GREEN CLOUD COMPUTING FOR ENVIRONMENTAL SUSTAINABILITY


A Dissertation Presented


By


TIRUMALA CHIRANJEEVULU

B. Tech & M. Tech in Information Technology and M.B.A in Operations Management


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By


TIRUMALA CHIRANJEEVULU



Supervised by


Dr. Hemant Palivela




APPROVED BY



*Nihar Behera*
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Admissions Director

# DEDICATION

To my spouse Sridevi, daughters Nikitha & Deepthi

## Acknowledgements

I would like to thank my guide Dr. Hemant Palivela for supporting and helping me all through my thesis at whatever point I had questions. I am exceptionally grateful to have him as my mentor and would have chosen him once more in the event that I had to do it one more.

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As a update for myself, I continuously utilize my self-created witticism underneath to overcome and accomplish anything:

'With self-reason and teach, you'll be able accomplish what you want.'

ABSTRACT

GREEN CLOUD COMPUTING FOR ENVIRONMENTAL SUSTAINABILITY

TIRUMALA CHIRANJEEVULU

2024

Dissertation Chair:

Co-Chair:

Public and Private Cloud infrastructure is keep increasing considerably in datacenter electrical power consumption, which has become a serious issue. Datacenter energy use for cloud computing applications affects the environment and raises operating expenses. One major issue with the current trend of energy scarcity and climate change is the power consumption of datacenters. As a result, we need cloud computing solutions that respect the environment and use less energy. Elevated energy consumption leads to harmful carbon emissions and increased operating expenses, which reduce cloud providers' profit margins. Thus, energy saving solutions are very much needed to reduce cloud computing environmental effects. To improve such solutions, a comprehensive analysis of cloud computing's power efficiency is very much necessary.

With quick improvement and inevitable utilization of web and information advancement, Information Security has gotten to be the leading most challenging issues for various organizations. Security specialists and pros have been endeavoring troublesome to secure the computers, information and centralized orchestrate system. These security threats increase more when information is held outside the interior computing environment. Besides, IT businesses are as of late pushed by environment control to decrease the CO2 impression of information development system, era and shapes lines. Concurring to afterward experiences IT industry is able of making 4 % of carbon impression through their immense utilization of imperativeness.

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**CHAPTER 1:**

## 1.1 Introduction

This dissertation addresses the problem of energy consumption and energy cost minimization at the level of individual (local data center) and several geographically distributed Internet data centers (global data center) in order to attain carbon neutrality. For data centers, the dissertation develops software-based workload management plans that integrate server power control, energy buffering, and energy buffering. The focus is on publicly available Internet services and cloud-based enterprise private services from companies like Microsoft, Amazon, GCP, and others. An overview of the research challenges, their causes, answers, and contributions are given in this chapter.

To meet the growing demand, Tier3 and Tier4 datacenters are utilized, which combine hundreds of IT infrastructure components like servers, storage, data backup, high-speed networks, and information security systems. Large datacenters are operated by a number of well-known companies, including Google, Microsoft, Oracle, IBM, and Amazon. One definition of the commercialization of technological innovations that is still in use today includes computer systems that are offered as pay-as-you-go utilities. The availability of scalable IT infrastructure and services on demand is rapidly shifting from an ownership-based approach to a subscription-based one with the introduction of cloud computing. Users can store, retrieve, and share any amount of data on the cloud. They may focus on honing their core competencies by utilizing the many benefits of cloud computing, like on-demand computing resources and quick and inexpensive software development capabilities. Businesses that need to process large amounts of newly created data can also benefit from cloud computing's amazing computational capabilities.

According to analysis by IDC (International Data Corporation), Internet companies (Amazon, Google, Microsoft Azure, Netflix, Alibaba, PayPal, Salesforce, Server hardware suppliers (HP, IBM, Cisco), Storage equipment suppliers (EMC, NetApp), Telecommunications Services providers (AT&T, Verizon) and virtualization software (VMware, Microsoft, Oracle) expect global IT cloud investment to reach $1.3 trillion by 2025, reflecting a 16.9 percent compound growth rate (CAGR). Global aviation has an estimated carbon footprint of 730 tons of carbon dioxide equivalent (MTCO2), or 1.4 percent of global emissions,

and the sector uses 800 Terawatt hours (TWh), or 3.6 percent of global electricity. to act This percentage is expected to rise to 3.2 percent in 2025. As a result, the energy use and carbon emissions of cloud infrastructures are currently a major environmental concern.

According to a report published by the European Union, emissions must be reduced by 7.6 percent per year to keep climate warming below 1.5 degrees between 2020 and 2030, and by 2.7 percent per year to keep climate warming below 2 degrees. Today, the need for 25,000 square feet of physical space and 10 megawatts of power increases the operating costs of a typical data center. Cloud service companies prioritize lower electricity costs over lower carbon emissions. Because cloud computing is a new technology, there are significant questions about its environmental friendliness. Therefore, as shown in Figure 1, Green Cloud transformation initiatives are necessary without compromising service quality (efficiency, responsiveness and availability).

As a result, data center operators are under increasing pressure to reduce their energy use, costs and carbon footprint. In particular, environmental activists have encouraged data center operators to prioritize renewable energy sources in their energy needs. In addition, governments and organizations around the world, such as the European Union's Emission Trading System, impose regulations that limit carbon footprints and provide financial incentives for reductions.

One of the means to reduce the use of data communication innovation (ICT) vitality is the adoption of green cloud arrangements such as virtualization, computer organization, cloud computing, paper reduction, network communication framework, travel reduction and computer recycling. These Green Cloud efforts have many green benefits and are changing IT forms and frameworks to protect the environment. However, efforts towards viability, recovery, productive use of assets and electronic waste (e-waste), and IT changes can put the framework and data at risk if "Green Cloud" operations and arrangements are not reviewed for security. view as a result, this can affect the continuity of the store and its resources.

This proposal provides a written review of Green Cloud from an information security perspective. The purpose of the proposal is to find out how Green Cloud can be a security risk areas of focus on information security and threats in Green Cloud arrangements developed to

ensure natural security. In addition to the proposal, the vulnerabilities of Green Cloud solutions are highlighted. The thesis presents the security challenges of the Green Cloud, which aims at the goal of a secure Green Cloud. Although the proposal does not address any specific safeguards, it provides an opportunity for further research in this area. I agree that the proposal's work focuses on the curious and important area of Green Cloud security.
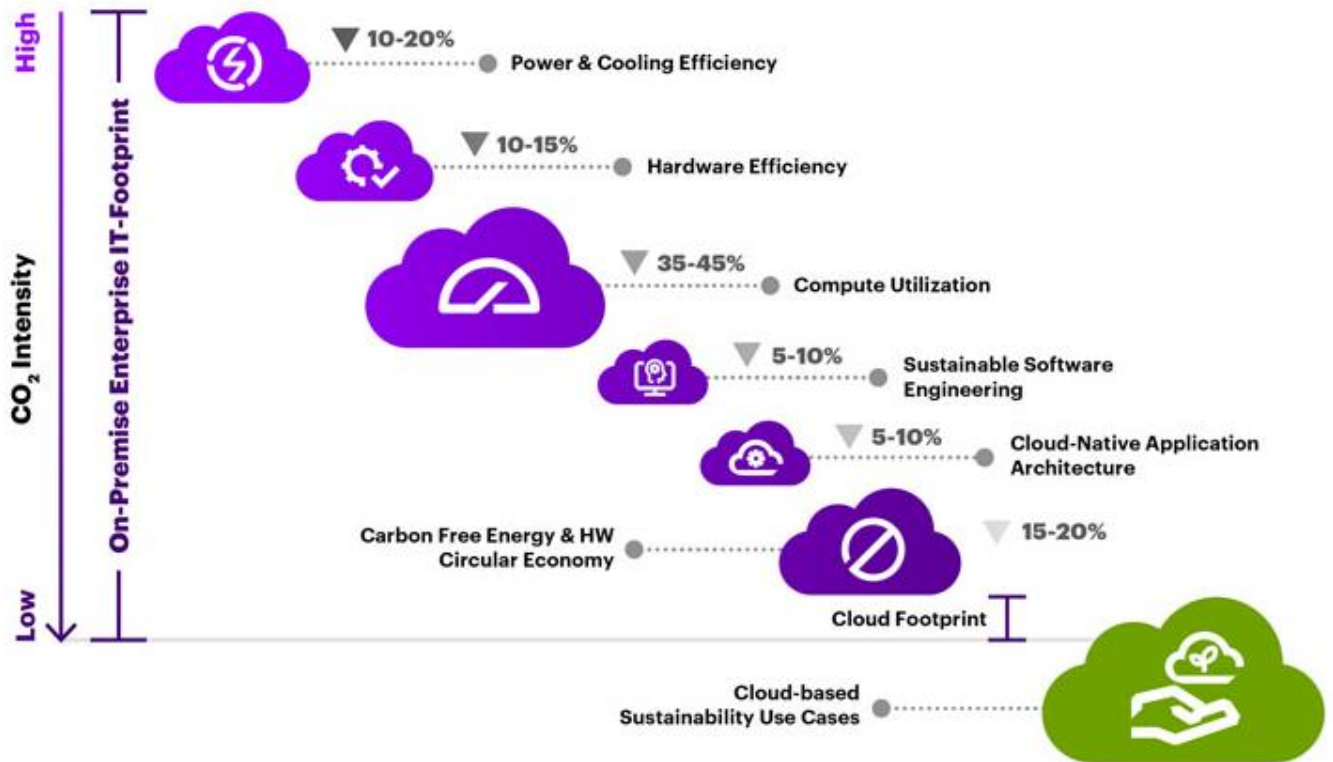


Figure 1: Carbon Emissions Reduction

1.1 Reason: There are many studies in the literature on the allocation of IT resources or the deployment of virtual machines, which consider the effectiveness of the cloud. For example, Yazir [24] developed virtual machine allocation strategies based on the system central unit power usage model to increase server utilization and reduce energy consumption. The proposed methods rely on the dynamic allocation of virtual machines at runtime, which reduces infrastructure energy consumption and maintains SLAs. On the other hand, Yin [25] suggested that energy usage metrics should be created for physical servers based on system processing units, I/O load, RAM, and network speed of virtual machines instead of using CPU power. However, the work of Lee et al. [26] discussed a heterogeneous, performance analysis based virtual machine scheduling algorithm that considers user requests

and server utilization. To determine the best distribution of virtual machines in servers, Zhao [27] combined the energy consumption model of physical machines with the performance model of virtual machines. In addition to energy consumption, they also consider load balancing, resource utilization, stability and reliability. A paradigm for deploying virtual machines has been developed that takes into account performance metrics, quality of service and information security standards and consumes less energy.

One of the arrangements to decrease the vitality utilization by Data Communication Innovation (ICT) is presentation of Green Cloud arrangements such as Virtualization, lean client, cloud computing, paper lessening, on-line communication framework, travel decrease and computer reusing. These Green Cloud endeavors have numerous green benefits and driving a alter in IT forms and framework for the assurance of environment. But the endeavors to diminish, vitality utilization, proficient utilization of assets and electronic squander (e-waste) and alter in IT may put the framework and data on hazard on the off chance that "Green Cloud" activities and arrangements are not surveyed from a Data Affirmation point of view. As a result, it can affect the coherence of commerce and its resources.

Today, data innovation is considered the heart of our personal and professional lives. Both our personal and business lives are extremely subject to data innovation and it is a real truth that life without data innovation is paralyzed (Sheep. J, 2009). In this way, organizations constantly engage in data innovation to develop and appreciate efficiency (Hu and Quan, 2006; Kohli and Grover, 2008) and use inventive innovation to achieve their high efficiency and competitive advantage. Be that as it may, this unexploited imaginative innovation additionally broadened the searchable and complex (Damanpour and Evan, 1984; Swanson, 1994; Tucker 2002). However, when organizations do not engage in innovation, they lose their publicity (Geisler and Kassicieh, 1997). In addition, IT has created natural problems and issues in waste transfer, utilization and production (Murugesan, 2008). The inevitable adaptation of information news therefore also has side effects on the environment. Awareness of this effect has attracted a prominent organization.

With the green cloud, data security (IA) and information security (IS) are exceptionally fundamental business prerequisites. To ensure the information framework (i.e. data security) of

any Green Cloud agreement, it is important to provide a level of assurance (i.e. data security) about the combination of security highlights and approaches and information security. For most organizations and businesses, their exclusive and sensitive data is an extremely necessary resource and its security is as important as securing the physical resource. In 2009, the Internet Complaint Center reported $559.7 million in losses due to cybercrime. Computer Security In more detail, it was found that in 2006, more than $52,494,290 worth of security problems hit businesses. (Esensten, 2011; Harris, 2010).

That is why it is increasingly important that information security is ensured in all forms of business. Nowadays, organizations realize that the misfortune of exclusive and customer information can damage the reputation of the organization (Russell and Gangemi, 1991).


Clearly Green Cloud has small to do with data security but in profundity it has solid connection between Green Cloud insurgency and data security concerns in IT industry (Grossman, 2011). Here is a conclusion from a master, Simon Mingay, inquire about bad habit president for Gartner says, a few of the companies may unconsciously giving absent data within the reports of their advance on natural issues (Green Cloud raises security fears, 2007). Other Green Cloud hones like portable computing and working from home present the hazard of data robbery and information security issues by moving the information exterior the neighborhood organize. Green transfer and paper diminishment too has security chance in case not legitimately carried out (Metzler, 2009).. Virtualization innovations and cloud computing brings their possess set of security dangers (Frangiskatos, Ghassemian and Diane, 2010). Typically, the objective of proposition to discover out how Green Cloud is emphatically associated to security and what are those security dangers related with green hones.


## 1.2 Goal

This research aims to identify ways in which green cloud practices and solutions can impact information security while supporting green benefits such as energy efficiency, cost reduction and carbon footprint minimization. This thesis is the result of a systematic literature review on the effects of Green Cloud implementation on information security. Therefore, the main objective of this thesis is to illustrate how green cloud paradigms and their inherent advantages can affect information security. The research focuses on the following area: (a) Green Cloud dimension and its holistic approach (b) Green Cloud initiatives

(c) Green Cloud from an information security perspective (d) The impact of green cloud practices on information security. The purpose of this study is to provide the public with information that will help Green Cloud solutions better protect data security.

## 1.3 Difficulties

Gartner research on Green Cloud shows that environment damaging issues, huge power consumption of IT and resulting higher CO2 emission, has developed the interest of IT industry towards the adoption of environment friendly use of IT approaches and operations. Large IT firms like IBM, Google, HP, Sun and other communication sector are implementing green plan and strategies. In May 2007, Gartner had predicted that 50% of medium and large IT organization in western Europe would declare a green imperative at the end of 2007 issues (Green Cloud raises security fears, 2007).

In this green movement, the security industry is critically analyzing the Green Cloud implementation. Some security firm's concern in going green, might reengineering the way we work, somehow compromise their fundamental operations or increase the security risk (The security industry's green legacy, 2011). Therefore, this analysis of security weakness and risk is very necessary to make sure that information and data is not under threat of any kind of malicious activities or because of poor implementation of Green Cloud processes.

The main Goal of this thesis to assess "Is Green Cloud threat to security?" by reviewing the current literature on green computing and its influences on Information Security with the idea of identifying security issues and leverage points (for future research) to improve information and business operational value in green computing. For the accomplishment of the Difficulties statement "Is Green Cloud threat to security?" can be will assess if further divided into smaller Sub questions:

How Green Cloud practices can impact the environments and What are the challenges in going green solutions?

## 1.4 Background and Reason

Thesis reason comes through the background which has been represented in Integrated Model;

Green Cloud from Information Security perspective. It shows that increase in $CO_2$ emission enables the Green Cloud and which motivates the Green Cloud solutions and Green Cloud implementation provides the green benefits which leads to decrease in greenhouse gas emission and lead to safe planet. But Green Cloud implementation could also have security threats, issues, challenges and vulnerabilities. These issues must need to be mitigated for a safe business. So both green benefits and Information Security should be combined at its best level to achieve the both goals of save planet and save business.
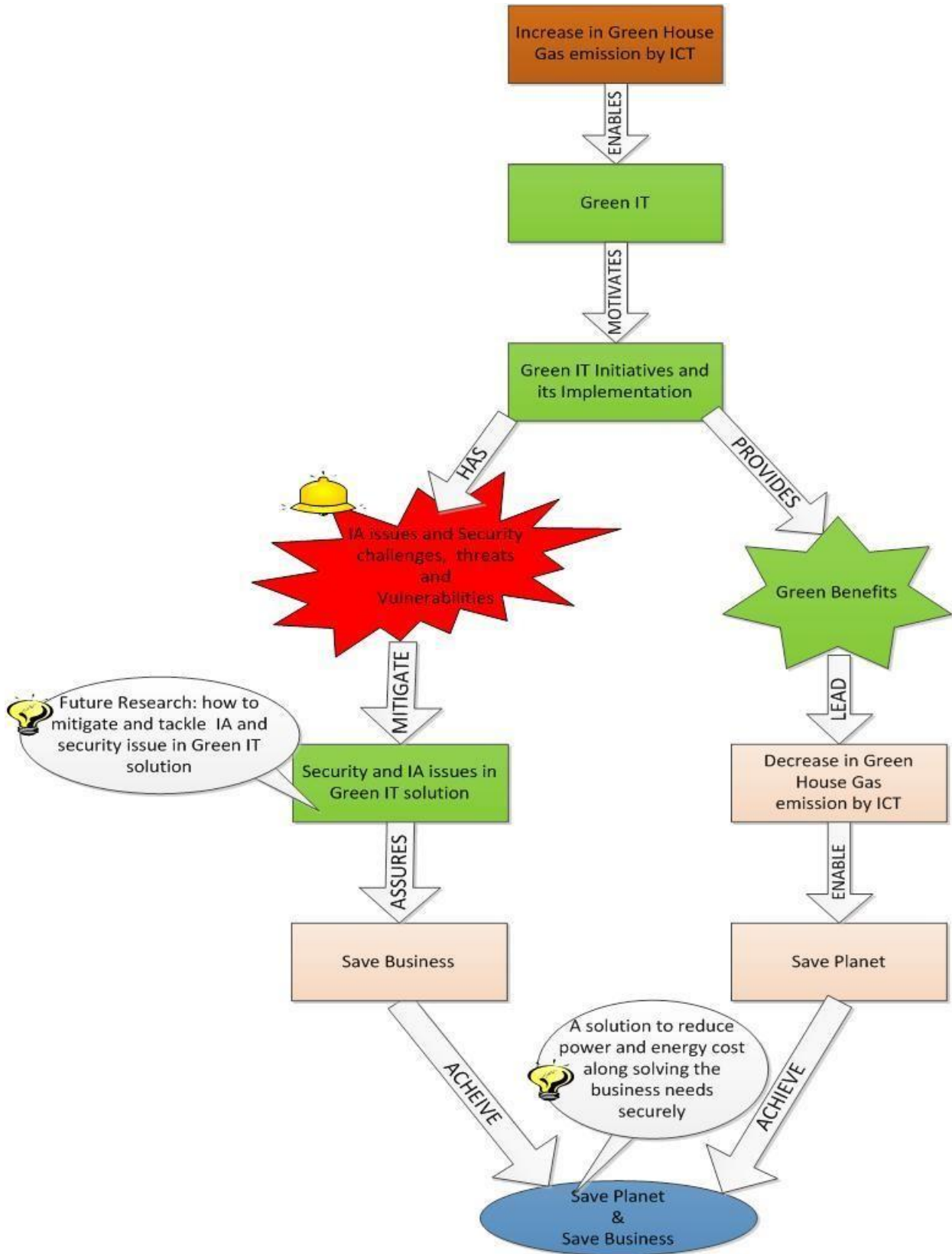
Figure 2: Green Cloud

1.5 Business Users

The study is written mainly for the IT business environment where Green Computing solutions are implemented and for those who are very concerned about information security. This research can make a significant contribution to the knowledge of Chief Information Officers (CIOs), Chief Information Security Officers (CISOs), Chief Information Security Officers and those who may be affected. This thesis is not done for the benefit of any particular organization.

1.6 Study Outcome

This study is Goal fully designed as a guide that briefly describes (a) Information Security aspects in Green Cloud solution (b) how Green Cloud can increase the information security threats and risks. The outcome of the study includes the security threats and vulnerabilities which give the reader with the idea of how green computing implementation can be made less vulnerable and secure, as a future work. The data analysis of literature review includes the security weaknesses and green advantages of Green Computing Technology. The derived data of the study, includes security weakness and risks, would be helpful for the IT companies to make the Green Cloud process information assured at a satisfied level.

After the introduction section, the remainder of this study is organized as follows. First, Section 2 is detailed description of the research design and methodology; how research work has been carried out. Section 3 gives the brief overview of Green Cloud, its dimension, its need and Information Security concepts and its facet in Green Cloud practices. Section 4 analyzes the different Green Cloud implementation to explore the security weakness, risks and challenges in each Green Cloud solution. Thesis concludes with a summary of the key findings and an outlook to further research questions.

# CHAPTER II:
# REVIEW OF LITERATURE

## 2.1. EFFICIENCY OF GREEN CLOUD COMPUTING

Modern data centers use the cloud computing model to host various applications on shared hardware platforms, from those that operate only for a short time (eg serving web applications such as e-commerce and social network portals for transients). workloads) to those that run longer (e.g. simulations or processing of large data sets) ). The need to manage different applications in the data center makes on-demand provisioning and resource allocation a difficult response to time-varying workloads. Most data center resources are statically allocated to applications based on peak load characteristics to maintain isolation and ensure performance. Until recently, data center deployments focused only on high performance, with little attention to energy use to meet these criteria. In addition to being expensive to run, data centers are also harmful to the environment. High energy costs and a huge carbon footprint are caused by the fact that these data centers have to use huge amounts of electricity to maintain and cool their many servers. With efficient processing and computing infrastructure, green cloud computing generally aims to use less energy. This is necessary to ensure the long-term viability of the rapidly growing cloud computing industry. If not, the power consumption of cloud computing, with its expanding front-end applications, large transaction databases, and devices connected to back-end data centers, would explode. To solve this problem, data center infrastructure resources must be effectively managed to support green cloud computing. To reduce energy consumption, cloud resources should be allocated primarily to meet the Quality of Service (QoS) provision required by the Service Level Agreement (SLA) of business users.

A Data Center could be a office built to house data innovation framework in- clouding servers, capacity frameworks and organize gear. Web benefit suppliers, and

enterprises utilize this office in arrange to supply secure and solid data innovation administrations such as putting away, preparing, and overseeing the information as well as professional- viding high-speed network-based applications. Data innovation operations are a pivotal angle of most organizational operations around the world. Subsequently, Data Centers are outlined in such a way that their long-term continuous operation is ensured. They utilize different repetitive or reinforcement methods in both computer program and equipment level to guarantee their unwavering quality. Encourage, they utilize a few air-conditioning controls and security arrangements to guarantee their warm security and security, separately.

Data Centers come in numerous sizes depending on their plan targets and functionalities. They run from little offices facilitating some computers without advanced control and cooling framework foundation to enormous offices facilitating hundreds of thousands of servers and advertising a assortment of cloud administrations. Little Data Centers are utilized locally by little endeavors such as colleges, while expansive scale Data Centers such as those given by Google, Amazon, and Facebook offer around the world online and cloud administrations. Assist, there are moreover a few Data Centers in between, i.e., medium Data Centers, such as those advertising facilitating administrations. This investigates centers on medium and expansive.

Computing servers are arranged in rows of racks with edge frameworks arranged in chassis in modern data centers. The hardware is arranged so that either front boards or back boards are facing each other in each route between two columns; this arrangement is commonly referred to as the hot aisle/cold walkway strategy. The majority of data centers make use of this cooling innovation, placing IT systems in a hot aisle/cold walkway configuration on an elevated floor. The elevated floor in the cold channels accentuates openings that allow cool air to enter the space; openings or other devices above the hot paths gather the heated air, which is transferred to the computer room air conditioner (CRAC).

The cooling framework's (CRAC) specified temperature should be more than enough

to prevent the computer nodes' temperature from rising above the manufacturers' recommended redline. In an ideal world, every hot topic would expressly return to the CRAC; but, in reality, certain hot topics do loop back to the computer servers. Because servers produce differently or receive different amounts of heat depending on their physical location, the room's warmth distribution is not uniform. This paper's configurations take warm distribution data centers into consideration.

Based on the aforementioned assumptions, this study proposes workload and server management strategies to maximize energy utilization, energy costs, and carbon emissions in cloud services. To achieve sustainability in the cloud, the studies consider the important components of energy and cost efficiency, i.e. carbon dioxide emission efficiency, cost efficiency and energy efficiency. It then manages the compromises associated with these elements and exploits their interactions.

The recurrent themes and assumptions in the answers are: The solutions are developed through the optimization of energy and cost management at the local and global data center levels. The optimization frameworks consist of models describing data center power supply and demand. The sources of the data center's power demand model are the workload distribution model, which accounts for performance requirements, and the power consumption model of the cooling system and servers. The power supply model has models for the grid, batteries, and on-site renewable power sources for data centers. The systems dynamically and periodically evaluate data center parameters (e.g., input workload) and make decisions about energy and cost management.

Framework is the primary source of control for data centers. The utility substation, which acts as the control's primary control source, allows the control to access the data center. The reinforcement of the control source is provided by other control sources. Specifically, in the event of a utility failure, a Diesel Generator Unit (DG) is typically employed as an additional source of reinforcing control. To automatically choose or switch between these two sources, an ATS (programmed exchange switch)

is used. The startup time of DGs is approximately 10-20 seconds, during which they must encourage to activate in order to provide control. Data centers use Continuous Control Supply (UPS) machines, which store energy amid control accessibility, to fill in this gap in time. The data center can be regularly controlled by UPS for ten to fifteen minutes. In data centers, UPSes are essentially installed centrally, with all IT equipment having access to their control [61]. In this configuration, a few Control Dissemination Units (PDUs) are encouraged to receive control from the UPS units. Transformers in the PDUs reduce the voltage and provide course control to a select few racks.

Some state-of-the-art data centers use distributed UPSs for servers or for groups of chassis [61]. The UPS will supply the PDU with power within the initial instance. In the emergency scenario, the UPS directly gives power to the server. Since the UPS in this instance does not need an inverter, control misery from mutilation is reduced. Nevertheless, this necessitates higher significant framework costs. The centrally associated UPS configuration is at the focus of the difficulties examined in this investigation. The alternative arrangements impact the number of option variables included and the numbers within the findings, but they do not change the nature of the issues, their arrangements, or the drift of the results. When using UPSes, there are a few causes of control waste, such as control misfortune from AC-DC transition and control waste associated with visiting, charging, and releasing UPSes. We do not contribute to the data center control framework design in this study, therefore we do not take into account the control wasteful aspects caused by the UPS's kind of transmission. We consider the energy-fetched minimum issues, where UPSes can be used to reduce the energy-fetched in addition to acting as a backup control source during a control blackout, by shaving off the top control request and power-fetched. The wasteful features of the UPS control that result from their charging and discharging are then taken into consideration.

Research in Design

A systematic effective literature review approach has been chosen to conduct this study because the goal of this study is similar to the goal of the literature review, filling the gaps of previous research work and extending preceding studies (Creswell,

2009, p. 25). Here it is necessary to give a brief explanation about literature review before applying it.

Literature review is much more then reviewing the collection of papers and previous research work. Hart (1998, p.1), defined, meaningful and effective review as "the use of ideas in the literature to justify the particular approach to the topic, the selection of methods, and demonstration that this research contributes something new" (Levy and Ellis ,2006, p.182). He further says that a high-quality literature review is deep and broad, rigor and consistent, valid and clear, effective and synthesize. It should not be a simple compilation of related material.

Research on green computing has been done to a very limited extent. Very few studies and news articles have reported information security risk as a difficulty for Green Cloud solutions (Green Cloud raises security mountains, 2007). Several Green Cloud solutions face security risks. This study examines and interprets previous literature to establish a link between green cloud and information security. The literature on various Green Cloud solutions and practices was analyzed to identify the hidden threat and security risk.

The methodology used in this study is a systematic approach to literature review based on the three-step literature review process guide for developing reliable and effective literature proposed by (Levy and Ellis, 2006, p. 182). The three stages of the literature review process consist of 1) literature review input 2) literature review processing and analysis 3) literature review output. The following figure provides an overview of the three-step guideline proposed by Levy and Ellis.



2. Processing

1. Input → 1. Know the literature 2. Comprehend the literature 3. Apply 4. Analyze 5. Synthesize 6. Evaluate → 3. Output
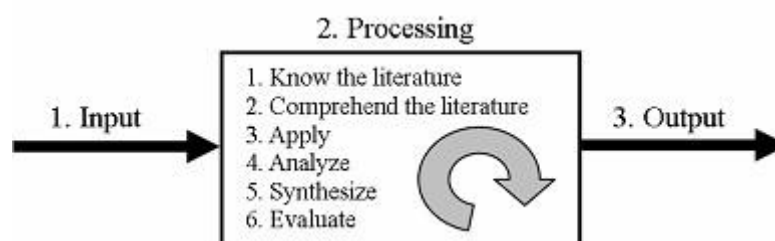
Figure 3: Stages of effective literature review

The thesis also complies with Webster & Watson's recommendations and guidelines regarding how to start an article, how to organize a review—such as the concept-centric approach to literature review—how to conduct research using backward and forward citation techniques, how to identify knowledge gaps in theoretical frameworks, and how to conclude (Webster & Watson, 2002, p.15-17). Levy and Ellis' recommended systemic approach has been chosen despite the fact that various literature review methodologies have been investigated. This is because their systematic literature review framework adheres to the standard data processing paradigm and is simple enough for beginner IS researchers and students to follow. The literature review is now a manageable undertaking thanks to the three-step process. Furthermore, Levy and Ellis have provided extremely helpful advice on how to handle the material seek for later on and how to study the literature. Levy and Ellis (2006) provided real-world examples of how to understand, apply, analyze, synthesize, and assess the literature.

