Architectural Design of an Efficient Data Center

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ABSTRACT

The purpose of this study was to analyze different data centers from design and function perspectives and develop a prototype of a data center for maximum efficiency. Relevant data on the designs and functions of several data centers as well as their advantages were gathered from various sources and analyzed. This is compared and summarized in this work. Finally, an architectural model of an efficient data center is developed. The proposed data center adopts several functions such as Virtualization, monitoring systems, Green IT, and dark strategy. These functions are expected to maximize efficiency, availability and agility, and reduce power consumption, space requirement, and cost of operations and staff salary.

KEYWORDS : *Data Center, Virtualization, Cloud Computing*

I. INTRODUCTION

A Data center is a facility used to house computer systems and associate components such as telecommunication and storage systems. It generally includes a server, storage, redundant power supplies, data communications and security [1]. Conventional data center required huge computer rooms and special environment in which it was operated in the early stage of computer industry. A single mainframe required a great deal of power, and had to be cooled to avoid overheating. Large data centers are industrial scale operations using as much electricity as a small town [2] and sometimes are a significant source of air pollution in the form of diesel exhaust [3].

In the present world, organizations depend on their information systems to run their activities and services. If a system becomes impair the services will be stopped completely. So, it is necessary to provide a reliable and secure infrastructure for IT operations to minimize any chance of disruption. A data center must therefore keep at high standards for assuring the integrity and functionality of its hosted computer environment. There has been good number researches into data center design and functions in the past few years and the findings show that there are several designs of data centers such as traditional server centric, modular, and cloud computing [4], [5], [6], [7], & [8]. Each design of data center adopted various functions to minimize disruption, space required, power consumption, and make the data center environment friendly. Nevertheless, it is very had to find a complete data centre integrated with all modern functions to make it more sustainable. This study is conducted through investigation of the design and functions of several data centers and finally developed an architectural model of a modern and sustainable data centre. The paper is organized as follows. Section 2 discusses the plan of the study, section 3 discusses the design of data center, section 4 describes various functions, section 5 proposed the design based on the analysis of the findings, section 6 includes the validity of the model, and section 6 presents conclusion of this paper.

II. PLAN OF THE STUDY

The objectives of this study were to:
a. Analyze design, and function with advantages of different data centers
b. Summarize and compared findings
c. Develop a technical design of a data centre with innovative functions

Relevant literature on data centre was collected from different sources such as online journals and conference proceedings, books, and internet websites. The data were analyzed on the basis of the design of data center, functions and their advantages. The data were then summarized to develop an architectural model of a

data center. Experts' opinions were sought on applicability and sustainability of the new model. Three data center experts provided positive comments on the new model (Appendix A).

III. DESIGN OF DATA CENTER

Derived from the business objectives and requirements of the applications hosted in the data center, the common design goals are found to increase performance, scalability, flexibility to support various services, and long time viability, and ensure security, high availability and manageability [5], [6] & [9]. Literature on the design of several data centers are given below.

IV. WIRE HOUSE SCALE COMPUTER DESIGN

The typical elements in warehouse-scale systems [10] included 1U server, 7´ rack with Ethernet switch, and a small cluster with a cluster-level Ethernet Switch /router (figure 1).

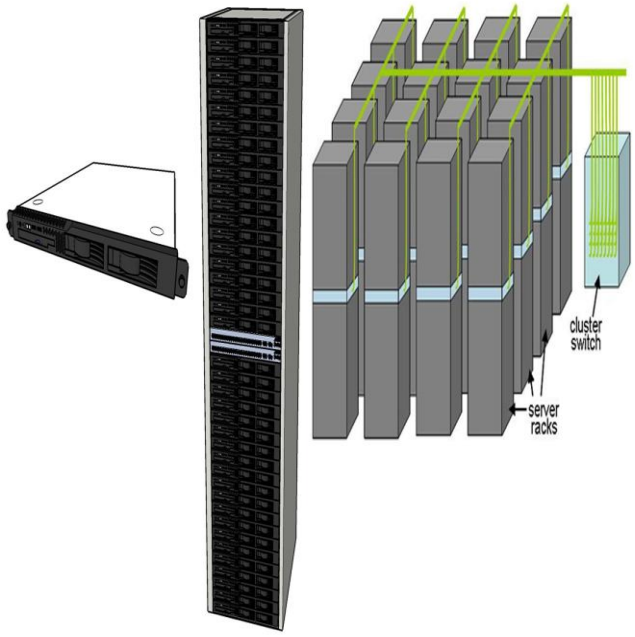

Figure 1. Warehouse-Scale System

Figure 1 depicts some of the more popular building blocks for WSCs. A set of low-end servers, typically in a1Uorbladeen closure format, are mounted within a rack and Interconnected using a local Ethernet switch. A key challenge for architects of WSCs is to smooth out these discrepancies in a cost-efficient manner. Conversely, a key challenge for software architects is to build cluster infrastructure and services that hide most of this complexity from application developers.

