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Empirical Study on Cloud Computing as a Solution for Low Utilization of Computing Resources

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ABSTRACT

This paper examines the effectiveness of adapting a cloud computing model to overcome the under utilization of computing resources within business organizations. The overall analysis of this study is based on data collected from an experiment conducted with the implementation of a cloud computing environment at Telecommunications Regulatory Commission of Sri Lanka. Further, a questionnaire survey was conducted to find the impact of the overall cloud computing model towards the business as perceived by the employees within the organization. Data on storage capacity usage, network connectivity, processor usage and memory usage before and after cloud computing environment implementation were collected over a period of two weeks. Data analysis indicates that there is a drastic improvement of the overall performance in computing resources such as storage, network and CPU and memory usage. Further, data collected from questionnaire showed that user felt the real improvement of performance of the systems in the cloud environment.

1. INTRODUCTION

Organizations in public or private sector are facing the problem of low utilization of computing resources irrespective of their level of business functionality due to inappropriate distribution of computing resources [1]. In fact, majority of governmental institutions were prone for underutilization of computing resources due to use of standalone systems. To overcome this problem experts have proposed solutions such as clustering, grid computing, utility computing and Software as a Service (SaaS) which are method of sharing computing resources. With the advancement of the computing technology and the web services, the internet based resource merging service carriage model has been created by utilizing the existing models which is known as Cloud Computing. Cloud computing has been quantified as an effective way of maximizing the resource consumption [2].

The origin of cloud computing can be seen as an evolution of grid computing technologies [3]. From the architectural point of view cloud is naturally build on an existing grid based architecture and uses the grid services and adds some technologies such as virtualization and some business models. In brief, cloud is essentially a bunch of commodity computers networked together in same or different geographical locations, operating together to serve number of customers with different need and workload on demand basis with the help of virtualization [4]. Cloud services are provided to the cloud users as utility services like water, electricity, telephone using pay-as-you-use business model. These utility services are generally described as X as a Service (XaaS) where X can be Software or Platform or Infrastructure etc. Many cloud applications are gaining popularity day by day for their availability, reliability, scalability and utility models. These applications made distributed computing easy as the critical cloud computing aspects are handled by the cloud provider itself.

Cloud computing is a paradigm of distributed computing to provide the customers on-demand utility based computing services [5]. Different cloud providers provide cloud services of different abstraction levels. E.g. Amazon EC2 enables the users to handle very low level details where Google App-Engine provides a development platform for the developers to develop their applications. The cloud services are divided into many types like Software as a Service, Platform as a Service or Infrastructure as a Service [6]. In terms of resource management as a key characteristic of the cloud computing model share all resources

simultaneously to all the uses at the same time. This allows latency intensive and interactive applications run naively in cloud. In today's world, most of the organizations underutilized their computing resources and maintain spare capacity just to cope with the huge spikes that sometimes get in the server usage [7]. Scalability is one of the major advantages to cloud users. Scalability is provided dynamically to the users. Users get as much resources as they need. Thus this model perfectly fits in the management of rare spikes in the demand.

At Telecommunications Regulatory Commission of Sri Lanka (TRCSL) the overall consumption of computing resources over the server infrastructures has deteriorated over the past few years. In fact, some of the systems are over-utilized as a result of unavailing scattering of computing resources throughout the organization. Many server systems are running under the expected level of utilization while some of the systems are unable to serve user requests as they are over utilized. As a result of that, few out of many servers are running out of storage, resulting frequent loss of network connectivity of the systems and using higher level of processing power. The main reason for this problem is under utilization of available computing resources at the organization. Therefore, this research study focuses on the problem of low utilization of computing resources at TRCSL and the objective of this research is to analyze the effectiveness of deploying a private cloud computing model to reduce the low utilization of computing resources within TRCSL.

2. RESEARCH METHOD

To achieve the objectives of the research a conceptual framework has been developed. With this framework, it's clearly denotes that the cloud computing strategies could be increased the utilization of computing resources within the context of the given organization.

