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COMPARATIVE DATA SECURITY MEASURES IN VARIOUS CLOUD COMPUTING PLATFORMS

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Abstract: Cloud computing is a distributed environment that encompasses thousands of computers that work in parallel to perform a task in lesser time than the traditional computing models. Recently there are many emerging cloud platforms to choose for run, deploy and maintain applications, offering a variety of services and tools at the disposal of a user, Clouds bring out a wide range of benefits including configurable computing resources, economic savings, and service flexibility. Cloud users are faced with the dilemma of selecting a suitable platform that meets their specifications. The aim of this paper is to compare three most widely adopted cloud platforms, Amazon Web Services, Microsoft windows azure and Google app engine based on some commonly shared features such as security, storage, Artificial intelligent and Networking to guide customers in selecting a suitable cloud platform. A cloud computing based services also face such kinds of security issues where applications deployed on cloud can face same kind of attacks as that on client-server model. The research method use for this paper was comparative method, primary and secondary data were use as instrument for collecting data. The result of the comparison concluded that AWS fits the needs of large companies due to their vast global reach. This paper is beneficial for potential users such as small mid-size enterprises, start-up developers and large companies for selecting a cloud platform that meets their requirements.

Keywords: Data Security, Artificial intelligence, Storage, Networking

I.INTRODUCTION

Cloud Computing (CC) in present days is developing and fast growing technology, which is being used around the world. In the past data were stored in hard drives on a computer however when the cloud computing came this technology replaced that hard drive. It is a new and emerging idea that uses virtual computing service through the internet or network on demand to access various shared resources namely servers, storage, interfaces, networks, services, and application which can deploy, allocate or reallocate computing resources dynamically and manage, monitor the usage of resources all the time.

A CC is basically a distributed architecture which is the combination of technologies, including multi-tenant application hosting, memory management, transaction management, resource scheduling, server virtualization, data access control etc. the three main concept of this technology are storage, processing and transferring of the information on the infrastructure (providers), which is not in the control policy (customer). The most widely used definition of the cloud computing model is introduced by NIST 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"(L. M. Haji et al., 2018).

Cloud computing increases the IT functionality and capacity of companies with the use of cloud computing companies need not worry about setting up new infrastructure or investing in training or adding more software, or personnel. So with all these features of Cloud Computing there are many security threats exist such as network illegal invasion or denial of service attack and also some specific cloud computing threats like virtualization vulnerabilities, side channel attacks and so many other abuse of cloud by attackers which posed a very big concern in the cloud to all users. (Ahmad et al., 2019)

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The cloud computing term means a set of servers such as Platform as a service (PaaS), Software as a Service (SaaS) infrastructure as a service (IaaS) and Fuction as a service (FaaS) that provide the resources and processors to the user in an efficient environment.(N.Khanghahi et, al. 2013). Cloud computing and their related technologies can split into two categories of technologies used by clouds. Also, cloud technologies refer to execute many tools of software based on cloud servers as Hadoop and Dryad, also framework of communication as HDFS (Hadoop Distributed File System), Amazon S3, (Z. N Rashid et, al. 2019). There are many clouds computing as Nimbus and Eucalyptus that allow the companies to make the development of their individual and unique clouds to provide the best efficiency of resources. On the other side, cloud technologies provide parallel computing (S. Suakanto et, al. 2012).
Distinctively, the main focus of this paper is to compare three popular cloud platforms namely Amazon web services, Microsoft window azure and Google app engine based on Four(4) selected features security, storage, Artificial intelligent and Networking to help small and medium sized enterprises or businesses and potential users make a choice of cloud platforms to adopt.

The research method use for this paper was comparative method. The chosen features of the selected cloud computing platforms are compared by the researcher's based on the existing Literature. The cloud computing platforms was analyzed and selected based on the features offered as services for users available on the website of the selected cloud platforms. These features include: security, storage, AI and network. The data collection for this paper work was collected using primary and secondary data base on features, security, storage, artificial intelligent and networking on the cloud computing.

RELATED WORKS

This section helps to sharp and defined understanding of existing knowledge in the problem area. It reviews literature in research studies which is relevant to the study. This section was establishing the importance of the study and relating it to the larger literature about the topic, filling the gaps and extending prior studies. It attempts to discuss rationale, issues and conditions for comparative data security measures on various clouds computing companies.