## 2.1    Why Conduct a Literature Review

Before explaining how the literature has been conducted, it is necessary to justify why literaturereview has been chosen for this study. Literature review is conducted for variety of reasons, as follows:

2.1.1.1    The purpose of this thesis report is to improve the IT community's present comprehension of green cloud technology and its exploration's addition to the current Body of Knowledge (Levy and Ellis, 2008).

2.1.1.2    The IT community is made aware of the areas in which further study is needed and the information that is necessary by this literature review.

2.1.1.3    The methodology in literature review is selected to give overall evidence of the researchissues.

2.1.1.4    One of the reasons for doing literature review is to ensure the validity of the evaluatedresults.

2.1.1.5    Furthermore, literature review builds a strong theoretical foundation from available resources(See Table 1 for resources) which helps to explain the Difficulties with

strong arguments and reasons (Levy and Ellis, 2006).

2.1.1.6    The literature review is also used to establish a connection between the ideal solutions for green cloud computing and the real-world applications of the technology, as well as to validate the importance of the information security challenges in the cloud.

2.1.1.7    This method of reviewing the literature also aids in identifying recommendations for further study on how to improve Green Cloud security from an information security standpoint, as well as what safeguards should be put in place and extra cautions to be taken when putting the Green Cloud Literature Review Process into practice.

2.1.1.8    Because it guarantees that all pertinent literature on green cloud has been gathered, the systematic literature review was selected. When we are not discovering any novel concepts or ideas, one of the steps in the literature review process, called the literature input process, provides a very positive indication that the material has been gathered. According to Webster and Watson (2002), doing a systematic search should guarantee that a reasonably comprehensive inventory of pertinent literature is gathered.

## 2.2    Literature Review Input

This section describes how literature has been search and gathered, with the help of specific approaches and techniques, introduced by Levy and Ellis (2006).

Literature review input process is the foundation of a quality literature review which is deep and broad, rigor and consistent, valid and clear, effective and synthesize, not a simple compilation of related material (Hart, 1998). If literature input is wrong, or of low quality, impertinent or inappropriate then whatever the data analysis or evaluation method is used, a quality and validresult cannot be achieved (Levy and Ellis, 2006).

### Literature Resources

It is true that importance of past literature resources cannot be denied. The previous research work and studies helps the other researchers to take advantage of it while deriving the new knowledge.To take advantage of previous work, it is necessary to look for literature resources (See Table 1) because a literature from quality resource can be confidently referred in owns new concepts for various Goals for example, to give direction to the reader or to prove the validity of the study.

Table 1 is the list of databases, where the searching has been carried out. Important criterion for searching the relevant material inside and outside the IT/IS outlets, has been followed as discussed in the following sub section "Search Techniques", where searched keywords are searched in all fields including the full text.

**Table 1: List of Literature Databases**

| S.NO. | Literature Databases |
|---|---|
| 1. | Digital Lab - ACM |
| 2. | EBSC Host |
| 3. | ScienceDirect- Elsevier |
| 4. | Google Scholar |
| 5. | Comp Soc & Xplore- IEEE |
| 6. | ABI – INFORM |
| 7. | Sage |
| 8. | Springers |

**Research Parameter**

In order to gather manuscripts relevant to the subject matter, under investigation, followingdifferent high-level keywords of Green Cloud are used for searching which are as follows:

2.2.1.1 Green Computing

2.2.1.2 Green Cloud

2.2.1.3 Climate Saver Computing

2.2.1.4 Green Threat

2.2.1.5 Green Technologies

2.2.1.6 Going Green

2.2.1.7 Green Grid

2.2.1.8 Green Cloud threat to security

2.2.1.9 Green Cloud and Information security

Levy and Ellis (2006, p.190) and Webster and Watson (2002) suggestion, about the keyword search, has also been followed. Different keyword or phrase has been used to search the literature. Buzzwords has been avoided as a keyword that appear and disappear in the literature. Search technique is not stick to a specific keyword. Further techniques has been discussed in below sub heading.

**Search Techniques**

To achieve the high degree of literature quality, following search techniques has been followed:

2.2.1.10   Searching has been started from the Journals guided by Levy and Ellis (2006, figure. 2) andWebster & Watson (2002).

2.2.1.11   Selected conference proceeding compiled by (Levy and Ellis, 2006, figure. 3) has alsosearched for the applicable literature.The literature input has also been gathered from umber of literature database vendors.

2.2.1.12   Backward and Forward search techniques, (Webster and Watson; 2002 and Levy and Ellis2006) has been used.

2.2.1.13   Most the searched worked is carried out electronically. Except the few books which areborrowed from the library or some purchased articles.

**Search Result**

To represent the search result, the Webster and Waston's (2002) suggested table format has beenused.

Below Table 2 display the result for the eight literature databases (mentioned in Table 1) from high level key word of Green Cloud. In the eight literature databases 876 numbers of studies related to the Green Cloud were found. Of these 876, 43 literatures were practical screened (practical screening includes reading and reviewing. Skim reading has also been done but only for those articles which were found not related to thesis subject matter) and after  practical screening and out of which 7 were found in pure context of information security and assurance issues in Green Cloud .  The remaining 36 only discuss the Green Cloud and its dimension and different solutions in details.

After extracting the knowledge of different Green Cloud solutions from the remaining

36 literature studies, further research carried out to find out the Information Security issues in eachGreen Cloud solution. For that Goal each Green Cloud solutions is separately searched in context to security issues. Below from Table 3- display the result for the eight literature databases (mentioned in Table 1) for each Green Cloud solution in context to security issues.

## Table 2: Literature Databases

| Literature Databases | # of unique hitsfrom high level keywords | # of studies remaining afterthe practical screening | # of studies concerning Green Cloud in information security context | Studies concerning Green Cloud in information security context |
|---|---|---|---|---|
| ACM (Digital Lab) | 23 | 4 | 1 | 1 |
| EBSCOhost | 8 | 4 | 2 | Green Cloud raises security fears, 2008 |
| Elsevier (ScienceDirect) | 23 | 10 | 3 | Grossman, 2012 Arnfield, 20010 Goucher, 2011 & Gorge, 2009 |
| Google Scholar | 643 | 17 | 2 | Esensten, 2013 |
| IEEE (Comp Soc &Xplore) | 18 | 13 | 2 | 3 |
| ProQuest (ABI/INFORM) | 34 | 2 | 2 | 4 |
| SAGE | 178 | 2 | 4 | - |
| Springer | 45 | 8 | 3 | Frangiskatos, Ghassemian and Diane, 2010 |

| | | | | |
|---|---|---|---|---|
| **TOTAL** | **972** | **60** | **17** | |

**Table 3: Finding results for "Green Cloud Computing" from Literature Databases**

| Literature Databases | # of unique hitsfrom "Green Cloud Computing" | # of studies remaining after the practical screening | # of studies remaining afterthe practical screening in information security context | Studies in Information Security & security context |
|---|---|---|---|---|
| ACM (Digital Lab) | 25 | 4 | 3 | Ristenpart, 2010 |
| EBSCOHost | 3 | 1 | 5 | |
| Elsevier (ScienceDirect) | 114 | 4 | 3 | Zissis and Lekkas, 2011 ;Svantesson & Clarke,2011; Li, 2012; Lombardi, 2012 |
| IEEE (Comp Soc &Xplore) | 36 | 14 | 8 | Sabahi, 2011; Kaufman, 2008; Greer, 2011; Chakraborty, 2018; Ren,2016; Carroll. M, Kotzé & Paula, 2015 |
| ProQuest (ABI/INFORM) | 4 | 1 | 4 | |
| Springer | 13 | 1 | 4 | |
| **TOTAL** | **195** | **25** | **29** | |

**Table 4: Search Result for "Network computer" from Literature Databases**

| Literature Databases | # of unique hits for "Network computer" in Green Cloud context | # of studies remaining after the practical screening | # of studies remaining afterthe practical screening in information security context | Studies in Information Security & security context |
|---|---|---|---|---|
| ACM (Digital Lab) | 44 | 1 | 3 | |
| EBSCOHost | 3 | 3 | 1 | |
| Elsevier (ScienceDirect) | 15 | 3 | 5 | Marc Hocking, 2011; Vlissidis, 2010; |
| Google Scholar | 18 | 3 | 4 | Intel Information Technology, 2010; |
| Springer | 15 | 3 | 4 | |
| **TOTAL** | **95** | **16** | **17** | |

**Table 5: Search Result for "Virtualization" from Literature Databases**

| Literature Databases | # of unique hitsfor "Virtualization" In Green | # of studies remaining after the practical screening | # of studies remaining afterthe practical screening in information | Studies in Information Security & security context |
|---|---|---|---|---|

| | Cloud context | | security context | |
|---|---|---|---|---|
| ACM (Digital Lab) | 13 | 7 | 3 | Ray, 2009 |
| Elsevier (ScienceDirect) | 86 | 6 | 5 | Li, 2011 |
| Google Scholar | 13 | 7 | 4 | Reuben, 2007; Chaudhuri, 2011; Williams, 2010; Rhodes, 2005 |
| IEEE (Comp Soc & Xplore) | 46 | 15 | 7 | Carroll. M, 2011; Mahalingam, 2008; Karger, P.A, 2008; Cleeff,2019; Sahoo, 2010; Vaughan-Nichols, 2018; |
| **TOTAL** | **158** | **35** | **19** | |

**Table 6: Search Result for "Computer Recycling" from Literature Databases**

| Literature Databases | No of unique hitsfor "Computer Recycling" | No of studies remaining afterthe practical screening | # of studies remaining afterthe practical screening in information security context | Studies concerning Green Cloud in information securitycontext |
|---|---|---|---|---|
| EBSCOHost | 54 | 4 | 3 | Smits & Cain, 2010; Hope, 2007; Liam, |

| | | | | 2008; Dubie, 2019; Filipek, 2007 |
|---|---|---|---|---|
| Elsevier (ScienceDirect) | 32 | 16 | 6 | Hinde, 2004; Jones, 2006; Jones, 2005; Jones, 2009; Jones, 2006; Mathieson, 2007; Nicho, 2003; Jones, 2009 (December) |
| IEEE (Comp Soc &Xplore) | 16 | 5 | 4 | Bennison & Lasher,2004 |
| Springer | 25 | 5 | 9 | Venter, 2008; Kwon,Lee & Moon, 2007 |
| **TOTAL** | **127** | **30** | **21** | |

**Management of Literature Review Input**

After searching the literature review input, the second daunting task is to manage the gathered literature for data analysis and evaluation. All electronically searched literature is primarily separated according to their subject matter. Different electronic folder was maintained, to keep the same subject matters aligned. This management technique helps me to look only into that folder which I required for literature analysis and writing.

# CHAPTER III:

# METHODOLOGY

## 3.1 Data Analysis Plan

Searching of relevant literature is certainly necessary part of the literature review but it is not enough to obtain the desire results. For the accomplishment of new theory and ideas, analysis and evaluation of the gathered data is also needed (Levy and Ellis, 2006).

The data analysis process involves series of steps which provide the researcher plan to extract the relevant concept and meaning in their research work. Webster and Watson (2002) " A review succeeds when it helps other scholars to make sense of the accumulated knowledge on a topic".

There are many theories available regarding the literature analysis process. This study is analyzed according to the guidelines recommended by Levy and Ellis (2006) i-e, know the literature, comprehend  the literature, applying the literature, analyze the literature, synthesize the literature and evaluate the literature which has been explained later in the section. This study also follows the suggestion of Creswell (2009), of organizing the literature into segments or theme based  on common categories, then process of bringing information  is  applied. Here themes  mean  three areas of Green Cloud dimension covering, Green design, Green use and Green disposal. So, the theoryof organizing data into themes is applied on Green Cloud dimensions where different Green Cloud approaches and solutions are analyzed separately one by one. The literature review flows like as shown in the below diagram, increase in greenhouse  gasemission enables the Green Cloud, Green Cloud motivates the Green Cloud solutions and its implementation which provides the green benefits lead to decrease in greenhouse gas emission and save the planet.
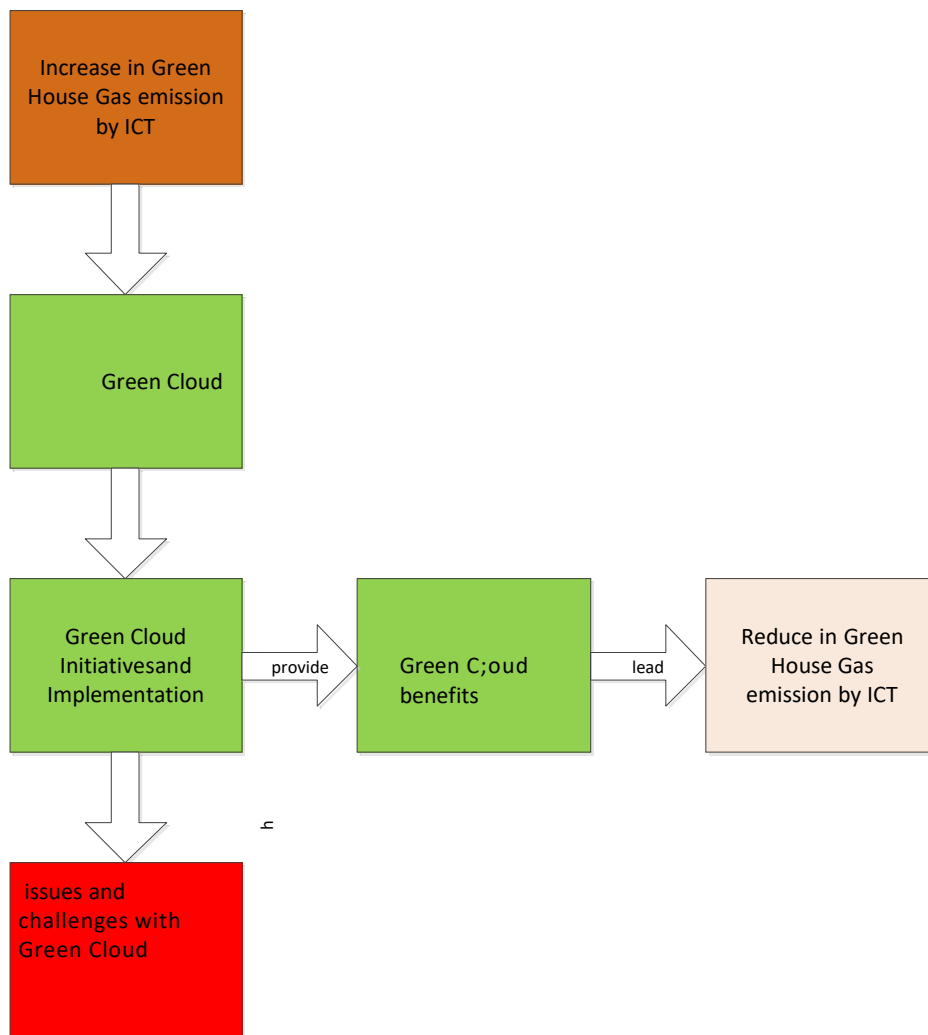
**Figure 4: Green Cloud combined View**

Literature analysis plan selected for this study, involves process of know the literature, comprehend the literature, applying, analyzing, synthesizing and evaluating the literature (Levy and Ellis, 2006).defined below:

Know the literature: means, analyze the literature which demonstrate that researcher has extracted meaningful information from it (Levy and Ellis, 2006, p.193). For example: Thesis has identifiedthe Green Cloud solutions having the information security issue.

Comprehend the literature: means, not repeating the article but reporting the significance and meaning of it(Levy and Ellis, 2006, p.193). For example, thesis has highlighted the importance of Green Cloud and security by comprehending literature

Applying the literature: means, classifying and demonstration activities (Levy and Ellis, 2006, p.199). For example, security issues have been discussed under the classification of

Green Cloud dimension.

Analyze the literature: means separating, connecting, comparing and selecting and explaining activities. For example, Thesis connects the Green Cloud with information security by finding  the security issues in Green Cloud solutions by selecting and explaining them.

Synthesize the literature: means, combining, integrating, modifying and rearranging, decomposing and generalizing activities. Above Integrated view model: Is Green Cloud threat to security and Integrated view model: Green Cloud from IA and Security perspective has been obtainedfrom synthesis activities

Evaluate the literature: means, assessing, deciding, selecting, judging, explaining, discriminating,supporting, and concluding activities. For example, Integrated model: Green Cloud from IA and Security perspective has been obtained from evaluation activities

### 3.1.1  Writing Plan

After literature input and analysis, the third critical part of literature review study is presenting the results derived from the data analysis. Successful literature review writing must be clear, logically structured around a central topic to reveal the key findings (Hart, 1998; Webster and Watson, 2002).In order to accomplish a good piece of writing, theme-based literature analysis and writing is conducted, inspired from work of Esensten (2011), which produce the theme centric results and outcome.

Selected areas of the study include current research in the field of Green Cloud, Security and Green Cloud and Green Cloud initiatives and methodologies. The results are presented in categories of different Green Cloud initiatives.

The theoretical framework investigates about the Green Cloud, the importance of Green Computing in IT industry and companies interest in Green Cloud. This section provides the reader the general information about the Green computing. How Green Cloud can help to protect the environment.Selected literature points out the different dimension of Green Cloud.

The section empirical setting and data relates the Green Cloud with IA and security. Give an overviewabout IA and IS.

The Analysis talk about the each Green Cloud approaches like Green design of IT system, Green manufacturing of IT system, Green use of IT system and Green disposal of IT system. This section explores the threats and vulnerabilities in each Green Cloud sector.

Moreover, to tell the reader, how I have extracted the main points and idea from literature after analyzing it and how and why I have assemble and assimilated the particular past research knowledge into my research work, a sound arguments adopted has also been followed (Levy and Ellis ; 2006, Figure 20, Hart, 1998).

Unfortunately, very few much of the work has been available on the current emerging threat of information security in Green Cloud processes and people are unaware of risk by going green in unsecured manner so to prove the credibility and validity of the research, theory of argument approach (Levy and Ellis; 2006, Figure 18 and 19) has also been adopted for proper development ofarguments.
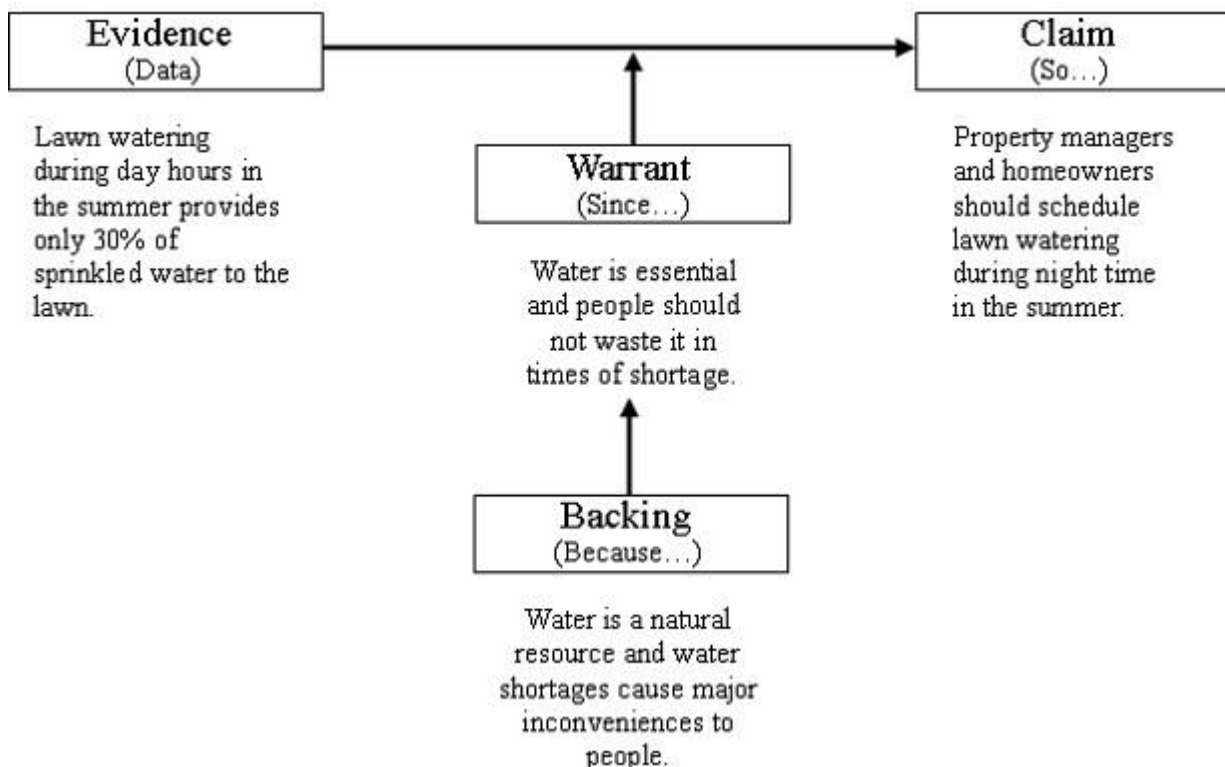


**Figure 5: Theory of Argumentation**

# CHAPTER IV:

# RESULTS

## 4.1 Theoretical Framework Results

The hypothetical system explores approximately the Green Cloud, the significance of Green Computing in IT industry and companies intrigued in Green Cloud. This area gives the peruser the common data around the green computing. How Green Cloud can offer assistance to secure the environment. Chosen writing focuses out the distinctive measurement of Green Cloud.

4.1. GREEN COMPUTING CAPABILITY OF CLOUD FEATURES

Lower carbon emissions are projected with cloud computing because of the energy efficient architecture and reduction in the footprint of the IT infrastructure with multi tenancy. The IT shared services model with virtualization concepts is a method for creating energy efficient Clouds that offers a significant improvement in the energy efficiency of Cloud providers. Virtualization is the technique of presenting a logical division or subset of computing resources in order to enable access to them in ways that are more favorable than the initial configuration Consolidating idle servers into several virtual machines (Virtual Machines) that share the same physical server and run at a greater utilisation rate allows businesses to realize significant cost savings in terms of space, maintenance, and energy.

4.2 Flexible Provisioning: Resource overprovisioning happens for a number of reasons, including the need to provision infrastructure cautiously in order to guarantee service availability and maintain a certain degree of service quality for end users, which leads to underutilized resources. In particular, frontend web apps demonstrate this. Such circumstances can be simply handled by cloud infrastructure. The virtual machines in a cloud infrastructure can be live relocated to another host if a user application requires more resources. The companies that offer cloud services monitor and predict demand and allocate resources accordingly. It is possible to consolidate applications on one server that don't require as much resources. In contrast to the cautious strategy of over-provisioning,

datacenters always maintain the active servers in accordance with current demand, which results in reduced energy usage.

In specific, non-thermal-aware server and workload solidification plans may cause cooling computing control tradeoff which is additionally seen by the related work [44]. Be that as it may, the existing thinks about are performed for a specific setting of Data Centers i.e., performing recreation or observational considers for a given Data Center warm profile and a given servers control proficiency. Given a wide extend of control proficiency for Data Centers, we ponder the questions of beneath what circumstances of Data Centers control effectiveness, a non-thermal-aware server union arrangement causes cooling computing control tradeoff and how to dodge such a tradeoff. We plan theoretical models to portray the control effectiveness of non-thermal-aware server union arrangements and give worst-case examination of the effect of a non-thermal-aware server con- salivation arrangement on the cooling and on the computing vitality. Such a procedure makes a difference Data Center administrators to choose on their server solidification arrangement. We hide- ther think about thermal-aware server and workload union arrangements to optimize the Data Centers add up to vitality utilization and guarantee maintaining a strategic distance from cooling computing control tradeoff. The existing thermal-aware planning calculations for Web data centers are heuristic within the sense that they are either based on reenactment ponders or don't give ensure on their optimality and maintaining a strategic distance from cooling-computing control tradeoff.

4.3 Multi Tenancy: Using a multi tenancy strategy, the architecture of cloud computing reduces overall energy usage and associated carbon emissions. Technologies as a service (SaaS) suppliers offer their services to many enterprises using the same infrastructure and software. This approach undoubtedly consumes less energy than numerous instances of software operating on different infrastructure. Multi tenancy on a single server also makes it possible to flatten the overall peak demand, which might lessen the need for extra hardware because enterprises often have highly variable demand patterns. The forecasting is better and the energy savings are greater the less irregular the demand.

4.4 Server Utilization: On-premises infrastructure typically operates with very low usage, occasionally falling as low as 5 to 10 percent of average utilization. Utilization rates of up to 70% are possible when using virtualization technologies to host and execute different

programs separately on the same server. As a result, it significantly lowers the number of active servers. Although servers running at high utilization require more electricity to operate, they can handle more workload with the same amount of power.

4.5. Efficiency of Datacenters: The power efficiency of Datacenters has a substantial impact on the overall amount of energy utilized by cloud computing. By utilizing the most energy-efficient technologies, cloud service providers can significantly boost the Power usage effectiveness of their Datacenters. Large cloud service providers can achieve the necessary Power usage effectiveness values of less than 1.2, or around a 40% power decrease over traditional datacenters. Modular server containers, water or air cooling, and advanced power management strategies including power supply meeting and measurements alarm methods have significantly increased the efficiency of power utilization in datacenters.

# CHAPTER V:
# DISCUSSION

## 5    Green Cloud Discussions

During recent years, world's climate is changing and resulting disaster Difficulties due to the excessive emission of $CO_2$, it has been accepted that $CO_2$ emission is the major cause of global warming and weather changes (Murugesan, 2008). But if we ask the people about what kind of organization are most often polluters of the environment and cause of $CO_2$ emission, majority of thepeople say the chemical industries. People don't think that the IT offices are also the part of the polluter groups. All our desktop PCs, servers, switches and data centers uses electricity and huge amount of electricity is used for cooling of it equipment (Murugesan, 2008). This huge amount of electricity not only cost money but  also generated from fossil fuel, coal and oil  which release carbon dioxide and generate more greenhouse gas emission, polluting the atmosphere (Murugesan, 2008). Furthermore, the e-waste and recycling of the electronic equipment also impact the environment. Gartner 2007 research estimated that IT accounts for over 2% of global $CO_2$ emissions and now it has reached to 3% (Frangiskatos, Ghassemian and Diane, 2010 &

Gartner 2007)—roughly the same amount as generated by air travel (Daly & Butler, 2009). So, today IT hasleveraged our both daily and business life but also proven to be Difficulties for environmental sustainability. Now organizations of all sizes have realized the danger to environmental sustainability and facing the dual challenge of increase computing capabilities along with the cost reduction and environment friendly practices (Scaramella and Healey 2007). To meet this dual challenge organizations are approaching and investing in Green Computing practices by maximizing the efficient use of computing resources to minimize environmental impact and its proper disposal.

Now understand, what does it mean by Green? Being Green means different things to different people. If we ask the number of Chief information officer (CIO) about "Being Green", every CIO will answer differently in respect to their organization. Some would say being green means to buying a technology that's more energy efficient, some would say reduce amount of electricity consume by data center, other would say buying hardware which are environment friendly (Lamb,2009). Being Green also means proper disposal and recycling of hardware. Virtualization is also considered as Green computing solution. Some would say, practice of using computing resources more efficiently while maintaining or increasing overall performance. In others opinion being green means adopting the all ways which can minimize the environmental impact with market growth opportunities. All CIOs are right in defining how to become Green, because Green Cloud is a vast subject and it is the combination of all above objectives (Lamb, 2009).

Although Green Cloud is becoming most popular and wide spreading technology among organization. However, there is lack of standardized universal definition of Green Cloud because of its vastness in subject matter.

"Green Cloud" is multi-faceted and encompasses the manufacturing and purchasing of energy efficient IT equipment, the efficient operation and utilization of hardware devices, as well as its proper disposal" (Murugesan 2008).

"Green Cloud is also about the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems (monitors, printers, storage devices, etc.) efficiently and effectively with minimal or no impact on the environment" (Murugesan, 2007).

Li and Zhou alluded a really point by point explanation of it, "Green computing may be a worldwide concept that involves framework design, framework computer program, parallel and conveyed computing and computer arrange. It points to decrease the control utilization of computer frameworks, give high-efficient, reliable and unavoidable administrations, and accomplish the objective of moo control of IT frameworks. Green computing too endeavors to develop a modern energy-awareness computing framework, inter-networking environment and computing benefit offices, bolsters the unused kind of computer design and computing worldview like cloud computing, and gives a low-power computing environment for personalized and differentiated data service" ( Li & Zhou, 2011).

The Green Cloud definition (also known as Green Computing) which has been extracted from the literature study and will be reflected throughout in thesis work is:

"Green Cloud comprised of activities, procedures, arrangements and data innovations that decrease the natural effect of IT by pointing to, decrease the control utilization of electronic hardware, sparing vitality, effectively utilize of asset utilization, space diminishment, decrease in equipment gear, diminish paper utilization, diminish voyaging, reusing, restoring and reusing computers and more vitally cash sparing & taken a toll decrease. For case, arrange computer, Cloud Computing, Virtualization, Paper lessening, versatile computing, travel decrease and computer recycling".

**Data Collection Strategy and Significance in my research area:**

Data centers are now essential to the efficient flow of information in our increasingly interconnected world. They are the data processing giants that manage the enormous amounts of data we produce every second. Beneath their ease and effectiveness, though, comes a startling fact: data centers are significant emitters of carbon dioxide. According to estimates, data centers use a startling 3% of the world's electricity and contribute roughly 3.7% of greenhouse gas emissions worldwide. As our reliance on the internet grows, these numbers are predicted to rise. Data centers use between 200 and 250 terawatt-hours (TWh) of electricity a year, to put this into context. That is the same as all of Sweden's yearly electricity use and the carbon emissions that the aviation sector produces.

