CONTRIBUTION OF CLOUD SERVICE PROVIDERS TO EDUCATION

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Abstract- The number of students and resource usage keep increasing each semester, education providers need to adopt cloud technology. To adopt cloud technology in education, the education provider needs to decide which cloud provider best suites. The attractiveness of cloud computing, which is the capability to run large applications on powerful, scalable hardware without needing to actually own or maintain this hardware is very important to education providers. This paper compared the three cloud providers' performance and decides which of them is the best for education. This paper compares the three giant cloud providers performance; Google, Windows Azure and Amazon Web Service. This paper used benchmarking tools to analyse factors to consider when testing for cloud performance. Different configurations of cloud instances were made on each cloud platform, keeping some factors at constant and varying a constant. The paper also reviews different learning methods in education and the best cloud provider's service that will be advantageous to each learning method

Keywords- Cloud Service Providers, Google, Windows Azure, Amazon Web Services, Cloud Technology.

I. INTRODUCTION

Of all inventions in IT, cloud computing remains an innovative technology that is changing how Information Technology is going to be perceived in the future. It is a technology that delivers resources to end users through web-based access rather than on a personal or remote computer or server, using per metered billing. Cloud technology features so many benefits that a traditional data centre or personal computer will not offer. Many of cloud computing characteristics that features its great benefit are on-demand usage, multitenancy, elasticity, resiliency, ubiquitous access etc. (Erl, Puttini, & Mahmood, 2013). Cloud computing is benefiting a lot of businesses around the globe, including education when the above characteristics are considered.

Cloud computing continuously brings new idea to how businesses can be done, and this is the same in education. Many organizations, such as Microsoft, Amazon and Google are providing cloud computing services that can feasibly be used in education. Evaluating the best cloud service for education becomes a major issue when considering the cloud computing provider that best suite education. There are different factors that should be put together, before any institution especially an education provider adopts one of the cloud computing providers. Factors to consider before adopting any cloud provider should be based on how the education provider will be able to benefit much from the services being rendered by the cloud provider. These factors include but not limited to the increase number of students every semester, how much the education provider is able to afford in terms of cost, what are the services rendered by the cloud provider that can support different learning models? These factors considered by the education provider will lead to the following questions, which determines how best to treat the factors mentioned above: what is the performance of the cloud provider in terms of virtual central processing unit (vCPU) and RAM, which of the providers charge lesser, what architecture did the cloud provider's service based, storage, how secure is the cloud provider with the student's database, how much support can the cloud provider give in critical time, what are the terms of condition in the cloud provider's Service Level Agreement, what is the cloud provider's network latency, if the education provider decides to go to another cloud provider in future, is their platform designed to be portable, does the cloud provider's bandwidth supports the education provider's, how much is the cloud applications scalable and how will its increment add to capacity cost?

This research aim to identify the best cloud provider for education providers bearing in mind the following factors only; virtual Central Processing Unit performance, Read Access Memory performance, associated cost of different configured resources, cloud provider's service that best suites different class delivery models. This paper will be based only on Microsoft Windows Azure cloud computing platform, relative to other cloud computing platform. This research has three main contributions. First, I analysed virtual central processing units, incrementing the number of vCPU and keeping storage and RAM at constant value, allowing different values for capacity cost. The same analysis is done for both RAM and storage, varying their inputs and keeping other associated variables constant. Secondly, I analysed Windows Azure's services that is beneficial to education providers. And finally, I analysed how Windows Azure's contribution to different education delivery models,

such as face-to-face learning, blended face-to-face/online learning and online learning modes.

This paper is organised as follows; Section II gave an overview of related work associated to this research. I analysed the methodology used for this research in section III, and the proposed model for different learning delivery will be discussed in section IV. Results of my research are shown and discussed in section V, while in section VI and VII, I discussed evaluation of my model, and conclusion of this research and gave possible areas and ideas that can help to further develop this research respectively.

II. RELATED WORK

Related work in this field will be divided into two categories: evaluating Windows Azure's performance and cloud computing in education. These two categories will be compared to this research work.

