RESEARCH ARTICLE   OPEN ACCESS

Virtual Cloud Computing; Future Development

Khaled Elbehiery*, Hussam Elbehiery**

(Computer Information Systems Department, DeVry University, USA
** (Computer Networks Department, Ahram Canadian University (ACU), Egypt*
Corresponding Author : Khaled Elbehiery

ABSTRACT
Today, Enterprises should take into consideration the cloud spending choices from 2019 – 2021 because of growing amounts of data that customer is creating. Connecting user to the internet or connecting businesses together brings success, higher shareholder value, and profits. While computing hardware is much faster and cheaper than it was in the 20th century, the enormous amount of data that IoT (Internet of Things) and the customer's expectation of a hyper-connected and personalized experience is driving the need for more advanced cloud-based solution. The paper takes the reader to an advanced technology journey of Cloud Computing, starting with virtual cloud infrastructure major components and ending with a new and unique homogenous cloud approach that brings the public cloud native infrastructure and their software API to the On-Premise environment to build and run modern and cloud-native applications anywhere reducing the resource cycles spent on updating and patching the environment**.**

Keywords - Cloud Service Provider, Virtual Cloud Computing, Virtual Cloud Networking, Virtual Cloud Storage, Homogeneous Cloud.

I. INTRODUCTION

The paper introduces the pioneer Public Cloud Services Providers that organizations likely to do business with and better fit in the IT model. It also defines the Virtual Cloud Computing that enables the customer to take the advantage of multiple Public Cloud Providers with a single pain of glass interface. Virtual Cloud Networking brings cost savings and agility to the table while Virtual Cloud Storage comes with integration of the customer applications into a unified interface with reducing the total cost of the infrastructure storage [1].

II. CLOUD SERVICE PROVIDERS

Cloud computing competition among Cloud Service Providers (CSP) has gone from a race to war. They are constantly upgrading their services what to offer the customer, adding new options to make it easy to adopt, adapting the prices, and expanding the service area not only regionally but globally. Three cloud providers have succeeded so far to dominate the world and stayed on the top, Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP). Amazon is the most mature and has the widest array of products and services. If you are highly reliant on Microsoft technologies and products like Office and .NET, you should consider Microsoft Azure. Google is often the cheapest option [2]. Fig 1 shows the top three public cloud providers of 2019; AWS, Azure, and Google.

Fig 1: Top three public cloud providers of 2019

Infoholic Research LLP, as one of the leads of market research arena has stated that the worldwide hybrid cloud computing market to grow at a CAGR of 34.3% during the period 2016–2022 to aggregate $241.13 billion by 2022 [3]. Fig 2 shows hybrid cloud management system market. Few readings are hidden; you can find the complete report at Infoholic Research.
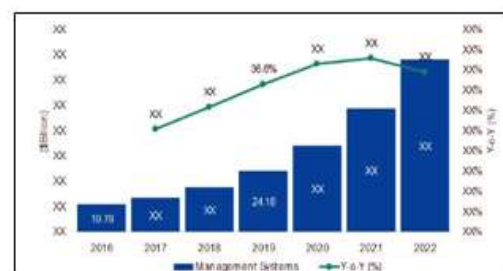

Fig 2: Hybrid cloud management system market revenue growth chart

When it comes to cloud service providers, the service's price is not the only factor to take into consideration to choose among them. Location of the service's regions; locally and globally is rated number one to determine which CSP to adopt a specific cloud provider especially if the desire to offload most of the workloads to the cloud. The need for more locations, regions, data centers are the terms of the equation to assure lower latency, higher bandwidth capability, and complying with the customers' Service Level Agreement (SLA) [4]. Fig 3 shows the top three cloud providers' global locations currently available; AWS, Azure, and Google.

Fig 3: Top three cloud providers' global locations; AWS, Azure, and Google

The race is not over yet, there are many places in the world are the next target to provide cloud services and, in some case, a whole region such the Middle East or a whole continent such Africa has not serviced yet and ready to enter the race as well. It is worth to mention that the number of the data centers or availability zones for a provider does not really reflect the popularity of this provider among the customers of this region, but the capability of the service such as supporting GPUs workloads or data mining, or service integration with the other regions might be the deciding factor then. Fig 4 shows cloud provider data center locations worldwide.
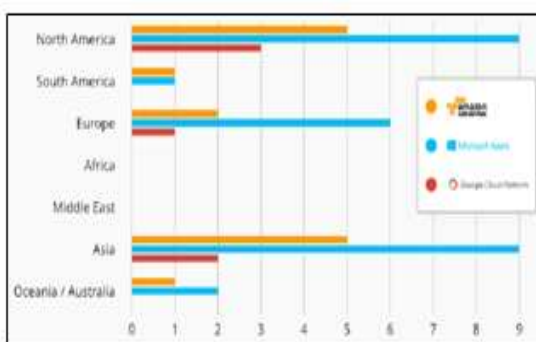
Fig 4: Cloud provider data center locations worldwide