I. Data Security in Cloud

Data security is a crucial security issue for most organizations. Before moving into the cloud, cloud users need to clearly identify data objects to be protected and classify data based on their implication on security, and then define the security policy for data protection as well as the policy enforcement mechanisms. For most applications, data objects would include not only bulky data at rest in cloud servers (e.g., user database and/or file system), but also data in transit between the cloud and the user(s) which could be transmitted over the Internet or via mobile media (In many circumstances, it would be more cost-effective and convenient to move large volumes of data to the cloud by mobile media like archive tapes than transmitting over the Internet.). Data objects may also include user identity information created by the user management model, ser- vice audit data produced by the auditing model, service profile information used to describe the service instance(s), temporary runtime data generated by the instance(s), and many other application data. Different types of data would be of different value and hence have different security implication to cloud users.

According to Pardini et al. (2017), it describes all the approaches for protecting networks, systems, and data from accidental or deliberate attack. Makeri (2017) indicates that cyber security involves a combination of innovation, practices, guidelines, training, activities, and risk management approaches used to protect assets in the cloud environment. Meanwhile, advancement in technology increasingly encourages cloud computing, mobile computing, and E-commerce to achieve different corporate objectives, enhancing the demand for cyber security (Makeri 2017). Although the technological innovations are relatively new and widely accepted in different industries, the available security models are inadequate and unreliable. Therefore, companies and private individuals face increasing vulnerability to cyber attacks due to the adoption of cloud computing, mobile computing, and E-commerce. In this regard, the attainment of global security and economic wellbeing requires enhanced cyber security for conventional and emerging technologies (Makeri 2017; Pardini et al. 2017).

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II. AMAZON WEB SERVICES (AWS)

An individual, organization (public, private, and government) can acquire AWS in the form of on-demand computing resources based on the pay-as-you-go style of billing. Cloud-based web administrations offer several different, focused frameworks and suitable building blocks and apparatuses for processing needs (Mitra, A., et al., 2018). From Amazon, Amazon Elastic Compute Cloud provides such facilities it allows clients to get continuous access to a virtual bunch of PCs with the help of the Internet. In this mode, client gets features as if he or she has quality PC hardware owned by himself/herself together with equipment (CPU and GPU for processing needs, RAM for memory requirements, hard-circle, SSD for information storing); a choice of working frameworks; establishing; and pre-stacked application program design, for instance, CRM, databases, servers to host websites, (Díaz, M., et al., 2016). AWS offers a vast array of cloud services that helps in the improvement of complex apps. It also allows the deployment of applications on a global scale at a minimal cost. The user just pays for the services used on a fixed rate (Chima D. O. et al.., 2019). Examples of some popular clients of AWS are US Navy, Unilever, Kellogg's, and Siemens (Purohit, 2017). Figure 3.4 shows the components of AWS which are Monitoring, Management, Tools, Networks, Processing, Content Delivery, Messaging, Payments, On-Demand workforce and the main features which are compute, storage and database available.

