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Article

Organizational effectiveness of data centers: A foundation for effective cloud architectures

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Organizational Effectiveness of Data Centers – A Foundation for Effective Cloud Architectures

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Abstract

Information Technology (IT) is integral to our day-to-day life and IT trends are dynamic and evolving. With an aim towards operational and technical excellence, Enterprises are moving towards Cloud enabled IT architectures. Various business and operational models are being evaluated and many global Enterprises have already started using Cloud based solutions. The fact remains – all of these Cloud enabled solutions are hosted out of Data Centers.

Data Centers are setups within an IT organization, where servers, storage, networking and IT management equipment are hosted to provide IT enabled services to the end-users. Data Centers are like sub organizations within an IT organization. Cloud enabled architectures for different Cloud models are configured on a set of IT equipment hosted out of these Data Centers. Therefore, Effectiveness and Efficiency of these Data Centers is absolutely essential for effectiveness and efficiency of Cloud enabled IT services. Effectiveness of Data Center organizations is therefore an important and crucial aspect of Cloud architectures.

This paper presents various factors and measures that contribute to Organizational Effectiveness of Data Centers – a foundation for an effective Cloud architecture. These factors and measures may be used as a foundational framework to be referred by the global Enterprises, who are moving towards an effective Cloud architecture. The findings are applicable to all such enterprises across private and public sector domains.

Key Words: Data Centers, Cloud Architectures, Organizational Effectiveness.

1. Introduction

In today's world, Information Technology (IT) has become an integral part of any organization and our day-to-day lives. Most of us touch IT and IT enabled services in one form or another – be it be booking a railway, airline or movie ticket, transacting through a bank, paying our utility or tax bills, applying for educational courses, on-line learning or citizen services through e-Governance etc., etc. IT trends have evolved over these years, for better.

In today's e-enabled world, IT technologies enabled with networking and virtualization are enabling newer forms of organizations. IT experts and vendors are arriving with newer models to optimize cost and increase efficiency. This in turn is leading to new and innovative ways to

structure an organization, define processes and involve people in more effective manner – all of this further leading to newer and innovative forms of organizations.

Cloud computing and Cloud enabled architectures adds to these evolving trends, where global Enterprises are exploring and adopting to various Cloud models, to reduce overall costs, increase efficiency and improvise end-user satisfaction. Many IT services have already been Cloud enabled.

But the fact remains – all such Cloud services and corresponding IT infrastructure is hosted in a back-end Data Center that hosts servers, storage, networking equipment, databases, applications etc. Data Centers form integral and foundational part of all Cloud architectures. Cloud enabled Data Centers utilize Cloud architectural parameters, including but not limited to Virtualization, Self-service portals, metering and billing etc.

Data Centers are organizations in themselves. Like any other organization, Data Centers also have a Structure, Processes to follow and People who manage and execute, with an overall objective to support organizational goal. Data Centers hosting Cloud services aim to achieve effective and efficient Cloud architectures. Efficiency and effectiveness of Data Center organization is therefore absolutely essential for effective Cloud architectures.

Organizational Effectiveness has been studied for various domains and for various organizations in different domains, but there is very limited information available on Organizational Effectiveness of Data Centers.

This paper presents the findings of a research study on “Organizational Effectiveness of Data Centers”, highlighting select measures and factors contributing to Data Centers’ Organizational Effectiveness. These measures and factors span across – employee satisfaction, customer focused approach, Total Cost of Ownership, Adaptability, IT efficiency and Facility efficiency.

The findings can be used by organizations that are evaluating and adopting Cloud models, to architect an effective underlying Data Center organization. The findings are equally applicable and useful to both private and public sector enterprises.

2. Theoretical Background: Data Center organizations - core of Cloud architectures

According to Gartner (2011), the emergence of Cloud computing, growing environmental concerns and the realities of big data workloads are changing the way Data Centers are built and managed. Cloud computing is currently emerging as a powerful way in transforming the IT industry to build and deploy applications. Today, end-users are looking at options of hosting their IT infrastructure in Cloud enabled environment, primarily to optimize costs and for the purpose of easy management and maintenance.