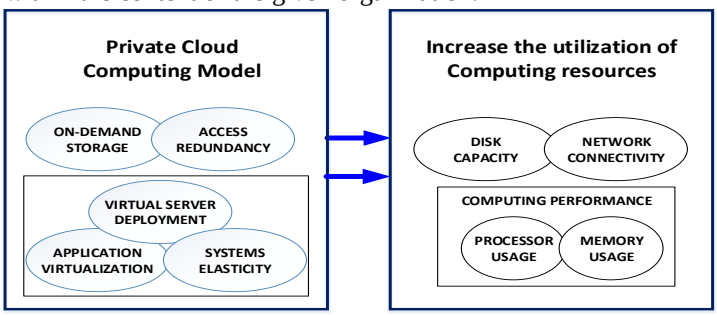

Figure 1: Conceptualize Framework

As outlined in figure 1, strategies of the cloud computing such as storage scalability, access redundancy, virtual server deployment, application virtualization and systems elasticity would upsurge and enriched the consumption of computing resources such as, disk capacity, network connectivity, CPU usage, processing power and server integrations. Further, detailing each of those interrelated concepts would be a way forward for the realization of the research objectives in depth as this provides the backbone to the whole study to be undertaken.

As defined by Creswell (1994), "*Assumption or the hypothesis stances a prearranged declaration that offerings the projected association amongst a sovereign and contingent variable*". In accordance, this research is based on following hypothesis:

- H_1: Cloud Computing would increase on demand storage capacity.
- H_2: Cloud Computing could offer uninterrupted network connectivity to the systems.
- H_3: Cloud Computing would improve the overall computing performance.

Experiment Design

The given hypotheses were measured by the implemented cloud model within the organization. Due to the criticality as well as confidentiality of the information transfer, a secure system of private cloud model has been adopted. With the deployed private cloud model, identified variables such as on demand offering of storage, uninterrupted network connectivity among the different sets of systems, fueling high computing performance were tested. Data on storage capacity usage, network connectivity, processor usage and memory usage before and after cloud computing environment implementation were collected over a period of two weeks. A survey was conducted among the sample of 66 employees, as a parallel process to the experimentation to analyze the personal opinion of using cloud model within the organization. The questionnaire consists with open-ended and close-ended questions answered by the respondents via several approaches such as telephone, email and fax. In addition to questionnaire survey, observations also were used

where the utilization can be monitored through a virtually formed atmosphere to supplement and increasing the computing consumption over the resources.

3. RESULTS AND ANALYSIS

The results of the overall research were analyzed from the information gathered through the installed test cloud environment and the questionnaire survey.

3.1. HYPOTHESIS 01: CLOUD COMPUTING WOULD INCREASE ON-DEMAND STORAGE CAPACITY

At TRCSL due to unequal allocation of computing resources, 75% of servers underutilize their usable resources where 25% of servers running out of required level of systems resources. As a solution to overcome this situation, one of the strategies of cloud computing model known as "providing on-demand storage" has been tested within the organization by using two (2) of the low resource utilization servers namely the DNS and DHCP. Figure 2 shows the usage of storage in two servers before and after the deployment of private cloud test environment. As of collected data, the amount of capacity required and the total usage of capacity is less than 10% of the total available capacity of those two servers as outlined earlier. As a result of that, 75 % of the highly usable space gets idle without been used for any system nor services.

