the literary review in the field of Green Software Engineering. The section III

describes about the proposed work used for finding Green and Sustainable Software Engineering methods. The section IV gives the conclusion about the new model and future research in this model.

II. LITERATURE SURVEY

The study of Green and Sustainable development was first introduced at the World Convention on Environment and Development in 1987[4]. It defined the Green software process as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It soon becomes a paradigm for software organizations. The research started with the software safety and security in the initial stages and currently focus was shifted to reduce waste or raw materials and save the environment, the concept of Green software becomes increasingly complex [5].

The hardware aspects are covered by Green IT concepts where many publications on sustainability of data centers were published. For instance, the code of conduct for data center efficiency [6]. There is no execution model and software tools to identify the estimation of energy consumption in these early design stages[7].This mixed role puts technology organizations under tremendous conflicting pressures, internally they are eco friendly and externally they are expected to design new products that improve the sustainability of the society at large[8].In the quality aspect the commoditization has resulted in the software industry coming under increasing pressure to develop and to deliver greater volumes of high quality products and services within cost and schedule constraints that are tighter than ever before[9].

This paper [10] pointed out lot of aspects related to quality. The quality is one of the aspects in testing of software where codes written by an automatic interpreter have less efficiency than codes written by an experienced developer. The paper [11] shows how the power reduction can be achieved through improved software design. It also pointed out the role of software engineers in reducing the power consumption of the application. This work [12] outlined about the importance of classification for Green quality factors and defines about the Green metrics. The work [13] discussed about the approaches which lead to identify challenges based on quality, requirement and design.

How does the sustainability differ from other approaches?

1) What are the types of requirement gathering method that lead to sustainable s/w solutions?
2) How do they differ from traditional Non Function Requirements (NFR) on requirement perspective?

The author [5] proposed software security considerations from 1980 to 2010 era, in which the developers focuses mainly on requirement and process, secure computations, verification of systems, software piracy protection ,architecture and design of secure systems, and trusting components are the secured development factors. In the year 1990 to 2010 the developers were focused designing for safety, testing at different levels for reliability and safety, certification and standard resources available on software safety requirements and analysis and hazard analysis are the above factors that comes under the software safety considerations.

In the year 2010 software sustainability considerations safety is an emergent property that arises when the system components interact within an environment [14].The supporting sustainability requires knowing the stakeholders as the key challenge and success factor for all the projects also for the sustainable and Green software. There is a lot of effort trying to combat pollution issues especially the European Union (EU) cap is the limited amount of emission from each country and it can be traded in the form of emission permit. Installations are able to hold credit but it will not be allowed to exceed the cap. However if the installations would like to emit more gas they have to pay in order to obtain credit, therefore not only carbon foot print or hazardous substance but also environment foot print has to be monitored closely by manufacturers. This method has to be set for software development industries[15]. Reducing the energy consumption and overall environmental impacts of data centers have become an important research area in future [16].The European commission's Europe 2020 strategy has targeted three key areas for sustainable growth. They are

1) 20% increase in energy efficiency
2) 20% reduction of green house gas emissions and
3) Increase the share of renewable energy by 20%.

So more concentration is required in these areas in both developed and developing countries. [17]

Software development plays a specific role in creating rebound effects. The usual response of software engineers is to increase the processing power and storage capacity available at a given price is to capture more of the same [18].This paper focuses on the Green potential of clouds such as:

1) How they have to be deployed for different user levels highlighting the related environmental risks?
2) Giving the growing importance of cloud computing the question is not whether it is green as it is now but how it can became really green?
3) Awareness and responsible behaviors are background condition to achieve sustainable and Green cloud computing.

One of the pillars of the information society strategy of the European Union is the application of ICT(Information and Communication Technology) to improve the quality of life and to foster environmental care and sustainable development [28]. Over a third of organizations in Europe do not implement Green IT practices the most prominent reason given is that there is no official legislation in their countries in enforcing Green IT practices. Less than one fifth of the organizations actually monitor how employees reduce their energy consumption [19]. The paper empirically analyzed the energy consumption induced by comparable MIS(Management Information System) applications namely, ERP(Enterprise Resource Planning) CRM(Customer Relation Management) and DBMS(Data Base Management System) and found out that:(i) not only infrastructural layers, but also the MIS application layer does impact energy consumption up to70% (ii)different MIS applications are satisfying the same functional requirements to consume significantly different amounts of energy (differences up to 145%), and (iii) in some

scenarios energy efficiency cannot be increased simply by improving time performance.[38]In this proposed model they try to cover the five sustainability dimensions and propose generic aspects for each one. For each generic aspect one can associate more detailed and quantifiable properties.