National Institute of Standards (NIST) defines Cloud computing as a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. Based on this definition, a Cloud model has five characteristics (Peter & Timothy, 2011) ie. On-demand access, resource pooling for optimal resource utilization, rapid elasticity for flexibility to configure or re-configure, measured services to monitor, chargeback and network connectivity through broadband access. NIST also defines three service models for Cloud computing. These are – “SaaS: Software as a Service”, “PaaS: Platform as a Service” and “IaaS: Infrastructure as a Service”.

SaaS is all about applications delivered as a service. Many of the Cloud service providers are hosting applications through SaaS Cloud models, examples include - email as a service, CRM as a service, Human Capital Management (HCM) as a service, Enterprise Resource Planning (ERP) as a service etc. PaaS is about providing an application deployment and development platform, as a service. This may include Database as a Service (DbaaS), Java as a Service, analytics as a service etc. IaaS is about providing consolidated and virtualized servers, storage, and operating system environment – a flexible and elastic infrastructure pool as a service to the end-users. All of these models comply with the characteristics of Cloud as defined by NIST ie. On-demand access, resource pooling, rapid elasticity, measured services and broadband access.

These models are evolving. As stated in PR Newswire (2013), the Open Data Center Alliance which is an independent consortium of global IT leaders who have come together to provide a unified customer vision for long-term Data Center requirements, has updated its Cloud Maturity Model (CMM) to include maturity models for Software as a Service (SaaS), PaaS (Platform as a Service), Infrastructure as a Service (IaaS) and Information as a Service (Info-aaS)

Cloud architectures can be deployed in variety of ways, including Private, Public, Community and Hybrid Cloud deployments. Private Clouds are generally designed for a single organization and not accessible to outside world. Cloud infrastructure for these deployments is hosted and managed within a private Data Center. Public Clouds on the other hand, are the ones where shared services are used by multiple organizations. In general, public Clouds are managed, maintained and hosted by third parties - these days by some of the global organizations. Community Clouds are used by a group of related organizations and Hybrid Clouds are deployments where services and applications are hosted both from private as well as public Cloud setups. In this case, both private and third party Data Centers are used.

The end-users are looking at co-locating their Data Centers to Cloud Data Centers (Janakan, 2013). A major advantage of Cloud computing is to host applications over the Cloud, allowing internal Information Technology departments to focus on core business processes, rather than the setting-up and managing back-end IT infrastructure - thereby freeing valuable expertise and resources. It also offers greater efficiency by allowing Data Center upkeep and maintenance to

be managed offsite. The solution allows data and applications accessibility, allowing the business to minimize costs by outsourcing services - avoiding the need to build, maintain and staff expensive new Data Centers (Tony, 2011). Location of Cloud Data Center is becoming increasingly important for the CxOs and is a important factor affecting their decision to move to Cloud.

Supporting dynamic loads with cost effective Quality of Service is key to Cloud architectures. Virtualization is core to Cloud computing and helps in unprecedented levels of flexibility, reliability and scalability. Modern Cloud Data Centers exploit virtualization for efficient resource management to reduce Cloud computational cost and energy budget. Virtualization empowered by virtual machine migration meets the ever increasing demands of dynamic workloads within Cloud Data Centers (Ahmad et. al, 2015). The benefits of Cloud computing, however, come at a high cost in terms of energy consumption, mainly because of one of the Cloud's core enablers, the data center (Castro et. al, 2016).

Data Center Networks (DCNs) are an essential infrastructure that impact the success of Cloud computing. A scalable and efficient Data Center is crucial in both the construction and operation of stable Cloud services (Wang et. al, 2015). Selection of Data Center plays an important role to improve performance as well as to reduce the cost (Jaikar & Noh, 2015).

The Cloud growth trend will continue (Kris, 2014) and Data Centers will continue to be Cloud's core enabler. CIOs of IT organizations have a choice between two paths - the Cloud or a traditional Data Center. There is advancement in Hybrid Cloud services and tools, where depending on the criticality and readiness of the data and application, data can be stored across the on premise Data Center and public Cloud Data Center. The trends also show Disenchantment with private Cloud.