In few years that cloud computing has emerged, there has been broad research in the field of cloud computing, among the research is performance in cloud services. Eduardo et al (Roloff, Birck, Diener, Carissimi, & Navaux, 2012) confirms that overhead communication between cloud provider and cloud consumer affects cloud performance and Windows Azure demonstrates better performance compared to other cloud provider because of its interconnectivity. Interconnections among applications also aid program portability, a good feature to look at when porting application from cloud provider to another. Windows Azure is a cloud platform that is very flexible that allows fast development, removing errors in programs and applications, and application management through Microsoft data center (Dordevic, Jovanovic, & Timcenko, 2014). Past work of Dordevic et al showed that their test result was in favour of Windows Azure when CPU and disk demanding programs are of great concerns compared to Amazon Web Services (AWS). They also confirmed that Microsoft Azure virtual hardware is stronger compared to other cloud providers. AWS has also proven to be more optimized for virtual machine running Linux because AWS has granular options that allow users to adjust instance configurations.

The role of cloud computing in education cannot be underestimated, that is why Faisal et al (Alshuwaier, Alshwaier, & Areshey, 2012) were able to do thorough research on this topic and came up with the following points: AWS assist education providers and their students by offering a free usage of AWS services which is highly scalable, dependable and flexible allowing students, faculty and researchers to develop extensive kind of applications. According to Faisal et al, Microsoft Azure hybrid model of resources allows students and researcher to make full use of Microsoft software for education. Incorporating Microsoft Live@edu into Windows Azure will serve range of need that include cloud based email, on-line document storage, Alumni communication, Enterprise class tool and on-line document sharing.

Mirza and Dhaka in their research (Zainab & Dhaka, 2014) on cloud computing for educational, emphasized the importance of cloud computing to education. Cloud computing will take away the maintenance burden from the educational provider. University needs to handle large number of simultaneous users. The intrinsic support for scale out applications and scale out data that Azure provides can handle much larger loads than more conventional web technologies. Education provider's load will vary significantly at the time of admission, examination and at the time of results. Many times education provider sites goes down when the traffic of student accessing the web is much. Running applications with high fluctuating demand of recourses always requires enough machines to handle such demand. And when the education provider is not in session, these machines are not in use, this meaning a waste of resources. If the application is running in the cloud, the education provider can expand its resource usage in the cloud and decrease back to smaller number if the need of those machines are not necessary. As cloud computing charges base per usage, so this solution is cheaper than maintaining a lots of mostly unused machines. To handle this demand of resource fluctuation, education provider needs to configure and load multiple Web role and worker role.

For cloud computing to function very well, each cloud provider has its own components and technology, due to there is no world acceptable standard technology for cloud computing (Technology, 2011). Because of this notion, Window Azure platform is built basically on Microsoft .NET framework (Chappell, 2009). The components of the Windows Azure platform are: Windows Azure that provides a Windows-based environment for running applications and storing data on servers in Microsoft data centers. SQL Azure that provides data services in the cloud based on SQL Server and Windows Azure platform AppFabric which provides cloud services for connecting applications running in the cloud or on premises. The three of these components can be used for education is regard to what each can do. Education provider can use Windows azure to run any of its learning management system application. SQL services can be used to manipulate student records and resource usage and Windows Azure AppFabric can be used as connection between a cloud based resource and on premise resources.

There are numerous ways cloud computing can contribute to education, Kumar et al (Kumar, Kommareddy, & Rani, 2013) emphasized this in their research. Microsoft Live@edu is available at no cost, and it helps IT departments to reduce the costs for IT infrastructure, such as maintenance., minimize time spent maintaining e-mail systems and on strategic initiatives, provide flexibility and collaboration with

peers and faculty, reduce the time evaluating risk and help make informed decisions about the use of educational cloud computing, free on demand resources-test and deploy large-scales applications in different environment, create applications that can be shared by many students simultaneously.