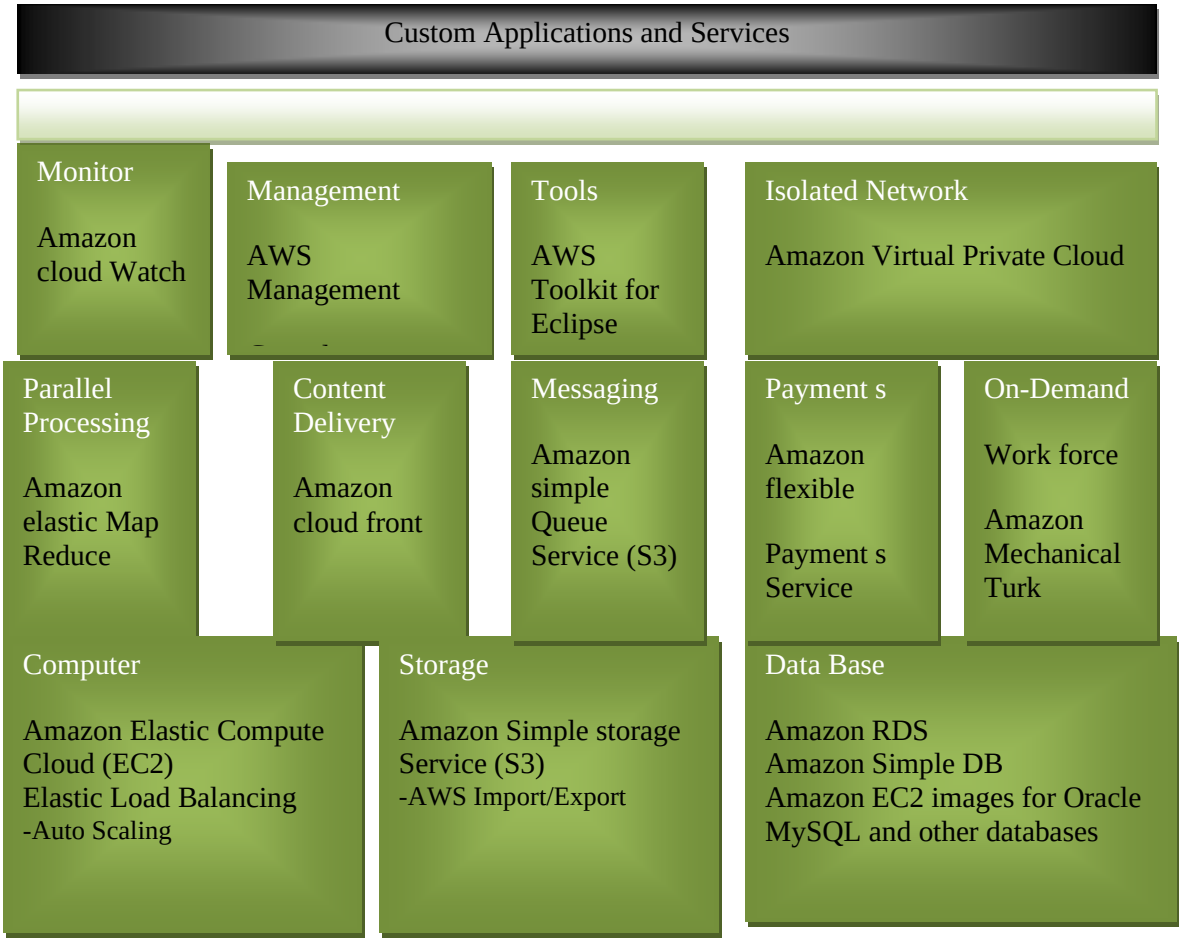

Figure 1.1: Main components of AWS (Understanding Amazon Web Services (AWS) Oracle Apps Epicenter, 2019)

The architecture of Amazon web services is primarily made up of four parts: Elastic Compute Cloud (EC2), Simple Storage Service (S3), Simple DB, and Simple Queue Service Amazon (SQS) (Padhy et al.., 2011; Laxamaiah and Sharma, 2019).

Elastic Compute Cloud Amazon (EC2): This allows a user to run numerous virtual servers on demand. It is scalable, efficient, protected and significantly affordable, as a user only pays for tools used (Laxamaiah and Sharma, 2019).

Simple Storage Service Amazon (S3): This provides a flexible asset space for storing any data easily accessible over the internet. It is also used to back up and archive files (Sweda and Dubey, 2018).

Amazon Simple DB: This is a form of non-relational database that enables a user to store data. It uses a simple read/write command from the Application program interface (Chima D. O, et al., 2019).

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Simple Queue Service Amazon (SQS): This is a service which passes a message among any cloud components (Laxamaiah and Sharma, 2019).

III. GOOGLE CLOUD PLATFORM

Google Cloud Platform As the name suggests, GCP provided by Google, and it is a set of cloud computing administrations. It works on the same platform, which is being utilized Google itself to run its end-client services like YouTube, Google Search (Aruna Irani, et al., 2019). Through the platform, the client can perform various cloud administrative tasks easily, such as information stockpiling, figuring of information, examining data, and machine learning. A charging card or ledger detail required for the registration process (Verma, A, et al., 2015). GCP gives the foundation a management stage and server less registering conditions. (Varghese, B. and Buyya, R., 2018). This cloud platform is provided by Google was launched in 2011.Google App Engine is mainly a platform as service that allows a user to develop and execute applications through Google framework, thus removes the need for expensive acquisition and maintaining of database, as it is managed by Google (Chima D.O, et al., 2019).

The objective of GAE development is to boost the online presence by allowing several users create apps for the web. It does not charge anything to get started, charges are made based on the use of storage and bandwidth by a user at an affordable price range (Laxamaiah and Sharma, 2019). It provides resources for data storage management, page monitoring, and asset utilization, testing and logging. It offers both PaaS and SaaS services. PaaS service such as GAE while SaaS services such as Gmail, Google doc, calendar and Google drive (Chima D.O et al., 2019). Examples of some popular clients of Google cloud are Snapchat, Coca-Cola, Motorola and Airbus (Purohit, 2017).