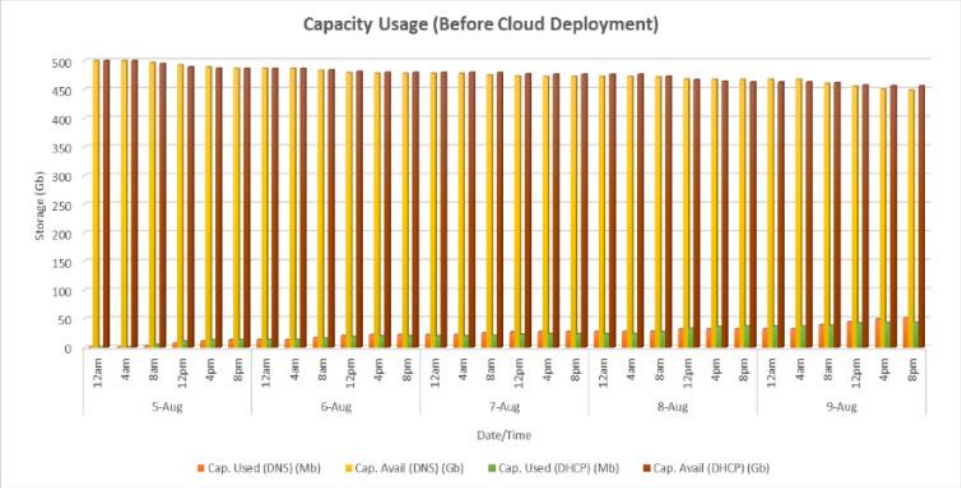

Figure 2: Capacity Usage (Before Cloud Deployment)

As per the indicators shown in figure 2, even during the peak hours the maximum average required capacity for any application consume only 0.8% of storage capacity available on each servers. According to the sample data of those two servers, at the end of five days the total usage on both servers has the average of 9.4% (47 GB) out of total available capacity of 1000 GB. But, some other servers are overwhelmed by the total exhaustion of storage capacity. As they are bound to serve for a single system, the resource wastage of 89.6% on storage device would cause a direct effect of under-utilization on other computing resources such as processing power. As a solution to the problem of capacity wastage, underutilizing of the storage device, the same servers are been connected to the private cloud computing model which has been deployed for the testing purpose of the undertaken research. With the cloud facility, currently available capacity on both servers (DNS and DHCP) could combine to form a virtual space holder (VSH). Pooling of resources as a one of the major feature of cloud computing, any system(s) or application(s) would be able to connect to the virtual space holder as it appears as a physical storage device on it. Then the connected system(s) be able to request for storage capacity up to the limit of availability. With the capability of on-demand storage feature in the cloud computing model, those systems will be giving out only the required level of capacity as needed. Yet, many systems can be benefitted through this feature, since multiple storage devices (servers, tape drives, SAN) can supplement the backend capacity requirement by simply connecting to the cloud controlling server. Figure 3 illustrates the capacity distribution (on-demand storage) of two systems among the total available capacity.

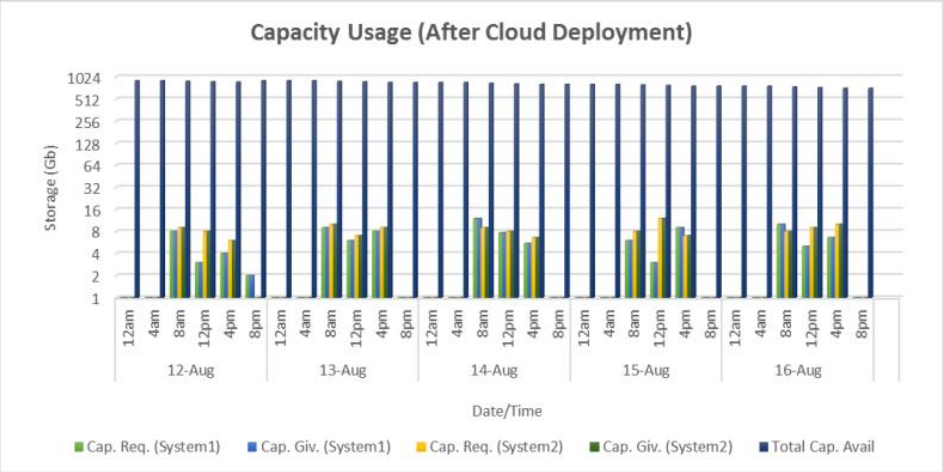

Figure 3: Capacity Usage (After Cloud Deployment)