Some of Windows Azure services can also be used for education purposes. Service like Azure Media service can be used to broadcast live classroom lectures to people far away on any device. Another service that can be used for education purpose is Azure RemoteApp that can be used to remotely access school resources from the cloud even on phones. Azure Media service can be used to broadcast live lectures to students that are using various platform to watch and listen to the broadcast.

All of the research paper, there is no research that has really been done to start exactly which cloud provider is good for education provider. This research will focus on the cloud provider that best suites education provider.

III. METHODOLOGY

The methodology used in this research includes the use of various benchmark programs. We used UnixBench, SysBench, Dbench and online software known as the Cloudscreener. Different benchmarks were used to the purpose of accuracy. Once two or more benchmark tool gave the same result, then we are sure of the benchmarks. All benchmark tools were downloaded, installed and compiled on VM's in respective cloud providers: Google, Amazon and Windows Azure. Benchmark tools were used to justify performance of each VM instance in its respective cloud provider. Many factors decides which cloud computing provider is the best, these factors include architecture of the cloud provider, security, cost, human factors, SLA (Service License Agreement), network latency, portability, bandwidth, memory, disk input/output (I/O), virtual CPU (Baillie, 2015). Among these factors named above, factors that can affect cloud provider's performance include platform architecture of the cloud provider, network latency, bandwidth, memory, disk I/O etc. This research work will be based on storage, vCPU and RAM. These factors were chosen because of the features of education provider: high increase of resource pooling which will affect the CPU, increase in storage for graduating students and Alumni purposes, that will increase the storage consumption as new students are enrolling and graduating student's file are moved to Alumni storage space.

Each of the factors considered were kept as a variable against other factors, that is, when configuring an VM instance, for example, storage value for each instance was varied, keeping vCPU and RAM at constant. These configurations gave rise to different cost value, which was later summed to compute overall Cost for each cloud providers. Table 1 and Table 2 are examples of two different instances with 2 vCPUs, 16GB of RAM and 50GB of block storage and 4 vCPUs, 16GB of RAM and 50GB of block storage. The performance was judged on the scale of 10 using Cloudscreenapp (Cloudscreener, 2015).

Table 1.An instance with 2 vCPU, 16 GB of RAM and 50 GB of block storage. Cost is per month.

Provider	Performance	Cost ($)
Google	9	117
Windows Azure	6.7	150
Amazon Web Services	6	145

Table 2.An instance with 4 vCPU, 16GB of RAM and 50GB of block storage. Cost is per month.

Provider	Performance	Cost ($)
Google	9.2	119
Windows Azure	6.8	152
Amazon Web Services	6.1	151

More than fifty instances were configured altogether. First using result from UnixBench, Dbench and SysBench from our real cloud instances, we were able to compare more than eight instances with Cloudscreener's simulations and we found that the variance is insignificant, then we ran most of the instances with Cloudscreener's simulation in order not to acquire excess charges while researching this work.

IV. CLOUD SERVICES IN EDUCATION MODEALS

This section presents how performance and cost are going to affect cloud provider adoption by an education provider, mainly justifying the cloud providers in three categories, basically on learning delivery models, which are face-to-face, on-line and blended learning.

4.1 Face-to-face learning: This category will not fully be implementing cloud computing services except for collaboration and storage service. The three major cloud providers, Google, Microsoft and Amazon are all having collaboration tools that stores, synchronizes and share files, and communicate among students and the faculty members. Amazon WorkDocs is a collaborating tools that shares and store files. Amazon recently launched Amazon WorkMail, a cloud-hosted email and calendar services alongside WorkDocs. Microsoft Exchange and Office 365 are both email and collaboration tool from Microsoft. In terms of cost, Amazon WorkMail offers $4 per user per month with 50GB of storage per person without its file collaborating tool. Amazon offers $6 per user per month with 50GB of storage for

Amazon WorkMail and 200GB of storage for Amazon WorkDocs(Amazon, 2015). With Amazon, users can choose region where their data resides: which is a good idea for legal and security purposes, but that mean in a case of outage, users will not get failover advantage to another data center. Google Apps offers $5 per user per month with access to Google docs and applications but with 30GB of storage. Microsoft cost $5.61 only for mails but includes 50GB of storage. According to Google's private policy (Google, 2015), Google uses user's information to serve users better while Microsoft specifically do not use user's information. To justify these statements, I have used 1 and 0 for cloud provider that support and do not support each feature. Fig. 1 shows the graph comparison among the three cloud providers.