V. SUPERCOMPUTER ARCHITECTURE

Supercomputer Architecture of data centre used custom CPUs, traditionally gained their speed over conventional computers through the use of innovative designs that allow them to perform many tasks in parallel, as well as complex detail engineering. Supercomputers today most often use variants of the Linux operating system [12]. A typical supercomputer consumes large amounts of electrical power, almost all of which is converted into heat, requiring strong cooling system. The memory hierarchy of the supercomputer architecture was designed to support high bandwidth , with latency less of an issue, because supercomputers are not used for transaction processing [12].

VI. MULTI –TIER DESIGN

Multi-tier design is the most common model used in the enterprise today. This design consists primarily of web, application, and database server tiers running on various platforms including blade servers,

one rack unit (1RU) servers, and mainframes. The multi-tier model relies on a multi-layer network architecture consisting of core, aggregation, and access layers, as shown in figure 2 [13].

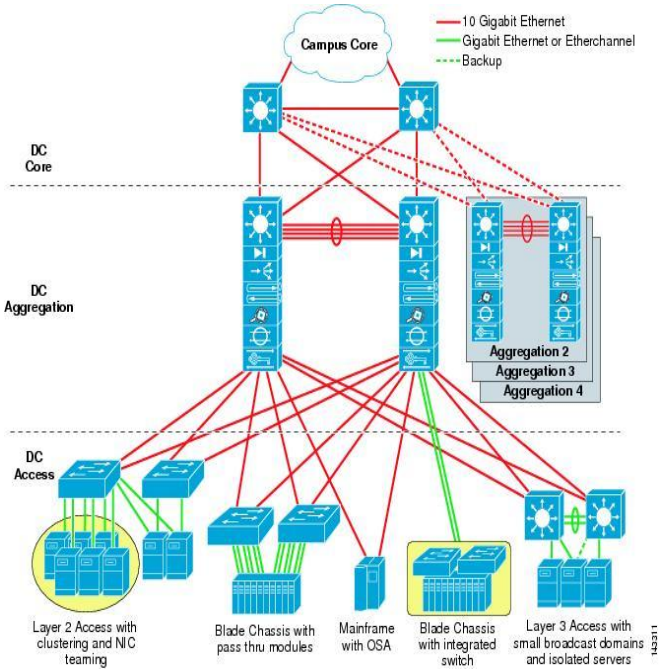

Figure 2. Multi-tier design of data center

Multi-tier design model supports many web service architectures, including those based on Microsoft.Net and Java Enterprise Edition. Today, most web-based applications are built as multi-tier applications The multi-tier model uses software that runs as separate processes on the same machine using interprocess communication (IPC), or on different machines with communications over the network [10].

VII. CLOUD COMPUTING DESIGN

Cloud computing is an emerging field of computer science and recent trend in Information Technology. It is a computing environment where computing needs by one party can be outsourced to another party and when need be arise to use the computing power or resources like database or emails, they can access them via internet [13]. More specifically, Cloud computing moves computing and data away from desktop and portable PCs into large data centers. A simple view of cloud computing architecture of data center [6] is given in figure 3.

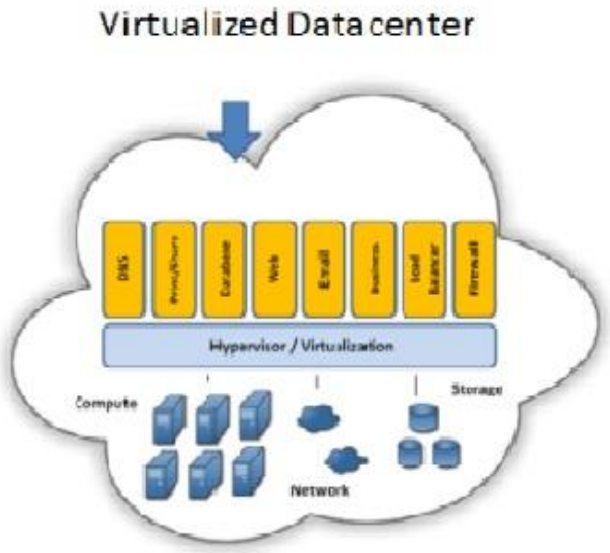

Figure 3. A simple view of cloud computing design of data center.