## Data Center Cost And Carbon Footprint

| Server Electricity Consumption | Security, Site Management & Maintenance | Cost Per 1,000 Servers Per Year |
|---|---|---|
| **0.150** kW / Hour | **20K$** Per Rack / Year | **860,000$** |

**Cooling Per Server**
**0.120** kW / Hour

**100K$** 1 Person Per 1K Servers Per Year

**Average Yearly Carbon Footprint**

**Electricity Costs**
**0.12$** Per kW / Hour

**CARBON FOOTPRINT IMPACT**

| COAL | NATURAL GAS | PETROLEUM |
|---|---|---|
| **2.21** | **0.92** | **2.11** |

CO2 Emissions Pounds Per kWh

| COAL | NATURAL GAS | PETROLEUM |
|---|---|---|
| **5.2M** | **2.17M** | **4.9M** |

CO2 Emissions Pounds

This is where things really become serious. Our future is in danger because of this increase. Experts predict that by 2060, we will run out of these valuable resources if we keep burning fossil fuels as if there's no tomorrow—quite literally. These massive facilities mainly rely on fossil fuels due to their sheer size and energy requirements, which is bad news for the environment. This significant energy requirement is a result of redundant infrastructure, cooling systems, and continuous server running. The results are obvious: a significant amount of greenhouse gases is emitted into the atmosphere, posing a threat to future generations.

Achieving a net zero future is firmly in the spotlight amidst the pressing worldwide push for sustainability. Green cloud computing provides a ray of hope in this crucial endeavor, changing the way we approach the utilization and harnessing of digital resources. Green cloud computing seeks to reduce the carbon footprint and overall environmental effect connected with data centers and IT infrastructure by utilizing cloud computing technologies and services in an energy-efficient and ecologically sustainable manner. It creates the conditions for a future in which environmental harm is reduced and the goal of reaching net zero reality becomes a reality by implementing eco-friendly activities, optimizing resource usage, and consuming less energy.

Research has indicated that moving to the cloud can result in up to 87% less IT energy

used. This astounding figure demonstrates the enormous potential we have to drastically lower our energy footprint by using cloud-based solutions.


Moving to the cloud can save up to 87% of IT energy

By moving **86 million** U.S. office workers to the cloud — we would use up to **87%** less energy. That's enough to power **Los Angeles** for 1 year.
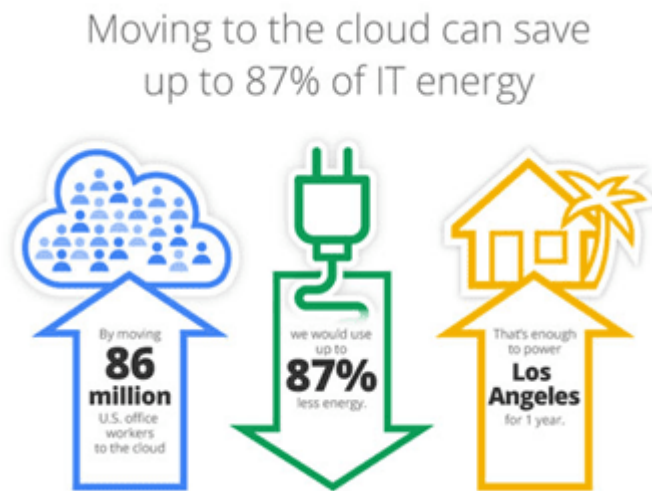
**The top five influential tactics that are redefining cloud computing for green environments and paving the way for carbon emissions to reach net zero:**



Unlocking the Potential of **Server Virtualization** — Embrace the Power of **Renewable Energy** — Unleashing **Energy Efficiency** Innovations — Consolidation for a **Sustainable Future** — Responsible Data Lifecycle Management

- Unlocking the Potential of Server Virtualization: Offering several benefits, server virtualization is embraced by green cloud computing as a fundamental approach. Virtualization enables servers to reach extraordinary utilization rates of 60–80%, resulting in previously unheard-of energy savings of up to 80%. Research has shown that virtualized settings have enormous potential and can outperform their non-virtualized equivalents.

- Accept the Power of Renewable Energy: Using renewable energy sources is essential to achieving environmental sustainability. Pioneering companies such as Microsoft are spearheading the initiative by pledging to run their data centers entirely on renewable energy. Microsoft accomplished a noteworthy accomplishment in 2020 when it reached a 100%

renewable energy usage rate. This remarkable accomplishment highlights the transformative power of adopting renewable energy and provides a model for others to follow.

- Unleashing Innovations in Energy Efficiency: The foundation of greener data centers is energy efficiency. Data centers can save a significant amount of energy by upgrading their infrastructure and applying energy-efficient designs. For example, Google's power use effectiveness (PUE) rating of 1.10 indicates that they operate with unprecedented efficiency. This outstanding achievement highlights the enormous scope for improvement within the business when compared to the PUE average of 1.67 for the industry.

- Consolidation for a Sustainable Future: Virtualization and cloud migration-driven data center consolidation provides a sustainable way to save expenses and energy usage. The Federal Aviation Administration (FAA) of the United States is a prime example, having reduced the number of data centers from 23 to 2. This consolidation initiative demonstrated the observable advantages that can be attained through strategic optimization, resulting in yearly energy savings of almost $15 million.

- Responsible Data Lifecycle Management: Data lifecycle management is a major focus in the field of green cloud computing. Cloud service providers take care of recycling and disposing of hardware appropriately, making sure that electronic waste is handled in an ecologically friendly way. By adopting sustainable methods, the negative effects on the environment are reduced. According to a thorough analysis conducted by the prestigious McKinsey Global Institute, green cloud computing could prevent an astounding 629 million metric tons of carbon dioxide emissions by 2025.

## 5.1 Why Green Cloud required

Nowadays, the shopper of computer world has quickly expanded and the costs of electronic thing has been diminishing radically and coming about within the development of commerce IT framework, innovation and quick development of Data Centers. Inevitably in close future IT trade, electronic gear and information middle and will gotten to be one of the biggest natural concern within the world.

Daly and Butller (2009), speak to the collected measurements and rates of IT commitment on natural affect. In 2008, it was evaluated that the overall sum of power devoured over all segments in Europe would develop at yearly rate of 2%. Whereas, inquire about by McKinsey (2007) anticipated, vitality utilization by computers and IT in common is anticipated to develop at an yearly rate of around 3% to 2030—much higher than the generally slant. Moreover, vitality seriously computing, web communication and Data Center are getting to be the speediest developing vitality utilize segment. Agreeing to a 2011 Stanford University/New York Times consider, Data Centers comprised 2 percent of U.S. power utilization in 2010 — a 250 percent hop since 2000 — and expanding appropriation of domestic gadgets counting computers and smartphones are driving up household vitality utilization at the same time (Union to spare vitality, 2011). Concurring to the report given by US Division of Vitality (2009), Data Center vitality utilization has been multiplied from 2000 to 2006, coming to more than 60 billion kilowatt hours per year and the anticipated number of vitality utilization would twofold till 2011. The Natural Security Organization (EPA) speak to the past and anticipated vitality utilization of Data Center from 2000 through 2006 with different scenarios portraying proceeded development through 2011 (US Division of Vitality, 2009).
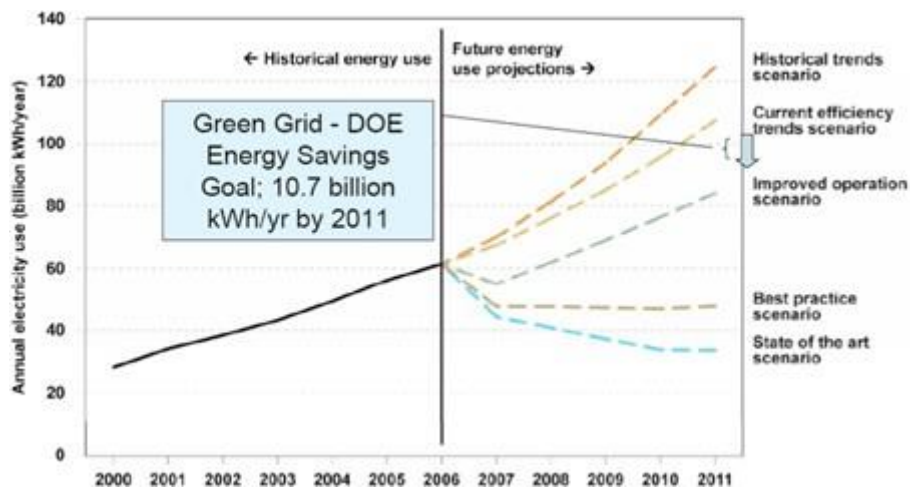


**Figure 6: Energy consumption in Datacenters**

On the other hand, IT hardware and equipment constitute the extreme natural affect from its generation to transfer stages. Amid the fabricating prepare of computers and servers, it

expends the power and at the conclusion of their life, they produce the unsafe fabric which affect the environment.

Due to the over quickening issues and Challenges of IT, Green Computing is getting to be most the promising and empowering innovation in IT industry and is broadly spreading among IT commerce and businesses, government segment and investigate establishing ( Li & Zhou, 2011).

5.2 Green Cloud Benefits

Data Tech investigate has summarized the benefits of Green Cloud in graphical shape as takes after. The person Green benefits of each Green Cloud arrangements will be advance illustrated in segment

**Over 60% of companies successfully realize benefits from Green IT**

■ Very Important Implementation Driver   ■ Successfully Realized

| | Very Important Implementation Driver | Successfully Realized |
|---|---|---|
| Decrease electricity use | 57% | 64% |
| Decrease consumables use | 57% | 66% |
| Increase features and functionality | 53% | 68% |
| Decrease other expenses/investments | 51% | 59% |
| Meet customers' demands | 49% | 68% |
| Realize utility / government rebates | 44% | 65% |

Figure 7: Green Cloud Implementations Factors

Organizations Interest in Green Cloud

Presently Green Cloud is getting to be the require of IT industry. Agreeing to Gadatsch (2011), 60% of the companies have received Green Cloud activities in administration portion. The overview too uncovers that Green Cloud hones are demonstrated to be fetched sparing and incredible victory was accomplish within the administration of datacenter and computer program (cloud computing). Noteworthy venture and assets have been seen in by the IT merchants to create vitality proficient servers, unused fabric plan and transfer of ancient computers. The Monster companies such as HP and Microsoft are

advertising the Green Cloud arrangements, methodologies, exhortation and green computer reusing (Glut, 2008) In any case, Daly and Butller (2009) said that IBM contends that still most of the organization isn't taking after the Green Cloud procedures and hones. Indeed, the a few of the companies has presented unused word related profile such as "Chief Supportability Officer", to be learned a capable in all issues related to Green Cloud and arrange among the all exercises within the company (Daly and Butller, 2009 & Pig out, 2008).
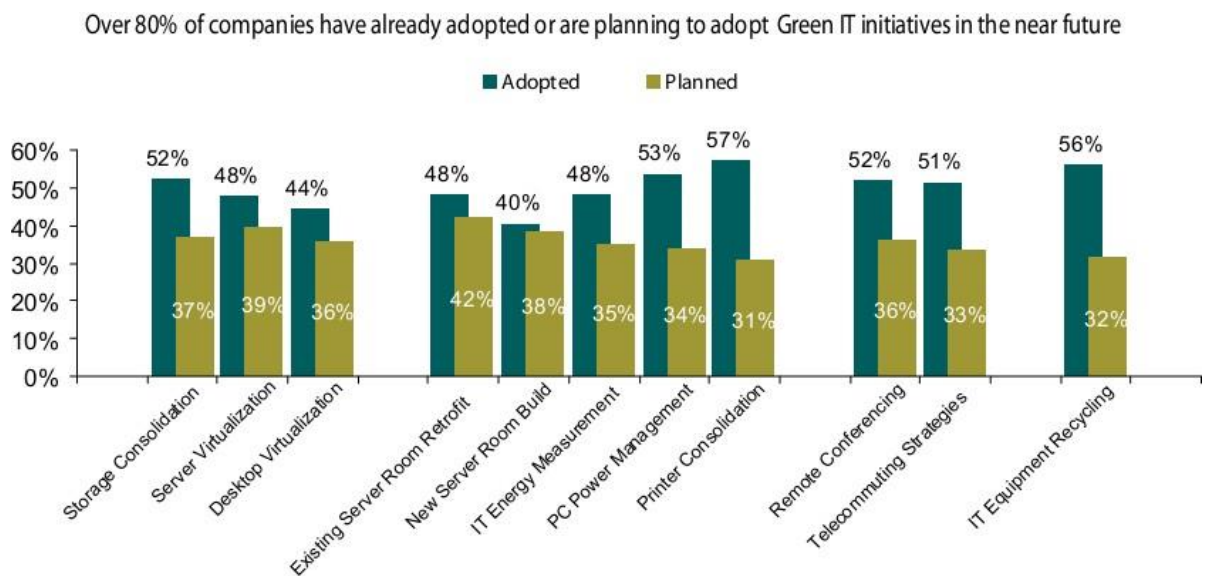


**Figure 8: Organizations Interest in Green Cloud**

## 5.2 Green Cloud

It is the truth that Data Security is the greatest prerequisite of today's trade and individual life. The fast development in volume of electronic data and traveling over the web, and expanding significance of data resource, has made its security and confirmation the beat most need of each organization. Also, as web-based framework and omni display arrange system has been entered into Data Innovation and has changed the way organizations are driving their commerce. Besides, the exceptionally later weight of sparing the planet is changing trade ideal models towards vitality sparing arrangements. Presently we ought to think approximately, how these modern methodologies of climate saver computing and tall computing capabilities, has been presented to achieve the IT based assignments, can

raise the dangers to Data Security.

The Going Green motivation, has bring a ocean alter in how stuff works, one of enormous Green activity case is, enormous room, fill with servers is presently being supplanted by virtualized server. A moment case of Computer, difficult drive and paper reusing can be cause of abusing Data Security on the off chance that information robbery or secret data is uncovered from it (Grossman, 2011). This alter can present effect on Data Security, which is the objective of the consider to investigate it.

Proposal will investigate what Data Security issues in different Green Cloud activities and for this Objective taking after table has been organized. This table arrange will makes a difference to speak to the proposition result of Green Cloud issue in connection to the recognized security issues whereas taking after area 5 will talk about approximately each of the Green Cloud issue in detail in connection to the security issues.

**Table 7: Information Security issues andChallenges in Green Cloud Solutions**

| Information Security threats, vulnerabilities and Challenges | | | | | | |
|---|---|---|---|---|---|---|
| | Green Design | | Green Usage | | | IT Disposal |
| Attributes | Networking | Cloud Computing | Online Communication Systems | Virtualization | Travel Reduction | Computer Recycling |
| Privacy | | | | | | |
| Confidentiality | | | | | | |
| Integrity | | | | | | |
| Authentication | | | | | | |

| Authorization | | | | | | |
|---|---|---|---|---|---|---|
| Access Control | | | | | | |
| Non-Repudiation | | | | | | |
| Trust | | | | | | |
| Data Segregation | | | | | | |
| Multi-tenancy Security | | | | | | |

## 5.3 Information Security

Sometime recently investigating the Data Security viewpoint in Green Cloud activities, it is vital to clarify the Data Security. After the digitizing of all information, cutting edge organization has realized that data is their greatest resource to ensure. Its expanding significance and volume has made the organization to concentrate on its legitimate assurance, accessibility, judgment and privacy. Presently, all clients are well mindful approximately the hazard and dangers connected behind the winning of the data over the web. They anticipate and request more security capabilities and affirmation from their arrangement suppliers and providers. Disappointment in Data Security can bring the overnight loses and notoriety harm in one's organization.

Within the broader setting, confirmation has many implications but within the data viewpoint, it is the degree of certainty that security highlights, structures and security approaches are legitimately connected on data framework. This certainty of security highlight execution and security approaches requirement guarantee the all traits (McKnight, 2002) of data security.

The U.S. Government's National Information Security Glossary defines IA as:

"Measures that ensure and protect data and data frameworks by guaranteeing their accessibility, astuteness, confirmation, secrecy, and non-repudiation. These measures incorporate giving for reclamation of data frameworks by consolidating assurance, discovery, and response capabilities." (Metzler, 2009).

Other than the degree of certainty approximately security highlights, it is additionally essential to analyze, how Green Cloud is ensuring its data framework, which comes beneath the data security.

Agreeing to James Anderson, Bad habit President of Data Security at Inovant, the world's biggest commercial processor of budgetary installment exchanges, In today's endeavor data security may be a "well-informed sense of confirmation that the data dangers and controls are in balance" (Whitman, 2008, p.3) and it has been too characterize as is the security of data and its basic components, counting the frameworks and equipment that utilize, store and transmit that data (Whitman, 2008, p.8).

# CHAPTER VI:

## SUMMARY, IMPLICATIONS, AND RECOMMENDATIONS

6.1 EFFICIENCY OF ENERGY IN CLOUD COMPUTING

Applications: The Software as a Service model has changed how software and apps are distributed and used. More and more companies are using Software as a Service model clouds in an effort to lower their IT costs. As a result, addressing energy efficiency at the application level is now essential. This layer hasn't garnered much attention because there are already a lot of apps in use and most new programmes are either enhanced versions of older ones or were made using tools that were already in place. If SaaS providers are interested in achieving energy savings at the application level, they should pay attention to deploying software on the appropriate kind of infrastructure that can run the programme most efficiently. The performance and power usage of the analysis are required by the software's use on various platforms and hardware. When building and implementing future applications, software developers should take energy usage at the code level into account by using Low-code, No-Code, and compiler levels in addition to the many energy-

efficient techniques recommended in the literature.

6.2 Software on the Cloud: The majority of research on virtualization and provisioning in the cloud stack focuses on Difficulties at the Infrastructure as a Service (IaaS) provider level, where the objective is to reduce the number of active resources needed to meet user application needs. the fundamental concepts for lowering power consumption for IT infrastructure, such as resource consolidation for virtual machines, demand forecasting, online migration, scheduling, and load balancing. The virtualization discussed in the previous section, which has a wide range of features including consolidation, live migration, and performance isolation, is a key component in these methods. Cloud providers are required to provide a certain level of service, so research has been conducted to decrease the frequency of SLA breaches while reducing energy use. One such technique is Sample-Replicate-Consolidate Mapping (SRCMAP), a storage virtualization method that offers energy proportionality for dynamic I/O workloads by condensing the cumulative workload on a subset of physical volumes proportionate to the I/O workload intensity. Numerous works that consider the thermal states or heat dissipation in a datacenter have also been provided for the dynamic scheduling of virtual machines and applications. Considering the heat factor improves the reliability of the scheduling procedure.
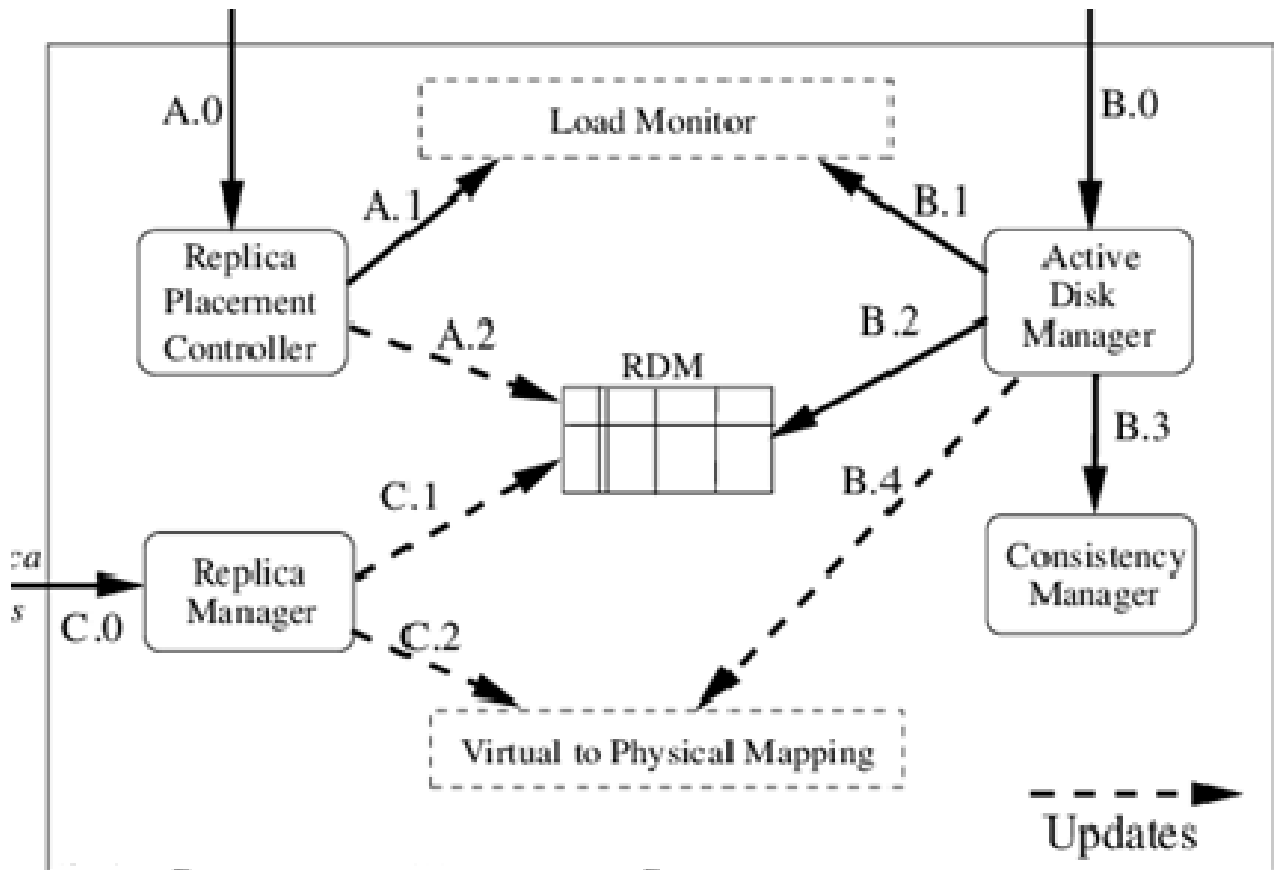
Figure 9: Storage Virtualization Manger

6.3 Datacenters: Hardware, Network, Storage, and Cooling On the first level, the Datacenter's location and intelligent structure are chosen. The two key factors in this are the energy supply and the equipment's energy efficiency. The Datacenters are being constructed in such a way that electricity may be generated from renewable resources like the sun and wind as a result. At the moment, the location of datacenters is dictated by elements like the environment, fiber-optic connectivity, and accessibility to a plentiful supply of inexpensive electricity. The main focus of cloud providers is business; hence energy sources are also generally evaluated based on cost rather than carbon emissions. Another issue is the cooling system in a datacenter, which uses about one-third of the total energy consumed.

6.4 There are water cooling systems and air-cooling systems in use. Both techniques must concentrate exclusively on cooling the hot equipment rather than the overall area. In server and storage devices and racks, it is advised to employ innovative energy-efficient cooling technologies including spray cooling, liquid cooling, and fluid cooling systems. The amount of energy required for the cooling system can also

be directly impacted by the outside temperature and climate. Some systems draw cool air from the outside to cool the Datacenter. Another degree of power efficiency is addressed by the use of power efficient servers and central processing units
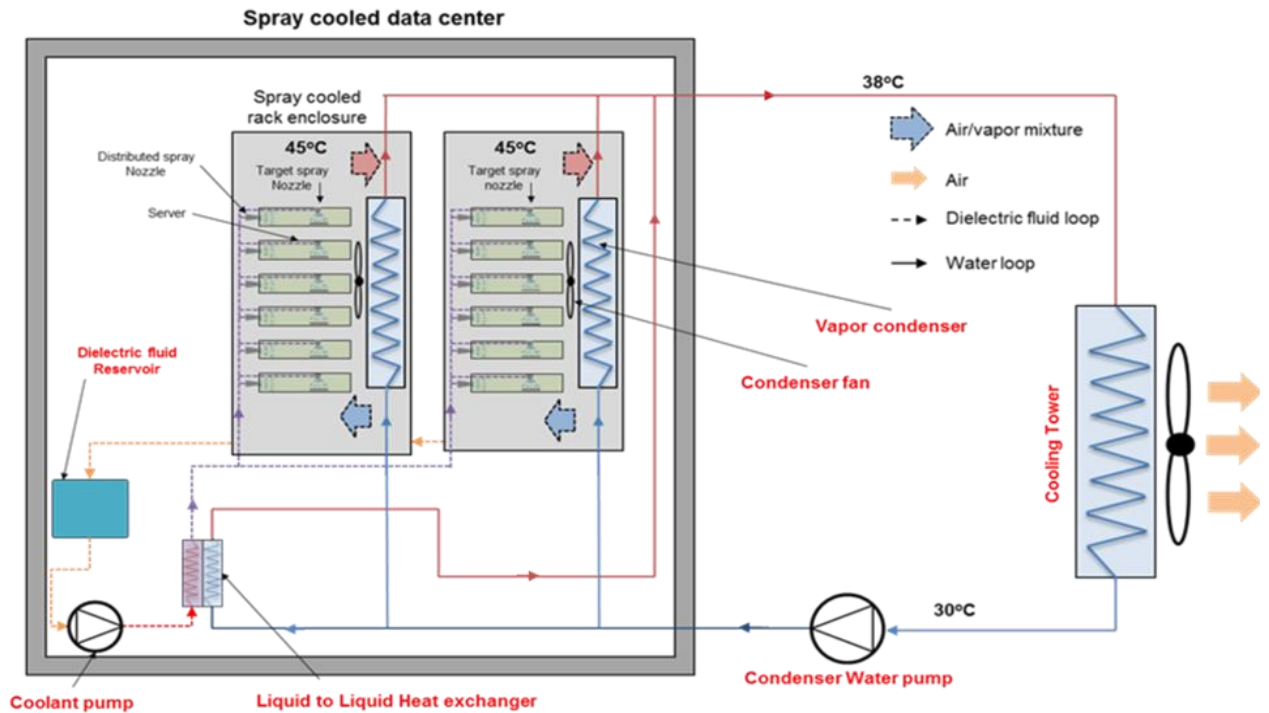


Figure 10: System of Spray Cooling

The usage of low energy processors can greatly reduce the power consumption of IT systems. Currently, a wide variety of new energy-efficient server models from producers like Intel and AMD are available on the market, and each of them provides a good performance/wattage system. The server architectures have clock gating or power gating, which slows down CPU clock speeds or shuts off idle CPUs. Multi-core processors can be used to further improve energy economy while also increasing computational power per watt. Utilizing energy-efficient discs, such as tiered storage, improves energy efficiency (SSD, SATA, SAS, FC). The power supply unit, which must be able to convert high voltage alternating current from the power grid to low voltage direct current in order to minimise power losses, is another component of infrastructure that must be designed with energy-efficient features. Eventually, additional fans inside the Power Supply Unit (PSU) lose and dissipate the heat produced by these circuits. The main elements that impact a power supply unit's energy efficiency are the load, number of circuits, and other elements (e.g., temperature). One possible solution is the suggestion that all Power Supply

Units be upgraded to ENERGY STAR-certified models. PSUs that guarantee a minimum efficiency of 80% under any load are given this certification.

Formalizing conditions for the presence of cooling-computing control tradeoff. We demonstrate a few lemma to recognize the parameters that influence the cooling–computing control tradeoff, specifically vitality proportionality, vitality proficiency of the Data Center (in terms of PUE), and the measure of the dynamic server set with regard to the accessible servers (Chapter4, Segment 4.1.2). The lemma give an easy-to-solve explanatory strategy to test the event of cooling-computing control tradeoff due to workload solidification.

Formalizing TASP and TAWD for both homogeneous and heterogeneous Data Centers. Within the to begin with level, TASP alters the number of dynamic servers to the approaching workload and chooses warm and control effective servers as dynamic servers to maintain a strategic distance from cooling-computing control tradeoff and spare vitality.

Measurement and Monitoring: In order to evaluate a datacenter's total efficiency and improve its performance per watt, Green Grid has proposed two specific metrics known as the Power Usage Effectiveness (PUE) and Datacenter Infrastructure Efficiency (DciE). PUE = Total Facility Power/IT Equipment Power and DciE = 1/PUE = IT Equipment Power/Total Facility Power x 100%
The power measured at the utility metre that is only used for the datacenter power is referred to as the total facility power. The energy used to handle, process, store, or route data inside a datacenter is referred to as the IT Equipment Power.

Network Infrastructure: Energy efficiency can be attained at the switches, firewalls, and routers levels as well as at the level of the network interface card. The issues of networking's energy efficiency are referred to as "green networking," which is the integration of energy awareness into network architecture, hardware, and protocols. The four categories of solutions that have been put out in the literature are proportional computing, resource consolidation, virtualization, selective connection, and so on. Rearranging the underused equipment through resource consolidation reduces global consumption. Comparable to consolidation, selective connectivity of devices entails

dispersed procedures that permit the individual pieces of equipment to lay dormant for a while, as transparently from the other networked devices as possible. Resource consolidation and selective connectivity are different in that the former pertains to shared resources within the network infrastructure while the latter permits shutting off unnecessary resources at the network's edge. As was previously noted, virtualization increases hardware usage by enabling multiple services to run on a single piece of hardware. Network protocols, individual devices, and components, as well as the entire system can all benefit from proportional computing. The two most popular uses of proportional computing are for adaptive link rate and dynamic voltage scaling. Network interfaces can use adaptive link rate to increase capacity while decreasing consumption. The dynamic voltage scaling lowers the Central Processing Unit load's energy status.

**Green Cloud in Information Security Perspective:**

On the face, Information Security (IA) has little to do with Green Cloud but in-depth Green Cloud has much to do with Information Security because Information Security not only assess the security features, principles and policies in computing devices or on network, but also where data and information is resides physically, travelling on the network in bits and bytes or available on the paper. Information Security also applied on where information is stored, how it is stored, how it is recovered when lost and how to destroy when no longer is needed (Metzler, 2009).

Paul Duckling, a senior technology consultant at Sophos, says, when everything is going green then there is an issue with Green Cloud business that people who want to sell Green Cloud, will bring the sea change in how we work and this new change can easily be the enemy of security (Grossman, 2011). Additional, Green Cloud Information Security challenge is with the electronic equipment recycling, laptop and computers containing the sensitive data, when go for recycling bring the security fears. In 2008 RBS, was a trusted and respected, financial custodian by general public, found that some of their redundant computers had been acquired from its disposal contractor and sold on eBay. The disks had not been properly wiped, so sensitive data was exposed (Goucher, 2009, p.9).