Whatever the case may be, Data Centers remain integral part of these deployments. Cloud infrastructure is hosted in these Data Centers, which may be private Data Centers for a specific organization or Third party Data Centers hosting Cloud services for multiple organizations. An efficient, sustainable and effective Data Center forms a foundation for the Cloud Computing architecture. Today, there are thousands of Cloud computing and Cloud services companies. All major Cloud service providers are growing and streamlining their Data Center facilities across many global locations (TalkinCloud.com) where they see good business potential for Cloud.

The unstoppable rise of the Cloud is fuelling the global Data Centre market, leading to a wide array of models to support virtualisation services in facilities (Willmer Gareth, 2015). The worldwide growth of IP services, such as VoIP and the trend for enterprises to put more and more applications in the Cloud has added to the pressure faced by Data Centres to deliver seamless and continuous services (Hawkes Alex, 2015).

Data Center effectiveness is an important criterion for the effectiveness of Cloud architectures.

Data Centers are also organizations in themselves – having their own structure, processes and people associated. Just like any other organization, Organizational Effectiveness is essential for Data Centers.

Organizational Effectiveness has been related to various measures and factors. Lewin and Minton (1986) summarized various definitions of Organizational Effectiveness. Amongst many factors, Organizational Effectiveness has been related to product maximization, cost minimization, optimal resource utilization and task specialization (Taylor, 1911), division of work (Fayol, 1925), employee satisfaction (Mayo, 1933), structure strategy congruence (Chandler, 1962), efficiency through economy of scales (Sloan, 1963). Organizational Effectiveness has also been related to multiple stakeholder satisfaction (Beer et. al, 1995) and the ability to transform inputs to desired outputs in achieving organizational goals (Gautam & Batra, 2007) in an optimal manner etc.

Organizations vary from one domain to another. Determinants of Organizational Effectiveness for an organization may also vary from one organization to another or from one domain to another, but the fact is that Organizational Effectiveness is critical to the existence of any organization and its importance cannot be ignored (Cameron, 1986).

As Data Centers form an integral part of Cloud architectures, Organizational Effectiveness of Data Centers forms a foundation for effective Cloud architectures. Several studies have been done around Organizational Effectiveness for various domains, but there is very limited information available in particular for Organizational Effectiveness of Data Centers This paper highlights the findings of a research study on select aspects of Organizational Effectiveness of Data Center organizations (Ahuja, 2011).

The findings may be used to improve effectiveness of Data Centers that will help in formulating effective Cloud architectures, leading to effective and efficient Cloud services.

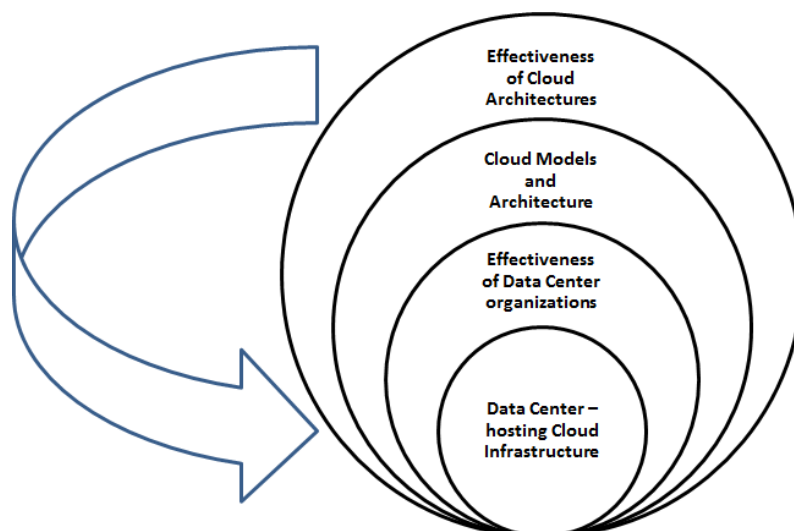


Figure 1: Effective Data Center – Core of Effective Cloud Architectures

3. The Methodology

A web based exploratory study showed that Data Centers are integral part of Cloud architectures. Data Center Organizational Effectiveness is therefore critical to effectiveness of Cloud architectures. Very limited information is available in specific for Data Centers' Organizational Effectiveness.