In the cloud computing design, the computer can no longer be thought of in terms of the physical enclosure that is, the server or box, which houses the processor, memory, storage and associated components that constitute the computer. Instead the computer in the cloud ideally comprises a pool of physical compute resources – i.e. processors, memory, network bandwidth and storage, potentially distributed physically across server and geographical boundaries which can be organized on demand into a dynamic logical entity i.e. a cloud computer [6]. It has multi-level virtualization and abstraction [14], and energy saving functions like green IT applications [15], [16]. The Design of different data centers discussed above may be categories as traditional and virtualized data center. The data shows that the traditional data center is server centric while the virtualized data center is network centric. Further, each design of data center has different advantages. The following section has summarized the functions and their advantages.

COMPARATIVE FUNCTIONS OF DATA CENTRE

Different functions of data center and their advantages are summarized and compared. These are explained below

VIII. VIRTUALIZATION

Virtualization of data center refers to the abstraction of resources to allow multiple operating systems to run on one system at the same time [10] and clouds are attractive computing platforms for data- and compute- intensive applications [17]. These platforms provide an abstraction of nearly-unlimited computing resources through the elastic use of pools of consolidated resources, and provide opportunities for higher utilization and energy savings [17]. Virtualization results in reducing total costs, maximizing energy efficiency, reducing power and space requirement, enhancing security, and increasing availability and agility [18], [17].

MONITORING

Monitoring of operations is an important function of a modern data center. A system monitor is hardware- or software- based system used to monitor resources and performance in a computer system [19]. A central monitoring unit may be operated by integrating central grid control as well as site scan monitoring system. They are used to display items such as free space on one or more hard drives, the temperature of the Data Center, UPS room, CRAC and other important components, and networking information. Other possible displays may include the system uptime with date and time. The monitoring system can identify the temperature and Humidity of Datacenter, CRAC, UPS room, Server Performance or Status, and the Server file system usages

GREEN IT

Green IT technology is a hot topic worldwide. A Green Data Center is a repository for the storage, management, and distribution of data in which the lighting, electrical and computer systems are designed for maximum energy efficiency and minimum environmental impact [20], [21]. Building and certifying a green data center or other facility can be expensive up front, but long-term cost savings can be realized on operations and maintenance. Another advantage is the fact that green facilities offer employees a healthy, comfortable work environment [7], [10]. In addition, green facilities enhance relations with local communities. Advantages of Green IT are reduction in staffing costs, reduce the threat of attacks upon the infrastructure energy saving.

LIGHTS OUT

The ‘lights-out’ or function of a data center ideally has all but eliminated the need for direct access by personnel, except under extraordinary circumstances (23). It can be operated without lighting because of the lack of need for staff to enter the data center. All of the devices are accessed and managed by remote systems, with automation programs used to perform unattended operations. Lights out function is also called dark data centre.

IX. PLATFORM, INFRASTRUCTURE, AND SOFTWARE AS SERVICES

Within each modern computing system architecture, innovative services such as Platform as a Service (PaaS), Infrastructure as a Service (IaaS), and Software as a Service (SaaS) may be offered. PaaS is a full or partial development and deployment environment that supports online access and collaboration between users via the internet. This type of environment saves investment in hardware and additional management personnel [23]. The Customer Relationship Management (CRM) and Enterprise Resource Management (CRM) programs may be made available through the data center of a SaaS provider [14]. However, PaaS and IaaS can be used in place of a brick-and-mortar facility.

PROPOSED DESIGN OF DATA CENTER

Cloud computing design is proposed for new model as it views hardware and software as commodities, possesses mass data computing and store, holds huge scalability and novel services such as SaaS, PaaS, IaaS [23] and good availability. Hence, it offers enterprises the opportunity to reduce hardware and software cost and the potential reduction of maintenance and support staff [15], & [24]. The architectural design (figure 4) incorporates several functions such as virtualization (computer, network and storage), monitoring system, green IT, lights out and other functions like SaaS, PaaS, and IaaS.