Joe Pucciarelli, a re-search director at IDC. "Anyone relying on ignorance of the threat as a business strategy will be un-pleasantly surprised" (McAlearney, 2007). It is possible that

data can be theft and compromised from the old equipment if not properly disposed of. Any bad guy can monitor the process and can easily carried out act of cybercrime. Ten years ago it was not much company's reputation issue, but today if any company is not aware of the associated risk with such task then the company will supposed to be negligent (McAlearney, 2007). So the risks of computer recycling are well known where assurance of data confidentiality can be easily compromised if not properly passed from recycling processes.

Green Cloud does raise the number of security issues and Difficulties. In order to discuss the security concerns, we first need to define the Green Cloud dimension and holistic approach, and its initiatives in more details and see what solutions are present in the market. This will help us to analyze what security challenges are emerging when engaging in a Green Cloud strategy.

Green Cloud Dimension

The global warming and environmental changes, putting the pressure on the organizations to change the way they are working before therefore environmental experts and scientist are encouraging the IT user to shift their corporate and social practices into environmentally sustainable solutions. Organizations are taking keen interest, with the help of IT, to reduce their carbon emission and developing and modifying the business in terms of healthy for the environment and cost effective. With the motive of saving planet and saving money, organizations has started thinking how to achieve environmental sustainability and cost effectiveness from IT side throughout its life cycle.

An IT equipment lifecycle is start from manufacturing, design, use and disposal and these are the

areas of focus where Green Cloud strategies can be applied. A very good holistic approach of Green Cloud is defined by Murugesan (2008).
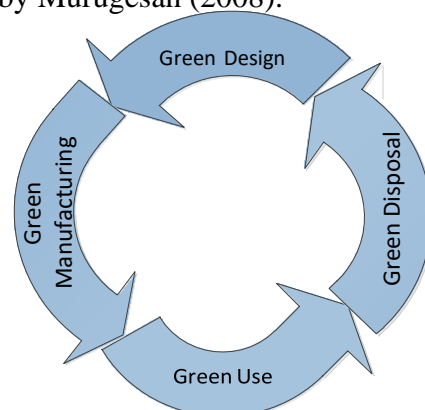
## Figure 11: Green Cloud Dimensions

Above figure is pick out from Murugesan (2008), defines the four areas of Green Cloud dimension. Each phase is the part of IT infrastructure and equipment life cycle. In later chapters, green initiatives of each Green Cloud dimension is discussed in detail with Information Security perspective.

Green Cloud Initiatives

The rapid growth and use of IT has exposed its effect on environment (Webber Lawrence and Wallace Michael, 2009). So enterprises are looking for the ways of environmental sustainability (Vykoukal Jens, Wolf  Martin, Beck Romainn, 2009). As, the main Goal of the thesis is to assess, does Green Cloud raise number of concern from security perspective and threat to security? So in order to assess those security concerns it is necessary to define Green Cloud initiatives and solutions which are in the market for going green. The approach of finding and defining Green Cloud initiatives and solutions helps us, how to mitigate the threats when engaging in any of the Green Cloud strategy.

Below Figure 12, shows the most common Green initiatives and solutions adopted or planning to adopt in near future by many small to medium organizations for moving towards green (Info-Tech Research Group, 2009). All these Green Cloud initiatives and solutions have been grouped under specific Green Cloud dimension, accordingly.
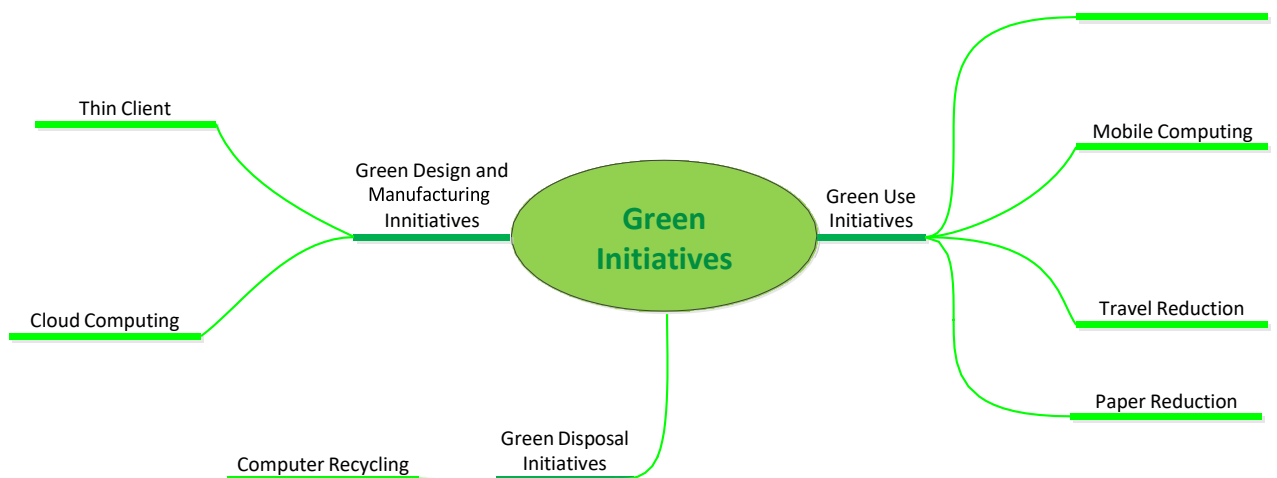


## Figure 12: Solutions in Green Cloud

In the following section of analysis, each Green Cloud solution is fully analyzed from green benefit andsecurity perspective under the relevant Green Cloud dimension.

**Analysis**

This section assesses the Information Security threats and risks in Green Cloud solutionswith respect to Green Cloud dimension.

**GREEN CLOUD DESIGN**

A green cloud framework that balances provider objectives with reducing cloud energy usage viewing the green Cloud architecture at a high level is shown in Figure 4 below.
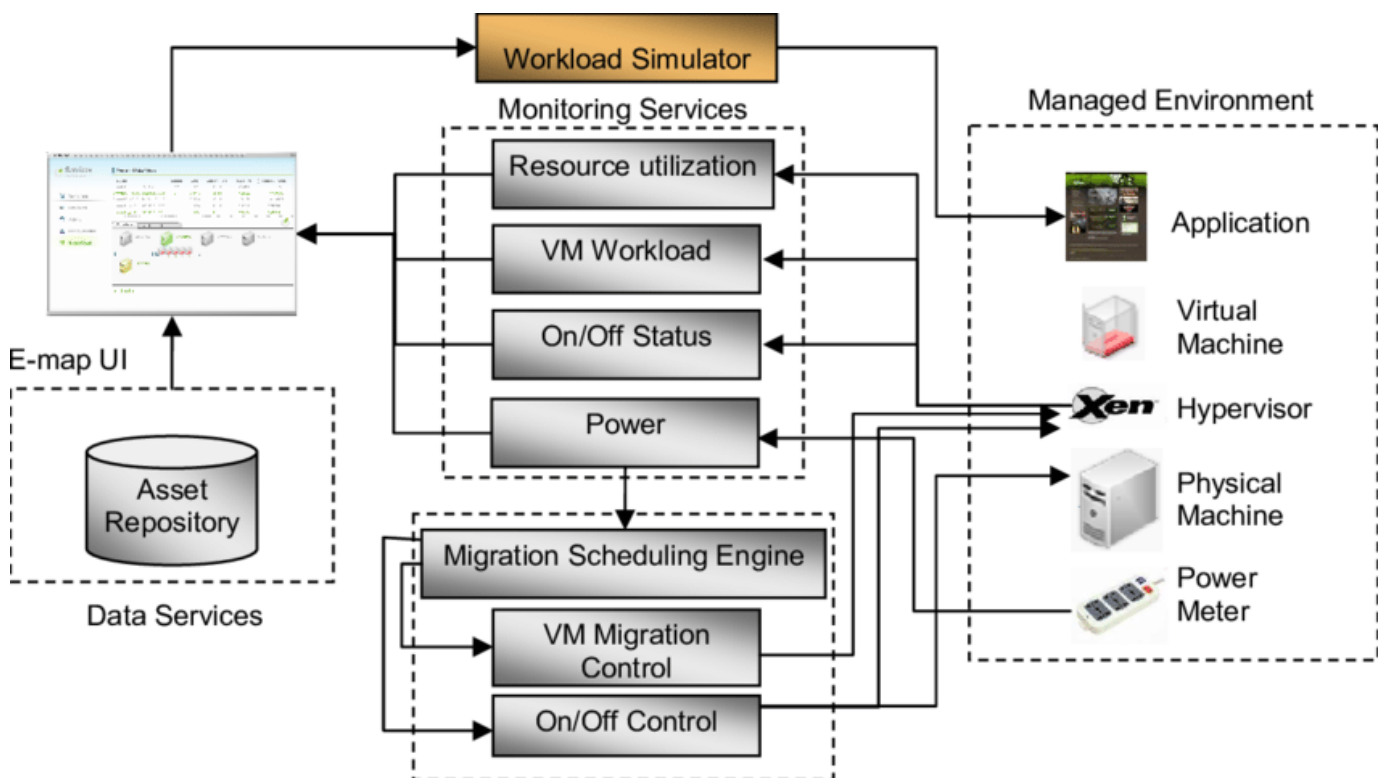


Figure 13: Architecture for Green Clouds

From both the user and service provider perspectives, this architecture seeks to make the cloud ecologically friendly. Users submit their requests for cloud services via a new middleware called Green Broker in the green cloud architecture, which manages the

selection of the most environmentally friendly cloud provider to fulfil the user's request. Software, platform, and infrastructure requirements are three of the different categories of user services. A public directory that the Cloud providers can use to register their services as green offers is accessible to the Green Broker. The green offers feature green products, a competitive price, and information on when to use them to emit the fewest carbon emissions. Green Broker collects the most recent energy characteristics from the Carbon Emission Directory for usage with various cloud applications. The Carbon Emission Directory keeps all data regarding the energy efficiency of cloud services current. When offering the desired cloud services, Green Broker typically analyses the carbon emissions from the cloud providers. This data may include the cost of the network, the power usage and cooling efficiency of the cloud datacenter services, and the energy carbon emission rates. It chooses the services that will result in the fewest carbon emissions after that, and acquires those services on behalf of the clients.

A user request's overall energy consumption can be tracked through the Green Cloud architecture. Its foundation is made up of two essential components: the Carbon Emission Directory and Green Cloud Offers, which keep track of each Cloud Provider's energy efficiency and offer incentives for them to deliver "Green" services. From the viewpoint of the user, the Green Broker is crucial for keeping an eye on and choosing Cloud services based on user QoS requirements, as well as for ensuring that there are no unnecessary carbon emissions when a user is being served. The method of offering these three service types (SaaS, PaaS, and IaaS) should be energy-efficient as well since they can all be accessible through the cloud generally.

Software as a Service Model: Because they are primarily deployed on the resources of Infrastructure as a Service providers, SaaS enterprises must keep an eye on the energy efficiency of their software design, coding, and deployment. The SaaS provider chooses datacenters for user service that are both close to users and energy efficient. Sensitive user data should be kept in the absolute smallest number of replicas utilizing energy-efficient storage.

**PaaS Model:** Generally speaking, PaaS providers offer platform services for the creation of applications. The platform makes it easier to create apps that guarantee system-wide energy efficiency. Include other energy profiling technologies, like JouleSort, to do this.

It is a benchmark for the energy-efficiency of software that calculates the energy needed to carry out an external sort. Additionally, platforms themselves may be created with various code-level optimizations that work in conjunction with the underlying compiler to execute applications in an energy efficient manner. Along with application development, cloud platforms enable the deployment of user applications on hybrid clouds. The platforms profile the application and decide which portions of the application or data should be processed locally and in the cloud for maximum energy efficiency in this scenario.
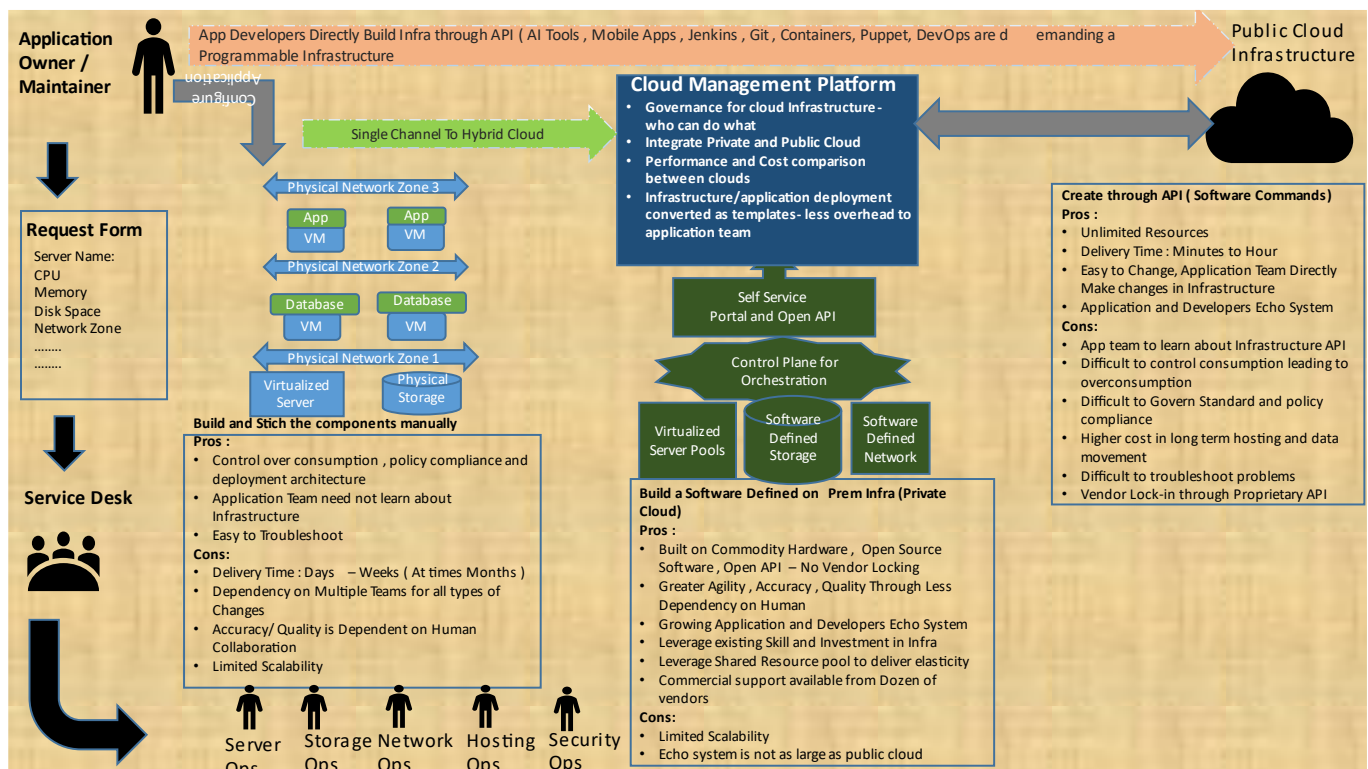


Figure14: Hybrid Cloud Infrastructure

**IaaS Model:** The success of the entire green architecture depends heavily on IaaS level providers because they not only offer independent infrastructure services but also support other cloud services. The energy consumption of virtualization and consolidation is further reduced by shutting off unnecessary servers. Numerous energy metres and sensors have been installed in order to assess the energy efficiency of each IaaS provider and their locations. These details are regularly promoted in Carbon Emission Directory by cloud

service providers. Numerous green scheduling and resource provisioning principles will help to reduce energy use. To encourage clients to use their services at off-peak or energy-efficient periods, the cloud service provider also develops various green incentives and pricing structures.
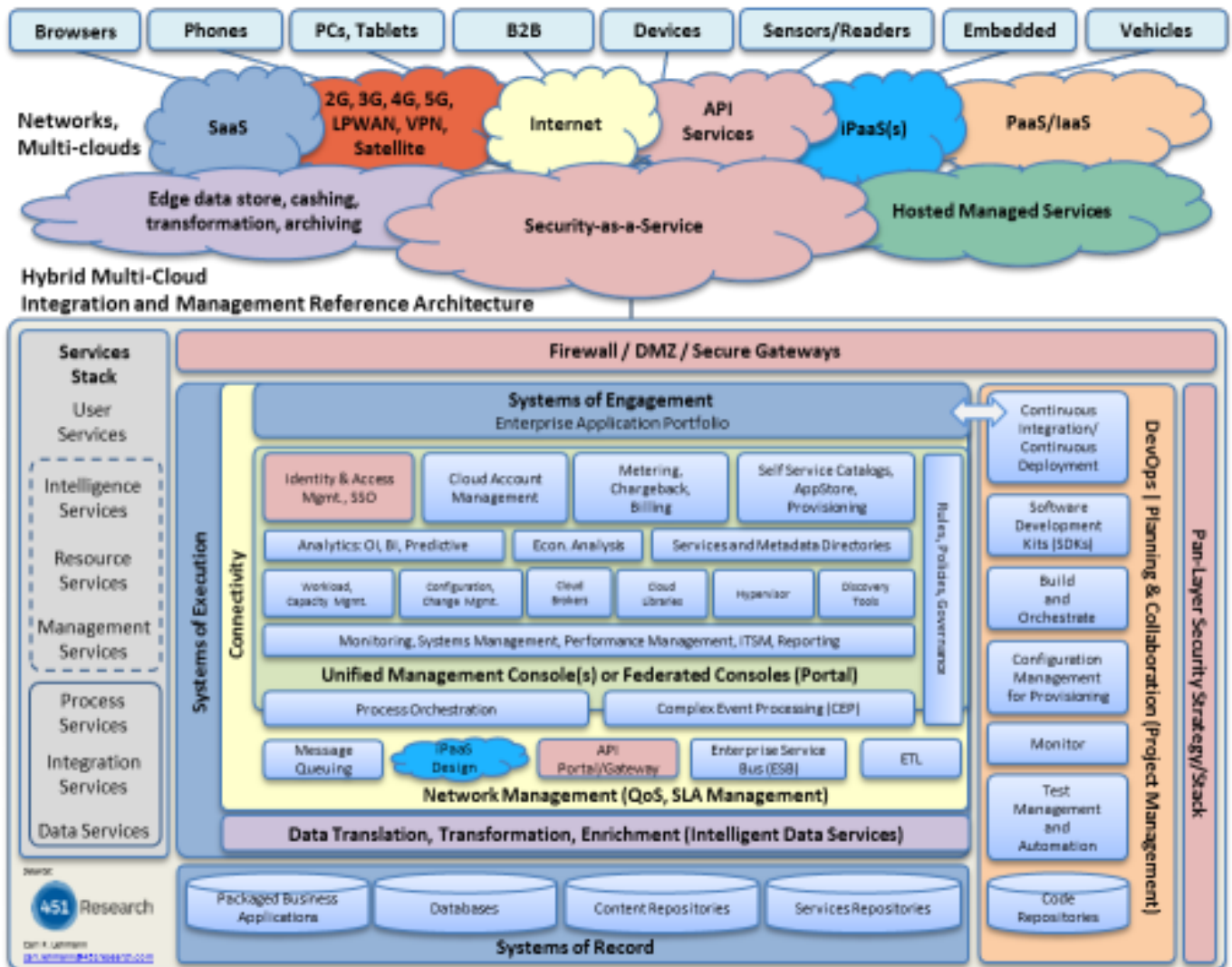


Figure 15: Enterprise architecture for multi-cloud

## Green Design and Manufacturing in Information Security Perspective

The green design and manufacturing process is not new concept it has been started from the time when human has realized that advancement in science and technology has start effecting on the natural resources and environment has been started polluted but now there is much more growing awareness of environmental impact of IT and increasing new demand of customer for energy and cost effective electronic equipment, computer, and

other related sub system and which has led the design and manufacturing enterprises to review their design and manufacturing strategies andprocesses (Deif, 2011). Therefore, the design and manufacturing enterprises are working on more objective to produce the electronic equipment, computers and system with minimal or no impact on environment.

The green manufacturing is the modern strategy which comprehensively considerate on environmental impact and resource utilization and resource consumption. Its aim is to a produce theproduct which has minimal impact on environment, maximum utilization and facilitate harmonious development of enterprise economic benefit and social benefit in its whole lifecycle from design, manufacturing, packaging, transport, use to scrapping and disposal (Jin-ying, 2011). This aim of green manufacturing can be achieved by employing green strategies, objective, principles and techniques and innovations to turn into eco efficient. In nut shell, as the word green is associated with the manufacturing process, then manufacturing becomes more aware about its production's impact on environment and consider such impact on its production planning and control (Deif, 2011).

Now if we talk about the green design, then green design deals with maintaining the environmental sustainability in its electronic design construction.

The salient example of green design and design are Network computer which do not have large memory and processing power as example which aims to reduce the power consumption of the IT resources (Joumaai, Kadry, 2012, Info-Tech Research Group, 2009 and Murugesan,2008). Second is cloud computing based on the characteristics of Grid technology, billed by consumption (Vykoukal, Wolf,Beck, 2009).

Few of green design and manufacturing initiatives are the cloud computingand Network computers. In rest of the chapter each initiative which will be illustrated in further details to analyze its impact on the degree of Information Security.
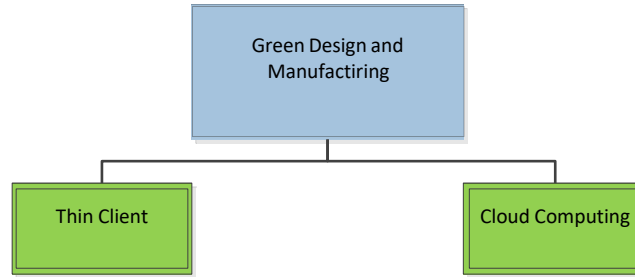
**Figure 16: Green Design**

## Cloud Computing: A Green Cloud solution and its assessment from IA and security perspective

The availability of high-speed internet connection and ip deliveries has shift the paradigms of the way IT world works. Today the small and medium size business companies instead of constructing IT infrastructure are relying on access to the shared computer resources, software, hardware and data storage resources, business application 'as a service' using internet technologies. These services are offered by external services providers to both corporate and individual over internet on use-on-demand and pay-per-use basis, called cloud computing.

Cloud Computing is derived from the Grid Computing technology in around 2007 that includes deployment of computing utility, SaaS, storage resources, applications and computation power by external service provider and obtaining them as services (Lamb, 2011 & Zissis and Lekkas, 2010).

There are many definitions of cloud computing based on the services currently offered and on discussion about service offering in future (Baliga, Ayre, Hinton, and S. R. Tucker, 2011, p-150). Below is the summarized definition of cloud computing covering its scope:

"Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of con-figurable computing resources that can be rapidly pro-visioned and released with minimal management effort or service provider interaction." (Baliga, Ayre , Hinton, and S. R. Tucker, 2011, p-150).

The main area of cloud computing service model are infrastructure as a service (IaaS), software as aservice (SaaS) and platform as a service (PaaS) and it can be deployed in

private, public, community and hybrid model (Jamil and Zaki, 2011; Carroll. M and Kotzé, 2011 & Baliga, Ayre, Hinton, and S. R. Tucker, 2011). Here we will not go into details of cloud computing services and deployment model. NIST (U.S. National Institute of Standards and Technology) have summarized the cloud computing definition in visual form in.
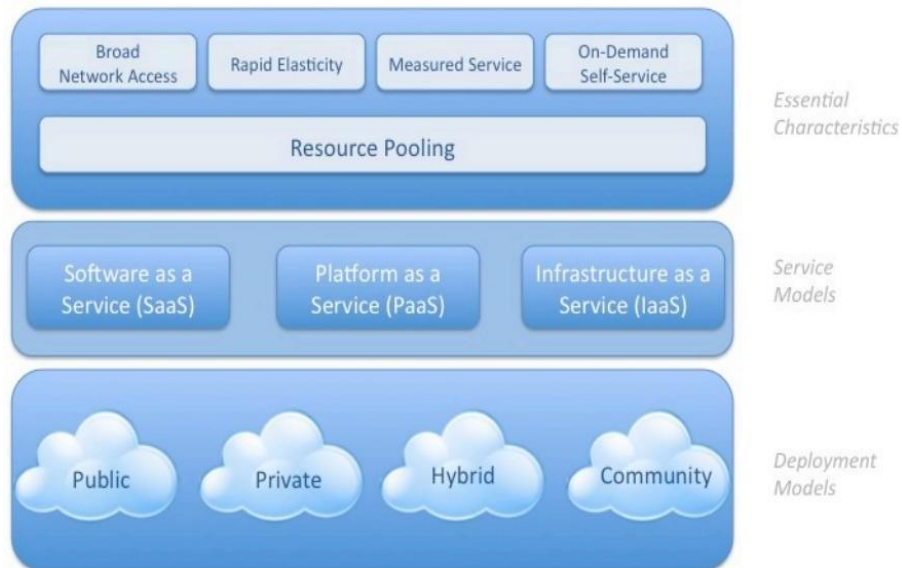


**Figure 17: NIST Model of Cloud Computing**

**Cloud Computing and Green Cloud**

The growing awareness of global warming and contribution of IT in global $CO_2$ emission has force the IT world to think about going green in IT. Today the major challenge of many organizations is to work and operate in going green manner. There is various solution that are working for the Goal of making IT Green, which has been discussed in this paper one by one.

Although Cloud Computing has not been dreamed up as a Green Cloud solution but cloud computing inherently has the green benefits in it and it also provide the Green Cloud benefits to the organization that are using it, which has been discussed in Table 1. Furthermore, the increasing importance of energy efficiency in information and communication technologies (ICT), has given the call to reduce the greenhouse gas

65

emission in ICT and to migrate towards the energy efficient computation, storage and communication technologies. Recently cloud computing has been given wide attention in this respect. It is growing as a promising approach to use the computation and storage resources and communication technologies in energy efficient manner with improve utilization of data centre. Now cloud computing is evolving as green cloud computing.

As we know that Green Cloud is refer to practice of using computer resources in energy efficient manner to minimize the environmental impact and reduce the power consumption while maintaining or increasing the overall performance and the same analogy is found in cloud computing where computing, storage and communication resources are used in energy efficient ways. It also incorporates the natural extension of virtualization technologies where two or more logical computer is run on a single physical machine with equal sharing of resources and enablesthe scalable management of virtual machines, thus allow the maximization of energy efficient resource utilization and resource sharing which incurs the energy saving architecture/model of

cloud services (Li. J, Li. Bo, Wo. Tanya, Hu. Chunming, Huai. Jinpeng, Liu. Lu & Lam. K.P, 2011).

**Business benefits of this Green Cloud Computing Research:**

1. Utilization of Renewable Energy: Reduces dependency on fossil fuels and carbon emissions by using renewable energy sources like hydroelectric, solar, or wind power.

2. Environmental Protection: Supports conservation efforts by reducing energy consumption and encouraging the use of renewable energy sources, which in turn lessens the impact on the environment.

3. Cost Reduction: IT Infrastructure resource use is optimized which lowers energy consumption and operating expenses for companies.

4. Better Brand Image: Shows a dedication to sustainability, improving the brand's standing and drawing in eco-aware consumers.

5.  Regulatory Compliance: Assists companies in adhering to environmental laws and guidelines, assuring compliance and lowering the possibility of fines.

6.  Technology Innovations: Promotes improvements in eco-friendly solutions within the tech industry by stimulating innovation in energy-efficient technologies and practices.

7.  Infrastructure Elasticity: Provides infrastructure that is both scalable and effectively distributes resources in response to demand, cutting down on waste and increasing efficiency.

8.  Draw in Eco-friendly Customers: Reach out to customers who value eco-friendly goods and services to grow clientele.

9.  Long-Term Sustainability: Encourages environmentally friendly practices in IT infrastructure to ensure long-term survival.

10. Maintain Talent Attraction: Draws in workers who are committed to sustainability, fostering a positive workplace environment and assisting in the recruitment of new talent.

**Green benefits in Cloud Computing**

The integration of IT and green management to reduce the $CO_2$ has given the call to the governmentand enterprises to adopt the low $CO_2$ gas emission technology and industries, to encourage them for more sustainable environment. So, in this order to save energy and reduce carbon emission, ICT is helping by multi user sharing of resources and reducing the IT related cost, power consumption and global warming. In the same regard to make IT industries and enterprises greener, cloud computing has moved from a fast-growing information technology (IT) field to the carbon reduction of high technology and high efficiency green management industry. Cloud computing architecture can also help meet the carbon reduction and environmental goal, the saving from the elimination of redundant and overlapping data center and server applications can save about 112 megawatts of electricity, reduce carbon emissions by more than 70 million metric ton (Liang Dung, Liang Dong & Chang, 2012).

The following table describe the green benefits associated with the cloud computing. The benefits listed are only those which have been found in the literature and further benefits may exist. The inspiration of presenting the green benefits in tabular form has been got from Esensten (2011) report.