The Figure below shows the structure of Google app engine which include client capabilities containing the tools available for a user, cloud computing services and the support services in place.

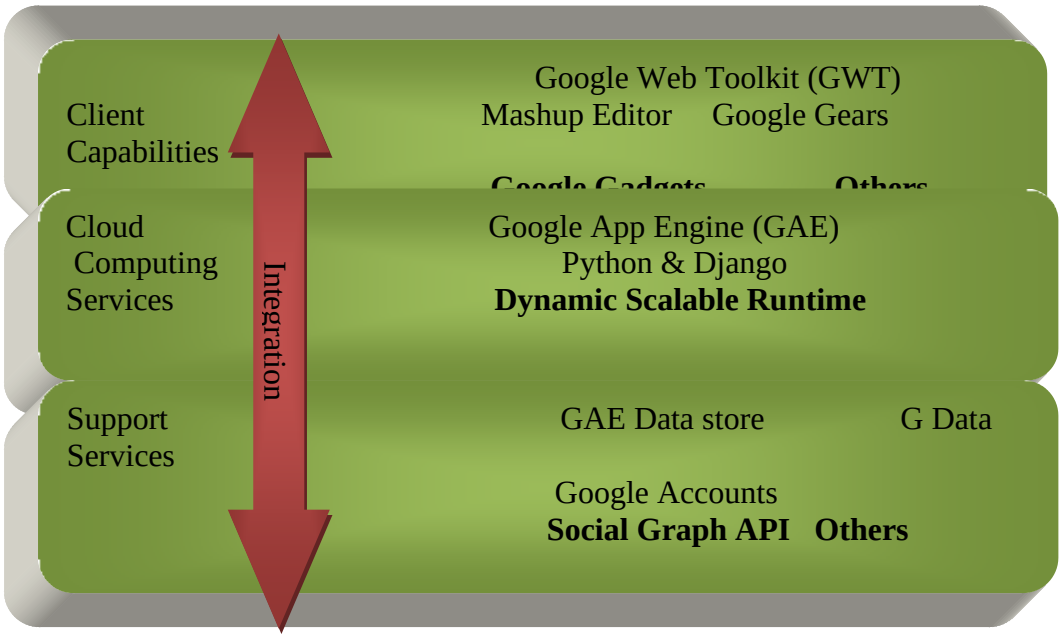

Figure 1.2: Structural design of Google App Engine (Laxmaiah and Sharma, 2019)

IV. MICROSOFT AZURE

According to Microsoft (2017) official definition, Azure is a cloud computing platform and infrastructure created by Microsoft for building, deploying, and managing applications and services through a global network of Microsoft-managed data centers. Microsoft Azure is a growing collection of integrated cloud services analytics, computing, database, mobile, networking, storage, and web for moving faster, achieving more, and saving money. With Azure, every client can be up and running fast, scale up or down as needed, and avoid high capital costs paying only for what you use .(Sherte L. O. et al., 2018).

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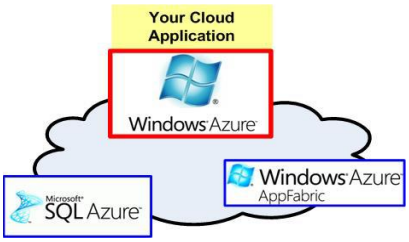
Shucheng Yu et al., (2016).It is also referred as a cloud computing service created by Microsoft for building, deploying, and managing applications and services through a global network of Microsoft-managed data centers. It provides platform as a service and infrastructure as a service (Sherte L. O, et al.. 2018) and supports many different programming languages, tools and frameworks, including both Microsoft-specific and third-party software and systems. Azure was announced in October 2008 and released on 1 February 2010 as Windows Azure, before being renamed to Microsoft Azure on April 2014 (2017). As per Steven Martin, the General Manager of Microsoft Azure at Microsoft this change reflects Microsoft's strategy and focus on Azure as the public cloud platform for customers as well as for Microsoft own services Office 365, Dynamics CRM, Bing, One Drive, Skype, and Xbox Live. The commitment to deliver an enterprise-grade cloud platform for the world's applications is greater than ever. Is being supported one of the broadest set of operating systems, languages, and services of any public cloud from Windows, SQL and .NET to Python, Ruby,n Node.js, Java, Hadoop, Linux, and Oracle. In today's mobile-first, cloud-first, data-powered world, customers want a public cloud platform that supports their needs whatever they may be and that public cloud is Microsoft Azure (2017).