Using the data collected via automated tools, a paired-samples t-test was conducted to compare the capacity required before and after the deployment of cloud computing (namely the "Pair 1") as well as to compare the capacity wastage before the cloud and after the cloud (namely the "Pair 2"). As per the results revealed, there was a significant discrepancies in the capacity requirement Mean (M) and Standard Deviation (SD), before (M=1.58, SD=1.75) and after (M=3.85, SD=4) the deployment of cloud in pair 1 with the significance of p=0.000. Apart from that, in the pair 2 the difference was considerably increased in the capacity wastage, before (M=474.67, SD=12.93) and after (M=1.0, SD=0.0) the deployment of cloud model with the significance of p=0.000. These results together with the figures shown above have proven that the deployment of cloud would be immensely affect the capacity requirements and provide on demand storage, thus massive declining of the wastage of disk capacity. Further, majority (60%) of responders are having positive feedback towards the storage capabilities offered by the private cloud model, based on the questions been enquired in the Section 2 (Storage) of the questionnaire as shown in figure 4.

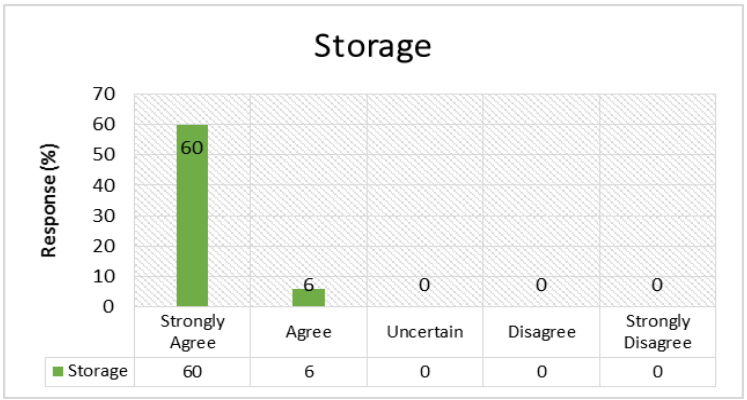

Figure 4: Increased Availability of Storage

3.2. HYPOTHESIS 02: CLOUD COMPUTING OFFERS UNINTERRUPTED NETWORK CONNECTIVITY TO THE SYSTEMS

Many users within the organization have experienced frequent network connectivity drop outs due to multiple user interactivity with the application server systems through a single interface. As a result of that, the information were flooded over the channels, get forfeiture and make severe impact on the systems and users. Thus the prevalent connectivity drop outs would negatively affect the business as it delay the sequence of processes being executed. According to the data collected, figure 5 outlines the situation where the drop outs of the network connectivity were much higher than the connected users in the analyzed time scales. According to the figure shown, whenever more users are connected, higher the level of connectivity drop outs for single network interface that fulfil the requirement of the users. Since the network plays an important role in the field of telecommunications, link breakages need to be minimized while offering systems connectivity to many users.

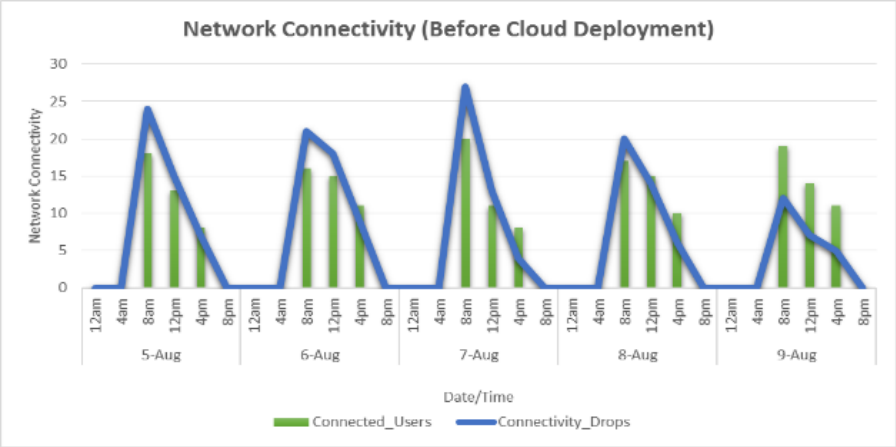

Figure 5: Network Connectivity (Before Cloud Deployment)