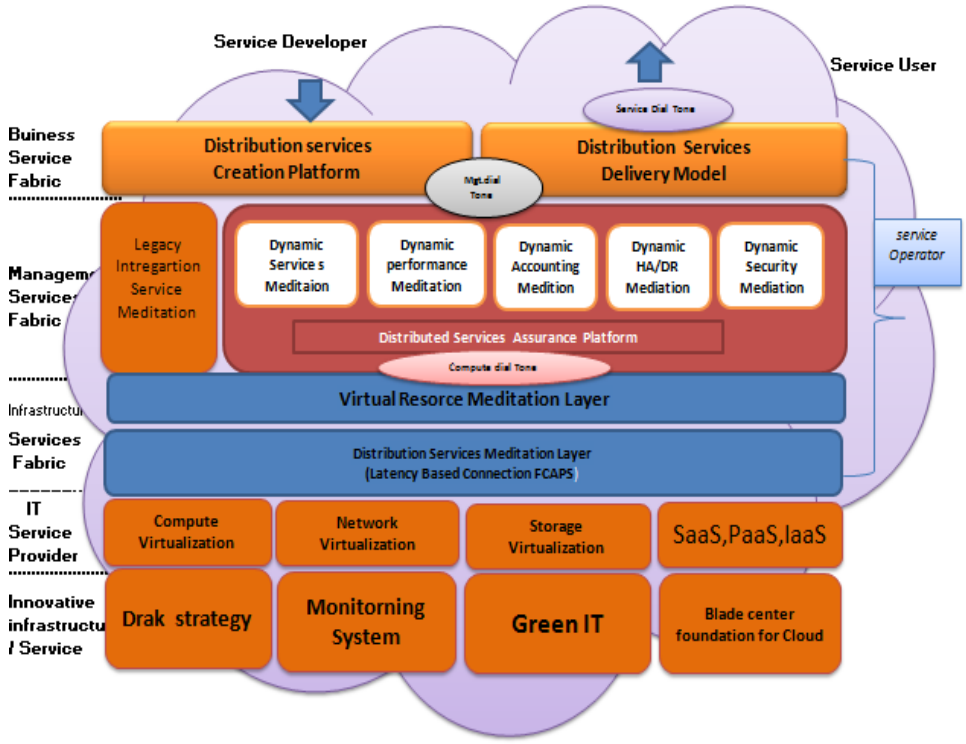

Figure 4. Architectural Design of proposed data center

The model will fulfill the needs of four categories of stake holders for deployment such as infrastructure providers, service providers, service developers, and end users [6]. Infrastructure providers are vendors who provide the underlying computing, network and storage resources that can be shaped up into logical cloud computers which will be dynamically controlled to deliver massively scalable and globally interoperable service network infrastructure. The service provider (SP) will provide organizations with consulting, legal, real estate, education, communications, storage, processing, and many other services as required and manage the application's connection to computing, network and storage resource. The end users can dynamically provision in real-time to respond to changing demands, and provide service providers the capability to charge the end-user by metering exact resource.The proposed data center is unique and efficient because it has been developed integrating several modern applications such as dark strategy, monitoring system, green IT. These strategies will reduce consumption of electricity and cost of extra staff. Additionally, services like SaaS, PaaS, and IaaS will increase novelty of the model.

VALIDITY OF THE PROPOSED MODEL

Since simulation of the proposed design was not feasible so the proposed model was sent to three data center experts who are working in different financial organizations for their comments. The experts offered their positive opinions regarding. regarding implementation and innovation of the model Comments from one of the three experts are presented below."The hypothetical model of a data center is an innovative approach and may be implemented in any organization."Another expert commented on the functions adopted in the design of the data center which is given below."The infrastructure shown in the data center such as virtualization, central monitoring system, dark strategy and green IT are innovations in data center infrastructure. The data center is found modern and may be implemented in any relevant organization." Experts' comments can be found in Appendix A.

X. CONCLUSIONS

The Proposed architectural design of data center enables dynamism, scalability, Reliability and security because of its noble functions -Virtualization, Monitoring system, Green IT, Dark Strategy and Blade Center Foundation. The functions integrated to this new model will address the main drawbacks of the traditional data center such as large infrastructure, and huge consumption of electric power. In addition, the above functions will boost efficiency of the data center. It may be mentioned that simulation of proposed data center was not possible as it is a theoretical model. However, positive comments made by three experts have increased validity and reliability of the model. Further investigation is needed to explore the limitations and challenges of the proposed architectural design.

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APPENDIX A

Expert Opinion

For validity and reliability of the proposed model opinions were sought from three data center experts. Scanned copies of their opinions are given below.