A basic framework of measures of Organizational Effectiveness was created using findings from literature survey of Organizational Effectiveness studies for various domains. In addition to this, exploratory study of two of the renowned Data Centers in India was also carried out. This was primarily an exploratory and participative ethno-research study; with coverage of a major Government and a Corporate sector Data Center in India. The study involved “inquiry from inside” as opposed to “from outside” (Evered & Louis, 1981), collating inputs from various stakeholders and also involved focus group discussions. Secondary data sources were also used to collect information on operational excellence of Data Centers. All these inputs were used to arrive at a base model on Organizational Effectiveness of Data Centers.

This base model was further used to formulate propositions, which were then used to create a questionnaire and diary of observation. The questionnaire and diary of observation was used to collect data from sixty three different Data Center organizations in India. Data collected via questionnaire was also complemented by qualitative inputs from fifty six one-to-one interviews with key Data Center stakeholders. These inputs were video recorded for in-depth analysis. In addition to this, inputs were also collected from three national seminars and 7 expert panelists.

Overall there were 145 valid questionnaire responses. Respondents were requested to relate Data Center Organizational Effectiveness to various measures on a Likert scale of 1 to 5, 1 pointing to “strongly disagree” and 5 pointing to “strongly agree”. These measures are highlighted below:

- Employee satisfaction.
- Customer focused approach.
- Adaptability.
- Lower Total Cost of Ownership (TCO).
- Well-defined processes.
- Flexible organization structure.
- IT (server and storage) efficiency.

- Facilities efficiency (UPS, power, cooling).

The questionnaire had various factors corresponding to each of these measures. Qualitative and quantitative data was analyzed using statistical analysis tools (WEFT for qualitative data and SPSS for quantitative data) to arrive at measures and corresponding factors contributing to Organizational Effectiveness of Data Centers.

Cronbach alpha test was done for items in individual sections pertaining to the factors corresponding to each measure - Customer focused approach, Adaptability, Employee Satisfaction, Efficiency and lower TCO. Cronbach alpha for most of the related items in the individual groups was within acceptable limit, ranging in 0.6 to 0.77, indicating consistency across items. Kolmogorov-Smirnova and Shapiro-Wilks normality tests were applied on the data. The tests showed a significance of less than 0.05 for all the items under Customer focused approach, Adaptability, Employee Satisfaction, Efficiency and lower TCO categories, implying non normal data. This led to application of non-parametric statistical tests including the Spearman rank correlation coefficient test. Descriptive statistics was also applied for all factors corresponding to each of the measures.

This paper summarizes the findings corresponding to these measures (mentioned above) and corresponding factors.

4. Data Center Organizational Effectiveness - Findings

A detailed analysis available as part of complete research thesis (Ahuja, 2011) highlights qualitative and quantitative paradigms that were used to arrive at the blend of measures and factors contributing to Data Center's Organizational Effectiveness.

Data collected via one-to-one interviews (qualitative data) and through the research questionnaires (quantitative data) was compared. Other qualitative inputs were also considered. Qualitative findings substantiated quantitative results. This helped in arriving at a list of top measures for Data Center Organizational Effectiveness.

Customer focused approach appeared as a top priority measure for Data Center Organizational Effectiveness. High availability, RAS (Reliability, Availability and Serviceability) and Security, which are the factors contributing to customer-focused approach also appeared in the top ten list of qualitative findings. For the purpose of this study, Data Center users were categorized as both internal as well as external end-users.

Data Center Adaptability, Data Center Employees' Satisfaction, Data Center Efficiency (including the green technology, IT and facilities efficiency) and Data Center lower TCO came up as other top measures of Data Centers' Organizational Effectiveness.

Based on these findings a model for "Organizational Effectiveness of Data Centers" has been arrived at (Ahuja, 2011). This is shown in Figure 2.

A significant correlation (using Spearman rank correlation coefficient test) has been shown between IT (i.e. servers, storage, and networking equipment) and facilities efficiency (i.e. UPS, generators, cooling equipment). These have been clubbed together under the “Data Center Efficiency” measure. Slight correlation has also been shown between flexible organization and employee satisfaction and also between adaptability and lower TCO.