III. VIRTUAL CLOUD COMPUTING

Cloud computing is considered one of the fastest growing technology in 21st century. Few years ago, the business model was about the enterprise customer to choose a cloud provider and starts to offload the workloads they have on-premise and that kept the business running for a while. New challenges came up such as different departments within the Enterprise found themselves locked in within a certain provider that accommodate with the majority of the needs but behaving poorly with regard to other aspects of the business. Multi-Cloud strategy has addressed this concern through enabling the enterprise to connect to more than one cloud environment simultaneously with one goal is to get the best service possible to address all aspects of the business [5], [7]. Fig 5 shows the Multi-Cloud architecture.
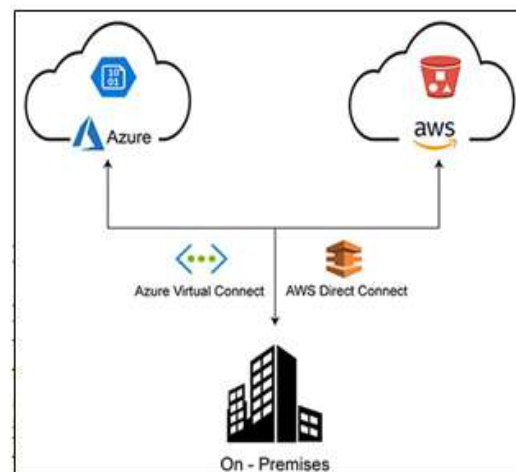
Fig 5: Multi-Cloud architecture

Financial wise, the Multi-Cloud model works very well for large-scale enterprises because they have the budget, resources, and the expertise to work on each cloud technology to produce a profit. However, in the case of medium to small-scale businesses, they need the same agility and advantages of Multi-Cloud architecture but they cannot afford the cost associated with it. A new strategy is born that resolved this issue, called "Virtual Cloud". Imagine from one single pain of glass, one interface API to create workloads or migrate them among multiple cloud providers when it is needed, have the capability to automatically adapt to certain parameters such as outages or natural disasters, or build the application on the a specific provider that best match the needs for it such as Microsoft SQL and Active Directory to run better on Microsoft Azure provider taking the advantage of the discount, they might offer to the customer [6].

A growing' specialized companies are taking the lead of being a Virtual Cloud Provider, partnering

with as many public cloud providers as they possibly can in different locations to offer the customers the best services of all cloud providers combined. They developing and adapting their software diligently to ease utilizing the service for the customer, offering consultation for cloud transformation, and working with their cloud providers' partners to lower the cost for their clients when it is possible. It is the newest evolution in the cloud computing environment that is getting better by the day and gaining attraction and endorsement worldwide [6]. Fig 6 shows the Virtual Cloud Provider model.
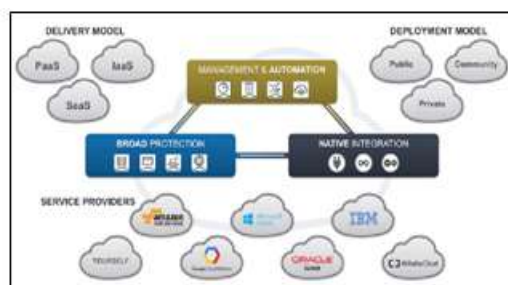

Fig 6: Virtual Cloud Provider model

IV. VIRTUAL CLOUD NETWORKING

Few years ago, word "Networking" had one meaning for the architects; physical routers and switches, and similarly word "Security" meant a physical firewall. This notion has shifted in the cloud computing era since the business these days in a need for an efficient agility to deliver services faster while maintaining the control of utilization and the lower cost of on and off-premises workloads resources. As such, network and security configuration are deployed in dynamic way with the appropriate adherence to the enterprise regulations and to the federal and state governance in case of GOV Cloud deployment.

A new generation of network and security virtualization called Software-Defined Networking (SDN) that minimizes the infrastructure provisioning time and resources, and accelerate the service delivery that reduce both the OPEX and CAPEX which means cutting the overall cost.

