

A Review on Green Software Development in a Cloud Environment Regarding Software Development Life Cycle: (SDLC) Perspective

Shehla Afzal¹, M. Faisal Saleem¹, Fahad Jan¹, Mudassar Ahmad²

¹Department of Computer Science, University of Agriculture, Faisalabad, Pakistan.

²Department of Computing, Universiti Teknologi Malaysia, Johar Bahru, Malaysia.

Abstract— Cloud Computing (CC) has been recognized and gained significant importance as an approach that can be used to save the energy of resources being used by organizations. CC is crucial in virtualization; that is helpful to reduce the use of the number of power consuming servers. Virtualization itself is being green as it is energy saving, cost effective and resource saving. For the use of resources, data centre, hardware, application platforms and application, there is a need to pay much more attention on energy consumption. The aim of this work is to highlight different approaches and guidelines for energy efficient software development throughout all the phases of Software Development Life Cycle (SDLC). Energy awareness should be introduced as early as possible to reduce the cost of energy consumption in later developments. The increasing usability of information, communication, application developments and the highly complicated computations there is a need to reduce energy consumption of computation, storage and communication. In this paper, CC and green computing are combined and a software development structure in an energy efficient green cloud computing has been proposed by dividing the structure into two parts, that is; the software part and the cloud deployment setup. Finally, approaches in Software Development Life Cycle (SDLC) stages related to energy efficient issue are recognized and make helpful to develop more friendly platforms for the software applications in a cloud deployment setup.

Keywords— Cloud Computing, Green Computing, Energy Efficiency, SDLC.

I. INTRODUCTION

Green Cloud Computing has become popular at present information technology setup of many large organizations. Organizations want to be more sustainable and to reduce the energy consumption and resources in use. The characteristics of Cloud Computing (CC) that it is virtualized, elastic and has a dynamic behavior it should be turn into green computing setup also. As the result of receiving considerable attention, CC is becoming popular approach for sending information and also for communication purposes in improving the consumption of data centre resources. For the efficient use of resources, data centre, hardware, application platforms and application, there is a need to pay much more attention on energy consumption issues. Cloud computing and green

computing (Green IT) are two areas of considerable attention where organizations invest in these days [1].

Cloud computing is becoming popular in publications as well as among information technology users [2]. Cloud computing is like a utility where customer pay and get services from organizations like Google, Amazon, IBM, eBay. Just like in Fig 1.



Fig 1: Cloud Setup

The most important part of cloud is the Internet; if you have access to Internet you can access your service from anywhere. It makes you to view and use your service even after moving physically. The broad scope of cloud computing is summarized in [3].

IT Technologies are becoming increasingly common because the Internet usage increasing day by day and the cost of computer hardware is decreasing. IT technologies are the base for the rapid development of society and economy as well. As organizations are more dependent on IT systems and it results in high energy consumption. It becomes necessary to explore a new paradigm for the energy efficient computing, called green computing [4]. It reduces the cost and energy consumption. In this paper highlighted that the energy related issues should be discussed and considered as early as possible

in the development of an application makes the application more energy efficient and the expenses regarding energy consumption can be minimized. It can also be defines as that it is the study and practice of designing, developing, using, and disposing of computers, servers, and associated subsystems such as monitors, printers, storage devices, and networking and communications systems efficiently and effectively with minimum impact on the environment [5, 6].The implementation of energy efficient central processing units (CPUs), real time devices, servers, applications, platforms also include in green computing. Previously from the application development perspective, Researchers haven't given as much attention to energy efficiency [7].

II. GREEN CLOUD COMPUTING

Green and cloud computing these two concepts are the backbone of this research as these help to design an application architecture that is most energy efficient in a cloud setup. Can cloud computing (CC) is an alternative to green computing? As previously researchers tell that by using virtualization CC is itself energy efficient technology. The key driver technology in clouds for energy efficiency is the "Virtualization" [8]. In past A.J. Younge and his colleagues proposed a green cloud framework a few years ago, but it covered only virtualization and data center operations [9]. Here in this paper the proposed structure covers green computing in an application development perspective, which can improve energy efficiency in cloud environments significantly in the very early stages of development process. 40% of people in IT departments believe energy efficiency and equipment recycling are important factors to consider and

about 65% believe that reduction of energy related operating costs is the driving factor for implementing green IT.