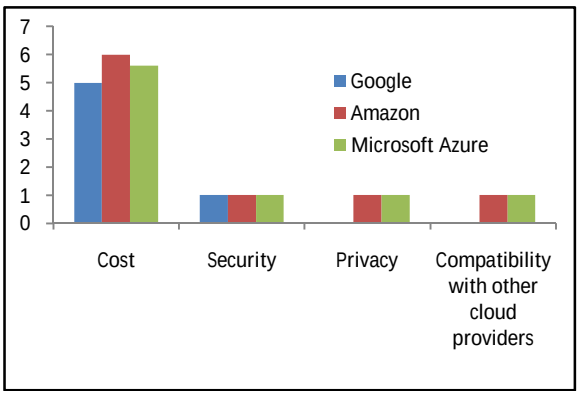

Fig. 1. Comparison among the three cloud providers

The above graph shows that Google is better in terms of cost but its collaboration tools is not compatible with others and it also lack privacy. Microsoft has shown strength in in all the factors above, same for Amazon but with relatively high value in cost.

4.2 Online learning: Google does not have any live streaming engine in its Google Apps marketplace except for Google video, which mean you must be a registered user of the platform before you can make a video call (Google, 2015). Windows Azure and Amazon both online streaming engine that be used to stream live classroom lectures to anywhere and any device. Azure Media service offers live streaming service that can be viewed on any device. With all set-up been done automatically with just clicks, Azure charges $2.0082 per input/output GB per month for the first 5 TB (Microsoft, 2015). Amazon has Wowza streaming engine that is complex to configure and charges $15.00 per month plus $0.10 to $0.60/hr (Amazon, 2015). Amazon and Azure services provide the option of setting the quality of broadcast being sent to end users. The above analysis shows that Azure is less expensive in streaming live lectures and it is very easy to configure.

4.3 Blended learning: Cloud computing usage in this learning category will combine both online and face-to-face learning features. Therefore, file sharing, storage, collaboration and live streaming futures in cloud providers should be considered in this category. In regard to this, Windows Azure stands competitive in the previous categories, which means it can be implemented well in blended learning system. But Amazon has the highest already deployed applications in its marketplace, which will make any education provider to easily deploy cloud-based Learning Management System (LMS) (Amazon, 2015), e.g. Moodle and ClassOwl(Amazon, 2015).

V. RESULTS COMPARISON

This section focuses on the strengths of the cloud providers mentioned above. First, Table 1 and Table 2 show that Google is the first to be considered when cost and performance are concern. Fig. 2 and Fig. 3 are graphs showing summation of the whole instances simulated that prove Google should be considered first by an education provider. But in email, collaborations and learning delivery, Windows from Microsoft should be the first on any education provider's mind, has it offers features among the three learning delivery methods. Though Amazon is expensive and its performance can be questioned, but it host great numbers of readily-deployed LMS and education applications, which is important when a cloud provider needs to exploit different applications for education in the cloud environment.

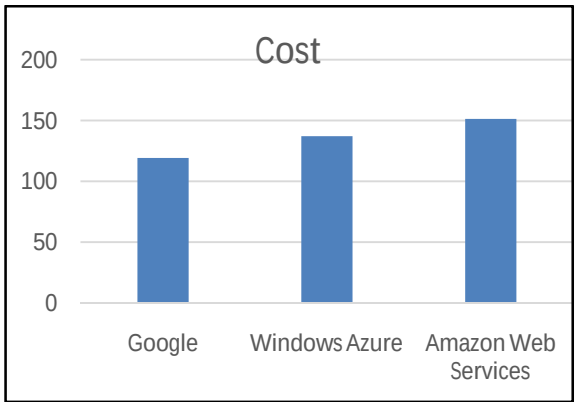

Fig. 2.