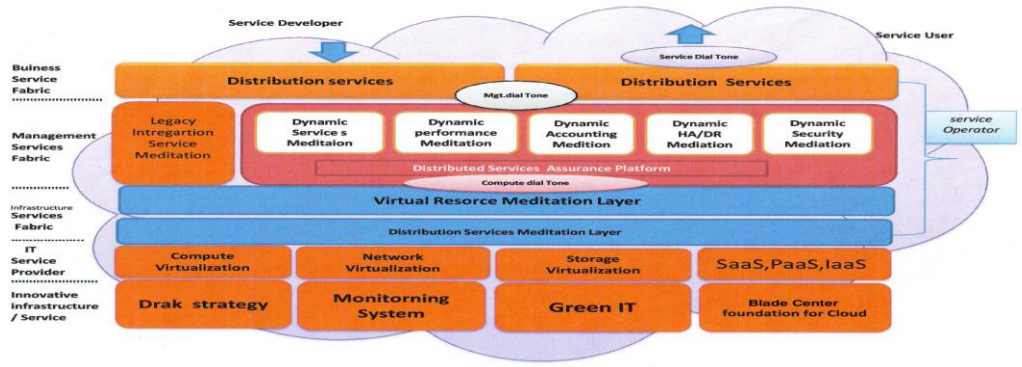

Figure: Architectural Design for Next Generation Data Center - Cloud Computing Infrastructure

The theoretical model of the data center develop by Sree Bishujit Chandra Das, a M.Sc. student of DIU is modern and latest and may be implemented for practical context.

15.01.2013
Jamm Abdul Alim
Manager, Data Centre
BRAC Bank Ltd.

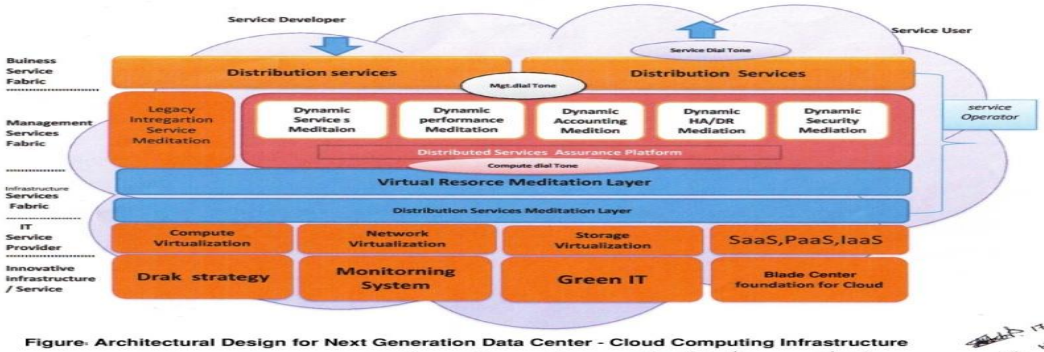

Figure: Architectural Design for Next Generation Data Center - Cloud Computing Infrastructure

The infrastructure shown in the data center such as virtualization, central monitoring system, dark strategy, and Green IT are innovations in Data center infrastructure. The data center is found modern and may be implemented in any relevant organization.

17.01.2013
SYED AHSAN HABIB (SPO)
IT INFRASTRUCTURE AND SYSTEM MANAGER,
IT DIVISION,
EXIM BANK LTD.

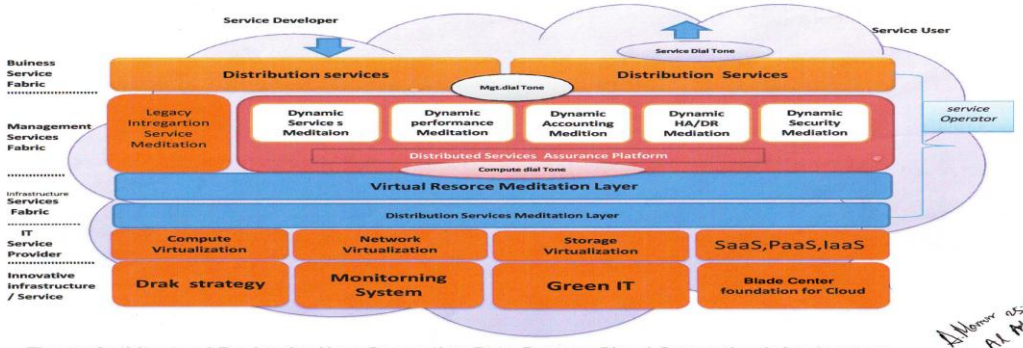

Figure: Architectural Design for Next Generation Data Center - Cloud Computing Infrastructure

The hypothetical model of a Data center is an innovative approach and may be successfully implemented in any Organization.

Abdullah Al Mamun 05.01.2013
Assistant Manager
ICT Division
Bank Ltd.