To find a solution to the connectivity problem, the virtualization technology has been implemented based on the feature of the cloud model. With the virtualization, any single interface could easily be converted into multiple segments, thus providing multiple connectivity to the consumers and interconnecting among various other systems. As a solution for the problem of frequent network connectivity drop outs, each one of the network interface cards been virtualized into four set of interfaces or network cards. Further, by using the capability of virtual switching functionality of the cloud computing model and the virtualization technology, loads to each end-point could easily be balanced. After converting the physical interface into a virtual interface, no single point of failure has been identified, as of all the incoming user requests are handled through the vSwitch functionality in which balancing out the load among the four different interfaces. As per the indicators shown in figure 6, neither drop out of the network connectivity nor user suspension has been arisen after offering multiple interfaces to interact with the system. Unlike the single network interface of a server system, virtualization technology makes it possible to offer more features than granular level bandwidth allocation and load sharing.

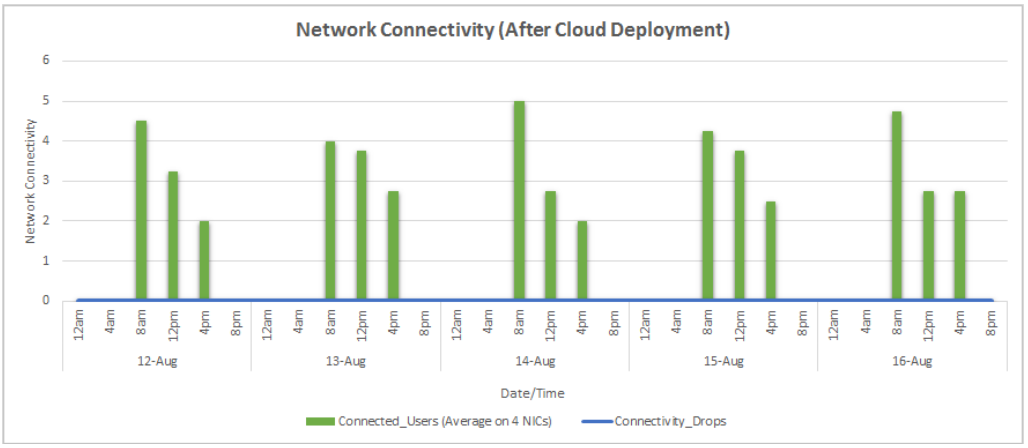

Figure 6: Network Connectivity (After Cloud Deployment)

One-sample t-test was used to compare the disparities and implication of the concept of cloud to find the availability of network connections on two scenarios namely, before and after the deployment of cloud computing environment within TRCSL. Results indicate that there was a significant difference in the network connectivity before and after the deployment of the cloud model. According to results, before cloud scenario, the network availability Mean (M) was 6.17 and the Standard Deviation (SD) was 7.23. After cloud scenario, the network availability Mean (M) was 50.00 and the Standard Deviation (SD) was 50.85. This indicate that the deployed cloud environment heavily impact on the computing environment having significance of zero (p=0.000), thus eliminate network connectivity dropouts.

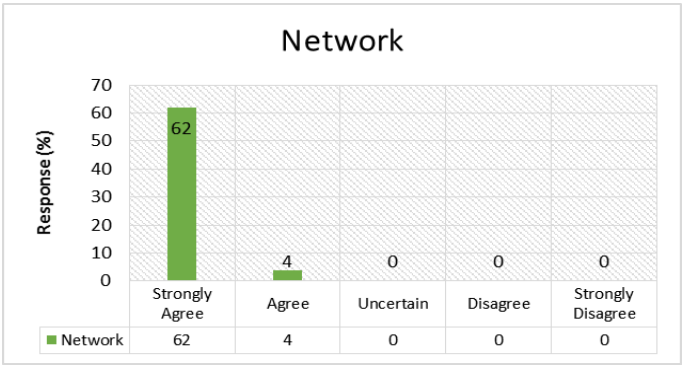

Figure 7: Increased Availability of Network Connectivity

Further, majority (62) of the respondent have positive feedback of the cloud networking where it engaged with the network virtualization as shown in figure 7.