**Table 8: Green Benefits of Cloud Computing**

| Green  Benefit | Description | References |
|---|---|---|
| Saving energy | Cloud computing is saving the energy by moving towards cloud virtualization in the form of server virtualization, network virtualization and storage virtualization. Server virtualization can increase the hardware utilization from 5 to 20 times and gives the opportunity to decrease the number of server consuming<br><br>power. | Yamini & Vetri, 2011 |
| Improve  utilization  of  data centerresources | Data center has moved towards the energy efficient IT infrastructure through virtualization and consolidation. Virtualization is promising technology, address green utilization of resources, facilities, space, power and cooling. Virtualization combines the more than two virtual machine on a single physical server thus maximizing the energy efficiency and minimizing the idle hardware time and hence the overall power consumption. Moreover, virtualization can assist in energy efficient self-management manner  by distributing work load in such a way that servers are either busy, or put in a low power sleep state or turned<br><br>off the server the unused server to save the energy. This | Lamb, 2011<br><br>Berl, Gelenbe, Girolamo, Giuliani, Meer, Dang & Pentikousis, 2010<br><br>Li.      Jianxin ,Li. Bo, Wo. |

| | has led to server consolidation, with heightened computer elasticity as well as significantly reduced electricity bills.<br><br>Thus Hardware virtualization, consolidation and reduced redundancy can achieve the energy efficiency. | Tianyu, Hu. Chunming, Huai. Jinpeng, Liu. Lu & Lam. K.P. 2013 |
|---|---|---|
| Energy efficient technology | Cloud computing is inherently an energy efficient virtualization technology, where information and services are run and stored remotely on the server in the ubiquitous computing cloud, cached temporarily at client site. At peak time of load, services can be moved to other parts of the cloud and the aggregation of a cloud's resources can provide higher hardware utilization.<br><br>Research also has been done on Virtual network architecture to add power saving mechanism into virtual network components. An energy aware network provision algorithm has also been designed to make the cloud more "green". Furthermore an energy aware routing algorithm has also been presented to minimize the power consumption of communication. | Berl, Gelenbe, Girolamo, Giuliani, Meer, Dang & Pentikousis, 2012<br><br>Chang.R.S and Wu. Chia-Ming, |
| No longer need large data center site at consumer site | Cloud computing provides virtualized, efficient infrastructure promotes energy efficiency and cost benefits to its consumer. Now consumer can accomplish their business functionality with less onsite IT resources rather than owing and managing their own systems and consumers are no longer needed to purchase assets for one time or infrequent intensive computing task. | Lamb, 2009<br><br>Bose & Luo. 2012, page 54 |
| Simplified management of resources and server | In cloud computing, server virtualization offers a way to help consolidate a large number of individual small machines on one larger server, easing manageability and more efficiently using system resources by allowing them to be prioritized and | Lamb, 2002 |

| | allocated to the workloads needing them most at any given point in time. | |
|---|---|---|
| Reduced server and power usage | Cloud computing offers the large number of user to share a single server and pool of resource via virtualization and consolidation, which increases utilization and in turn reduces the total number of servers required. During periods of low demand, some of the servers enter a sleep mode which reduces energy | Baliga, Ayre, Hinton, and S. R. Tucker, 2012 |
| Reduced power consumption and cost at client side | As cloud computing offers the required services on demand, so the client PC and server does not perform large computationally intensive tasks, so the power consumption and cost of PC can be reduced by deploying less powerful computer. | Baliga, Ayre, Hinton, and S. R. Tucker, 2013 |
| Reduced total cost of ownership | As cloud computing eliminate the need for customer to | Baliga, Ayre |

| (TCO) for client | buy, deploy, own and maintain their own applications, IT infrastructure and system. Cloud computing providers take the responsibility to provide the infrastructure, platform and storage as a service to its customers. | , Hinton, and S. R. Tucker, 2014 |
|---|---|---|
| Lower total cost of ownership (TCO) Of cloud computing | In cloud computing, cloud service provider (CSP) takes the responsibility to run the servers, backups, operating system, software, databases, cooling, power, space etc. They manage the users to share the pool of resources, on a single instance of the software, they can amortize Costs over thousands of customers. This yields the reduced TCO | Lamb, 2019 |

| Energy efficient utilization of resources in cloud computing system | Energy consumption and resource utilization are highly coupled in the cloud computing. Recourses underutilized or over utilized still consume the high energy as compare to efficient utilization of resources. Task consolidation is an effective technique to increase resource utilization which is enabled by virtualization to perform several tasks concurrently on single physical resource. Task consolidation not only contributes in energy efficiency but also make the resources free which sitting idle and drawing power. | Lee.Y.C & Y. Zomaya. 2012 |
|---|---|---|
| Reduce number of hardware equipment | One of the objective of cloud computing is efficient utilization of resources which yields in less number of hardware equipment and potential reduced global $CO_2$ gas emission | Chang.R.S and Wu. Chia-Ming, |
| Saving in IT related cost | Cloud computing provides compelling savings in IT related costs including lower implementation and maintenance costs; less hardware to purchase and support; the elimination of the cost of power, cooling, floor space and storage as resources are moved to a service provider; a reduction in operational costs; and paying only for what is used (measured service). Cloud | Carroll. M, & Kotzé, Paula, 2013 |
| More sustainable environment | Cloud computing helps organizations to reduce power, cooling, storage and space usage and thereby facilitates more sustainable, environmentally responsible data centers. Moving to the cloud further frees up existing infrastructure and resources that can be allocated to more strategic tasks. | Carroll. M, Paula, 2012 |

**Assessing the IA and Security Challenges in Green Cloud Computing**

Today modern computing technologies is not only facing the technical challenges but also facing the challenge of environmental sustainability in term of high power

consumption. As the size of IT infrastructure grows the effective Green Cloud solutions and initiatives also required to develop for minimization of the global carbon gas emission. Going green and saving cost are the key objectives of an organization and Cloud computing helping its consumer organization to reduce cost, power consumption, hardware, storage, cooling and space usage and facilitating more environmental sustainable green data centre. Hence the cloud computing is fast moving to less carbon emitting green cloud computing. As green cloud computing is massively extension of virtualization technologies and consists of virtualization-based platform so it also raises the serious security issuesand data privacy with in the cloud environmental general and in particular extensive virtualization techniques in particular. So before taking the entire advantages of Green Cloud, it is necessary to assess the security assurance mechanism of green cloud computing architecture.

**Efficient Data Analysis methodologies and tools used for Data Analysis findings with examples**

With its transformational potential, data plays a vital role in the adoption of cloud computing and green cloud computing. As more businesses go to the cloud, data becomes the vital component that drives sustainability and innovation. Businesses can get important insights, allocate resources optimally, and make data-driven decisions that promote efficiency and environmental responsibility by utilizing the enormous potential of data. Organizations can use data analysis to find trends in energy use, increase productivity, and adopt sustainable practices. Organizations can embrace the cloud and green cloud computing by using data as their compass, opening up a world of opportunities for a more eco-friendly and productive future.

Assessing current data infrastructure and comprehending its energy usage and environmental impact is the first step. Collect information on energy consumption, carbon emissions, and resource utilization to get down to the specifics. This evaluation serves as a starting point for tracking advancement and establishing goals for energy efficiency. Knowing where we stand is essential to taking significant steps forward since knowledge truly is power.

Next, it's time to embrace consolidation and virtualization's power. Using virtualization technology, we can host numerous virtual servers on a single physical server, allowing to

consolidate computing resources. As a result, fewer machines are required, which allows for better efficiency, reduced energy use, and optimal resource management. Like organizing data center to make it function more intelligently rather than harder.

Let's speak about load balancing to help allocate resources even more efficiently. Load balancing techniques allow us to divide workloads among servers equitably, avoiding any one computer from becoming overworked and using up unnecessary energy. Finding the sweet spot where resources are utilized most effectively can result in improved energy efficiency and superior performance.

Let's focus on optimizing data storage now. We can use some resourceful methods to reduce the amount of energy used in this area. To lower storage needs, think about putting data deduplication and compression into practice. We can also look into tiered storage, which places less-often visited data on lower-energy-consuming storage tiers and frequently accessed data on high-performance drives. These procedures reduce the energy required for data storage while optimizing storage capacity.

Analytics and monitoring are essential to transition to a greener data infrastructure. It's time to put in place all-inclusive technologies that let we monitor environmental parameters and energy consumption closely. Gaining important insights into data center's operations is possible with real-time monitoring of resource utilization, cooling efficiency, and power consumption. Additionally, we can anticipate energy demands, identify inefficiencies, and optimize energy use like an expert with the help of analytics. With data-driven insights at disposal, we will be able to make wise decisions that result in operations that are more economical and environmentally friendly.

**Real-Life Use Cases and Benefits of Green Cloud Computing:**

Although cloud providers are frequently the first to adopt green cloud computing methods, other businesses from a variety of industries have also significantly reduced their carbon emissions by using green cloud computing. Here are few instances:

Walmart: To promote sustainability in its business practices, one of the biggest retailers in the world, Walmart, has embraced green cloud computing. The business decreased

carbon emissions and improved energy efficiency by moving its e-commerce platform to the cloud. Walmart reduced their energy use by 15–30% and eliminated an estimated 460,000 metric tons of carbon dioxide emissions yearly by utilizing cloud technologies. [Source: Corporate Sustainability Report from Walmart]

Siemens: Using green cloud computing, the multinational business that operates across multiple industries has improved sustainability. The business optimizes energy management and lowers energy usage in buildings and industrial processes by leveraging cloud-based software platforms. Siemens has assisted its clients in achieving energy savings of up to 30% and reducing carbon emissions by an estimated 80 million metric tons through data analysis and the application of intelligent algorithms. [Source: Sustainability Report from Siemens]

Schneider Electric: Adding green cloud computing to its portfolio, Schneider Electric is a pioneer in energy management and automation solutions. The business uses cloud-based systems to gather and examine data from energy networks, buildings, and industrial sites. Schneider Electric has helped its clients achieve energy savings of up to 30% and cut carbon emissions by an estimated 70 million metric tons by optimizing energy usage and implementing energy-efficient practices. [Source: Sustainability Report by Schneider Electric]

Philips: To promote sustainability throughout its operations, Philips, a well-known technology business specializing in lighting and healthcare solutions, has adopted green cloud computing. Philips has enhanced the energy efficiency of its lighting systems, optimized resource allocation, and decreased the environmental impact of its goods and services by leveraging cloud-based platforms for data analysis and management. The business assisted clients in achieving up to 80% energy savings and a 32 million metric ton reduction in carbon emissions. [Source: Sustainability Report from Philips]

BMW: Using green cloud computing, the well-known automaker has improved its environmental initiatives. The business analyzes vehicle data, maximizes energy use, and enhances manufacturing procedures using cloud-based platforms. BMW was able to reduce energy costs by up to 15% and its annual carbon emissions by about 92,000 metric tons by utilizing cloud technologies. [Reference: Sustainability Report by BMW]

**The following noteworthy tools are very helpful in the Data Analysis shift and discoveries for green cloud computing:**

Energy and Sustainability Management: With the help of this tool, businesses can keep an eye on and control their environmental effects, energy use, and sustainability programs. It helps create and monitor sustainability targets, pinpoints opportunities for improvement, and offers real-time insights into patterns of energy consumption. Through the use of this application, businesses may optimize energy consumption and lower their carbon footprint by making data-driven decisions.

IoT Suite: Energy efficiency and management are greatly impacted by the Internet of Things (IoT). Businesses can connect and manage IoT devices and sensors using IoT Suite, gathering data in real time from several sources. Through the analysis of this data, organizations can acquire valuable insights into patterns of energy usage, pinpoint possibilities for energy conservation, and facilitate predictive maintenance to enhance operational efficiency.

Machine Learning: Algorithms for machine learning can help forecast demand, optimize energy use, and improve operational effectiveness. A framework for creating and implementing machine learning models tailored to use cases involving energy is offered by machine learning. By using these models, businesses can increase their operational sustainability through energy forecasting, anomaly detection, energy optimization, and predictive maintenance.

Virtual Machines: A key element of cloud architecture are virtual machines, or VMs. Businesses may effectively increase their computer resources and virtualize servers by using virtual machines. By optimizing resource use, businesses can save energy consumption and the expenses of maintaining physical servers.

Data Lake Storage: Today's businesses produce and evaluate vast amounts of data, including operational, meteorological, and sensor data. A scalable and affordable option

for storing and analyzing large volumes of data is offered by data lake storage. Employing data analytics capabilities enables businesses to find patterns, spot inefficiencies, and maximize energy use.

Power BI: With service integration, Power BI is a potent business intelligence tool. Businesses can use interactive dashboards and reports created with Power BI to visualize and analyze data connected to energy. This enables them to evaluate sustainability activities, keep tabs on energy consumption, and effectively share insights, promoting a data-driven culture of energy efficiency.

Virtual Desktop: Virtual Desktop lessens the requirement for on-premises infrastructure by enabling businesses to offer remote work capabilities. Companies can maximize office space, save energy consumption related to office operations, and cut carbon emissions from commuting by allowing workers to work remotely.

DevOps: DevOps procedures encourage teamwork and automation in the creation and implementation of software. Businesses may automate testing, optimize resource usage, and streamline application development processes with the help of DevOps. This reduces waste and energy consumption associated with traditional development processes and leads to faster and more efficient software delivery.

In Cloud computing there are set of principles and policies includes privacy, governance, reliability,surveillance, telecommunication and capacity but among all of them the most important of all cloudconsumers is Information Security. These security concerns are originated from the fact that customer store their data at remote server under the control of service vendor, residing at any location and rely on the software application to store and execute it (Svantesson & Clarke. 2010).

This section analyses the Information Security in green cloud computing. Here, we discuss the assessment of the IA and security issues which are arise due to energy efficient technologies and practices to make cloud computing green. This study outline the several critical security issues found in the literature and point out the importance to motivate the future investigation and researchof security solutions that will help the growing adoption of trust worthy green cloud computing. Here, we do not consider the general security

issues associated with cloud computing.

## Trust

Trust is the new topic in the field of computer science. It measures the degree of confidence that consumer have on computer system or model. It is used in convincing the observer and user that process, system, design or model is correct and secures (Zissis & Lekkas, 2010). The concept of trust is move around the parties like in cloud computing, cloud computing users believe that cloud infrastructure will behave as expected and required and ensure the strong security mechanism. In cloud computing trust has become the biggest concern for the cloud consumer. This certainty of trust in cloud computing can be expressed in customer's faith in integrity and soundness operation, and successful implementation of security control and measures where all security risks is eliminated or reduced to minimum level.

Trust in cloud computing is dependent upon its infrastructure, technology, model and governance. The organization who wants to reduce their IT related cost of floor space, money, power and cooling are moving towards the virtualization-based cloud computing. Where they are basically delegating the all controls of their data to the cloud infrastructure owner and come under the mercy of service provider that they will enforce the sufficient security mechanism and policies andguarantees the implementation of security controls to deal with the all-associated risk of cloud computing and virtualized infrastructure. This trust can be expensive when owner is failed to provide the service as expected and required (Zissis & Lekkas, 2010).

## Multi-tenancy Security

As we know that green cloud computing is basically virtualization-based cloud computing platform, which offers the deployment of scalable and energy efficient software application and services. It also deals with the energy efficient utilization of resources and hardware achieved through the increased sharing of hardware and multitenant cloud architecture environment (Li. Jianxin , Li. Bo, Wo. Tianyu, Hu. Chunming, Huai. Jinpeng, Liu. Lu & Lam. K.P, 2011).

Multi-tenancy is the fundamental characteristics of green cloud computing, which

optimize the resource utilization. Several aspect of multi-tenancy is used to keep the cloud green, including from memory, program, server, storage, network and data. In green cloud computing, users are sharing the resources at the network level, host level and application level. Although users are kept isolated from each other at virtual level. The CSPs also employ hardware virtualization, in which multiple users execute the same application on the same hardware. The application is made to split its data and configuration virtually so that each user has access to a unique instance of the program. The underlying hardware resources are used more often thanks to this multi-tenancy architecture. Because virtualization eliminates the need for any upfront hardware setup or purchase, it reduces the management burden for CSPs and enables efficient and effective resource provisioning and re-allocation (Li. Jianxin, Li. Bo, Wo. Tianyu, Hu. Chunming, Huai. Jinpeng, Liu. Lu & Lam. K.P, 2011 and Ren, Wang. C, & Wang. Q, 2012).

In spite of the numerous other and green benefits of multitenant cloud design, postures a number of serious security dangers and vulnerabilities to both CSPs and clients. It moreover affect the confirmation of privacy and protection property of clouds. Since multitenant virtualized cloud engineering share same usefulness of existing working framework and application in non-virtualized physical natural, so computer program bugs and recently recognized risk are the essential danger to multitenant virtualized environment (Ren, Wang. C, & Wang. Q, 2012). In multi-tenancy, question reusability can moreover lead to vulnerabilities in case not appropriately controlled (Li. Jianxin, Li. Bo, WO, Tianyu, Hu, Chunming, and Huai. Jinpeng, Liu. Lu & Lam. K.P, 2011). Moreover, for the correct asset administration and utilization, several forms of virtualization must ought to reliably observed and secured. Moreover the developing estimate of multitenant cloud environment and utilize of these virtualization technologies brings extra security concerns and makes the support and security affirmation more troublesome to realize (CSA, 2009 and Ren, Wang. C &Wang. Q, 2012).

Security and Privacy

Amazon EC2 gives it client the instantiate of Virtual Machine (VM) on request. These virtualization strategies permit the multi-tenancy of client and maximize the utilization of assets beneath the moo capital. In this situation, client believe on the cloud proprietor for the security, privacy and keenness of their information and computation. Be that as it may, it isn't the case; such cloud framework permits other clients and adversaries' VM

on the same physical machine which raises non self-evident dangers of protection and privacy spillage. Considering the circumstance where, foe and casualties are on the same physical machine and foe can enter from the separation of VMs and elude the hypervisor by means of vulnerabilities or side channel assaults and damage the other customer's security and secrecy (T. Ristenpart, 2009).

In virtualized environment, the other situation of information secrecy spillage is conceivable when information is ostensibly eradicated or expelled. The need of solid get to control component and abuse of application vulnerabilities can too lead into breach of privacy (Zissis & Lekkas, 2010).

Security, privacy and multi-tenancy are the greatest challenge of the open cloud computing (Greer, 2010). Due to developing virtualized and multi-tenant framework of cloud, it is exceptionally troublesome to fathom the protection issue, but it can be simply guaranteed by solid benefit level assention (SLA) or through the utilize of private cloud. In any case, to secure the security and privacy of information, the solid segregation arrangement is must require at level of virtualization or to uncover the chance and situation choices specifically to clients (Subashini and Kavitha, 2010 & T. Ristenpart, 2009).

Judgment

The virtualized based green cloud computing offers the sending of vitality proficient organize program application (NetApp) by ethicalness of progressed utilization of assets. It is vital that NetApp is stacked with out tempered by different malware such as infections, Trojans, worms and rootkits which are the risk for VM. Issue with malware like rootkit is that it can cover up its claim handle and elude from customary arrange security. In spite of the fact that there are a few astuteness estimation exist like Tripwire, astuteness estimation design (IMA), policy-reduced keenness estimation design (PRIMA) and Google Chrome OS but they have broadly known impediments (Li. Jianxin , Li. Bo, Wo. Tianyu, Hu. Chunming, Huai. Jinpeng, Liu. Lu & Lam. K.P, 2011). For illustration IMA is executed through Linux bit LSM which is inalienably helpless to bypass assault and Tripwire recalculate the hash esteem of the record when record have been changed but the malware program which alter the record keep the hash esteem same. (Li. Jianxin, Li. Bo, WO. Tianyu, Hu. Chunming, Huai. Jinpeng, Liu. Lu & Lam. K.P, 2011).

However, security isolation at different level is the technique to counteract for NetApp integrity preservation but Difficulties is NetApp can be downloaded from a third party which may contain malicious code (Li. Jianxin, Li. Bo, Wo. Tianyu, Hu. Chunming, Huai. Jinpeng, Liu. Lu & Lam. K.P, 2011).

Get to Control

Get to control of virtual assets is additionally a major challenge of virtualization-based cloud computing (Greer, 2010). In green cloud computing a expansive number of client offers the assets and a few get to control component is there to encourage the confirmation component like oVirt, built on libvirt permits to oversee the facilitated VMs. oVirt too give the extra secure
communication (GSSAPI/SASL2) and verification component (Kerberos/LDAP) for get to of inaccessible asset pools. Li. Jianxin (2011) moreover said the related confinement of over said approach, oVirt as it were give a straightforward identity-based confirmation component without considering the real-time security approach overhauling and assessment for the multi-tenant asset pool

Information Isolation

As mentioned above, multi-tenancy is the basic characteristic of green cloud computing. A expansive number of clients store their information through the application given by SaaS. In cloud computing it is happen that information of numerous clients dwells on same area and where interruption of information can happen in numerous ways for case by abusing the vulnerabilities of application or by infusing client code into SaaS framework (Greer, 2010) . A client can too infuse the conceal code into the application, in case the application executes this code without confirmation, at that point there's a high potential of interruption into other's information. There's moreover required to characterize the user's information boundary not as it were physical level but too at application level as well (Subashini and Kavitha, 2010).

Authorization

The other issue of VMs is the control of director on have and guest working framework. Idealize segregation isn't found in Current virtual machine screen (VMMs). There are numerous bugs establishes in well-known VMMs where client can elude from the VM

in spite of the fact that in virtualized visitor environment the VMMs ought to not allow the benefits to impedances with have framework. Additionally, there are vulnerabilities found in all virtualization software which can be abused by pernicious clients to bypass certain security confinement and pick up benefits. For case, Microsoft virtual PC and server's powerlessness permits the visitor working framework client to run code on have or on another visitor working framework. Such vulnerabilities too permit the height of benefits. One more illustration of authorization and benefit issue is in Xen caused due to an input approval mistake in tools. This could be misused by 'root' clients of a visitor space to execute subjective commands in space by means of extraordinarily created passages in grub.conf when the guest framework is booted (Subashini and Kavitha, 2010).

This section has assessed the IA in green cloud computing environment. Doubtless there are number of benefits offered by the Green Cloud cloud computing (Carroll. M and Kotzé, Paula, 2011 & Subashini and Kavitha, 2010) but green approach of virtualization and multi- tenancy has its own risk too (Li. Jianxin , Li. Bo, Wo. Tianyu, Hu. Chunming, Huai. Jinpeng, Liu. Lu & Lam. K.P, 2011). So it is highly required for cloud computing community to take proactive measure to assure the IA. Eventually it is also necessary for all users migrating towards the cloud computing who are interested in utilizing the cloud computing products for the Goal of sustainable environment that they must ensure the all associated security challenges of privacy, confidentiality, access control and authorization. They must also ensure that the product they are going to use is of their need and risks are well understood (Svantesson. Dan and Clarke. Roger, 2010). In other way around they must have strong SLA agreement or at least must be aware of it.

**A Green Cloud solution using Network Computing:**

Network computer machine is also a Green Cloud solution (Joumaai, Kadry, 2012, Info-Tech Research Group, 2009 and Murugesan,2008). In the design of Network computer, application and functionality are run on the remote server in the network and have no RAM and CPU (Vykoukal, Wolf, Beck, 2009 and Info- Tech Research Group, 2009).

**Green  Benefits in Network computer**

Network computer has less function capabilities and move all complex functionality to remote server Therefore, Network computer draws one-fifth power of desktop PC (Murugesan, 2008 ). Desktop virtualization and Network computer machines reduces the power consumption and environmental impact ofuser infrastructure (Info-Tech Research Group, 2009). According to Info-Tech Research (2009), Network computer uses a 4.8-watt power supply as compare to typical computer which used up to a 250- watt power supply; so the reduction in electricity usage is 97, 98 percent, with all the functionality.

**Availability**

Network computer computing environment has a risk of unavailability of services. An outage in the central network and server can affect the business services. Until the dependent resources and network of Network computer is recovered from the outage (Hocking, 2011 and Intel Information Technology, 2010). The research also discovered that Network computer environment is downright for Denial of service attack (Vlissidis & Hickey, 2010).

**Access Control**

Network computer computing environment have the access control vulnerability. Centralizing of data and application also introduce the centralized threat. A network of thin connected to servers also opens the many access points for the attackers. Than attackers can access the server storing the data and application and compromise the entire IT infrastructure (Intel Information Technology, 2010).

**Confidentiality**

Research on different client devices discovered that "thin-client environment could be hacked by hackers to be used in botnets. Open sources and off the shelf software can be used to carry out the eavesdropping activity on a standard thin-client device (Vlissidis & Hickey, 2010).

Most of the cases, the security management model is compromised as all credential traffic is passed in clear text and network is open for sniffing. (Vlissidis & Hickey, 2010).

**Integrity**

In the research article by Vlissidis & Hickey (2010), mentioned that a typical Network computer model consist of remote application cluster accessed by Network computer. A management server is also deployed for the deployment of patches, firmware and configuration information and management of securityin Network computer computing environment. The research  is done on different Network computer device such as HP Compaq T5700, Wyse V90L, Wyse S10, IXL Itona V17, with their respective management software, reveals that there is no encryption between the Network computer and management software and protocol and all text are transferred in clear text and with a high risk of man-in-middle attack and layer 2 network attack except the HP Compaq T5700 which used the encryption  technique (Vlissidis & Hickey, 2010).

**Authentication**

Following the above define scenario of typical Network computer model, the lack of authentication and encryption technique also lead to spoofing. For example attacker listens to the device (Network computer) service probe and can launch ARP spoofing attack to connect the Network computer to malicious server. This attack further lead attacker to reconfigure, update and execute command on the host machine the same privileges of the management software suite. For example research reveals that in Wysl device it is possible to reconfigure and execute commands without authentication (Vlissidis & Hickey, 2010).

**Green Cloud Use in Information Security standpoint**

After the Gartner investigate (2009) approximately commitment of Data Innovation in worldwide warming. Ready to decently say that data innovation is making a difference to annihilate the planet (Webber & Wallace, 2010). To relieve this dangerous Challenges, Green Cloud empowers the green utilization (Murugesan, 2008). Cut vitality costs by running IT gear and other IT framework productively in ecologically sound way (Webber & Wallace, 2009 and Murugesan, 2008).

By focusing on the green utilization of IT, we are able create an naturally feasible IT

division. The key objective of Green Utilize is to decrease the vitality utilization of utilizing computer frameworks and information middle (Murugesan, 2008).
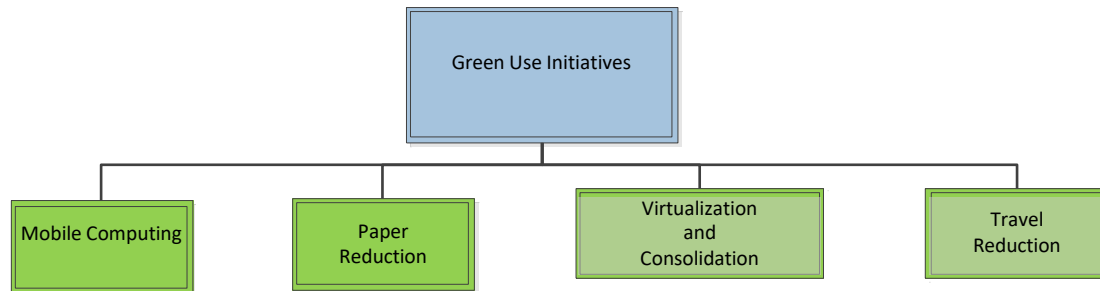


**Figure 18: Green Usage Initiatives**

The transformation of computer has given the fast development to information center. Organizations are introducing more Information centers. Information centers have number of servers. In final decade the number of servers has expanded from six crease to 30 million (Murugesan, 2008). Each server draws power. Close to the colossal sum of vitality utilization by information center, operational fetched of information center is additionally getting to be basic issue. Green Utilize too accentuation to move forward the vitality productivity of information centers. Unused vitality proficient hardware, and virtualization, capacity solidification is one of the methodologies to spare the vitality in information center. Murugesan, (2008 ) specified that in acquiring study 50% of the datacenters proficient accept that they have spare vitality by selection of virtualization. Murugesan, (2008) too conversation around the overview by Sun Microsystems Australia, where 80 percent of respondents said they utilize energy-efficient advances and 60 percent said they utilize framework virtualization.

In arrange to encourage the decrease of control utilization, travel lessening, going paperless, portable computing too come beneath the green utilize activities. Shockingly numerous organization are embracing travel lessening, going paper less, portable computing to decrease the control and fuel utilization and diminish negative affect on environment (Bose and Luo, 2011 & Info-Tech Inquire about Gather, 2009).

In rest of the chapter each activity has been gotten to in advance detail in terms of green arrangement and from Data Security point of view.

Infrastructures Virtualization: A Green Cloud initiatives

This area briefly talks about the virtualization innovations and how these advances can be utilized in information center. It too incorporates the green benefits of virtualization. The objective is to evaluate the IA and security shortcomings of virtualization. This area does not make an endeavor to create references to numerous items advertising of virtualization advances.

Within the later year, the developing request of computational work has made the information centers fundamental building square of IT foundation. Information centers are found in each division counting money related institution, government organization, media and instruction framework. To meet the require of organizational gigantic computation, preparing expansive scale capacity and reinforcement, information center growth is rising exponentially. This the fast development within the measure of information centers, coming about in tremendous utilization of control and power, space and taken a toll (Uddin, 2010). This colossal sum of vitality utilization causes the nursery gas emanation. US EPA report to Report to Congress on Server and Information Center Vitality Proficiency Openings conducted in 2007 assessed that nation's servers and information centers expended almost 61 billion kilowatt-hours (kWh) in 2006 which is 1.5% of add up to U.S. power utilization and costs $4.5 billion. As information centers is the quickest developing segment, so the vitality utilization was gathered to roughly twofold by 2011(US EPA, 2007, p-7).

Virtualization advances can offer assistance organization to decrease the control utilization and increment vitality productivity and assets utilization and can play its critical part of green arrangement in forms of server virtualization, capacity virtualization and client virtualization (Lechner, 2007 & Lamb, 2009).

Server Virtualization. Server utilization is the foremost promising innovation to decrease the control utilization, address the issues of space, cooling, fetched and asset utilization. (Bose and Luo, 2011, Esensten, 2011, Sheep, 2009, Vykoukal, Wolf & Beck, 2009 and Lechner, 2007). In

2006, Gartner evaluated that more than 90% of the organization are using virtualization to x86 server space and fetched and its decreased the advertise of x86 server by 4% (Lechner, 2007). Concurring to the Universal Information Organization (IDC) 18% of all new servers dispatched within the fourth quarter of 2009 were virtualized, an increment from 15% compared to 2008 (Huber, 2010). The server virtualization advertise is anticipated to develop 30% a year through 2013 (Huber,2010).