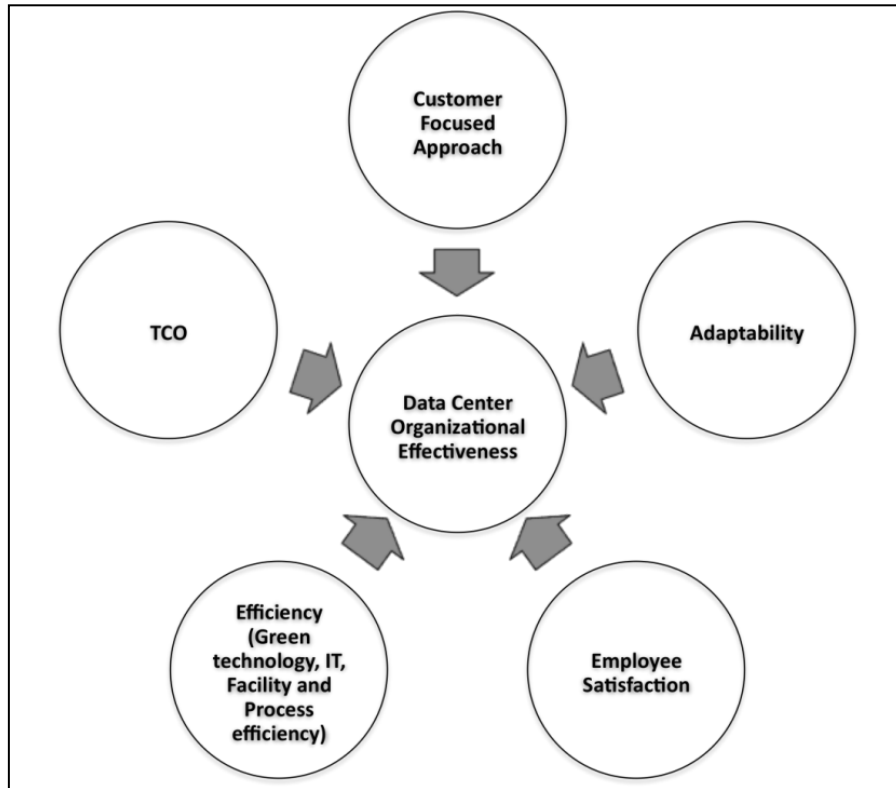


Figure 2:

Gautam Model - Organizational Effectiveness for Data Centers

Ahuja &

Customer focused approach is shown as a top measure of Data Centers’ Organizational Effectiveness. Customer focused approach has further been associated with end-user satisfaction.

“24/7 availability”, “Security”, having a “user friendly interface”, having “well-defined processes” and “continuous updates and programs” to inform and educate the users appear as top 5 factors contributing to customer focused approach.

Figure 3 depict overall descriptive statistics for the factors contributing to customer-focused approach. A correlation has also been shown between “Programs to update and educate end-users” and having “well-defined processes”.



Figure 3: Factors – Customer Focused Approach

Adaptability of Data Centers to have enough flexibility to take care of present as well as future unknown requirements is shown as another key contributor of Data Center Organizational Effectiveness.

Within the measure of Adaptability, “*Virtualization and consolidation*”, “*Training and updates*” and “*Online upgradability*” are shown as top factors.

Figure 4 depicts descriptive statistics of factors contributing to the Adaptability, a key measure of Data Center effectiveness.

Adaptability is a key parameter for Cloud architectures. Factors contributing to Adaptability are therefore critical for effective Cloud architectures. Virtualization is a technique of creating virtual, rather than actual instances of operating environments, servers, storage or networks. Consolidation is a technique of combining separate entities into one - this may be consolidating smaller servers’ into one large physical server, consolidating silo’s of storages into an enterprise class storage or consolidating various databases onto one platform. Virtualization and consolidation leads to better resource utilization, ease of management and efficient usage of power, space and cooling requirements. “*Virtualization and Consolidation*” is a key parameter of Cloud enabled architectures. “*Online upgradability*” is also important to take care of unseen future demand and contributes to flexibility, again a key parameter of Cloud architectures. The online upgradability is applicable to UPS, generator systems, cooling systems as well as real estate.