Replicating the network infrastructure configurations and applying the security measures are no longer taking months from purchasing the hardware to deploy and manually configure with the possibility of human errors of duplications and misconfiguring the physical appliances. It is however deployed in few minutes in an automated fashion that significantly shorten the time to deliver the new service, offering the application to the users rapidly and accelerate the Return Of Investment (ROI).

This newly dynamic and logical way to deploy network and security reduces the cycles for the architects and the engineers to learn new

Operating Systems (OS) for different physical appliances, different graphical interfaces to interact with. It is however super-efficient visual, highly redundant, and elastic system, not only between different racks of the data center but across the region and it can expand worldwide. Because the networking and security features are built in software, it improves the data center levels of agility, security, and economics that were previously extremely costly with physical networks.

Two major strategy to implement Software-Defined Networking (SDN), it all depends on your business model, the enterprise size, and future plans for expanding the business.

First strategy "Do It Yourself" through adopting a specialized Software such as VMware NSX, Big Switch Networks, and AWS Transit Gateway. This method perfectly fits when the enterprise employs highly educated architects and engineers, having technical skills to deploy and utilize the software along with the enterprise commitment to financially support and keep the architects and engineers.

As of April 2019, Big Switch Networks is ranked 4th in Software Defined Networking (SDN) vs. VMware NSX which is ranked 1st in Software Defined Networking (SDN), however AWS Transit Gateway is considered a new simplifying evolution of connecting businesses on a global level. VMware NSX delivers a completely new operational model for networking that forms the foundation of the Software-Defined Data Center. NSX provides a complete set of logical networking elements and services—including logical switching, routing, firewalling, load balancing, VPN, quality of service (QoS), and monitoring. These services are provisioned in virtual networks through any cloud management platform leveraging the NSX APIs. Virtual networks are deployed non-disruptively over any existing networking hardware [8], [10]. Fig 7 shows VMware NSX (VMware, 2017). Cisco defines SDN as Software Defined Wide Area Network (SD-WAN) where traffic, rather than use MPLS, would use the centralized controller to send traffic in an intelligent manner to better utilize the links (Miller, 2017) while Cumulus Networks (2017) talk about bare-metal switches and ability to run Linux. Other people might think that SDN is the open switches, such as produced by Facebook (2016) which allow running open source software.
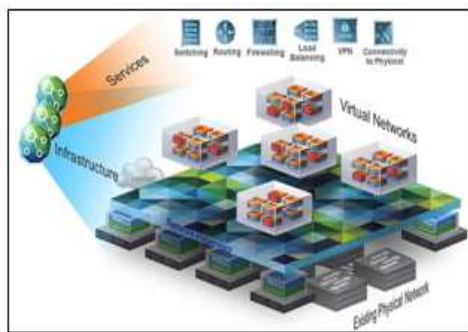
Fig 7: VMware NSX

Second strategy through a 3rd party called Managed Service Providers (MSP) to orchestrate and manage the cloud network and security for your small to medium size business when the architects and engineers are not available with the capacity to accommodate with the business demands. The MSPs offer different tiers of services' designs from a single cloud provider to multiple, with any scale needed including the On-Premises to fit into the business goals [11].

One of the pioneers MSP to provide this service is Aviatrix Systems. Aviatrix establishes an abstraction layer between the public cloud provider's networking primitives and the application to simplify the creation of logical cloud networks and services for hybrid connectivity, data security, multi-cloud connectivity, monitoring and troubleshooting. The solution consists of two components: Aviatrix Controller; and the Aviatrix Gateways, all of which are deployed in public cloud provider' VPCs or On-Premise' environment [9], [12]. Fig 8 shows the illustration-planes for both Aviatrix Controller and Aviatrix Gateways.
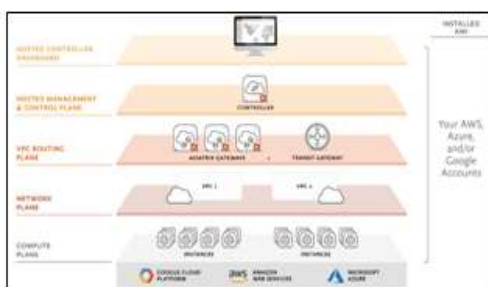

Fig 8: Illustration-planes for both Aviatrix Controller and Aviatrix Gateways

V. VIRTUAL CLOUD STORAGE

The ordinary understanding of cloud storage is the storage that belongs to a public cloud provider. it is accessed and utilized by the applications running on the compute resources that belong also to the same cloud provider. The technology and business' demands have evolved and the need for freedom of choice becomes imminent.