3.3. HYPOTHESIS 03: CLOUD COMPUTING WOULD IMPROVE THE OVERALL COMPUTING PERFORMANCE

The overall computing power of the server systems significantly affect the business as a whole. Under utilization of computer resources such as processor (CPU) and memory affect immensely on the computational capabilities of server systems.

3.3.1 Processor Usage

In majority of the servers that are deployed within TRCSL processor power was under utilized for OS functionalities and processing of applications. As shown in figure 8, the overall usage of processors have been 50% on most of the time. Due to that reason, half of the processing capabilities were ceased, thus resulting high wastage. Further, the processors would always be idle on non-working hours as there are no I/O functions performed.

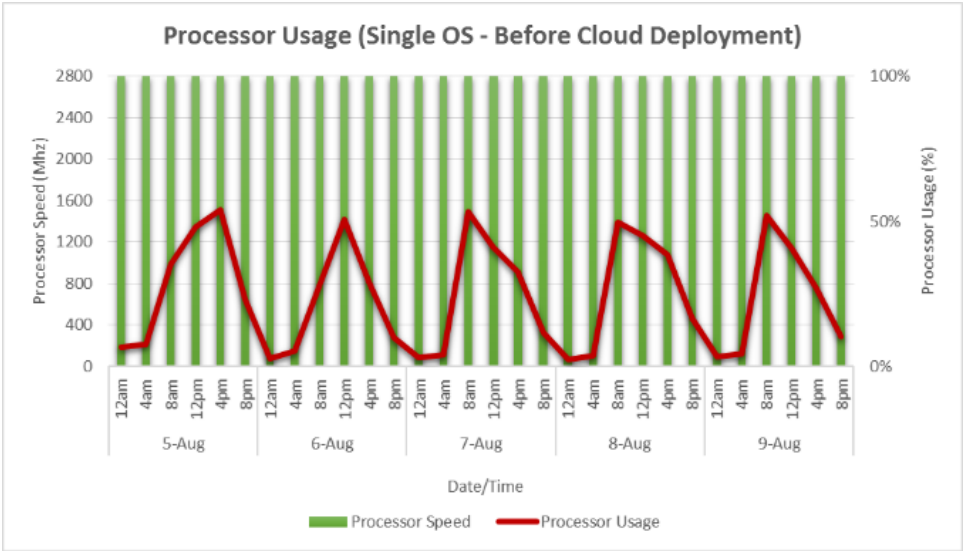

Figure 8: Processor Usage (Before Cloud Deployment)

As a solution to overcome the under utilization of processor power, virtualization has been implemented. The effectiveness of virtualization technology into the server systems is shown in figure 9 in which, the processor caters for two operating systems on a single server over the Virtualization platform. Since then the usage of the processors have been increased up to the maximum reachable level to fuel the systems as they required. The running instances of virtual machines, scale up the sublinear utilization of CPU to the maximum peek point where the system would hold. Further, the multiple users could connect to each of those systems in parallel to other systems in the line. As a whole, the resource wastage of the processor either be minimized or eliminated. Further to the analysis of data which were collected via the automated tools, one-sample t-test was conducted to compare the processor usage before and after the deployment of cloud computing. As per the results, there was a significant variance in the Mean (M) and Standard Deviation (SD) of processor usage with regards to before (M=0.24, SD=0.19) and after (M=0.53, SD=0.37) the deployment of cloud with the significance of p=0.000.