Server virtualization gives organizations a way to Green Cloud usage by advertising a way to part the equipment assets into numerous littler virtual machines and run on a single physical machine (Sheep, 2009, Vykoukal, Wolf & Beck, 2009, Murugesan, 2008 p.29 and Velte and Elsenpeter, 2008). In virtualization, a program, Virtual machine screen (VMM) moreover known as hypervisor, gives the stage to host multiple working frameworks running concurrently and sharing distinctive assets among each other to give administrations to the conclusion clients (Huber, 2010 and Uddin, 2010). Virtualizations of server are simple to oversee and utilize the framework assets more effectively. By running numerous virtual servers on single shared foundation increments multitasking capabilities, utilization of server additionally permits prioritization and assignment of assets concurring to the workloads (Huber, 2010, Sheep, 2009 and Vykoukal, Wolf & Beck, 2009).

**Figure 19: Energy saving with increased virtualization**
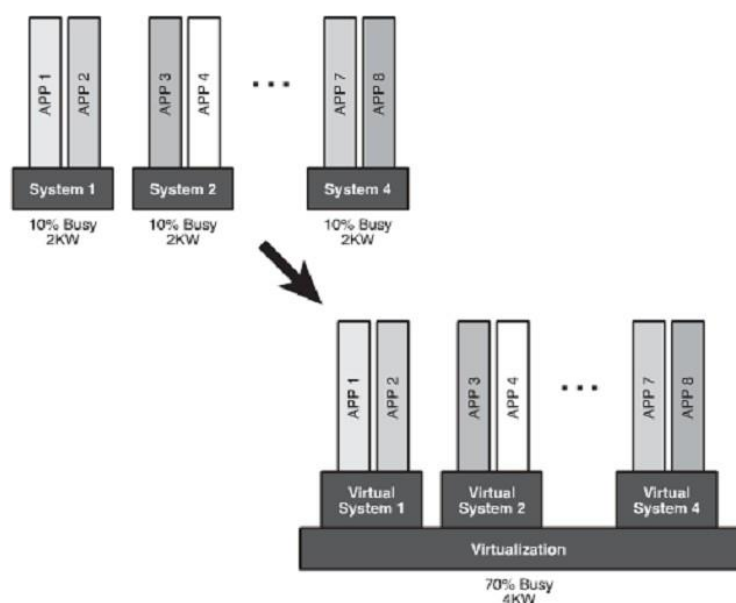
Datacenter Capacity Virtualization:

Virtualize the physical capacity from different organize capacity gadgets so that they show up to be a single capacity gadget (Chaudhuri, 2011). E.g. Capacity Zone Organize (SAN), excess cluster of autonomous disks (Attack).

Datacenter Organize Virtualization:

Combines computing assets in a organize by part the accessible transfer speed into free channels that can be alloted to a specific server or gadget in genuine time (Chaudhuri, 2011).

Green Benefits of Virtualization

The following table describe the green benefits of virtualization. The benefits listed are only those which have been found in the literature and further benefits may exist.

**Green Benefits of Virtualization**

| Green Cloud Benefits | Details | Guides |
|---|---|---|
| Infrastructures utilization | Storage and compute virtualization increases the hardware utilization from 6 to 22 times and power consuming. | Lamb, 2015 Harmon, 2009 |
| Reduction in Cost | Different storage and server hardware | Lamb, 2008 Lamb, 2011 Bose & Luo, 2011 |
| Energy Savings | Using virtualization, and consolidating hardware with a physical machine also saves energy consumption | Ronan, 2016 |
| Physical desktops reduction | In desktop virtualization, the green benefits of changing the desktop lie essentially in diminished | Agarwal |

| | control utilization, but moreover that imbecilic terminals will not have to be updated as regularly as PCs so acquiring and hardware transfer prerequisites are diminished. | &Nath, 2012 Ronan, 2012 |
|---|---|---|
| Physical office space reduction | Data center space reduction with Infrastructures virtualizations. | Anonymous ,2009 Bose & Luo, 2012, p-31 Ronan, 2001 Murugesan, 2007, p-10 |
| Efficient resource utilization | Compute virtualization & consolidation helps to increase the utilization where server CPU and RAM is underutilized. | Lamb, 2004 |

**Concerns with Security in Infrastructures Virtualizations**

One of the green arrangements to diminish the vitality utilization in IT field is presentation on Virtualization innovation. Other than it green benefits to diminish the vitality utilization and productive asset utilization, virtualization moreover presents challenges of security dangers and its claim vulnerabilities (Frangiskatos, 2013).

This segment investigations the Data Security issues made by utilize of virtualization innovations. Here, we examine the evaluation of the IA and security issues and framework vulnerabilities which are with in vitality effective innovations of virtualization and to form computing greener. This ponder diagrams the several critical security issues found within the literature and point out the significance to spur the long run examination and investigate of security arrangements that will offer assistance the developing selection of virtualization.

Secrecy:

We know that VMM (virtual machine screen) is put at a lower level than the VM. VMM can see interior the information of VM and screen its execution. This observing and see interior handle is called contemplation. The contemplation includes of VMM (hypervisor) to see interior the VMM can debilitate the secrecy. This highlight can be abused and can breach the privacy of VMs and can take the information from them (Cleeff, 2003).

Within the world of server virtualization, there's no physical association between the servers. The doors between the servers do now not exist. So on the off chance that one virtual server get compromised it can put others servers on chance as well, expecting that security code of application cannot be bug free (Frangiskatos, 2015).

Confidentiality can moreover be breached in case the segregation among the VMs isn't emphatically kept up. For illustration, a useful highlight "Share clipboard" permits information to be exchanged between VMs and the host can be utilized as a portal for exchanging data between cooperating malevolent program in VMs (Reuben, 2007). Other illustration is VM Elude assault. It happens when the separation between VMs and between has is compromised. In VM Elude, program running in VM totally bypass the hypervisor and get get to to have machine. Since have machine is the root, so the program get get to to have machine can effortlessly get the root benefits and totally break down the security system of virtualization (Reuben, 2006). In case of getting authoritative benefits, it can moreover execute visitor to visitor assault (Reuben, 2009). In case of capturing hypervisor, assailant can get get to to base framework and different virtual machines on the same host.

Other point, where confidentiality can be undermined is virtual arrange association between VM and have. VMs are connected to have machine through virtual center or switch. It can empowers visitor machine to sniff the parcel or in more regrettable case to divert the bundle by ARP harming (Reuben, 2000).

The other risk in virtual environment is twofold embodiment assault. It encapsulates activity with different 802.1q envelopes. An external envelope is erased to be in reverse consistent; local VLANs strip the outer envelope from the outline, clearing out the inward parcel. A switch at that point diverts to another VLAN than the one at first expecting after the outer envelope is erased (Esensten, 2014).

In capacity virtualization SAN, there are numerous sorts of risk and one of them is detached assault which compromise of activity investigation to of activity investigation, observing of unprotected communications, unscrambling feebly scrambled activity, and capturing confirmation data such as passwords (Mahalingam, Karthikeyan, 2000, p.123).

In organize virtualization (NV), side channel assaults influence the privacy of mystery data. Side channel assaults target the co-hosted virtual machines by utilizing the Amazon EC2 benefit (Natarajan & Wolf, 2013, p.238 and Ristenpart. 2010). This danger is practically equivalent to to cloud computing (Natarajan & Wolf, 2012, p.538). Moreover, in network virtualization, assailant can able to sniff the state of physical assets on the network foundation to assault the co-hosted virtual arrange (Natarajan & Wolf, 2013, p.321). Compromised arrange foundation (NI) can moreover lead to screen VN exercises on arrange activity and damage the client privacy and security (Natarajan & Wolf, 2013, p.421).

In NV infrastructure, VNs are disconnected from each other but this modern framework too lead to modern assaults. Aggressor can rent the portion of the asset to survey the vulnerabilities and functionalities of the co-host VN. An instantiated VN can moreover dispatch assault to co-host VN by cross side channel assault and take the data (Natarajan & Wolf, 2014, p.123). Underneath figure appears the distinctive sorts of assaults in NV.
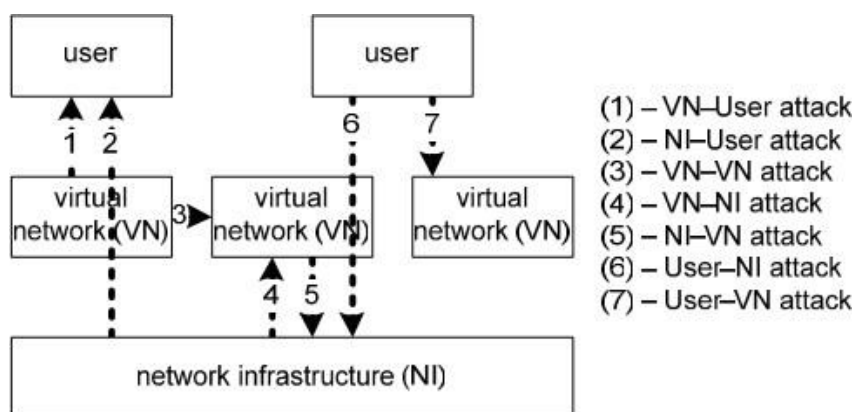


**Figure 20: Potential issues with virtualized Network**

Keenness:

Another include on VMM is intercession and roll back activities of VM. For case Microsoft Hyper-V to reestablish the VM on prior state in the event that a Troubles is recognized. But this highlight can moreover bring the capacity to debilitates the judgment of the exchange done on a VM and can control the state of a VM (Cleeff, 2012).

Virtualization moreover incorporates a more prominent insider risk to astuteness of the VM. Where an worker can effortlessly duplicate the number of virtualized machine on USB and change them at domestic and duplicate back to company's organize (Frangiskatos, 2013).

Insufficiently confirmation of party recognizable proof at both conclusion of communication channel or lacking assurance of channels judgment can cause a man in center assault. It permits the aggressor to get to the channel. Man in center assault happens since that virtual framework does not intrinsically ensure communication (Esensten, 2001).

TCP session seizing may to happen through rolling back the VM when convention reusing the arrangement number (Esensten, 2003). Another danger is virtual machine clients and handle can manhandle the logging work intentioned or inadvertently and surge the expansive sum of information in log records. Such dangers and vulnerabilities are presented through misconfiguration and fumble (Esensten, 2004).

In case have machine compromise, at that point malevolent client can effectively get get to to all VMs advertisement can modify, duplicate, move the VMs and put information at chance (Chaudhuri, 2006). In capacity virtualization, other risk is Dynamic contain, which endeavors to break security highlights, present pernicious code, or take or alter data (Mahalingam, Jayaprakash, Karthikeyan, 2012, p.156).

Just like the server and capacity virtualization, network virtualization (VN) too contains a risk of assaults. In NV, organize foundation (NI) and virtual arrange (VN) work beneath a benefit level understanding (SAL). In case NI is compromised than facilitated VNs can too be compromised and affected NI can alter VN data (e.g.

convention) and its operation and damage the concurred SLA. The assailant can compromise the virtual organize (VN). Assailants can run malevolent convention work to control or alter the typical usefulness of convention and it can moreover intentioned alter or control the information activity related with a specific VN (Natarajan & Wolf, 2009, p.58. Additionally a pernicious VN can moreover disturb the administrations of NI (Natarajan & Wolf, 2014, p.64).

Accessibility is considered one of the highlights of virtualization. But the accessibility of applications running on VMs can be influenced which can be way better get it from the couple of cases, one of an assault on the virtualization framework of the internet facilitating company VAServe, where 100.000 locales were erased. So virtualization cannot be totally accessibility dangers free (Cleeff, 2009) and moment, in 2008 when numerous VMware clients were prevented from logging onto their virtual servers as a bug dispersed in a program update effectively ceased the boxes from controlling up (Dubie, 2008).

The greatest danger to accessibility is when hypervisor gets dissent of benefit (DoS) assaults (Frangiskatos, 2012). In virtual environment the have machine and visitor machines (VMs) share the physical assets like CPU, memory and arrange assets. So, it is conceivable that visitor machine forces DoS assault by taking the all-conceivable assets and cleared out no assets accessible for other visitor (Reuben, 2005).

In virtualization, all VMs are depending on the single equipment which is the single point of disappointment. In spite of the fact that VMs are decoupled from the equipment but they are still dependent on the equipment. Disappointment within the hardware most likely lead to disappointment in VMs, which can drive a reboot and make the Challenges of unwavering quality and accessibility (Sahoo, 2015).

The other risk to accessibility of information is through changing CPU cover to off which might lead into VM crash and information loss (Esensten, 2014). Organize virtualization moreover features a risk of DoS assault on physical organize which can bring down the NI and all virtual facilitated systems (Natarajan & Wolf, 2014, p.59).

Realness

Virtualization makes identification Difficultiess. In case a VM is copied there now not is one unique machine. Moreover, the personality of the machine utilized for communications (such as the MAC address) might alter amid a exchange (Cleeff, 2010).

The other danger in virtual framework in the event that have machine is compromised, at that point assailant can get get to to all virtual machines or in other case of any malware interferes the virtualisation layer (hypervisor) , it can pick up get to to all VMs on the have computer, including the generation VMs, causing expanded security chance (Chaudhuri, 2012).

Believe

In NV, compromised NI can abuse the guaranteed SLA between facilitated VNs and NI, in this way increments the believe issue in NV (Natarajan & Wolf, 2002, p.532).

Vulnerabilities

The virtualization framework is more helpless to assaults since a few virtual machines are running on physical equipment and more focuses of section and more gaps to fix, Besides the vulnerabilities in one VM can influence the other VMs or have machine (Reuben, 2008).

Most of vulnerabilities are deliver due to misconfiguration and fumble of virtual framework (Chaudhuri, 2001). The most noticeably awful case is when virtual system establishment, hypervisor or have machine is compromised (Chaudhuri, 2003). Most vitally, as hypervisor is program and any powerlessness in hypervisor can put all VMs at chance (Chaudhuri, 2018).

The pace with which virtualization innovation is being received. It is also creating the security concerns for the organization. It is getting to be exceptionally fundamental to form virtual framework more secure and strong. Satisfactory information is required to legitimately arrange, review and oversee the virtual framework (Chaudhuri, 2019).

**Paper less with online communication methodologies**

Going paper less and moving towards on-line communication system is one of the Green Cloud solutions (Agarwal and Nath, 2011, Frangiskatos, Ghassemian and Diane, 2014, p.148 & Velte,2009). .

One can imagine that reducing the paper usage in an organization can help to protect the environment. As less the usage of paper, the less no of trees were cut for its production. Additionally, its tonner, maintenance, storage and disposal requirement would be less. Therefore, saving the money and environment both.

The threat of computer and internet security is one of the great challenges for on-line communication system. With the current popularity of on-line communication system, paper systemhas been replacing by it. But there is a conflict situation i-e use of internet and user mobility, on linecommunication system has introduced various kinds of threat and risks. Many organizations expanding their business via connecting to internet and automatically reduce the  paperconsumption. This section assesses the IA and security challenges associated with on-line communication system. Here, I assume that on-line communication include mobile computing system and internet computing.

Viewpoints OF THE GREEN CLOUD Innovation

The objective of this ponder is to address the Challenges of empowering energy-efficient asset allotment, which can eventually lead to Green Cloud computing Datacenters, in arrange to meet the request for computing administrations from competing applications and spare vitality. Figure 5 portrays the high-level design for the Green Cloud computing infrastructure's arrangement of energy-efficient administrations. The taking after primary substances included:

Customers/Brokers:

Clients of the Cloud or their brokers send benefit requests to the Cloud from any area within the world. It is critical to note that clients of conveyed administrations and Cloud

shoppers can contrast from one another.

Green Asset Allocator:

Serves as a conduit between clients and the cloud framework. To supply vitality productive asset administration, the taking after components must connected:

Green Arbitrator:

Arrangements with shoppers and brokers are conducted to finish the SLA with the characterized charges and punishments based on the consumers' Quality of Benefit needs and vitality preservation measures (for infringement of the SLA). A quality of benefit metric can, for occurrence, be the satisfaction of 96% of demands in less than 3 seconds. The benefit examiner analyzes and assesses the benefit prerequisites some time recently choosing whether to endorse or deny a submitted ask. As a result, it needs the foremost later data on stack and vitality accessible from Vitality Screen and Virtual Machine Supervisor, individually. Customer profiler:

A buyer profiler assembles nitty gritty data almost clients so that more noteworthy clients can get particular treatment over less noteworthy ones. Estimating is decided upon in arrange to effectively oversee the supply and request of computer assets and enable service allotment prioritization. Vitality Screen: Determines which physical hardware has to be on or off by keeping an eye on it. Benefit Scheduler:

Allocates demands to distributed Virtual Machines and decides asset privileges for alloted Virtual Machines. In arrange to meet request, it too chooses when to include or evacuate Virtual Machines. The Virtual Machine Chief keeps track of the assets that Virtual Machines have get to to as well as their availability. Moving virtual machines between distinctive physical machines is additionally its duty. Bookkeeping:

Screens the real utilize of assets by inquiring utilize data to decide costs. Utilizing past utilization data can offer assistance with conveyance choices. Numerous Virtual Machines can be powerfully begun and stopped on a single physical computer in arrange to meet acknowledged demands. The capacity to design various resource partitions on the same physical machine in arrange to fulfill assorted benefit ask requests manages framework

directors the greatest degree of adaptability. Different virtual machines with different working frameworks may run concurrently on a single physical machine. Workload utilization can be combined, and unused assets can be turned off. Physical machines:

The basic physical computer servers give the equipment design for building virtualized resources to fulfill benefit requests.

## Confidentiality

The massive production in laptop computer and usage of wireless connection has increase the threat to the confidentiality. All of the laptop personal or enterprise's contain confidential and secret information like personal or business information, bank account, PIN Code, addresses, credit card numbers and owner's company information etc. In practice the greatest threat to current laptop are losses or theft which can cause leakage of confidential information. Here is also a weakness with keeping the data encrypted that physical attack on laptop can recover the encryption key by analyzing the RAM (Pasquinucci, 2009).

Confidentiality of user information stored on computers could be threaten by spying software which monitors the user activity and captures confidential data (Mendyk-Krajewska and Mazur, 2010, p.436) and Trojan horses are able to establish remote connection and could transfer information to intended remote location (Mendyk-Krajewska and Mazur, 2010, p.436).

The other threat from hacker is once they get access to the system they can create backdoor which can be use even when all vulnerabilities are secured (Mendyk-Krajewska and Mazur, 2010, p.437).

A recent virus attack known as Gambler attack. It attacks user who visited infected webpages. It uses the vulnerabilities of extensions of webpages handling Flash Player and PDF files. By using vulnerabilities in plug-ins of Flash Player and Acrobat Reader, it installs applications that enable the proper attack. The application monitors the user network activity and registers user store passwords. Application also redirects the user to infected webpages by replacing the Google search result (Mendyk-Krajewska and Mazur, 2010, p.438-439).

Wireless communication system also has security issues and threats. AirSnort, WepAttack, WepDecrypt, coWPAtty, KisMAC, wpa_crack are the tools used to break the existing security of wireless network. They are easily accessible and easy to use. They use to capture the packet and gain access to wireless network and causes of man-in-middle attack (Mendyk-Krajewska andMazur, 2010, p.439).

**Integrity**

The other major threat to on line communication system is from malware, Which could be downloaded or transferred to the system unknowingly while unintentionally visiting the malicious website or link, opening an email attachment. The aim of such malware is to violate the integrity and data modification of the system (Mendyk-Krajewska and Mazur, 2010, p.436).

**Authorization**

The recent most dangerous threat is Conficker worm also known as Downup, Downadup or Kido.It uses the vulnerability of Windows Server system platform (programming error – buffer overloading) as well as various COM services used by all Microsoft Windows operating systems. This worm has greatest power of spreading and as infected millions of computers. Worm

through malicious code gives the control of computer to worm writer (Mendyk-Krajewska and Mazur, 2010, p.438).

In recent year, in 2008, a mass number of botnet creation has been observed. Hacker takes control over the computer with the help of software (Mendyk-Krajewska and Mazur, 2010, p.439).

**Continuity**

DoS is the most popular attack to affect the availability. Very recently, I received an instant message on social network from my family member. The message has a link and saying " Oh, Ican't believe it is it a picture!". As message is popup from my family member so I consider safe to open it to see my picture and thought she want to show me

some old pictures of our childhood. After clicking the link a file is save into my pc and then it automatically start sending the messages to my all contact list again making the same message "Oh, I can't believe it is it a picture! and with a link" and it automatically shut down the messenger application. As all my contact trust me sothey also opened me which supposed to be send from me, before I informed them. This malware make the system unavailable time to time automatically and wide spreading to others via VoIP , messengers and social networking applications and using me as a sender.

As discuss before about the worm, Conficker, it also affect the availability of various application of the system. It shut down the number of system services, e.g. Windows Security Center, automaticupdates, Windows Defender (protection against spyware) or the service of reporting Windows errors (Mendyk-Krajewska and Mazur, 2010, p.438).

It is very complex task to maintain and achieve the security in online-communication, mobile computing system because the system has varying threats and security issues. These issues are getting advancement along with technologies development. It is extremely important that every computer user is well aware of the security threats of the time and apply the most effective security solutions for Information Security

**Reduction in Travel with a Green Cloud solution and its virtualizations perspective**

Reduction in travel is also taken into effect with Geen Cloud solutions. This travel reduction eventually helps to protect the environment.

**Green Cloud Benefits in Reduction in Travel**

To achieve the goal of environment protection many organizations are adopting the travel reduction initiatives. Travel reduction is helping to reduce the fuel consumption and travel cost associated with flying or driving to remote location offices and client side. Travel reduction is also reducing the travel cost and fuel burning (Agarwal and Nath,2011& Info-Tech Research Group, 2009).

The travel reduction initiatives consist of: remote conferencing and collaboration such as video andteleconferencing between different remote offices and second is telecommuting strategy and

capabilities based on virtual private network, remote access to organization, working from homefacilities (Info-Tech Research Group, 2009, p. 13).

**Security challenges in Travel Reduction**

This section assesses the security challenges associated with remote connecting using collaboration tools and communication methods.

Secrecy

Numerous organizations issue the tablet and PDA to their laborer for portable working and get to the arrange from domestic. These computers have token verification instrument to get to the organization arrange which is very secure. But still individuals utilize their unmanaged domestic PC to get to the corporate organize. These unmanaged PC seem present the worm and infections to the organize (Hocking, 2011, p.18). A few malwares program plays a cleverly trap with the anti-virus, by stowing away the infection and gives an uninfected record to the anti-virus program (Hocking, 2011, p.18).

One danger to tablet given to the representatives for farther get to office is, tablet robbery which can cause spillage of secret data. Here is additionally a shortcoming with keeping the information scrambled that physical assault on tablet can recoup the encryption key by analyzing the Slam (Pasquinucci, 2009).

**Awareness**

The changes of remote conferencing collaboration and telecommuting strategies have brought real changes regarding the Information Security. In remote working environment, user completely relies on the availability and reliability of the network. A user than expect network, computer and service connection all work 100% (McKnight, 2002). There could be a case that user working from home and have a very important schedule meeting to attend and VPN connection is failed to establish.

**Hardware Disposal to maintain Green Cloud for Environment friendly**

The fastest growth of telecommunication and information technology and its extensive usage duringthe last two decade has expedited the massive production, manufacturing and usage of IT equipment. Concurrently, creating the Difficulties of mass disposal of it for the whole world (Choi, Shin, Lee and Hur , 2006).

According to research of Grossman conducted in 2006, Americans alone own 200 million computers and each year around 7 million tons of high tech electronic becomes obsolete in America(Grossman, 2006 & Gibbs, Melvin, F. McGarrell and Axelrod Mark, 2009). In 2007, according to research firm Gartner, US business and consumers throw away 133,000 PCs each day (Filipek, 2007). In UK, the figure of throwing away PCs has been reached to around 50 million tons (Gibbs, Melvin, F. McGarrell and Axelrod Mark, 2019). An estimated value of 6.5 million tons of waste electrical and electronic equipment (WEEE) is dispose of in Europe (EU) with an increment of 16- 26% in every 6 years. In china a huge amount of 70 million unit of PC was become obsolete by 2010 as estimated (Ongondo, Williams and Cherrett. 2011). The similar huge amount of WEEE become obsolete and disposed in many other countries of world, Africa, India, Japan, Nigeria, Kenya, Argentina, Brazil, North America (Williams and Cherrett. 2000).

The vast majority of IT equipment is end up in landfill and shipped to developing countries of Asia Africa where they dissemble, incinerated, dispose or recycle them in environmentally friendly manner or dumps them in the land. Heavy metals which is part of a PC like lead, mercury and cadmium, produce the adverse impact on ground and pollute the water and can also cause of fire. The burning waste also contributes in environmental pollution and depletion of ozone, causing global warming (Agarwal and Nath, 2012 &Gibbs, Melvin, F. McGarrell and Axelrod Mark, 2010).

The increasing e-waste into landfill and its hazardous consequences on environment is most critical driving factor of adopting recycling initiative (Info-Tech Research Group, 2008). To deal with the Difficulties of e-waste disposal, Environmental Protection Agency (EPA), develop the electronic recycling program to collect, reuse and recycle the electronic and electrical equipment with the help of local government, electronic manufactures, and retailers. In Green Cloud, the same idea of e recycling is preceded.

A Green Cloud activity and its evaluation from IA and security point of view:

Computer (e-waste) reusing is the as it were activity beneath the green transfer so green transfer cruel reusing and reprocess electronic and electrical fabric, utilize them in green fabricating of IT gear (Murugesan, 2008). Especially within the field of IT Green Cloud advances the reusing, restoring and reuse and reusing of individual and versatile computers, Individual computerized help and difficult disks etc., in natural neighborly ways (Murugesan, 2008). Agreeing to Murugesan, Green Cloud spins around the 3Rs, reuse, repair and reuse.

Reuse:

Rather than throwing the ancient computers into the landfills to form the natural Difficulties. Consumers ought to deliver it a few one who can reuse it and essentially rather than buying the unused computers each year and for each unused extend, ready to reuse the computers components and get it from electronic-reuse segments (Murugesan,2018).

Repair:

In Green Cloud, buyers are empowered to purchase the restore item rather than exhausting parcel of cash on modern things (Murugesan, 2018). The repair things are those computers which are sold beneath the ensure approaches or due to a few minor abandons or such as the issue of not just like the colors etc. At the conclusion of life computer, if computers are buries within the arrive or burn, both burring and burning produce the dangerous effect on the environment. Green Cloud advances, to deliver the conclusion of life computers and EEE (Electric, Electronic Hardware) items to reusing segments, where reusing divisions can reuse the computers parts and other embellishments (Murugesan, 2008).

Right now numerous nations are starting, drafting, embracing the squander electrical and electronic gear (WEEE) directions and administration hones. In EU the WEEE mandate control, limitation of unsafe substances (RoHS) and vitality utilizing items mandate (EuP directive, for the aim of vitality utilizing items and their free development within the Europe) has been actualized (Ongondo, Williams and Cherrett. 2012).

In WEEE order direction, inclusion of producer and merchant of EEE advances the point of recycling

and reusing of ancient EEE. Under the control, producer take back their ancient EEE from buyers and guarantee the correct reusing and re-usage of it and diminish the transfer of squander. On the other hand, they too guarantee the transfer of WEEE utilizing naturally sound strategies (Ongondo, Williams and Cherrett. 2010). With the noticeable exception of EU, numerous creating nations are moderate and missing behind the right management of WEEE. Most of the creating nations have casual reusing segments. In china, larger part of WEEE is reused by casual reusing divisions, workshops. In 2006, around 7 million people groups utilized in e-waste reuse (Ongondo, Williams and Cherrett, 2000 & Yu, Williams, Ju, Shao, 2011). In 2008, around 0.9 million are utilized in e-waste reusing, where 96% of individuals enlisted within the casual recycling sector (Yu, Williams, Ju, Shao, 2011). China too confronting with the Difficultiess of orderly takes back for reusing, need of obligations from producer, retailor and consumers (Ongondo, Williams and Cherrett, 2010).

In India the most of the WEEE recycling sectors is terrace based unlawful moment of EEE and moreover missing in reusing directions. Comparable to china and India, other nations like Africa, Nigeria, and Kenya are too have the casual reusing divisions (Ongondo, Williams and Cherrett, 2011).

**Benefits for Green Cloud by doing IT hardware recycling**

Technology Research Group in 2012) has clearly described the green cloud benefits with IT hardware recycling as following methods



**Figure 21: Benefits with Green Cloud by doing IT hardware Recycling**

The taking after table moreover portrays the green benefits of Computer Reusing. The benefits recorded are as it were those which has been found within the writing and assist benefits may exist.

**Green cloud Benefits with Computer Recycling**

| Green Benefits | Description | References |
|---|---|---|
| Environmental Benefits | Recycling methods to protect the soil and environment from polluting the ground with e-waste | Agarwal and Nath, 2012 Murugesan, 2008 |
| E Waste Reduction | Through frequent recycling programs, thee-waste is keep decreased gradually | Technology Research Group,2020 Agarwal, 2016 |
| ITequipment amount decrease in landfill | By doing recycling less amount of IT equipment is disposed in landfill | Technology Research Group,2014 |
| Space saving | Recycling of old hard disks, motherboards and accessories of computers also benefits in term of storagespace because companies running out of space to keep old IT Infrastructure equipments. | Technology Research Group, 2015 |
| Companies good Reputation with customer | Companies get back to customers with the good reputation through proper recycling methods. | Technology Research Group,2018 |
| Economical benefits | The research study is also indicate that reselling of e-makes money with different methods | F. McGarrelland Mark, 2020 |

| | | |
|---|---|---|
| Save capital expenditure | Rather than tossing the old computers into landfills, we will reuse, repair and reuse them, which spare us from buying and creating the unused computer as a result spare the capital consumption | Murugesan, 2009 |

Surveying IA and security challenges in Green Transfer:

The over measurements of out-of-date ancient computers and the sum of WEEE arranged of in each nation, appearing the development transfer burden of the IT hardware. As a result, the advertise of e-recycling has been creating. This reusing advertise of ancient computer is additionally bringing the challenge of security and IA.