2.1 Requirement Engineering Perspective

Requirement engineering involves eliciting, analyzing, documenting and maintaining the complex set of requirements for a software system. [35] In this paper [35] the author raised the 3 types of research related questions about support of environmental sustainability by requirement engineering such as:

1) How to make environmental sustainability a first –class quality objective for development?
2) How does the necessity can be implemented in a requirement approach?
3) How can one assess the impacts of a given software system for environmental sustainability, including both direct and indirect effects and considering different groups of stakeholders?

[40] Applying the principles of system thinking, sustainability can be defined as preserving the function of a system over a time span.

2.2 Design Perspective

In software engineering, a design pattern is a general reusable solution to a commonly occurring problem in the software design process [20]. The work [21] pointed out the considerations on Green and sustainability in the design process. This paper focused on a lot of ideas about how to promote Green software values. Energy efficiency should be given more important when it comes down to general algorithm efficiency where there is a need to make thing runs fast with less hardware. But this is amplified and driven by pricing schemas of cloud resources and cost saving: that needs to write efficient software that can do more with limited resources. This will translate into power efficiency when there is an increase in the amount of work done per CPU Cycle.

There is a myth on Green software engineering which denotes that if the software is built more efficiently then it will consume less energy. So there is a need of global standard which should be bigger than any practitioner who promotes it. Otherwise it will be really hard to raise the awareness. The work [22] describes the best examples for studies published on the average electricity consumption of a single Google search query. In 2007 EPA (Environmental Protection Agency) data center reported to the US congress that by 2011 the peak load will be generated on the grid by data centers in US alone. It would be close to 12 GW which is equivalent to the output from 25 base load power plants where research community need to focus on this area.

In terms of chip manufacturing, a study [22] shows that the amount of resources and energy consumed are measured as a ratio against the weight of the final product (chip) which is one of the highest amongst all manufacturing industries. Thus the environmental impacts of these associated manufacturing industries should also be considered when analyzing the ecological impact of a computer. Many developing countries do not have efficient recycling

facilities for packaging and shipping of computers. In the point of disposal many developed countries have introduced laws for e-waste recycling but owing to the high operational costs, most e-waste ends up in developing countries where appropriate recycling facilities and stringent environmental laws do not exist. The author proposed a solution for these environmental issues with the use of virtualization with Green. But again that the use of virtualization with Green also raises many research oriented questions for future investigation. [23]

Designers of software technology are responsible for the long term consequences of software designs. There is a perception that sustainability is a distinct discipline of research and practice with few defined connections to software where as sustainability is a pervasive concern that translates into discipline-specific questions in each area it applies [24]. Programmers should write efficient algorithms via writing a compact design of codes and data structures based upon the application, programming language, and the architecture of the hardware but optimization comes from only through experience.[25] (Re-)Designing business models and business processes according to the principles of sufficiency (instead of maximizing port) and decoupling of resources from economic growth.

2.3 Coding (or) Development Perspective

The coding methodology will differ from experienced developer to fresh developer, the experienced developer will develop or write a code in optimized style, but fresher will write in their own style which is not proper optimization of coding approach. So one have to consider this aspect also for developing the coding and the style. [36] This process is described in three aspects like system, function, and time horizon. System is a software development company, function with minimized environment impact and sufficient economic balance and time horizon depends on the company size and the general duration of the projects. In development process the company needs to concentrate about energy efficiency, energy consumption and performance based suitability of development of coding. [37] The increasing usage of computers and other electronic devices (for example smart phones, sensors) are continuously impacting ones overall energy consumption. By raising energy costs in computers and in mobile devices which implies the optimization and the adaptation of computer system with this point of view both the companies and the developers implement the sustainability then one will give the 3rd star for that companies,

2.4 Green Metrics

There are different approaches that are related to Green metrics of the software [26]. This paper pointed out the Green software metrics that are defined in the software engineering literature and also raised two research related questions on Green software engineering and Green metrics such as