As Fig 2 shows, we the proposed structure is divided into two major parts: the software and the cloud setup. In service handling includes all the expectations that a customer has with the cloud service providers (CSP). CSP should consider all the services for application those having high priority and compulsory for the application running in a cloud setup as well as can consume high energy if they don't give importance like if an application requires high availability, it's the responsibility of CSP to must keep backup resources which run constantly to meet this requirement, it effects negatively as backup resources consume energy all the time running. Hence there is a need to include energy related conditions and guidelines in to track energy consumption. Cloud customers and providers can highlight these terms regarding energy usage.

Software and cloud structure are two main parts; where the software part of cloud service includes system software and application software. Developers should design energy efficient OS and application. In the Cloud structure Service Provider data centers need many types of processing CPUs, hardware, storage and network devices to run a cloud setup. The design, construction, and maintenance in data centers include in a cloud structure and they greatly affect the environment and natural resources. So there is a need of physical facilitative resources regarding to cloud structure. In results the design and implementation of cloud setup components can affect energy consumption. Service Models and their responsibilities depend on the cloud model that is being used in the cloud environment.

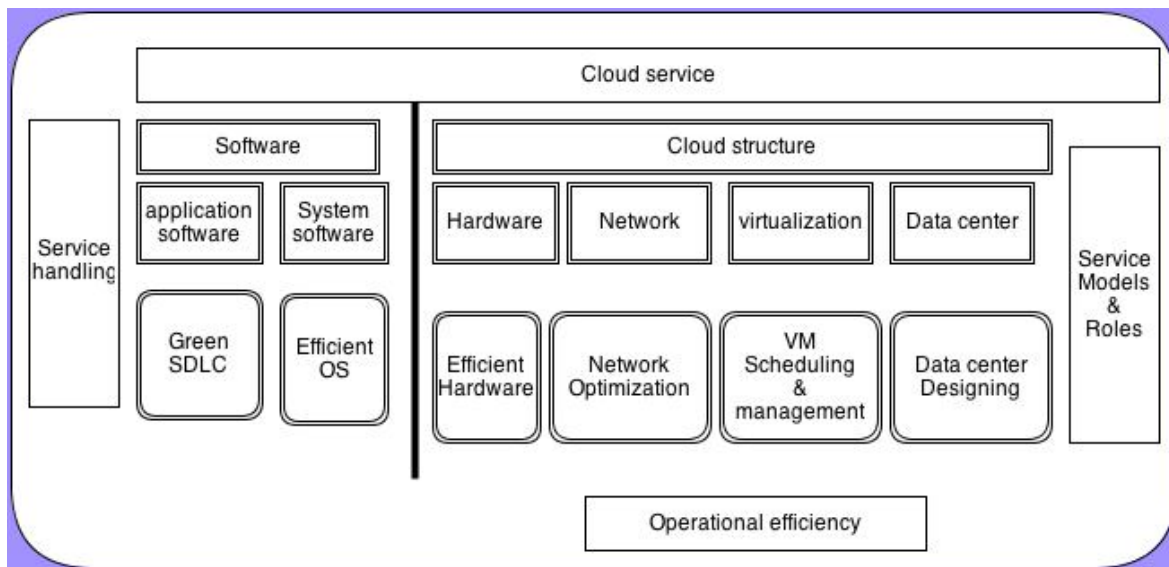


Fig 2: Energy Efficient Cloud Structure

III. GREEN SOFTWARE DEVELOPMENT LIFE CYCLE (G-SDLC)

Software Development Life Cycle (SDLC) is an organized and properly refined process that is being used by many organizations for the development of software applications.

To introduce any concept early in the development ensures its efficiency after developed as well, just like to introduce the concept of energy efficiency early in the SDLC ensures that it will be propagated throughout the SDLC phase results in reduction of energy related expenses. Proposed work highlights various approaches and guidelines for energy aware software development process [10] being compared to traditional SDLC. Energy efficient SDLC for cloud applications can be described in two concepts: the first one is the green computing and second is cloud computing. Here, five SDLC phases are discussed how green and cloud characteristics might affect them.