Getting rid of old computer through recycling and reusing, while keeping the environmental sustainability, is not an easy job. E-recycling and reuse is also coupled with the threat of data loss, confidentially and privacy. Many researches has been undertaken to determine assurance of information protection during and after the computer recycling and disposal (Jones, 2007). Andy Clark, head of forensics for UK info security consultancy firm Delica, has been asked, "Do things goes wrong during recycling?" He replied, yes, Green Cloud is in the people's mind they recycle the hard disk and computer without knowing the assurance of information security and how recycling will be carried out (Mathieson, 2006). People's give high importance to security before the system come into service and assure the security perspectives during its service period too but when it comes to its end of life and going to disposed of, very little effort is carried out to assure that data is properly removed from the system (Jones, 2005).

In 2005-2006, Dell started the green regeneration campaign, in Beijing and Shanghai, for collecting the old computers from its both corporate and private users. Dell also provided the compensation of 0.17 USD for 1kg of old computer and 3.78 USD for whole computer,

to the consumers. But the consumers had to bring the computers to Dell stores by themselves, which means cost of transportation is bearded by the consumers. As a result, Dell only collected the 57,000 kg of used computers in 2006-2008 from china, which is quite less as compare to amount of 46 million kg collected from around the world only in year 2007. So the consumer found a good choice of selling their old computers to informal recycling sectors and majority of the consumers sold their computers to informal recycling and reuse sector (Yu, Williams, Ju, Shao, 2011).

**Privacy and Confidentiality**

One of the ways of data theft and loss are from the data that is left on the old computers when they are disposed of or sent for recycling. Many criminals and people with ill intentions gain the confidential data and information from the old recycling computers (Hinde, 2004).

According to an estimate, around one billion of computers have become obsolete till 2011 (Bennison & Lasher, 2005). With such large number of obsolete computers, confidentiality and privacy concern are very critical to protect.

Both corporate and individual user stores the very confidential information on the computer.Business users store the personal information, pay rolls, client information, business goals, account information, patient health records, credit card numbers, and social security numbers. Normal individual users also save the private and confidential information like credit card numbers, accountnumbers, family information, addresses, phone numbers, passwords and other personal data. Mostof the cases organizations and individual users are not aware of the security measures and policiesto be followed when giving their PCs for recycling. A number of cases, confidentiality and privacy leakage have been noticed in recycled computers as discussed below.

According to Jones (2007), in past, large organization donated their old PC to charities center and school, and get rid of the burden of computer disposal. But today, the liabilities on health and ground have made this impractical. They have few options; first they can carry out the computer data cleaning and disposal by themselves, using their internal

resources. Second they can find an organization and handover the computer to dispose of. Third option, they can contact a reputable and major recycling company to carry out this job with government regulations. Assure  the complete cleaning of the data before recycling.

The all three options are seeming to be quite safest in terms of IA, but only large and big organization can afford and do this. What about small organization, to get rid of old computer with assurance of data security? Where they have limited numbers of staff. But on the hand, what organization knows about the recycling companies, processof computer disposal and recycling. Do the organizations check the processes before giving the old PCs to them? Do organization's equipment are recycled in the market after the all measures of security concerns? Unfortunately, the situation is not as good has it should be. Number of research has revealed that data is not properly cleaned from the old computers. Many of the organizations areunaware of policies and their legal policies (Andy, 2013). At the same, individual user are also paysvery less attention on privacy and information leakage through their old recycled computers (Kwon,Lee & Moon, 2006).

In 2009, a research study was taken on 300 used hard drives. These hard drives were purchasedfrom online market of used electronic items. Among the hard drives, 34% was found with confidential information of bank account and credit card details, medical records, confidential business plans and personal ID numbers (Smits & Cain, 2011).

In a recent article, it was revealed that a security expert discovered a VPN device bought on  automatically connected to a local council's confidential servers (Francisco's, Ghassemian and Diane, 2011, Sparkes, 2009).

In 2004, University of Glamorgan and Edith Cowan University in Australia, carried out research to find out whether critical information is still resides on the second-hand disks. The disks are purchased from different resources and from different regions.  Surprisingly,

they found, a numberof valuable and sensitive information is still available on the disks or can be easily recoverable (Jones, 2007).

In 2005, the same research was carried out, sponsored by British Telecommunications (BT) and Life Cycle Services (LCS). This time research was carried out on large scale, including the disks from a greater number of countries (Jones, 2015).

The results obtained from the both researches are shown in the below tables by the Jones (2014).

MATERIALS AND Procedures FOR GREENER CLOUD

To change over cloud computing frameworks more naturally neighborly, basically three methodologies have been tried. In test settings, the strategies have been tried in Datacenters. The strategies genuine down to earth application is still being investigated. The procedures are:

Methods for energetic voltage and recurrence scaling

A useful clock will be included in each electronic circuit. In arrange to control the supply voltage, the operational recurrence of this clock is changed. This procedure can't be adjusted to meet changing prerequisites since it depends so intensely on the equipment. The power investment funds are moreover minor when compared to other approaches. The taken a toll deflected to power investment funds proportion is additionally humble.

Strategies for apportioning assets or moving virtual machines

The applications are run on a number of virtual computers that are housed on each physical framework in a cloud computing environment. Based on the different requests and assets that are accessible, these virtual machines can be migrated between has. The relocation methodology for virtual machines is emigrate them with the slightest sum of control increment conceivable.
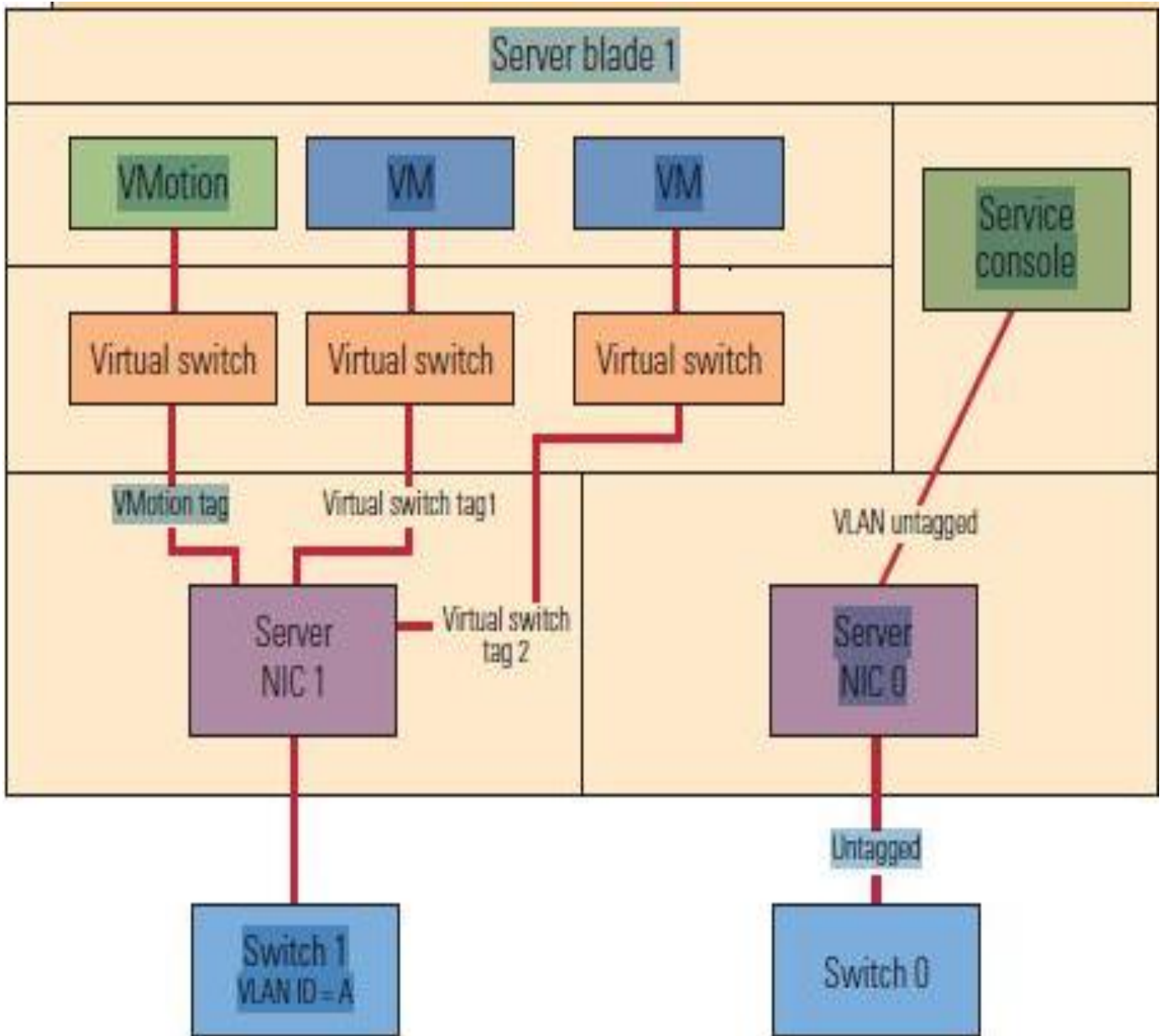
Figure 22: Architecture for VLAN

Algorithmic strategies concurring to test ponder, an perfect server employments almost 70% less control than a completely used server. The desired energetic workload on the servers is to begin with discovered by the green planning methods using a neural organize indicator. At that point, superfluous servers are turned down in arrange to diminish the number of servers that are working. This increments all other levels by diminishing the amount of vitality utilized at the areas of utilization. Extra servers have moreover been put in put in arrange to help in keeping up benefit level

understandings. The extreme objective is to keep the level of customer care is high whereas bringing down the entire taken a toll of possession.

9.3. OPEN Discussions AND Troubles Fathoming

In this portion, we highlight noteworthy open issues that can be settled at the level of framework asset administration. Cloud computing situations essentially depend on virtualization advances to empower the capacity to move virtual machines over physical hubs by means of live or offline movement. This makes it conceivable to powerfully solidify virtual machines to a little number of hubs in agreement with the current asset needs. As a result, the Datacenter's by and large vitality utilization can be diminished by turning off or putting sit still hubs in a power-saving mode (such as rest or hibernation). Forceful Virtual Machine unions may result in performance loss and a SLA infringement in spite of the vitality reserve funds. Calculations for asset administration effectively address the trade-off between framework execution and vitality utilization.

Energetic Asset Allotment with Vitality Mindfulness

Datacenters presently utilize virtualization increasingly as often as possible since of later progressions within the equipment segments utilizing hypervisor innovations. It encourages energetic relocation of Virtual Machines in agreement with QoS necessities by empowering the development of virtual machines between physical hubs consistently by utilizing live partition mobility. When not in utilize, virtual machines (Virtual Machines) can be conceptually isolated and condensed into a little number of physical hubs utilizing hypervisors; inert hubs can too be turned off. At the minute, cloud Datacenters put less consideration on asset allotment that points to boost vitality proficiency; instep, it organizes accomplishing SLA whereas guaranteeing exceptional execution. To dissect execution and vitality proficiency, the fundamental issues must be settled. Visit control blackouts may compromise a server's constancy. It is Difficulties from a QoS angle to turn assets off in a energetic environment

since of workload inconstancy and forceful solidification. The other, SLA upkeep, makes it challenging to accurately control application execution in virtualized frameworks. A virtual machine cannot precisely mirror the behavior of a physical machine. The virtual machine's time estimations are wrong as a result of the timekeeping Difficulties that take after, which may lead to dishonorable SLA authorization. To overcome all of these troubles, proficient solidification approaches that can lower vitality utilization without compromising the used-specified QoS standards are required.

Datacenter asset provisioning and determination based on Quality of Benefit

Since the execution levels they convey to their clients shift, it is fundamental in cloud computing to select assets whereas taking Quality of Benefit into consideration. Moreover, cloud apps may display different workloads. to distinguish common patterns and practices and explore stack estimating procedures that might eventually lead to more successful asset provisioning. Advertising shoppers workload union and asset choice approaches that advantage from execution and vitality investment funds is another objective.

Virtual Arrange Topology Optimization

Virtual arrange topologies are frequently made in virtualized datacenters as a result of associations between virtual computers. The arrange communication may utilize organize switches with a critical control utilization on the off chance that the communicating Virtual Machines are alloted to has in a few racks or walled in areas. It is significant to screen communication between Virtual Machines, organize them on the same or adjacent hubs, and set control utilization limits in arrange to diminish this information exchange taken a toll. Since movements take more vitality and have a hindering impact on execution, the reallocation controller must make beyond any doubt that the advantage does not outweigh the taken a toll some time recently beginning one.

Thermal and Cooling Frameworks Operations optimization:

The electrical vitality utilized by computing assets is generally changed over to warm. Various Difficulties are brought on by tall temperatures, such as lower framework accessibility and unwavering quality as well as shorter device lifetimes. To maintain a secure working temperature for the system's components, avoid glitches, and anticipate framework breakdowns, the produced warm must be scattered. In arrange to examine and create a modern warm administration calculation that tracks the physical nodes' warm state and disperses work from the overheated hubs to other hubs, the unused issues incorporate knowing when and how to reallocate virtual machines to decrease the sum of power utilized by the cooling framework whereas keeping up secure asset temperatures, limiting movement overhead, and keeping up execution. By abating down the cooling frameworks of warmed hubs, it is conceivable to empower common control dissemination in this situation. We must create a strategy to control the temperature that produces utilize of the temperature varieties between unmistakable workloads and shuts them off at the correct time. Components can be viably utilized when the QoS of the hosted apps does not request CPUs to operate at full capacity. We might broaden it to require into account the case when various assorted apps with different QoS prerequisites make utilize of the framework at the same time.

Consolidating Virtual Machines Effectively to Oversee Heterogeneous Workloads
Clients have got to virtual machine provisioning and application allotment through cloud foundation administrations. This comes about within the capacity to apportion numerous application sorts (such as venture, logical, and social organize apps) on a physical have. Finding the proper applications to execute on a single have for ideal asset use is the trouble. The challenge of coordination assorted sorts of workloads isn't inspected by current strategies for uniting virtual machines in Datacenters in an vitality effective way. These strategies ordinarily concentrate on a certain workload sort or don't take differing application sorts into consideration whereas accepting a uniform workload. A record server

can be effectively coordinates with a computationally seriously (logical) program since the last

mentioned makes utilize of circle capacity and network bandwidth while the previous essentially

depends on CPU speed.

**My Derived Formula for Virtualized Infrastructure effective management:**

Along with productivity management, server height accessibility is also very important for mission-critical applications in a virtualized infrastructure. Consequently, the following formula that I came up with.

**Y  = [ X * (H-1)] / H**

Y = % of utilization of resource on each server in Cluster (considering all the servers are having same

configuration).

X = Maximum utilization of a Server at any point of time with N+1 redundancy should not exceed

70% of utilization

H = Number of Servers in a Cluster (H>1)

If two hosts in a cluster, the utilization of any Server should not exceed 35%. (Y) = [ 70 * (2-1)] / 2 =

35 %

If three hosts in a cluster, the utilization of any Server should not exceed 46.67%.  (Y) = [ 70 * (3-1)] /

3 = 46.67 %

If four hosts in a cluster, the utilization of any Server should not exceed 52.50%.  (Y) = [ 70 * (4-1)] /

4 = 52.50 %

**Table 11:**

**A comparison between my research framework maturity model and Global Cloud Service Providers (AWS, Azure, Google ) for IT Infrastructure Virtualizations:**

| Recommended maturity rating for IT Infrastcruure Virtualizations | | | |
|---|---|---|---|
| | Global Industry ratio | My research framework ratio | Conclusion and Recommendations |
| Server Infrastcruure | 3.9 | 4.6 | - Target for a higher server virtualization ratio of 4.6 than industry (Global ratio 3.9). x86 Virtualization ratio maximum is to 1:35 with 70-75% utilization<br><br>- Enable the high availability with active-active OS clustering for effective utilizations of Compute resources |
| Storage Infrastcruure | 4.1 | 4.8 | - Enable efficient storage units with data efficiency technologies like thin provisioning, compression which optimizing storage capacity<br><br>- Data movement between storage tiers which helps in reducing operational expenditure<br><br>- Should consider investing into Software defined storage solutions which will enable API management within different class of storage for effective utilizations<br><br>- Data copies through snapshots to reduce the physical data copies |
| Data Backup Infrastcruure | 4.3 | 4.9 | - Enable data backups with virtual disk-based appliance<br><br>- Framework for disk-based back-up for BCVs for backup infrastructure power reduction<br><br>- Dedupe technologies in primary and DR regions to maximize the storage utilization and minimize power consumption, Data center space<br><br>- Storing backups with longer retention with fiber channel S3 and Glacier devices for less power consumption |

**Source of Information:**

**https://cast.ai/blog/cloud-pricing-comparison-aws-vs-azure-vs-google-cloud-platform/**

**https://embee.co.in/blog/aws-vs-azure-vs-google-cloud/**

**APENDIX C   INTERVIEW GUIDE**

Response time is the primary measure of cloud performance as seen by end users. There should be a limit on how long a response time takes, or how long a delay people experience. In this case, the Service Level Agreement (SLA), a contract between service providers and users, statistically limits the response time: Challenges

For this reason, the delay requirement measure is often determined by calculating the percentile of requests that should be delayed within a reference delay (e.g., the 99th percentile delay). Thus, given a workload arrival rate to a data center, the performance model of a server provisioning strategy calculates the number of active servers needed to statically bound the response time observed by end users. We adapt the following models from the related literature, some of which we evaluate independently in specific experimental studies: Performance models based on queuing theory and CPU utilization thresholds are both applied. The next section includes an overview of the models and a brief synopsis of their application in the research.

Performance Model Based on CPU Utilization Threshold Although web traffic is not CPU-intensive, relevant research has demonstrated a strong association between the quality of service (QoS) and the CPU utilization level; also, exceeding the CPU usage level results in a breach of the SLA.

### Table 12: 2005 and 2006 Comparison results of the survey

**Table 1: Comparison of results of the 2005 and 2006 surveys**

|  | 2005 | 2006 |
|---|---|---|
| Total Number of Disks UK and Australia | 116 | 253 |
| Faulty/Unreadable | 13 (13 %) | 90 (36 %) |
| Wiped | 17 (16 %[1]) | 73 (45 %[1]) |
| Commercial Data Present | 60 (70 %[2]) | 42 (47 %[2]) |
| Individual data present | 51 (59 %2) | 44 (49 %[2]) |

1 %ages are of the readable disks
2 %age of readable disks that had not been wiped

This compares the findings from the disk surveys conducted in 2005 and 2006, focusing exclusively on disks bought in the Asia and EMEA regions.

A comparison of the results from the disks obtained at each location.

| Table 2: A comparison of the results from the disks obtained in the different regions. | UK | Australia | Germany | North America | Totals |
|---|---|---|---|---|---|
| Total Number of Disks Analysed | 200 | 53 | 40 | 24 | 317 |
| Faulty/Unreadable | 87 | 3 | 30 | 12 | 132 (42 %) |
| Wiped | 55 | 18 | 4 | 1 | 78 (42 %[1]) |
| Commercial data present | 28 | 14 | 4 | 6 | 52 (28 %[2]) |
| Individual data present | 35 | 9 | 3 | 7 | 54 (29 %2) |

1 % are of the readable disks
2 % of readable disks that had not been wiped

In 2004, two MIT students purchased 143 used hard disks from eBay and secondhand computer retailers. 129 of the hard disks could still be used. According to Bennison and Lasher (2005), 69 hard drives held the private information of the previous user, including credit card numbers and medical records, and 32 hard drives still hold data that may be recovered.

The 3Rs program for getting rid of outdated computers is helping to reduce the negative effects of IT on the environment (Info-Tech Research Group, 2019, p. 17 and Murugesan, 2009), but if it isn't done correctly, it can also lead to security problems and difficulties with information leakage. While safe sanitization by multiple overwrites can wipe all data from disks (Kwon, Lee & Moon, 2007 and Lamb, 2010), data encryption and personal resource recycling can also be used to remove data entirely (Jones, 2015). Organizations must still alter their policies and practices, though, to guarantee that all data has been deleted from the disks.

Key Findings Discussed in Regard to Thesis Question: What Effects Can Green Cloud Practices Have on Information Security?

The government and IT industry are being forced to use Green Cloud solutions, like cloud computing and network computers in computer design and manufacture, due to the IT sector's role in the rise in $CO_2$ emissions. In a similar vein, Green Cloud solutions like virtualization, paperless transactions, internet computing, and less travel are also changing how we use IT. Additionally, electronic computer recycling programs are changing. Green Cloud is now promoting computer hardware and electrical device recycling. Every one of these green cloud options has a unique implementation strategy, unique security issues, and was previously covered.

Virtualization is a leading example of security difficulties. Virtualization of data centers has numerous security issues, including guest-to-guest attacks, egress from the hypervisor, vulnerabilities in the hypervisor's features, escalation of privileges, compromise of the host computer, etc. A second instance is recycling a significant number of computers, wherein inadequate policies and procedures are adhered to. The confidentiality and privacy of data are greatly threatened by such recycling processes.

Green computing involves merging information security challenges in a new way by transforming technology consumption into smart and energy-saving solutions. In a novel approach, the security concerns of all the various Green Cloud solutions are combined by implementing those power-aware IT practices. However, some green cloud solutions—such as "virtualization," "travel reduction," and "computer recycling"—that were developed with the express purpose of saving energy also have information security issues that are unique to that concept. On the other hand, other Green Cloud activities, such as network computers and online communication systems, are already widely used in today's market. However, network computers are replacing desktop PCs and are being used everywhere. Comparably, reducing paper use and utilizing online communication while enforcing them in all organization types can raise the risk of security breaches.

Speaking of cloud computing, it's a new, developing technology that wasn't initially intended to be a Green Cloud solution but is now developing into Green Cloud Computing as it moves closer to the goal. Increasing virtualization and multitenancy in the cloud computing environment is necessary to make it more environmentally friendly, however this green strategy of multitenancy and virtualization is not without risk. As a result, as clouds get greener, security risks may increase.

Green Cloud is not a theory anymore. Numerous businesses are adopting a green approach using a variety of techniques, such as installing energy-efficient air conditioning units, monitoring and optimizing energy use, sharing plans for the Green Cloud, and putting in place effective application and data storage (Lamb, 2010). It is undoubtedly a very large area. Green computing and IT encompass all applications, procedures, performing arts, and projects that try to save energy, lower $CO_2$ emissions, and save costs. It is imperative to note that the emergence of security concerns is contingent upon the specific Green Cloud solution that the company has chosen to use. For instance, if a company cools the floor of its data center to reduce the amount of energy used for cooling, then clearly there are no security risks associated with such solutions. Therefore, a company considering a green solution has to be aware

of the inherent security risks associated with each green cloud solution. Knowing the related security concerns can help we determine how to address security by implementing both general and specialized security solutions to meet energy-saving and safety objectives.

The stated Green Cloud practices in the thesis actually mix and integrate the security challenges of multiple Green Cloud solutions in one location, in addition to posing information security difficulties that are authentic to the idea alone. Therefore, the Green Cloud is bringing about a significant shift in the requirements for IT implementation, and these profound changes are posing new information security issues.

Key Findings Discussed in Relation to Thesis Question: What Information Security Issues Do Each Going Green Solution Present?

The chart in segment 6.2 has given the exceptionally fast understanding to security dangers, vulnerabilities challenge of each Green Cloud arrangement. This will appear us what security dangers and vulnerabilities have to be be moderated when arranging to embrace a Green Cloud solution. Result also helps to discover out what may well be the most excellent Green Cloud security methodologies to take after for an organization that have been as of now or within the prepare of getting greener.

This proposal report demonstrates not one or the other the Green Cloud could be a theory nor the related issues. The security data brought out in this proposal has been accumulated from diverse sorts of considers. These considers are based on the perception, learn from the collective involvement of others (creators of articles) from the field, based on prove, broad investigate with point by point case think about, interviews, , speculation that can be tried and confirmed. Grossman (2012), Goucher (2009), Armfield (2019) and Glut (2018) are inquired about articles. These inquire about articles are based on the suppositions from the IT field master that how they see the effect of Green Cloud on data security. They have too collected a few prove and encounter of security Challenges of Green hone. Green Cloud raises security fears (2006), Goucher (2018) and Glut (2011) have too displayed the collective information and data, perceptions, prove and theory which can be tried and confirmed. Whereas Frangiskatos (2000), data security and digital forensics address notes, is an experimental consider with prove and inquire about. Well organized, begun from the Troubles of energy consumption and solution to the vitality utilization and taken after by the Security challenges of virtualization. Esensten (2014) have moreover done the experimental thinks about by planning the

information for investigation, conducting distinctive information investigation, moving more profound to understand data and after words translating the information. The overall considers are blend of perception, encounters and experimental ponders.

The arrangement to the developing control utilization has been found and winning within the frame of Green Cloud but proposal has brought up the basic issues of security in Green Cloud. The security challenges related with Green Cloud hones cannot be essentially belittled. Daze appropriation of vitality sparing innovations on one side can spare the environment but on the other hand can make encourage challenges. Proposition keeping the significance of green computing has bring forward its grimy mystery as well.

Proposal comes about may offer assistance any organization to distinguish and see up the Green Cloud security issues and avoid them from event.

Coming to the point how one ought to take the proposal. Proposal has recognized the significance and necessity of Green computing but too has attempted to explore the other security portion of it. There were numerous speculation and news articles who speak approximately the security dangers of the Green Cloud. Proposition has demonstrated that Green Cloud increases the security challenges. These security challenges are not outlandish to maintain a strategic distance from a reasonable and keen security strategy can relieve these security issues.

Each organization ought to explore for the Green arrange but with superior administration and techniques. It implies, through appraisal, one should know the environment of the trade and after that choose how to roll out the green hones and plans. They thought to figure out which green arrangements are more fitted for their environment. Dissect the more reasonable green arrangement against each displayed security issues and challenges of this thesis' result and maybe they can think past for security agreeing to their current implementation and situation.

Once we know the challenges of security, we will be able actualize the security arrangement to maintain a strategic distance from the episodes. Proposition has made individuals to realize that Green Cloud usage cannot actualized effectively it needs the evaluation of the environment, distinguish and guarantee the foremost reasonable arrangement and how organization can get greener. Dissect the recognized arrangement in terms of security. Join the security techniques in green arrange by identifying the possible and reported security issues of green arrangement. In this way security ought to be the

fundamentally portion of the green plan.

Thesis comes about appear that to consolidate the security aspect, one doesn't ought to think out of the box. Once can think about and inquire about the showcase for that particular green arrangement and check the accessible security arrangements and either can advance them or invent them agreeing to their possess security issue. In this way for a effective green roll out, one ought to make green arrange and methodologies, solid security arrangements and methods, raise the security mindfulness. This will empower the organization to secure environment and cash and will offer assistance to extend the generally security level.

Inquire about Delimitations- In spite of the fact that the proposition has been effectively finished but taking after are the confinements. The impediment is around the accessible writing, exceptionally few writings are accessible who conversation almost the Green Cloud and security together. Most of the writing as it were talking almost the significance and preferences of Green Cloud. Few of the articles who talk approximately Green Cloud in terms of security. These few articles are based on perceptions, individual and experts' supposition or either as it were examining the virtualization as Green Cloud arrangement danger to security. But this restriction is overcome by distinguishing the green arrangements in all zone of plan, fabricating, utilize and transfer.

Noteworthiness and commitment to the existing information and hone based on the truth that changing climate has drawn the consideration of commerce holders and government around the world to contribute in Green Cloud. Numerous trade and government has realizes the benefits of Green Cloud and moving towards the green activity to spare the planet and cash (Info-Tech inquire about gather, 2018). Proposal implies the Data Security portion of the Green Cloud which has not been surveyed in detail some time recently. The current investigates articles of Grossman (2012), Goucher (2009), Arnfield (2018) and Green Cloud raises security fears (2005) are more near to perception, speculation and experts' suppositions and sentiments. Articles are not exceptionally solid approximately the subject that what they have concluded from it and what genuine danger they see and discover in different Green Cloud arrangements.

The articles are not broad almost how Green Cloud can affect the data security and what are the security challenges covered up in green arrangements. It more likes a collective representation of data and information sharing. Grossman (2016) mention in his article that there are security hazard covered up behind a few green activities but all through the article the security dangers has not been displayed but

a few imply almost the issues display in virtualization and cloud computing. He too notices that "Green Cloud has more to do with security issues". But this explanation has not been defended. This proposition work has displayed the covered-up security chance in all major green arrangements and has clarified how Green Cloud can affect security and can increment the chance level. In article of Computer week after week, Green Cloud raises security fears (2007); creator has hypothesized approximately the security dangers and has as it were displayed the prove almost computer reusing.

After words articles talks more almost the Green Cloud data and significance. Additionally, Goucher (2009) in her article relates the green risk as it were to reusing of paper and computer. Article is more based on perception and speculation. But exceptionally critically, these articles have given a standard for proposition work and truly given a great helpline to achieve the work.

Presently talking approximately, the articles composed by Glut (2009). She has organized the letter exceptionally pleasantly. Beginning from the Green Cloud definition and after that making the interface to security dangers. She has moreover said the measurement of Green Cloud and activities. She has too examined the related security dangers with different green hones. Whereas Frangiskatos (2012), as it were limited the Green Cloud to virtualization. The title of articles reflects that article will talk approximately the different Green Cloud hones as well but article as it were talk about the virtualization but in reality green risk isn't limited to virtualization. This proposition has demonstrated that green danger isn't limited to virtualization and reusing as it were. Proposition moreover evaluates the Green Cloud from IA and IS perspective in all major Green Cloud activities and concluded the security dangers and challenges beneath the security qualities. This proposal has meant the other feature of security in Green Cloud, which not as it were empowers secure planet but moreover to spare the trade by satisfying all security needs.

The key discoveries and comes about of the proposal give the profitable commitment to the field in hypothesis and hone of Green Cloud. As small inquire about has been carried out on Green Cloud from IA and IS point of view so distant. This proposal is to begin with approach which hypothetically analyze the connection of Green Cloud with IA and IS and the related danger to security. Proposal have thinks about the Green Cloud arrangements and have discover out the security issues and have displayed in regard to security qualities which has not been done some time recently. Current thinks about (Esensten, 2011and Francisco's, 2010) are adhere as it were to the virtualization as a green computing arrangement and have displayed as a danger to security. Proposal has covered the all measurements of Green Cloud and has done a information investigation in each measurement and have gathered all prove of security

risk in each person arrangements and at long last made translation of analyzed information in result and conclusion.