Segregating the compute resources from the storage that enable the applications to run on the On-Premise data center while the storage belongs to a public provider is a customer choice. Freedom off being storage locked in to one public provider, the businesses desire to utilize the storage from multiple providers seamlessly, the latter evolution is called "Virtual Cloud Storage" [13]. Fig 9 shows the traditional model where the storage coexists with the compute resources versus the Virtual Cloud Storage model where those components are segregated.
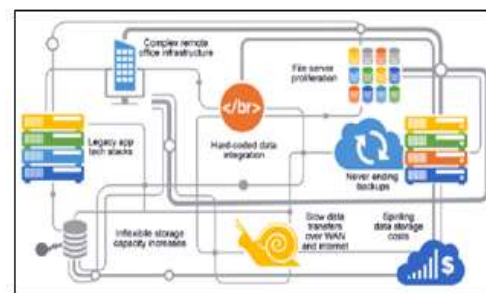
(a)

(b)

Fig 9: Cloud storage models (a) Traditional storage model (b) Virtual Cloud Storage model

Manmade disasters such as building on fire and water damage or natural disasters such as hurricanes or flood usually come with enough insurance might cover the losses but never the data. Virtual Cloud Storage is the new data insurance ever known to businesses since the cloud evolution had started. Today, the cloud disaster has become a term in financial technology equation to avoid failures and protect the businesses from money loss [15], [16]. There are few classes of Virtual Cloud Storage:

a. <u>Cloud Data Storage:</u> It enables the enterprise compute resources to remotely access the data through a shared file system. It also helps to simplify and accelerate moving the data of all types and sizes into and out of the public cloud.

b. <u>Archiving Storage:</u> A long-term storage environment and likely very cheap that can replace tape drives with a main purpose of

archiving and regulatory compliance that tolerate retrieval latency, a popular example is AWS Glacier.

c. <u>Off-Premise Storage:</u> In this case the enterprise instead of investing on On-Premise environment, it accesses same storage with the same software On-Premise but on a storage vendor remote facility and it is "On Demand" service which means pay as you go.

d. <u>Gateway Storage:</u> A hybrid storage cloud augmenting your on-premises environment with the provider cloud storage, for bursting, tiering or migration. Two examples are AWS Storage Gateway and NetApp HCI with Cloud Volumes ONTAP solution.

e. <u>Backup and Disaster Recovery:</u> A fully managed backup service that makes it easy to centralize and automate the back up of data across public cloud services located in the cloud as well as the on premises using a storage gateway.

Best practice for backup is to have three copies of your data; the original, a local on-premise copy, and a copy offsite which become more agile and dependent that it could be a permanent replacement of the local on-premise. The disaster recovery demands are exponentially growing in different formats and options in respond to the importance of the data value and size. A key factor for this success is the lower cost and simplicity to implement and deploy [14], [17]. Fig 10 shows the disaster recovery growing demands. Fig 11 shows the cloud disaster recovery options vs cost.
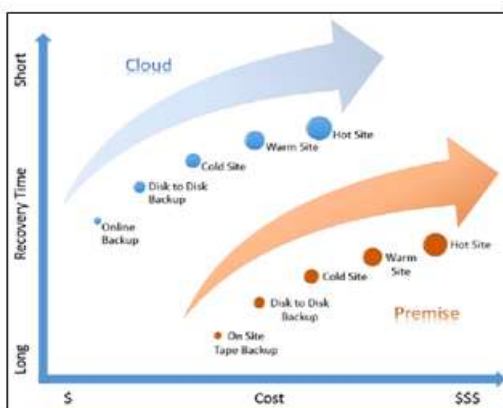

Fig 10: Disaster recovery growing demands

Fig 11: Cloud disaster recovery options vs cost

VI. HETEROGENEOUS TO HOMOGENEOUS CLOUD

By definition, Heterogeneous is when different entities exist together but maintaining their boundaries, on the other hand Homogeneous is when those boundaries are dissolving to a point you can't tell anymore if they are actually different entities or become one entity.

Everything has been covered so far, from On-Premise private cloud hardware and software wise are working independently from the public cloud that have their own gear, even with the concept of hybrid cloud is nothing but making the private and public cloud work together seamlessly but they are still having the boundaries of being two different entities [20].