1. What Green metrics have been proposed in software engineering literature?
2. How Green metrics can be classified?

This paper also pointed out many Green software metrics which are used in the software engineering literature. A Green factor defines the Green software must fulfill the properties. It needs one or more Green metrics which measures the factor fulfillment in software for instance if one Green factor stillness. [10] This paper additionally

pointed out how to obtain Green quality which is determined. The work presented [32] the quality assurance techniques corresponding to the requirements which are needed; it necessitates future research in establishing sustainability metrics as well as assessment techniques. In [7] Green soft model it has the ability to represent three categories of sustainability criteria and metrics for software products they are (I) common quality criteria and metrics (II) directly related criteria and metrics and (III)indirectly related criteria and metrics. Depending up on the classification the quality properties "Modifiability" and Reusability" take effect in the development phase, where as the properties "portability, supportability, performance, dependability, usability, and accessibility" take effect in the usage phase. In [27] a Green model for sustainable software engineering energy awareness in systems can be obtained and calculated through Green metrics such as the Green Performance Indicators(GPIs) found in[28,29,30,31]here GPIs are classified into four classes here GPIs are classified into four classes: IT Resource Usage GPIs that compute resource usage, the Application Life cycle KPIs(Key Performance Indicators) that define efforts required to develop or redesign applications and reconfigure IT-infrastructure, the Energy Impact GPIs that represent the environmental impact of data centers, and the Organizational GPIs that describe organizational factors..[32] Green IT will happen only when all the stakeholders involved in delivering and consuming IT services are aware of the functionality of the service delivers and of the relationships between the associated Quality of service levels and environmental-impacts metrics. The work [33] presented that Information Technology (IT) can be regarded as a special resource for business processes. On one hand, IT is useful for collecting, processing and providing information in order to determine and to improve ecological indicators for business processes from the perspective of "IT for Green". On the other hand, IT itself requires natural resources for the design, manufacturing, use, and disposal of the required hardware and software (perspective "Green for IT").In the work [22] Green metrics are used as a tool to measure the actual carbon footprint of SBAs(Small Business Administration). This makes measure ones an eligible keyword for one's search strategy. The work [34] presented a generic metric to measure software and a method to apply it in a software engineering process. All the metrics related approach will help in tuning and in defining the quality of the application developed by the company, the quality control and the quality assurance will derived only with help of testing

2.5 Implementation or Maintenance

It is important to concentrate these approaches in two point of view (36) (i) whether that company produced a new application for the new customer.(37) (ii) whether that customer already used an application for that customer the company is providing a new technologies It is like that one need to think about the old system and about the disposal[37] sustainability of the software system during its maintenance period until replacement by a new system includes continuous monitoring of quality and knowledge management. [39] Green IT shows that information technology can also help to create a sustainable environment through the following

1. Modifying supply chain , production activities and organization flow
2. Creating more efficient business operators, buildings and system.

3. Helping the decision making process by analyzing modeling, and simulating of environmental impacts that may occur
4. Auditing and reporting the organization's energy consumption and savings

III. PROPOSED WORK

From the literature survey the following research challenges are identified for the use of SDLC (Software Devolvement Life Cycle) technique in the area of sustainable software using Green technologies. In the previous study of the work there is no high importance for the requirement analysis related to Green. If much concentration given to this phase the throughout the life cycle it becomes Green. In this analysis phase one have to raise a question in the aspect of sustainable software engineering using Green technologies. Based on this problem a new model was proposed in this research work. Figure 1 shows the how the CMM(Capability Maturity Model) model is working equivalent to the SDLC approach ,and also shows the star values for each phases.

SDLC Energy Star Model.