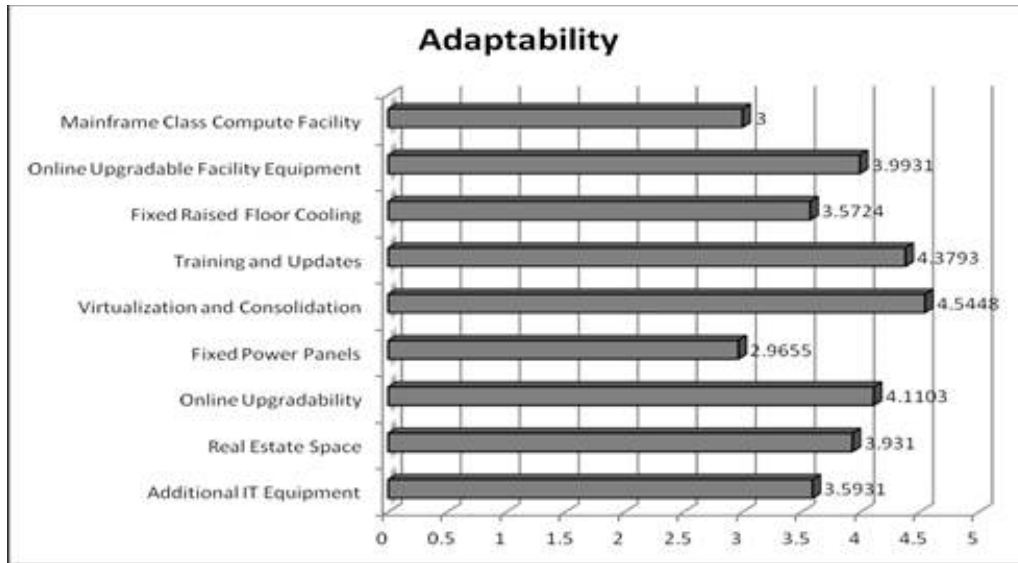


Figure 4: Factors – Adaptability

Employee satisfaction is also shown as a key measure of Data Centers’ Organizational Effectiveness. It is important for any organization to have happy and motivated employees who can contribute their best in meeting organizational goals. This is also shown applicable for Data Center organizations.

“Trainings and updates”, having “A conducive work environment”, having “Challenging assignments” , “Promotions based on achievements” and “High salaries” have been shown as key factors contributing to employee satisfaction of Data Center employees.

A correlation has been shown between “Challenging assignments”, “Autonomy” and “Organizational flexibility”, implying that Data Center employees get motivated in a flexible, autonomous environment and by working on challenging assignments.

Figure 5 shows descriptive statistics of Data Centers’ employee satisfaction.