Late 2018 and continuing 2019, a new approach has arisen from few public cloud venders pioneered by AWS announced they can bring their reliable hardware and software to the enterprise On-Premise facilities utilizing same design allowing the customer to use the same native cloud provider API, this new service is known as "AWS Outposts". This Homogeneous approach not only has brought both private and public entities to work together closely but having the same interface to manage both environment simpler and more efficient. AWS brings its cloud to On-Premise, sells the hardware, install it, and maintain it if the customer is willing to. It is considered a unique future vision that has got the attention of the rest of the public and private cloud vendors to a point that Forbes, the American lead business magazine focusing on finance, investing, and marketing has published that it's not that servers are being redefined by AWS in a way that competes with traditional server vendors. Rather, the whole concept of what it means to compute within the four walls of the data center is being challenged [19].

Hybrid cloud market leaders such as VMware has supported the cloud homogeneity approach by working in conjunction with AWS for extending VMC (VMware Cloud) arms, which means that it could be deployed on public cloud vendors environments such as AWS, IBM, or Rackspace to On-Premise AWS Outposts, which brings the best of both in the worlds as well with one API for native AWS services that also supports VMware's enterprise-class SDDC software powered by VMware Cloud Foundation. VMC on AWS integrates compute, storage and network virtualization products (VMware vSphere, VMware vSAN and VMware NSX) along with VMware vCenter management, optimized to run on dedicated, elastic, bare-metal AWS infrastructure [18]. Fig 12 shows the VMware Cloud on AWS Outposts.
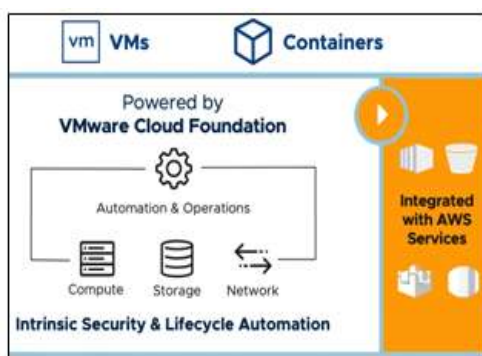
Fig 12: VMware Cloud on AWS Outposts

VII. CONCLUSION

Serverless computing, data mining, and machine learning are the outcome of the massive growing of cloud computing. According to IDG, "73% of IT buyers have at least one application or a portion of their computing infrastructure in the cloud". Advanced cloud computing topics are illustrated in this paper but the most important question for the customer remains, in which public cloud provider should the customer invest, or should the customer take the advantage of some or all the public providers by going virtual, should the customer utilize the virtual network and storage to accommodate with business needs and enabling the business to extend the services globally, or should the customer even go further and let the public cloud providers come to its own On-Premise and build a homogenous cloud. Ultimately, it is the customer choice.