Key Components Microsoft Azure

There are three main components in the Azure Platform. These are Windows Azure, SQL Azure and Windows Azure AppFabric. Each of them is described in the following text:

- **Windows Azure** - Is one of the main components of Azure and represents the cloud operating system or runtime where the cloud applications can be executed. It is designed to run on cheap commodity hardware and on same time provides scalable compute, storage facilities and a Windows-based environment for storing data on servers in data centers managed by Microsoft (2017).
- **SQL Azure** -As a cloud-based relational database, makes the power of Microsoft SQL Server available in a Cloud Hosted offering. In fact, is an extension of Microsoft SQL Server and runs in the Azure cloud. Additionally, SQL Azure offers standard relational database features such as views, triggers, stored procedures and indexes. The data in the SQL Azure database can be accessed by the Tabular Data Stream (TDS) protocol (Sherte L. O, et al.. 2018). SQL Azure offers a relational database service called Microsoft SQL Azure Database, and using SQL Azure Database, the user can easily deploy a large number of relational database solutions.
- **AppFabric** – This platform provides cloud services for connecting applications running in the cloud or on premises. As a feature, it allows developers to connect applications and services, to secure cloud or off the cloud services with new or existing security frameworks (Sherte L. O, et al.. 2018). Windows Azure AppFabric can be seen as an entity that interconnects on-premises solutions to Windows Azure solutions, and even Windows Azure solution to other solutions within the cloud.



V. COMPARATIVE STUDIES ON CLOUD COMPUTING PROVIDERS

Dutta and Dutta (2019) conducted analyses of top three leading cloud platforms according to them which were AWS, Microsoft and Google. Their analyses focused on what these platforms provided in regards to storage, compute and management tools. In their analyses they concluded that even though AWS has the higher market share, it would be inaccurate to assume it offers the best services, this is because Microsoft and Google platforms certainly have additional benefits for services and better security mechanisms. They gave a recommendation for organizations to use more than one platform to minimize risk.

Laxmaiah and Sharma (2019) analyzed three well known cloud platforms which included Google, AWS and Microsoft azure. They focus of their analyses was to compare these platforms based on the following features, cloud services, platform supported, language supported, integrated DB support and SLA. They concluded from their analyses that each platform has a well-defined feature for users. Their paper is going to have an extension of Microsoft azure practical implementation.

Wahid and Banday (2018) conducted a paper, comparing AWS, Microsoft Azure and Google based on the following parameters CPU, memory and Price. Their paper was focused on helping customers in India in decision making of

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cloud platform in regards to cost and performance. They result of their analyses concluded that AWS was the best choice among the mentioned platforms due to its range of machine type as well as broad available cost plans, thus making it easier for user to choose an option. While Microsoft and Google were fast thriving and providing a range of quality and affordable cost plans, the analyses was in complete favor of AWS.

In summary of the related work many research, related to this study was conducted. A study by Laxmaiah and Sharma (2019) analyzed three well known cloud platforms which included Google, AWS and Microsoft azure. They focus of their analyses was to compare these platforms based on the following features, cloud services, platform supported, language supported, integrated DB support and SLA. They concluded from their analyses that each platform has a well-defined feature for users. Their paper is going to have an extension of Microsoft azure practical implementation.

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Therefore in views of the related studies the researcher was conducting a similar study with the above views on AWS, Microsoft azure and Google App base on the following features security, artificial intelligent, networking and storage. The result of the comparison concluded that AWS fits the needs of large companies due to their vast global reach. This paper is beneficial for potential users such as small mid-size enterprises, start-up developers and large companies for selecting a cloud platform that meets their requirements.

VIII. RESULTS AND DISCUSSION

The result of the comparison of these platforms based on the main features selected shows the different features used by them, while some are the comparable, others have superior qualities. Each feature used for comparison was discussed in all three platforms before listed in a tabular form. This explains the type of services provided by the three selected cloud platforms which includes infrastructure, platform and software as a service. Most of platforms offer all three available services. The features used for this comparative study were chosen based on the current information made available on the primary and secondary data of the selected platforms and the related research.

Cloud Service Type

This explains the type of services provided by the three selected cloud platforms which includes infrastructure, platform and software as a service. Most of platforms offer all three available services.

AWS: Offers all three service types, Infrastructure as a service, platform as a service and recently launched software as a service. It is popularly known for its top notch Infrastructure as a service solution worldwide though.