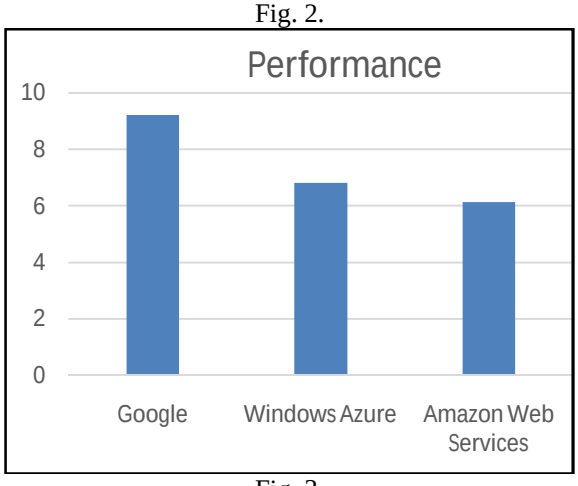

Fig. 3.

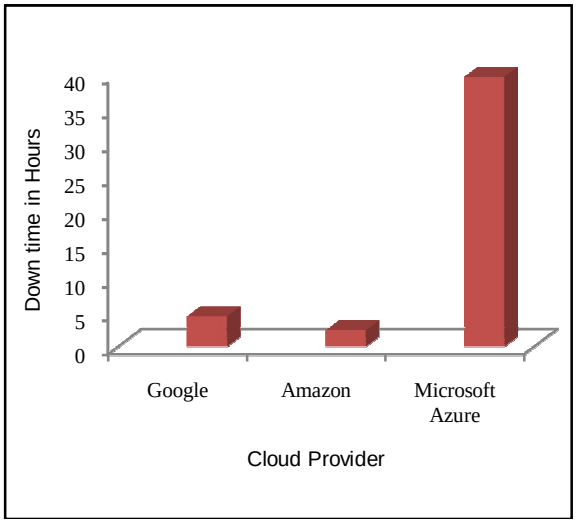

Fig. 4. Reliability Comparison among the three cloud providers in 2014

Reliability is one of the major factors need to consider when using the cloud services. When it comes to the higher educations, students need to have uninterrupted services from the cloud as most of their information and documents will be accessed from the cloud (Fig 4). The study conducted by cloud harmony in 2014 shows that amazon is the most reliable with the downtime of less than 4 with google competing with closer to 5 hours downtime. The major issue with the Microsoft Azure was the over 40 hours of downtime in 2014.

This research paper is different from the previous work done by others. First, this research work used different benchmarking tools to justify the performance of cloud providers and using the three categories of learning delivery methods in respect to cost, service each delivers to decide the best cloud provider that suites education. This research work gave a clear picture of the performance and road map for education provider, when deciding which cloud provider to adopt in their system. It also emphasises what factors contributes to performance of a cloud provider when an education provider is considering this adoption: vCPU and RAM. The research shows that Google is the best in performance and cost.

CONCLUSIONS

Cloud computing is gradually becoming unavoidable in education these days. As the number of students and student resource demand are increasing each semester, there is need to keep up with the trend and deciding the best cloud provider for these purposes becomes a major concern to education provider.

The result shows that Google is the best cloud provider when performance and cost are concerns. The result also show that Windows Azure services are better option for email, collaborations among student and also serve as a better option for face-to-face, online and blended learning. Amazon Web Service have handful of readily-deployed Learning Management Systems, which education providers can easily deploy.

This research work did not benchmark other factors that can result in slight change in performance, factors such as cloud provider's platform architecture, security, network latency, portability, bandwidth and disk input/output (I/O). This research work did not also consider cloud provider's Service Level Agreement (SLA); a document binding the education provider and cloud provider with their common terms of agreement. Further research can be done on these factors, to help education provider make better decision in future.

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