ACKNOWLEDGEMENTS

REFERENCES

[1]. Debra Prentice, The pros & cons of public, private, or hybrid Cloud, Arrow Solutions Group Blog website, USA, December 28, 2018. [Online]. Available:
[2]. https://www.arrowsolutionsgroup.com/blog/pros-cons-public-private-hybrid-cloud/
[3]. Cloud Computing comparison 2019 AWS vs. Azure vs. Google, Full Scale Blog website, USA, March 06, 2019. [Online]. Available:
[4]. https://fullscale.io/cloud-computing-comparison-2019-aws-vs-azure-vs-google/
[5]. Worldwide Hybrid Cloud Computing Market to grow at a CAGR of 34.3% during the period 2016–2022 to aggregate $241.13 billion by 2022, Infoholic Research LLP, India, June 2016. [Online]. Available:
[6]. https://www.infoholicresearch.com/press-release/worldwide-hybrid-cloud-computing-market-to-grow-at-a-cagr-of-34-3-during-the-period-2016-2022-to-aggregate-241-13-billion-by-2022
[7]. Peter Alguacil, Comparing the geographical coverage of AWS, Azure and Google Cloud, Atomia Company Blog website, Sweden, November 24, 2016. [Online]. Available:
[8]. https://www.atomia.com/2016/11/24/comparing-the-geographical-coverage-of-aws-azure-and-google-cloud/
[9]. Sujit Karpe, Creating a Multi-Cloud environment with Azure, AWS & On-premise, Saviant Intelligent Solutions Company Blog Website, USA, April, 2019. [Online]. Available:
[10]. https://www.saviantconsulting.com/blog/multi-cloud-environment-aws-azure.aspx
[11]. Secure cloud infrastructures and applications, Fortinet, Inc. Solutions\Enterprise & Midsize Business website, USA, April, 2019. [Online]. Available:
[12]. https://www.fortinet.com/solutions/enterprise-midsize-business/multi-cloud-security.html
[13]. C.P.Chandgude, G.B.Gadekar, Core of Cloud Computing, International Journal of Engineering Research and Application (IJERA), ISSN : 2248-9622, Vol. 7, Issue 4, (Part -3) April 2017, pp.76-81.
[14]. Dariusz Terefenko, A Comparison of Multiprotocol Label Switching (MPLS) and OpenFlow Communication Protocols, MSc. thesis, Institute of Technology Tallaght, Dublin, Ireland, April 2018, (DOI:10.13140/RG.2.2.14457.98404)
[15]. The AVX Controller and Gateway provide an easy way to setup and manage all your cloud network use cases, Aviatrix Systems, Inc. products/how-it-works website, USA, April, 2019. [Online]. Available:
[16]. https://www.aviatrix.com/products/how-it-works.php
[17]. VMware NSX; The Platform for Network Virtualization, Virtual Graffiti Inc, VirtualizationWorks\VMware Authorized Online Reseller website, USA, April 2019. [Online]. Available:
[18]. https://www.virtualizationworks.com/NSX.asp?utm_term=vmware%20nsx&utm_campaign=VMware+*183&utm_source=adwords&utm_medium=ppc&hsa_tgt=kwd-66102300321&hsa_grp=14297681581&hsa_src=g&hsa_net=adwords&hsa_mt=e&hsa_ver=3&hsa_ad=160488001394&hsa_acc=9041622380&hsa_kw=vmware%20nsx&hsa_cam=12253929&gclid=Cj0KCQjwnKHlBRDLARIsAMtMHDH9DOAKaOTC-Smqlb-8QEjnJlWko6QgdkMsue8mq5CVFt08e0suJAwaAqjNEALw_wcB
[19]. Vijay.G.R, A.Rama Mohan Reddy, Security Issue Analysis in Cloud Computing Environment, International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622, Vol. 3, Issue 1, Jan-Feb 2013, pp.854-857.
[20]. Gurpreet Kaur, Manish Mahajan, Analyzing Data Security for Cloud Computing Using

Cryptographic Algorithms, International Journal of Engineering Research and Applications (IJERA), ISSN : 2248-9622, Vol. 3, Issue 5, Sep-Oct 2013, pp.782-786.

[21]. Yolande Yip, SoftNAS Improves Cloud Storage Price/Performance Barriers and Fulfills Its Cloud Fabric Vision and Mission, SoftNAS®, Inc. website, USA, July 24, 2018. [Online]. Available:

[22]. https://www.softnas.com/wp/softnas-improves-cloud-storage-price-performance-barriers-and-fulfills-its-cloud-fabric-vision-and-mission/

[23]. Timothy King, Zetta BDR Survey Finds Diversity in IT, Slow Cloud Adoption, Solutions Review website, USA, March 31, 2015. [Online]. Available:

[24]. https://solutionsreview.com/backup-disaster-recovery/zetta-bdr-survey-finds-diversity-in-it-slow-cloud-adoption/

[25]. Joseph Talamantez, CLOUD COMPUTING 101, ADVANCE2000 Blog website, USA, October 4, 2018. [Online]. Available:

[26]. http://www.advance2000.com/cloud-computing-101/

[27]. Rachna Arora, Anshu Parashar, Secure User Data in Cloud Computing Using Encryption Algorithms, International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622, Vol. 3, Issue 4, Jul-Aug 2013, pp.1922-1926.

[28]. Arvind D Meniya, Harikrishna B Jethva, Single-Sign-On (SSO) across open cloud computing federation, International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622, Vol. 2, Issue 1,Jan-Feb 2012, pp.891-895.

[29]. William Lam, VMware Cloud on AWS Outposts: Cloud Managed SDDC for your Data Center, VMware, Inc. website, USA, November 28, 2018. [Online]. Available:

[30]. https://cloud.vmware.com/community/2018/11/28/vmware-cloud-aws-outposts-cloud-managed-sddc-data-center/

[31]. VMware Cloud Foundation Planning and Preparation Guide, VMware Cloud Foundation 3.5, Copyright © 2018 VMware, Inc.

[32]. Gurudatt Kulkarni, Ramesh Sutar, Jayant Gambhir, Cloud Computing Infrastructure as Service Amazon EC2, International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622, Vol. 2, Issue 1, Jan-Feb 2012, pp.117-125.