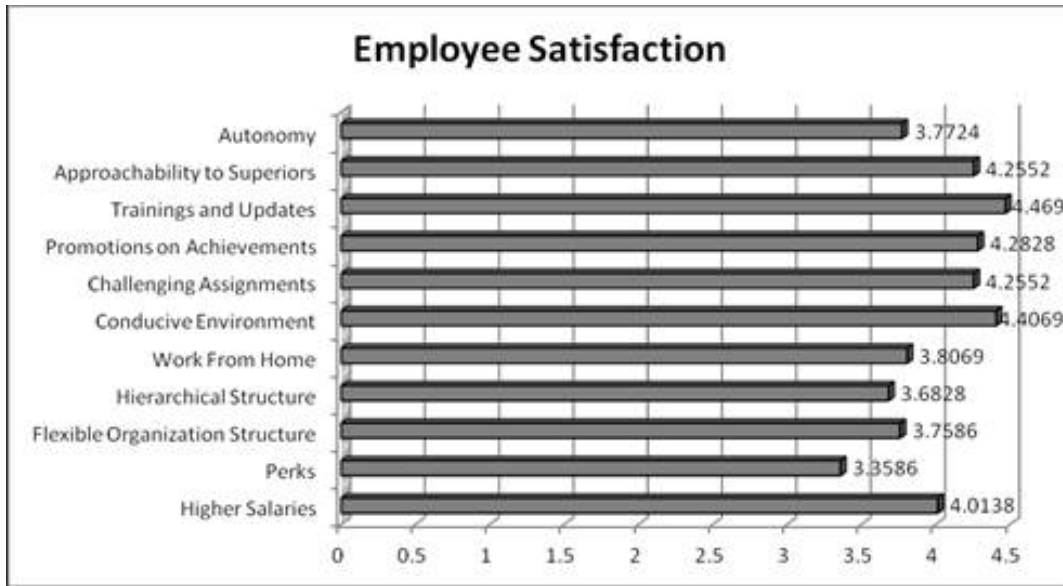


Figure 5: Factors – Employee Satisfaction

Data Center efficiency has also been highlighted as a key measure contributing to effectiveness. Respondents emphasized on the use of green technology along with optimal use of power and cooling resources. IT efficiency as well as facilities equipment efficiency has been rated as key contributors of efficiency.

The study also mentions that green technology and energy efficient architectures are endorsed by key Data Center stakeholders. Use of “*energy efficient power & cooling equipment*”, “*energy efficient servers & storage*”, “*virtualization & consolidation*” and “*reduction in carbon foot print*” have been as key factors contributing to the measure of Data Center efficiency.

Figure 6 summarizes descriptive statistics of factors contributing to Data Center Efficiency and awareness towards Green Data Center architectures.

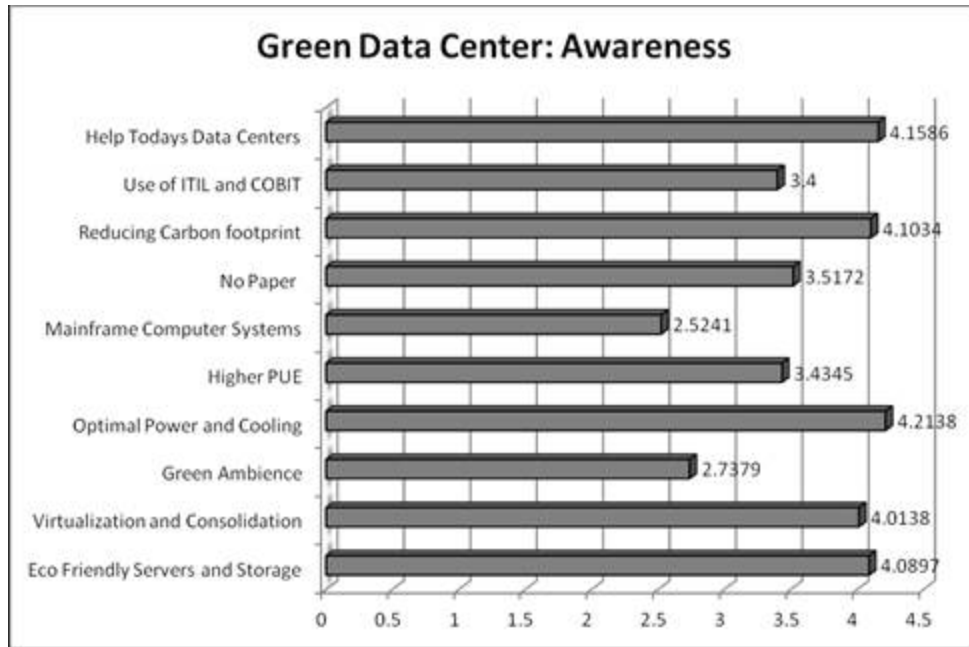


Figure 6: Factors – Data Center Efficiency

Lower Total Cost of Ownership (TCO) has also been shown as a key measure for Data Center effectiveness.

The study highlights various factors that emerged as contributors to lower TCO. This included deployment of “*eco-friendly equipment*”, use of “*flexible, easily deployable, easily serviceable and easily upgradable equipment*”, a “*centralized department*” with an authority and funding to purchase IT (server, storage) equipment as-well-as build data center facilities, and having “*appropriate Service Level Agreements (SLA’s) with both the cooling and power providers*”.

A correlation has been shown within most of these factors. “*Online serviceability*” of equipment was related to “*ease of deployment*” and “*ease of upgrade*”, leading to lower cost of ownership. A strong correlation has been shown between “*having SLA’s with power as well as facilities providers*”, indicating the importance and dependence on power and cooling and also the need to have well defined SLAs for both. “*Centralized department*” showed minor to strong correlation with all other factors, indicating the interdependence of power, cooling, serviceability and upgradability parameters, and importance of having a single view to reduce overall TCO.