A. Software Requirement Specification

There are two types of requirements: functional and non functional. Functional requirements means the expected business requirements; the necessary functions performed by the software and the non functional requirements include performance, security, portability, flexibility, availability, and usability. Here the greener approach into the software requirements means that there is an addition of sustainability into the specifications of software. To increase the sustainability some important questions that should be asked during the requirements gathering phase just like to check that because of a cloud setup is there any need of additional software requirements for example maybe some additional security and communication requirements are required in a cloud environment? Is there any need or is there any proper way to measure the energy consumption of the application in a cloud hence it would be an additional requirement?

B. Software Design

Design phase includes the classifications of data, architecture, and interface design; however, most of the designs focus on modules, abstractions levels, data structures, and software architectures but a good design should also include energy efficiency. For example, if the modules are dependent there will be consumed more energy because of overhead of communication. Graphical User Interface (GUI) design is an area where an effective design can save energy by reducing the user interactions with the interface [11]. Data structures and algorithms affect the efficiency of a software computation and they may increase the energy consumption of computation. Unnecessary use of loops, controls, switch statements and branching in algorithms require additional computation resources and in results extra energy consumed. To reduce the complexity and energy usage of an algorithm analysis should be done. For example, in a cloud scenario, encryption is a key functionality for security related challenges, and generally the Advanced Encryption Standard (AES) encryption algorithm consumes less energy than Data Encryption Standard (DES) [12].

C. Software Implementation

Because of the cloud setup, there is a need of some important guidelines those should be under notice while designing the application. Like redundancy and uncontrolled data flows, loops and branching statements consumed more energy; hence they should be avoided in designing energy efficient cloud application. An efficient code in the cloud scenario reduces both costs and energy consumption just like by using several tiers of abstraction that could distance the code from the processor increases energy consumption. More use of the existing programming techniques those can help to reduce an application's CPU consumption e.g, the loop-unrolling mechanism reduces the instructions to control the loop by rewriting them in a new sequence of instructions that can be executed in parallel. The number of parameters should be controlled to enhance the energy consumption in a network during information transmission.

D. Software Testing

A planned testing process can save money, time and energy by identifying defects as early as possible. Testing itself consumes resources and is a critical SDLC phase. Tests related to sustainability should check energy consumption for major In the Test planning the tester should be well aware of the scope and objectives of testing energy consumption in the cloud. A complete knows how about the approach which is being in use for testing energy consumption. The testing team should create and execute well defined test cases related to energy consumption they should also analyze the results of security and performance testing to evaluate energy consumption trends in various conditions also find out the number of people and amount of equipment allocated for testing the affect of energy use; and how to measure energy use. There are additional testing requirements with respect to network, performance, and security because of cloud setup. As security validation and quality assurance require additional effort. Security and trust are major challenges in the cloud, it is necessary to fix the bugs and to remove them can result in additional effort, usage of additional resources, and energy consumption. CSPs control hardware and infrastructure monitoring, so they must track energy use.

E. Software Maintenance

Application and software maintenance responsibilities depend on the model which is being used in cloud service. While choosing the service provider, compare needs to the cloud services available. If there will be a need of technological changes at any point more storage space can be purchased from cloud provider.

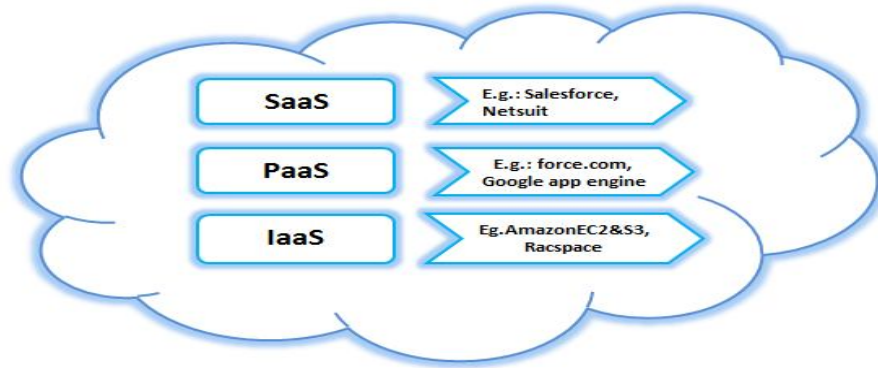


Fig 3: Cloud Services Types

There are three types of cloud providers that can be subscribed as shown in Fig 3: Software as a Service (SAAS), Platform as a Service (PAAS), and Infrastructure as a Service (IAAS).