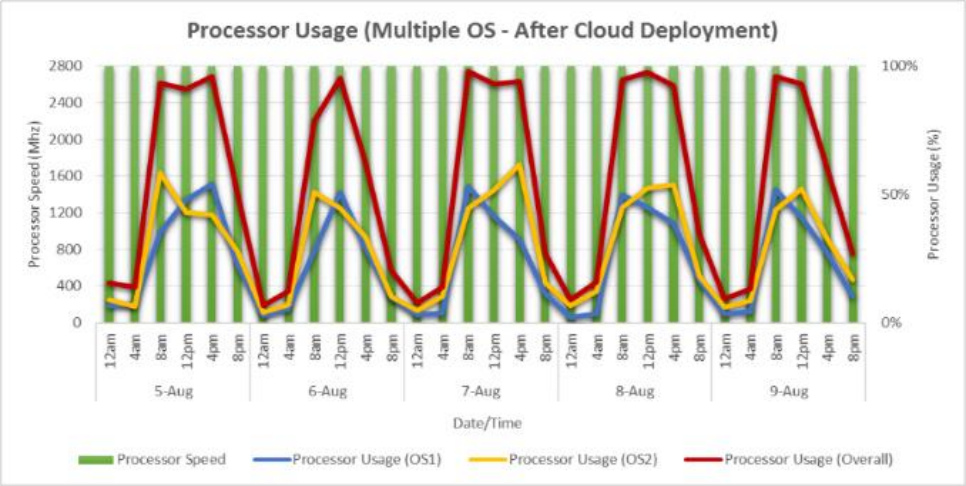

Figure 9: Processor Usage (After Cloud Deployment)

3.3.2 Memory Usage

As shown in figure 10, irrespective of the speed of the memory in the server, the memory capacity that has been used is less than 50% throughout the day during work hours.

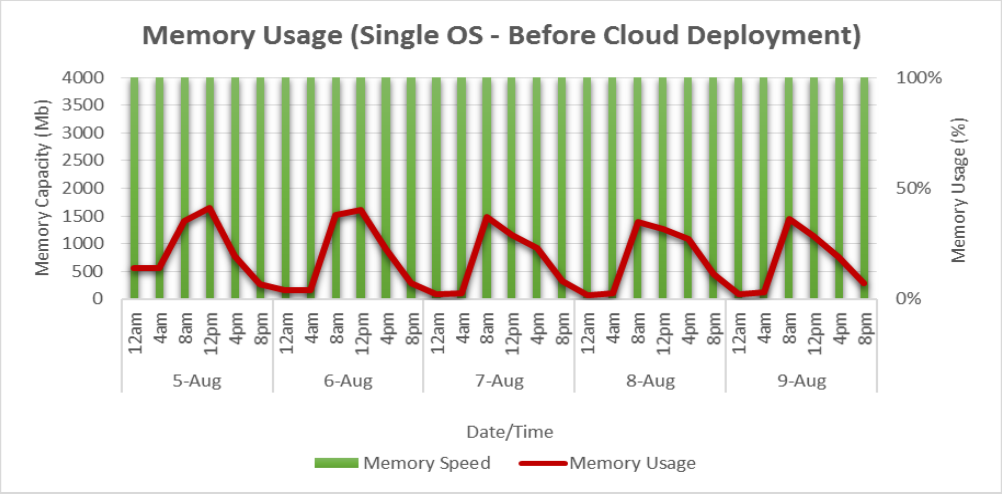

Figure 10: Memory Usage (Before Cloud Deployment)

After deployment of virtualization on multiple operating systems and applications, as shown in in figure 11, the average use of memory has been increased by 25% compared to before cloud implementation.