Figure 7 highlights the factors contributing to lower TCO.

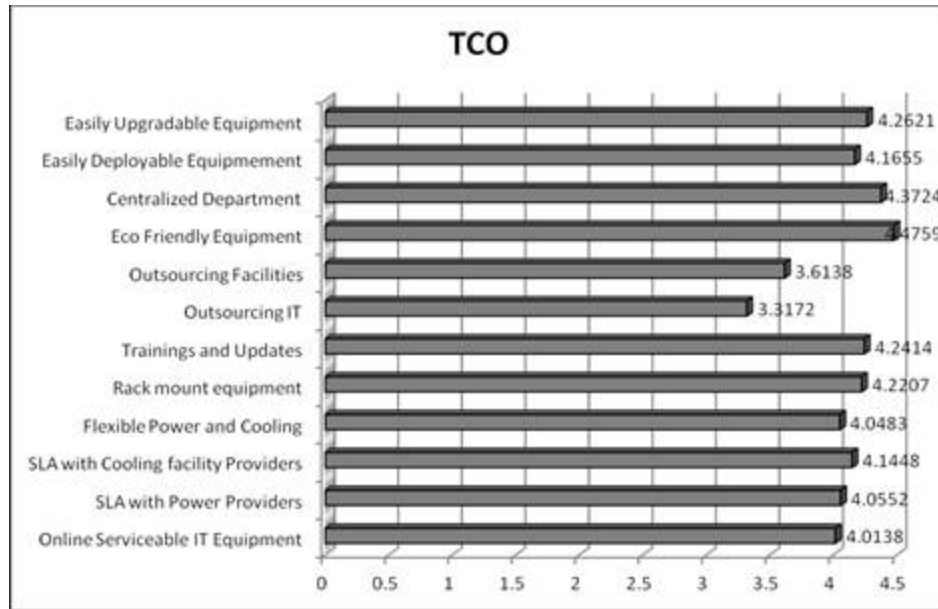


Figure 7: Factors – Lower TCO

In summary, Customer focused approach, Adaptability, Employee Satisfaction, Data Center efficiency and lower Total Cost of Ownership (TCO) appeared as key measures of Organizational Effectiveness of Data Centers. Each of these measures has series of contributing factors as highlighted above.

5 Conclusion

Emerging trends in Information Technology (IT) and its usage in our day-to-day life is just a beginning to a monumental change in our society that is geared up for Digital Transformation. Transformation of IT, emergence of Big Data workloads and growing concerns for management and cost of IT infrastructure in an eco-friendly manner has led to popularization and adoption of Cloud technologies. Cloud infrastructure, be it be Public, Private or Hybrid Cloud, is hosted out of a Data Center. Data Centers form an integral and core part of Cloud Architectures.

These Data Centers are organizations within themselves. Effectiveness of Data Centers is critical to effectiveness of Cloud architectures. This paper refers to a model for “Organizational Effectiveness of Data Centers”, summarizing key measures and corresponding factors that define the model.

The model referred in this paper, is first of its kind generic model on “Organizational Effectiveness of Data Centers”. It can be used as a reference for designing new Data Centers or for evaluating effectiveness of existing Data Centers.

Data Centers being integral and foundational part of Cloud architectures, this model and corresponding findings may be used to design effective and efficient Cloud architectures.

The model defines key measures of Data Centers' Organizational Effectiveness that include "Customer focused approach", "Adaptability", "Employee satisfaction", "Efficiency (green technology awareness, IT and facilities efficiency)" and "Lower TCO".

The findings are applicable and of greatest use to

- Data Center stakeholders – including but not limited to Data Center managers, administrators, users, designers and architects
- The organizations thinking of moving towards Cloud architectures
- Private and Public sector Cloud service providers
- IT Policy makers - both in private and public sector domains

In addition, the model for "Organizational Effectiveness of Data Centers", presented in this paper, further opens up research avenues in the dynamic and evolving domain of Cloud Data Centers. Each component of the model is a food for thought for researchers - to be further explored and researched in arriving at insightful information for effective and efficient Cloud architectures.

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