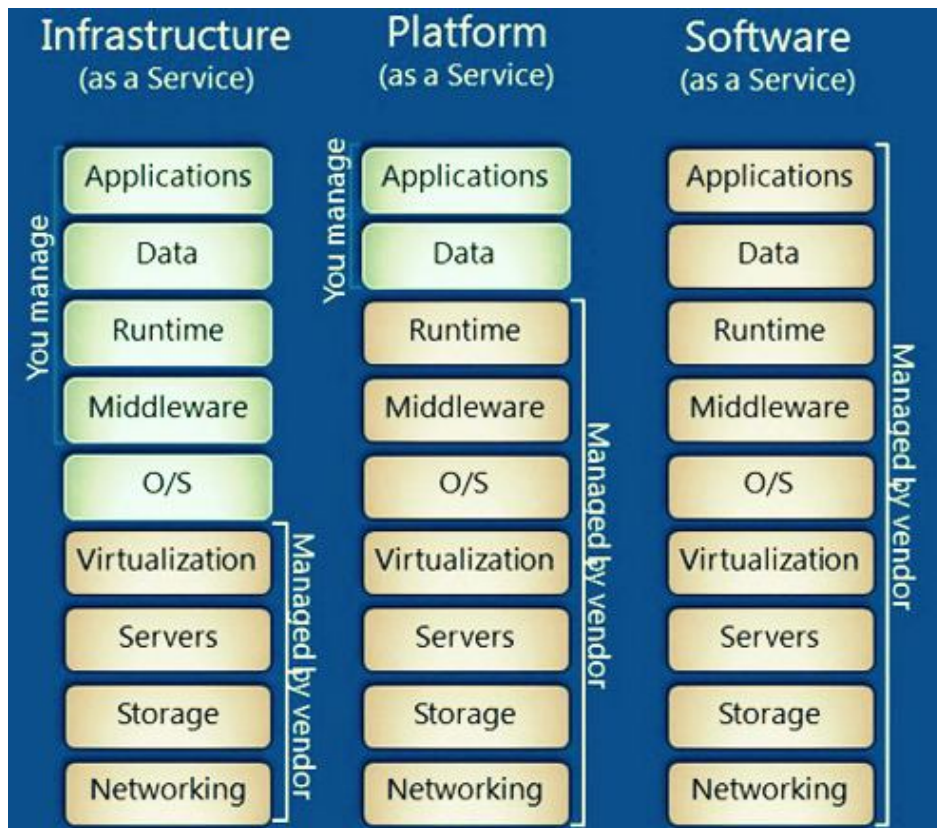


Fig 4: Chart showing simplified explanations for the three layers of cloud computing

In IAAS the customers can get servers, storage without caring about collocation, rental or data centers. Hence the cloud service providers are mainly responsible for the storage and resources, such as hardware and software.

In PAAS, the cloud provider should maintain the platform as they provide users with complete development environment to support the development lifecycle from design, implementation, debugging, testing and deployment. With PAAS an entire software environment can run at the service

provider while not worrying about the technology underneath it. The main advantage of PAAS is the cost saving in all the development cycle steps. PAAS providers allow cloud users to focus on the application development by reduction the cost resulted from the upgrading of platform.

In SAAS the customers do not need to keep or maintain any infrastructure or install the applications on every machine. They just need high network speed that enables them to access their applications normally by web browsers. Hence, SAAS is interesting for those companies who access software shared between multiple users. By using this model the responsibility only lies with the cloud provider for application maintenance.

IV. SUMMARY

In this paper we have discussed briefly about green cloud computing and an energy efficient software development in a cloud setup. Energy efficiency currently has a low priority, but increasing adoption of the cloud requires that cloud should be green as well. Cloud computing and green computing is combined and a cloud structure has been proposed. The approaches in SDLC stages those are energy efficient and can be helpful to develop more friendly platforms for the software related to sustainability has been described as well. The author suggested that to introduce the concepts of energy efficiency early in the SDLC ensures that it will be propagated throughout the SDLC phase's results in reduction of energy related expenses for later. Future work of the research needs to promote its work to make the computation, networks,

storage, and computer usage energy efficient as much as possible just like in a software development life cycle.

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