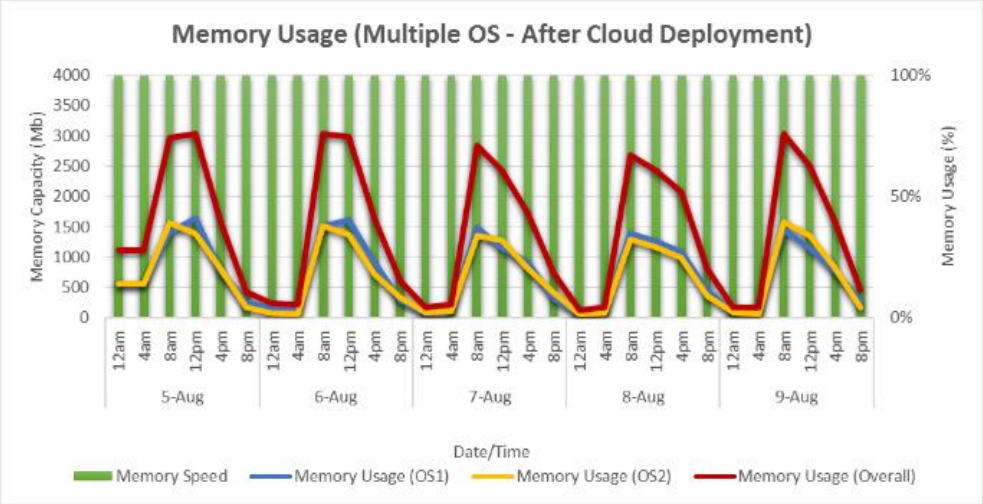

Figure 11: Memory Usage (After Cloud Deployment)

One-sample t-test was conducted to compare the usage of memory before and after the deployment of cloud computing. As per the results obtained, there was a significant variance in the Mean (M) and the Standard Deviation (SD) of usage of memory before (M=0.18, SD=0.13) and after (M=0.36, SD=0.27) the deployment of cloud with the significance of p=0.000. The result suggests that the cloud computing model does have a positive impact on the usage of memory. With the survey been conducted for the evaluation of the understanding of the employees towards the migration aspects of the cloud computing model, they have expressed their view towards the impact of virtualization technologies to improve the computing performance.

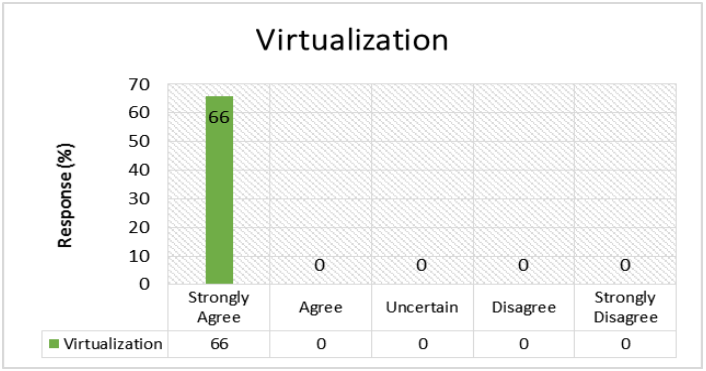

Figure 12: Increase of overall Computing Performance

According to the results shown in figure 12, all of the employees have claimed that the virtualization improves their computing power to a greater level.

4. CONCLUSION

The study was conducted to find a solution to overcome the underutilization of computing resources of server systems. The study was conducted in two phases, where in the first phase, overall evaluation of the impact of cloud computing has been tested through the deployed cloud environment at TRCSL. In the second phase of the study, employee survey was conducted by distributing questionnaires to evaluate the real effectiveness of cloud computing environment in the business. Three hypotheses on storage, network and computing power were tested using the implemented test environment of private cloud computing infrastructure. The results have shown that cloud on-demand storage has positive impact on resource utilization of the servers. According to the results, the network virtualization as a feature of cloud computing has significant impact over the network connectivity, thus enhance the connectivity levels. Further, data analysis shows that the cloud computing feature of server integration has positive impact on overall computing performance in terms of processor and memory usage. Questionnaire analysis has shown that there are positive feedback from employees towards the deployment of cloud computing. Therefore, in conclusion it can be stated that the deployed private cloud computing model has positive impact on server

infrastructure in increasing the utilization of computing resources among the server systems within the organization, thus improving the performance of computer recourses.

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