Proposal advances the unused information within the current arrange where current articles are more based on perception, speculation and hypothesis. In past writing, Green Cloud security issues as it were restricted to virtualization and reusing whereas proposal inquired about others green practices where security dangers are too covered up. Proposal minimizes the investigate hole and argumentation imperfections by bringing forward the confirmed and experienced security dangers. Proposal has set up the legitimacy of green risk and show it more way better way. By concluding the security dangers in unthinkable frame beneath the security traits. Proposal comes about gives a more useful frame work that which security quality will be affected by which green arrangement and how it can be affected. Proposition tells that it is no more a hypothesis.

The IS level of previous information needs within the legitimacy of issue. Proposition commitment has given the life to the Challenges. Some time recently that all writing is very scattered, most of the writing examined security issues of Green Cloud in shape of theory and restricted to virtualization. Proposal has secured the all those green activities where security issues have been found and how the level of security dangers can be expanded.

Majorly, this proposition may draw the consideration of Green Cloud taking after IT industries to too center on the covered-up security issues in going green other than taking the points of interest of taken a toll diminishment and control administration. Disregarding the other side of Green Cloud can lead any organization into startling monetary, data and reputation misfortunes.


**Future work and Proposal:**

This proposition utilizes the writing think about to gives the profitable work to address and list the data security dangers and vulnerabilities, be that as it may this require assist thinks about to expand how to handle these security issues and what security counter measures can be connected to fortify the security perspective of Green Cloud. The proceeded utilize of orderly writing audit may well be taken after to distinguish moderation of found security issues. Close to the writing audit, government educate, IT organizations that encompasses Green Cloud arrangements the natural maintainability, may well be most prominent utility, to pick up on hand involvement and working security measures. In depth, a case

consider might moreover be suggested to illuminate the related security issues in conjunction with the correct direction how to control and minimize them. Another inquire about thought, A Delphi ponder, a strategy of an iterative handle utilized to gather and distill the judgments of specialists employing a arrangement of questionnaires interspersed with criticism (Skulmoski, Hartman and Krahn, 2006), can be embraced for the achievement of proposition.

But interestingly due to the restricted number of contact and assets are accessible to carry out this strategy. Restricted number of judgments isn't adequate to legitimate the result of proposition.

This proposition and future work can moreover contribute and offer assistance the Green Cloud division, how to make computers, plan computer program and equipment, how to utilize electronic gear and innovation and in final how to legitimate reuse, to attain the both objective of data security and affirmation and a more economical environment.

In this way the significant future work required here to explore almost the security control degree to overcome and minimize the distinguished security dangers and issues. Guarantee the degree of confidence that security highlights, models and security approaches are appropriately connected on data framework. These proposals permit Green Cloud to be executed in a way which leverages the qualities the green technologies and allows execution of security controls to relieve the security shortcomings.

Proposition comes about too address the security experts, chief data security officers and managers to plan necessary methodologies and approaches to form the arrangement more security resistant. In spite of the fact that going green is getting to be need of time, not an alternative (Murugesan, 2008) and have numerous benefits other than decrease in vitality utilization but Green Cloud implementers ought to too consider security circle holes in Green Cloud and include the security specialists, and experts to arrange best hones, standards and approaches to handle the security issues.

Moreover, utilize the IA program, to incorporate the hazard administration, when moving the existing conventional forms and IT arrangements to Green arrangements. IA and hazard administration plans guarantees the assurance of touchy information while still remaining Green.

**Summary:**

Evidence that IT is contributing to environmental destruction includes high power consumption data centers, underutilized IT resources, paper consumption, hardware that is disposed of in landfills without being recycled, and inadequate recycling regulations (Webber and Wallace, 2009). In order to save the environment, the government and the IT sector are acting in their respective capacities and preparing for and implementing green cloud adoption.

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The term "Green Cloud" refers to the integration and application of novel technologies, including computer recycling, network computers, cloud computing, virtualization, paper reduction, mobile computing, and travel reduction. Each of these green cloud options has unique security problems and installation processes. As a result, the thesis has looked at Green Cloud from a distinct angle in terms of information assurance and security.

This thesis added to the body of knowledge regarding the security risks associated with green cloud computing in a number of ways. This analysis of the literature establishes a connection between Green Cloud technologies and the security posture and performance of any utilizing enterprise. As a result, it offers further light on information security and assurance flaws in the green cloud industry. The thesis's main conclusions support the hypothesis that, if not well assessed and managed, the "going green" idea will result in new security concerns.

The thesis thus concludes that, in addition to the common security threats and vulnerabilities, green cloud practices also have more specific security risks and vulnerabilities because of the greening aspects and techniques. Examples of these include integrity issues resulting from malware attack in NetApp loading, privacy and confidentiality issues of cloud computing due to its growing size of multi-user environment, and many more. In addition, there are a number of other problems with virtualization, such as guest-to-guest attacks, privilege escalation, hypervisor escape, and lastly, inadequate recycling policies and procedures that jeopardize the security and confidentiality of data. Undoubtedly, green cloud solutions offer numerous advantages for both businesses and the environment, but as section 6.2 makes clear, these solutions are not without their restrictions.

In summary, the thesis findings and results are important and beneficial to the organizations that intend to use ICT to reduce CO2 emissions while reaping the financial and operational advantages of green cloud computing. Green cloud technology has been shown to be effective in lowering greenhouse gas emissions and protecting the environment, but it can also increase security risks and threats, potentially

posing a threat to business values and data if not properly understood and addressed. Therefore, it's important to remember the security components of becoming green in order to save the planet and securely meet company needs. Understanding the business in its entirety and conducting a thorough assessment to determine how and where the organization's business processes and systems may be made greener are essential for a safe and successful Green Cloud implementation. Next, arrange for the integration of Green Cloud solutions with virtualization, cloud computing, network computing, green data centers, and computer recycling practices. This will make it possible for the company to apply Green Cloud within Information Security policies, allowing for a degree of balance between security and Green Cloud.

## REFERRENCES

☐ Agarwal, Shalabh and Nath, Asoke. (2011). "Green Computing - a new Horizon of Energy Efficiency and Electronic waste minimization": a Global Perspective. 2011 International Conference on Communication Systems and Network Technologies

☐ Aggarwal, Sanjeev and McCabe. Laurie. (2009). The Compelling TCO Case for Cloud Computing in SMB and Mid-Market Enterprises. A Hurwitz white paper.

☐ Alliance to save energy. (2011). Information Technology. Retrieved from,

☐ Anonymous, (2008, 29 April). Cost Savings and IT Space Constraints Top Reasons Why Retailers Adopting Virtualization, Reports Microsoft Survey, ProQuest Central.

☐ Arnfield Robin, (2009). Information security goes green. Infosecurity, Volume 6, Issue 3, April 2009, p. 32-34,36

☐ Ashenden Debi, (2008).Information Security management: A human challenge? Information Security Technical Report 13 (2008). pp, 195–201. Elsevier

☐ Atay Serap, Masera Marcelo(2011). Challenges for the security analysis of Next Generation Networks. Information security technical report 16 (2011) pp.3-11

☐ Balig Jayant , Ayre . Robert  W. A, Hinton Kerry , and S. R. Tucker. (2011, January). Green Cloud Computing: Balancing Energy in Processing, Storage, and Transport. Preceding of the IEEE. Volume 99, No.1, p.149-167

☐ Barnes, S. J. (2005). Assessing the value of IS journals. Communications of the ACM, 48(1), 110-112.

☐ Bellovin Steven M, Benzel terry V, Blakley BoB, Denning Dorothy E. Diffie Whitfield, Jeremy Epstein & Paulo Verissimo.(2008, January/February). Information Security technology Forecast 2008 .

Bennison, Peter F and Lasher Philip.J (2004. May). Data security issues relating to end of life equipment. Electronics and the Environment, 2004. Conference Record. 2004 IEEE International Symposium

☐ Berl, Gelenbe, Girolamo, Giuliani, Meer, Dang and Pentikousis. (2010). Energy-Efficient Cloud Computing. The Computer Journal , Vol. 53 No. 7, p. 1045-1051

☐ Bianzino Aruna Prem, Chaudet Claude, Rossi Dario, and Rougier Jean-Louis(2012). A Survey of Green Networking Research. IEEE Communications Surveys & Tutorials, VOL. 14, NO. 1, First Quarter 2012.

☐ Bhattacharya, Kamal (2010, 15th December).The Impact of Virtualization and Cloud Computing on IT Service Management. Interview with Douglas J. King. Business & Information Systems Engineering. pp, 49- 51. Springer

☐ Bose, Ranjit and Luo, Xin, (2011). Integrative framework for assessing firms' potential to undertake Green. Journal of Strategic Information Systems 20 (2011) – Elsevier. P. 38–54

☐ Cameron, Kirk W. (2009, May).The Road to Greener IT Pastures. Published by the IEEE Computer Society. pp, 87-89.

☐ Carroll. M & Kotzé, Paula. (2011). Secure Cloud Computing, benefits risks and controls. IEEE.

☐ Chakraborty Rajarshi, Ramireddy Srilakshmi, Raghu T.S, Rao H. Raghav, (2010, July/August).The Information Security Practices of Cloud Computing Vendors. Published by the IEEE Computer Society. Computer.org/ITPro. pp,  29-37

☐ Chang. Ruay-Shiung and Wu. Chia-Ming. (2010, August).Green Virtual Networks for Cloud Computing. 5th International ICST Conference on Communications and Networking in China (CHINACOM). p, 1-7

☐ Chaudhuri, A., Von Solms, S.H., & Chaudhuri, D. (2011, January). Auditing security risks

in virtualIT systems. ISACA Journal, 16-25.

☐ Chowdhury N.M. Mosharaf Kabir and Boutaba Raouf, (2009, October).A survey of network virtualization. Computer Networks 54 (2010). pp862–876. Elsevier

☐ Choi Byung-Chul, Shin Hang-Sik , Lee  Su-Yol and Hur Tak. (2006). Life Cycle Assessment of a Personal Computer and its Effective Recycling Rate. Int J LCA 11(2) p.122 – 128

☐ Cleeff Andr´e van, Pieters Wolter, Wieringa Roel, (2009).Security Implications of Virtualization: A Literature Study. 2009 International Conference on Computational Science and Engineering - IEEE

☐ Cloud Security Alliance. (2009, December). Security Guidance For Critical Areas of Focus in Cloud Computing V2.1.

☐ Colwill C J, Todd M C, Fielder G P and Natanson C. (2001, 3 July). Information Security. BT Technol J Vol  19 No 3 July 2001. Springer.

☐ Creswell, J. W. (2009). Research design: Qualitative, quantitative, and mixed methods approaches (3rd ed.). Thousand Oaks, CA: SAGE.

☐ Cumming Roger. (2002, December). The evaluation of Information Security. Cover Feature. IEEE Computer Society.

☐ Daly, M. & Butler , T. (2009) . Environmental responsibility and Green Cloud: An institutional perspective.  17th European Conference on Information Systems,  Verona, Italy

☐ Damanpour, F., and Evan, W. M. (1984). "Organizational Innovation and Performance: The Difficulties of Organizational Lag," Administrative Science Quarterly, Volume 29, Number  3,  p.  392-409.

☐ Deif, Ahmed M. (2011, 7 june). "A system model for green manufacturing".  Journal of Cleaner Production 19 (2011) 1553-1559. ScienceDirect, p. 1554-1559.

☐ DiRamio Denise, (2008). E-waste: Whose Difficulties is it? Communications News [0010-3632] vol:45 nr:6 pp:36 -36.

☐ Dubie Denise, (2008, August). VMware bug bombs virtual servers. Retrieved from

Network World.

☐ Dubie Denise (2009). How to protect corporate data and the Earth - when dumping IT gear source: American metal market [0002-9998] vol:117 iss:19-2 pg:9

☐ Esensten Joseph (2011, February). "Security strength and weakness of virtualization as a green computing solution". Raytheon, Inc. page 15.

☐ Feig, Nancy, (2008, March). Growing green data centers. Wall Street & Technology. ProQuest Science Journals.

☐ Fickes, Michael (2004, December). The Digital Trash Challenge. Electronics recycling programs are the next industry challenge. wasteage.com

☐ Filipek, 2007. Think twice before discarding old computers. The Internal auditor [0020-5745] vol:64 iss:2 , p.15

☐ Freschi Cynthia, (2008, May). Going 'Green' in the Security Industry. Security, ISSN 0890-8826, 05/2008, Volume 45, Number 5, p. 56

☐ Gabriel Chris,(2008). Why it's not naive to be green. Business Information Review. Vol 25(4): p, 230–237. Sage

☐ Gadatsch, Andreas (2011, 28 October). "Comments on "Green Cloud: A Matter of Business andInformation Systems Engineering?", Business & Information Systems Engineering, EISSN 1867-0202, 12/2011, Volume 3, Number 6, p. 397

☐ Gartner Research (2007). Gartner Symposium/ITxpo 2007: Emerging Trends. Gartner Inc.

☐ Garg Saurabh Kumar, Yeo Chee Shin and Buyya Rajkumar. (2011).Green Cloud Framework for Improving Carbon Efficiency of Clouds. Euro-Par 2011, LNCS 6852, Part I, p. 491–502, Springer

☐ Geisler, E. and Kassicieh, S. K. (1997). "Information Technologies and Technology Commercialization," IEEE Transactions on Engineering Management, Volume 44, Number 4, p. 339-346.

☐ Geyer, Roland & Blass, Vered Doctori. (2010).The economics of cell phone reuse and recycling. Int J Adv Manuf Technol (2010) 47:515 – 525. Springer.

☐ Gibbs Carole, Melvin Jennifer, F. McGarrell Edmund, Axelrod Mark. (2009, July). Electronic waste and organized crime-assessing the links. Phase II Report for the INTER POL Pollution Crime Working Group.

☐ Gorge, Mathieu. (2008). "Are we being 'greenwashed' to the detriment of our organisations' security?". Computer fraud and security [1361-3723] volume :2008, issue:10 p.14 -18

☐ Goucher, Wendy (2009, July). "The green threat". Original Research Article, Computer Fraud & Security, Volume 2009, Issue 7, p. 9-11

☐ Green Cloud raises security fears. (2007). Computer Weekly, 12(1), p. 30-32. Retrieved fromBusiness Source Premier database.

☐ Greer Melvin, (2010). Survivability and Information Security in the Cloud. 2010 International Conference on Dependable Systems and Networks Workshops (DSN-W). pp, 194-195

☐ Grossman , Wendy M. (2011, 28 March). "The dirty secret of Green Cloud".

☐ Hacking News, (2002). Who said SAN is secure? Elsevier Science. Computer Fraud and Security.

☐ Harmon Robert. R, Auseklis Nora, (2009, August).Sustainable IT Services: Assessing the Impact of Green Computing Practices. Portland International Conference on Management of Engineering & Technology, 2009. PICMET 2009. – IEEE Xplore

☐ Hart, C. (1998). Doing a literature review: Releasing the social science research imagination. London, UK: Sage Publications.

☐ Hendrickson Chris.(1994). Product Disposal and Re-Use Issues for Portable Computer Design. IEEE

☐ Hinde, Stephen (2003, May). Careless about privacy - Computers & Security, 2003 – Elsevier Volume 22, Issue 4, p. 284–288

☐ Hischier R, Wager P, Gauglhofer J. (2005, June). Does WEEE recycling make sense from an environmental perspective? The environmental impacts of the Swiss take-back and recycling systems for waste electric al and electronic equipment (WEEE). Environmental Impact Assessment Review 25 (2005). pp, 525 – 539. Elsevier

☐ Hocking Marc, (2011, June). "Network computer security in the cloud". Network Security, Volume2011, Issue 6, p. 17-19. Elsevier

☐ Hoesing, Michael T, (2009). Virtualization Security Assessment. Information Security Journal: A Global Perspective, 18:pp.124–130, Taylor & Francis Group, LLC

☐ Hope Michele, (2007, April). The fine art of data destruction. Accesses from networkworld.com. pp 27- 35

☐ Hu Juanli, Deng Jiabin & Juebo Wu, (2011, 27 October).A Green Private Cloud Architecture with global collaboration.Springer Science Business Media, LLC.

☐ Hu, Q. and Quan, J.(2006, 1 November) , "The Institutionalization of IT Budgeting: Empirical Evidence from the Financial Sector,' Information Resources Management Journal, Volume 19, p. 84-97

☐ Huber Nikolaus, Quast Marcel von, Brosig Fabian, and Kounev Samuel, (2010). Analysis of the Performance-Influencing Factors of Virtualization Platforms OTM 2010, Part II, L NCS 6427– Springer. p, 811-828.

☐ Info-Tech Research Group. (2009, January). Green Cloud: why mid-size companies areinvesting now. By Info- Tech Research Group and sponsored by IBM.

☐ Intel Information Technology, (2010, April). Evaluating Thin-Client security in a changing threat landscape. Intel white paper.

☐ Jamil, Danish and Zaki, Hassan. (2011, April), Cloud Computing Security. International Journal of Engineering Science and Technology (IJEST). Vol 3, Number 4, p. 3478

☐ Jin-ying, MA (2011). 'Green' Conceptions in Manufacturing. Shandong University of Technology Zibo, China. IEEE, p. 639-642

☐ Jones, Andy (2005, March). "How much information do organizations throw away?". Computer Fraud & Security, Volume 2005, Issue 3, March 2005, p. 4–9 – Elsevier.

☐ Jones, Andy (2006, September). "Cradle to grave – security failure to the very end". Computer Fraud & Security,Volume 2006, Issue 9 - Elsevier,  p. 4–8

☐ Jones, Andy (2009, 20 June). Lessons not learned on data disposal, digital investigation 6(2009) -  Elsevier, p.3–7

☐ Jones, Andy (2009, November). "Recycling more than your IT equipment" - NetworkSecurity, Volume 2009, Issue 11, Elsevier, p. 8-9.

☐ Joumaa Chibli, Kadry Seifedine, (2012).Green Cloud: Case Studies. 2012 International Conference on Future Energy, Environment and Materials. Energy Procedia 16, p. 1052 –1058. Elsevier

☐ Karger, P.A, ( 2008, September-October). I/O for virtual machine monitors Volume: 6 ,Issue: 5. pp, 16 – 23. Security & Privacy, IEEE.

☐ Kaufman, Lori M. (2009). Data Security in the World of Cloud Computing. Co published bythe IEEE computer and reliability societies. p, 61-64. IEEE security and privacy.,

☐ Kavanagh, Ronan (2009, March). IT Virtualization Helps to Go Green. InformationManagement volume 19. Issue 2. ProQuest Central

☐ Kohli, R., and Grover,V. (2008). "Business Value of IT: An Essay on Expanding Research  Directions  to keep  up  with  the  Times,"    Journal of the Association for Information  Systems,  Volume  13, Number 1, p. 23-38.

☐ Krikke Jan.(2008). Recycling  e-Waste: The Sky Is the Limit. IT Pro, Published by IEEEComputer Society.

☐ Kwon Young Chul, Lee Sang Won, and Moon Songchun (2006). Personal Computer Privacy: Analysis for Korean PC Users. IWSEC 2006, LNCS 4266, p. 76–87- Springer

☐ Lamb, John P (2009, April). The greening of IT: how companies can make a different forthe environment. Upper Saddle River,  NJ:IBM Press. Preface: page xxv.

☐ Lamb, John P (2011). Green Cloud and use of Private Cloud Computing in South

Africa. 8th International Conference Expo on Emerging Technologies for a Smarter World (CEWIT),2011. IEEE.

☐ Lechner Rich, (2007, 24 September). Using virtualization to boost efficiency. Tech Update,networkworld.com- Proquest Central. p-24

☐ Lee. Young Choon and Zomaya Albert. Y, (2010, 19 March). Energy efficient utilizationof resources in cloud computing systems. The journal of supercomputing. Springer

☐ Leung Adrian, Shengb Yingli and Cruickshank Haitham (2007), The security challenges formobile ubiquitous services. Information security technical report 12 (2007) pp.162–171. Elsevier

☐ Levy, Y., & Ellis, T. J. (2006). A Systems Approach to Conduct an Effective LiteratureReview in Support of Information Systems Research. Informing Science, Volume 9.

☐ Li. Jianxin , Li. Bo, Wo. Tianyu, Hu. Chunming, Huai. Jinpeng, Liu. Lu and Lam. K.P. (2011, 11 May). Cyber Guarder: A virtualization security assurance architecture for greencloud computing . Future Generation Computer Systems 28(2012) p.379–390

☐ Li, Qilin & Zhou Mingtian. (2011). The Survey and Future Evolution of Green Computing.ACM International Conference on Green Computing and Communications, IEEE 2011, pp p. 230-233.

☐ Liang. Dung-Hai, Liang. Dong-Shong and Chang. Chun-Pin. (2012). Cloud Computing andGreen Management. 2012 International Conference on Intelligent System Design and Engineering Application.

☐ Liu Lu, Masfary Osama and Li Jianxin, (2011).Evaluation of Server Virtualization Technologies for Green Cloud. Proceedings of The 6th IEEE International Symposium on Service Oriented System Engineering (SOSE 2011), pp-79-84. IEEE Computer Society

☐ Lombardi Flavio and Pietro Roberto Di, (2010). Secure virtualization for cloud computing.Journal of Network and Computer Applications 34 (2011) pp, 1113–1122.

☐ Mahalingam. P, Jayaprakash. N and Karthikeyan. S, (2009). Enhanced Data SecurityFramework for Storage Area Networks. 2009 Second International Conference on Environmental and Computer Science - IEEE Computer Society, p.105-110.

☐ Mathieson, (2007). Don't be green. Infosecurity Volume 4, Issue 6, September 2007-Elsevier,  p. 26–29.

☐ McAlearney Shawna, (2007 , January 30). Dispose of IT Equipment Without Sharing Secrets.

☐ McConnell. M, (2002). Information Security in the Twenty-First Century. Supplement toComputer. Security & Privacy 2002

☐ McKinsey Inc. (2007). Reducing U.S. Greenhouse Gas Emissions: How Much at WhatCost? Green Cloud: Corporate Strategies.

☐ McKnight. Walter L. (2002, July). "What is Information Security?" The Journal ofDefense Software Engineering. p. 4-6.

☐ Mell.P and Grance. T, NIST. ( 2009, June). Accessed from Security Guidance for CriticalAreas of Focus in Cloud Computing V2.1. 2009.

☐ Mendyk-Krajewska Teresa and Mazur Zygmunt, (2010, May). Difficulties of Network SecurityThreats. 3rd Conference on Human System Interactions (HSI), 2010. p.436-443. IEEE Conference Publication.

☐ Metzler.F (2009). What security professional should know as information security evolvesas Information Security. White Paper: Achieving Information Security in a green computing environment, Savvis.

☐ Murugesan, San (2007), "Going Green with IT: Your  Responsibility  toward Environmental Sustainability", Cutter Business-IT Strategies Executive Report.

☐ Murugesan, S. (2008, January-Febraury), "Harnessing Green Cloud: Principles andPractices," IT Professional, , p. 24-33.

☐ Murugesan, S. (2010, March-April). Making IT Green. computer.org/ITPro. Published bythe IEEE Computer Society.

☐ Natarajan, S.; Wolf, T. (2012). Security issues in network virtualization for future internet.2012 International Conference on Computing, Networking and Communications (ICNC), p.537-543. IEEE

☐ Nicho Sandy, (2000, April). PC recycling industry fails to clean up its act Computer Fraud& Security. Volume 2000, Issue 4, 1 April 2000, Pages 1–2

☐ Ongondo, Williams and Cherrett. (2010, 13 December). How are WEEE doing? A globalreview of the management of electrical and electronic wastes. Waste Management 31, p. 714–730

☐ Pasquinucci  Andrea , (2009, March). The security challenges of mobile devicesComputer Fraud & Security, Volume 2009, Issue 3, p. 16-18. Elsevier

☐ Pounder Chris. (2001).The European Union Proposal for a Policy Towards Network andInformation Security. Computers & Security, Vol. 20, No. 7. pp, 573-576. Elsevier

☐ Ray Edward and Schultz Eugene, (2009, April).Virtualization Security. Proceedings of the5th Annual Workshop on Cyber Security and Information Intelligence Research: Cyber Security and Information Intelligence Challenges and Strategies.

☐ Ren. Kui, Wang. Cong, and Wang. Qian. (2012, January/February).Security Challenges forthe Public Cloud.  Published by IEEE Computer Society.

☐ Reuben Jenni Susan, (2007). A Survey on Virtual Machine Security. Seminar on NetworkSecurity

☐ Rhodes Colleen, (2005).Security Considerations for Storage Area Networks. The InfosecWriters Text Library, East Carolina.

◻ Ristenpart.T, (2009, November), "Hey, You, Get Off of My Cloud! Exploring InformationLeakage in Third-Party Compute Clouds," Proc. 16th ACM Conf. Computer and Communications Security (CCS 09), ACM Press, 2009, pp. 199–212.

◻ Russell. D, & Gangemi, G.T. (1991). Computer Security Basics. Sebastopol, CA: O' Reilly& Associates, Inc. (p.20).

◻ Subashini. S and Kavitha. V (2010,11 July). A survey on security issues in service deliverymodels of cloud computing. Journal of Network and Computer Applications 34 (2011), p.1–11.

◻ Sabahi Farzad, (2011).Cloud Computing Security Threats and Responses. IEEE 3rd International Conference on Communication Software and Networks (ICCSN). p, 245-249

◻ Sahoo Jyotiprakash, Mohapatra Subasish and Lath Radha, (2010).Virtualization: A Survey On Concepts, Taxonomy And Associated Security Issues. Second International Conferenceon Computer and Network Technology - IEEE

◻ Scaramella, Jed and Healey, Matt (2007), "Service-Based Approaches to ImprovingData Center Thermal and Power Efficiencies", IDC White Paper, May 2007.

◻ Sinnett (2010). Green Cloud is more than a 'feel good' Issue Financial Executive; Morristown[0895-4186], Year 2010 vol:26 nr:2. pp- 60 -63.

◻ Skulmoski Gregory, T. Hartman Francis and Krahn Jennifer, (2006). The Delphi Method forGraduate Research. The Delphi Method for Graduate Research, Volume 6.

◻ Smits Phil and Cain Marlyn. (2010, November). Waste away. Best's Review, ISSN 1527-5914, Vol 111, Number 7, p. 82. EBsC Host.

◻ Southwood, Liam (2007, 14 September). How to dispose of old computers. Accessed frombdonline.co.uk. Building Design, ISSN 0007-3423, 09/2007, p. 21 EBSC Host

◻ Sparkes Matthew, (2008, 29 Sep). Council sells security hole on Ebay.

☐ Svantesson. Dan and Clarke. Roger.(2010). Privacy and consumer risks in cloud computing-computer law & security review 26 (2010). P. 391-397. Published by Elsevier Ltd.

☐ Swanson (1994). "Information Systems Innovation among Organizations," Management Science,  Volume  40, Number 9, p. 1069-1092.

☐ Ting, David, (2011,February) Thinking thin: addressing the challenges of client computing.Network Security

☐ The security industry's green legacy, (2011, 28 Febraury), Magenta Security.

☐ Tucker, R. B, (2002). Driving Growth through Innovation: How Leading Firms areTransforming their Futures. Berrett-Koehler  Publishers  Inc.,  San Francisco.

☐ Turner Mary Johnston and McKnight John,(June, 2008). IT Powers Green Business, IBMInformation Infrastructure to meet new emerging green initiatives and needs in IT. Enterprise Strategy Group Report.

☐ Uddin Mueen and Azizah Abdul Rahman (2010, October). Server Consolidation: AnApproach to Make Data Centers Energy Efficient & Green. International Journal of Scientific & Engineering Research, Volume 1, Issue 1.

☐ US Department of Energy. (2009). Federal Energy of Management Program, Data CenterEnergy Consumption Trends.

☐ US Environmental Protection Agency (EPA), (2007, 2 August). Energy Star Program. Report to Congress on Server and Data Center Energy Efficiency Opportunities. Public Law109-431

☐ Vaughan-Nichols, S.J. (2008, August). Virtualization Sparks Security Concerns. FreelanceTechnol., Mills River, NC. Volume: 41 , Issue: 8, p.13 – 15 – IEEE

☐ Velte Toby, Velte Anthony and Elsenpeter Robert, (2008). Green Cloud: Reduce Your Information System's Environmental Impact While Adding to the Bottom Line- McGrawHill

☐ Venter, H. (2007). New Approaches for Security, Privacy and Trust in Complex Environments: Proceedings of the IFIP TC-11 22nd International Information Security Conference (SEC 2007), 14-16 May 2007, Sandton, South Africa. Springer. pp. 461-466 .

☐ Vlissidis Paul and Hickey Matthew , (2010, April)." Network computers: slim security?" NetworkSecurity, Volume 2010, Issue 4, April 2010, p.  16-19. Elsevier

☐ Vykoukal Jens, Wolf Martin, Beck Roman, (2009). Does Green Cloud Matter? Analysis of theRelationship between Green Cloud and Grid Technology from a Resource-Based View Perspective. Pacific Asia Conference on Information Systems (PACIS). PACIS 2009 Proceedings

☐ Webber Lawrence and Wallace Michael, (2009). Green Tech How to Plan and ImplementSustainable IT Solutions. AMACOM, a division of American Management Association.

☐ Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing aliterature review.*MIS Quarterly, 26*(2), p.13-23.

☐ Welch Donald, Ragsdale Daniel and Schepens Wayne. (2002, December).Training forInformation Security.

☐ Williams Bryan & Cross Tom (2010).Virtualization System Security. IBM Corporation.
☐ Whitman, Mattord, (2008). Principles of Information Security 3:d Ed., , ISBN10:1423901770, ISBN13: 9781423901778 Thomson, Course Technology , 2008.