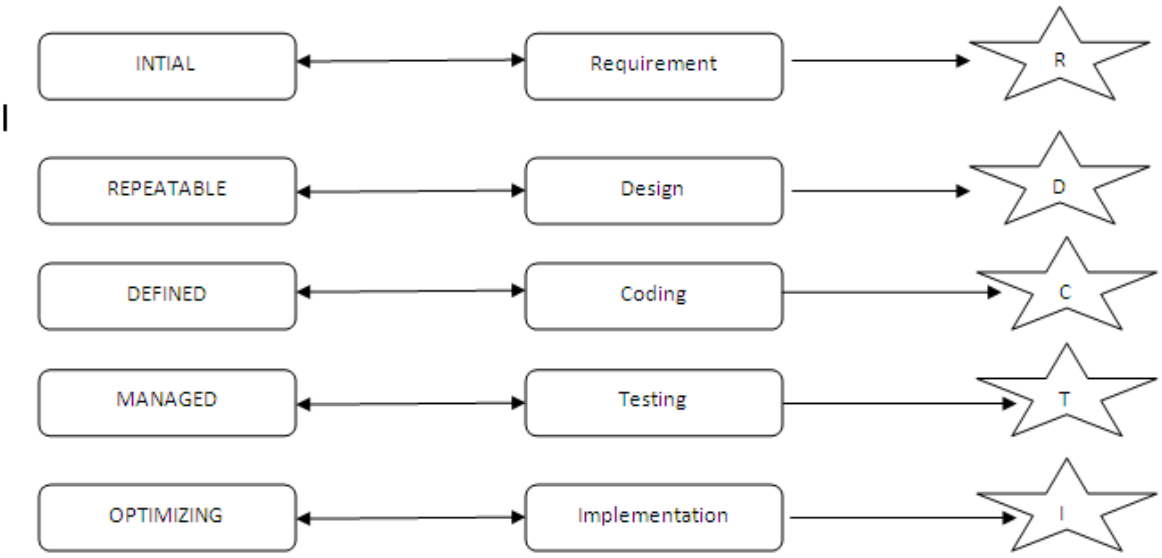

Fig :1

3.1 Requirement

In software development process the requirement collection is a very important aspect for software development companies. In this process anything may go wrong or requirement may not be collected as per user specification, this it will create a serious problem in future, this may affect the economy, social, technical and environment .Collection of requirement is a very important role, when one collecting the requirement that time itself one have to ensure about sustainability of software, whether it is functional requirement or non functional requirement .If one

collected the requirement as per Green and Sustainability based then one can give a star for that process of activity. This process is equivalent to the CMM (Capability Maturity Model) level process of the first stage Initial.

3.2 Design

It is a second important aspect in SDLC phase based on the requirement collected from the customer companies' one have to create a mock design to show the customer. Here also one has to implement the sustainable methodology with Green IT. If a design is created as per the satisfied level of sustainability then one have to give the 2nd star for that companies .This process is equivalent to the CMM level process of the second stage Repeatable. It is equivalent to the repeatable process through the design of the forms, database, architecture the developer, data base administrator, and architect they need to work for this process have to meet the customer satisfaction level .If they satisfied in the point of Green and Sustainability condition here the designer, Data base administrator and architect need to give more concentration for performance of the data base, energy efficiency of the application, and server speed.

3.3 Development (or) coding

The most important aspect in SDLC is development or coding .The coding style will vary from developer to developer if the code is written in optimized level and also it will considers about the Green and Sustainability approach then one will provide the 3rd star for that company, for maintaining the complete coding as clean code .The new comer for that company also needs to follow the defined code. This process is equivalent to the defined process of CMM level here the developer needs to define the coding style in the sustainability approach.

3.4 Testing

After design and development of activities got over in the sustainable based SDLC phase, Testing is playing the next important role. Testing almost determines the quality of the product, testing the company released the product with as per the software quality and then one will give the 4th star for that company. It is equivalent to the process of CMM level Managed because after releasing the software the company needs to maintain and to manage the application as per Green and Sustainability approach.

3.5 Implementation

It is the last stage of the Sustainable SDLC phase, in this phase of activity the company will be implementing the new application, or updated version will be releasing for maintaining the existing application. For that reason they may release a new user manuals, DVD (Digital Versatile Disk), CD (Compact Disk) in explaining how to use the application .Once another updating version will be released the company needs to ensure what they are going to do with the old one and for that what are the precaution measures will be implemented to maintain that sustainability .If we follow the sustainability methodology in implementation area then one can give the final star for that company.

The following figure shows how to implement the sustainability in SDLC phases in software engineering .Depending up on the implementation one will consider the Green and Sustainability rating of the company. Figure: 2 shows the star values for the company when it will get certification for Sustainability model.

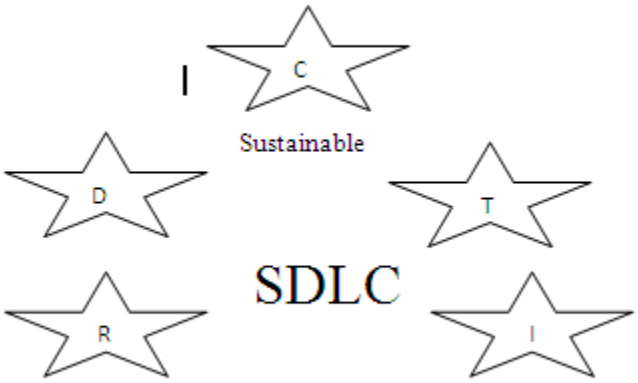

Fig:2

IV.CONCLUSION

The main challenges of the 21st century are the global impacts of the environment. The environment impacts may be in any form like noise, heat, radiations and power consumption. The above set of factors affects the environment [1] directly or indirectly which gives negative impacts on economy, society, human beings and environment that resulted from development, deployment and usage of the software. In the development of a software application, there exists many life cycle models, where each model has its own sustainability and environment threats. But most of the research activities focus only on energy efficiency and energy consumption. This work proposes a new software model called SDLC Energy Star model in each phases of the life cycle of software engineering where one tried to implement the star values and tried to achieve the Green and Sustainability in SDLC in software developing companies. In future research what are all the green metrics we need to provide for getting star values in each phases of the SDLC.

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