Microsoft Windows Azure: Offers all three service type just like AWS, Infrastructure as service such as Virtual machines, web hosting, test and development, Platform as a service such as development framework and Software as a service such as email, calendars and Microsoft tools.

Google App Engine: Primarily offers platform as a service. Which makes it unique than others in this regard. It could be used by developers to build a SaaS.

A survey conducted in 2018 by Right scale cloud report on Enterprise Scorecard adoption of AWS, Azure and Google Table 4.3 below, shows there is competition within this three popular cloud platforms in terms of adoption, year over year (YoY) growth in adoption, adoption of beginners, and virtual machine (VM) footprints. Even though AWS holds a major percentage scores with enterprises, Azure is fast growing with a strong number of adoptions and Google are growing steadily as well and lead in terms year to year growth of VMs (Weins, 2019).

Table1.1: AWS vs Azure vs Google Enterprise Scorecard (Weins, 2019)

Area	AWS Cloud	Azure Cloud	Google Cloud
%Adoption	68%	58%	19%
YoY Growth in Adoption	15%	35%	26%
% Adoption in Beginners	47%	49%	18%
% with Footprint > 50 VMs	58%	44%	17%
YoY Growth in Footprint > 50 VMs	14%	38%	42%

Comparison chart of cloud service providers: Amazon Web Services (AWS) | Microsoft Azure | Google Cloud Platform

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Table 1.2: Comparison of Security Services on AWS, Azure and GCP

AWS	Azure	GCP
• AWS Security Hub • Type-II (SAS70 Type II) certification, firewall, X.509 certificate, SSL-protected API, Access Control List	• Azure Security Center • Filtering routers Firewalls Physical security	• Cloud Security Command Center • Google Secure Data Connector (Uses RSA/128-bit or higher AES CBC/SHA and TLS-based server authentication)

IX. COMPARISON OF STORAGE SERVICES ON AWS, AZURE AND GCP

Amazon Web Services

Amazon Web Services Elastic Block Store (EBS) presents persistent storage to various instances of EC2 and do not depend upon instance life. EBS provides block level storage volumes. There are two kinds of EBS volume: i) Standard volume and ii) Provisioned IOPS volume. Amazon S3– It stores objects up-to 5GB and Volumes ranging from 1GB to 1TB in size.

Window Azure

WA provides storage to store large amounts of unstructured data. A blob is a file of any type and size. There are two types of blobs in Windows Azure Storage: i) block blobs and ii) page blobs. Block blobs consist of blocks (each block up-to 4MB) and are efficient when uploading large blobs. Page blobs are a set of 512 byte pages; optimized for random Read (R) and Write (W) operations.

Google APP Engine

It has a transient disk of size 10GB (by default) tied to the Virtual Machine's instance lifetime. Developers can store objects and files up-to-the size of TBs and are able to control access to the data (access-control). Auto-scaling is an inbuilt feature of App Engine. No matter how many users are active or how much data the apps store, GAE can scale with flexibility.

Storage features (Muhammad A.K et al., 2020).

Features	Cloud Service Providers		
	AWS (Amazon)	Azure (Microsoft)	GCP (Google)
Object Storage	Amazon S3	Blob Storage	Google Cloud Storage
Block Storage	Amazon Elastic Block Store	Azure Managed Disk (Built-in Service)	Persistent Disk
File Storage	Amazon Elastic File System	Azure Files	Cloud Filestore

Artificial intelligence (AI)

Artificial intelligence (AI) consciousness is playing a key role in changing the paradigm of every single noteworthy region of computing and innovation. AI works to create systems that can learn to mimic human behavior from prior experience and without manual intervention. AI, which was once said to be rigid and a language of extreme computer intellectuals, has now become flexible and is being used in many areas (L. Tredinnick, et al.. 2017). AI has a lot of potentials, and what is being utilized at present is far less than what it has. Reasoning enables various advancements by gathering the chronicled information, to play out a careful examination of them, distinguish the examples, and manual to make ongoing decisions. With the assistance of AI logic, it helps the consumer automate the method and increases knowledge by removing the plausibility of mistakes when performing the manual operation. Industry (Mohammad Riyaz Belgaum, et al.. 2021) supports the creation of a "smart factory" through process automation. The information

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technology field is commanded by a few different innovations, like cloud computing, the internet of things, and software-defined networking (SDN) with their enormous qualities in an interrelated space. However, there are various technologies supporting industry and contributing to the levels of productivity. AI with these technologies is at a revolutionary catalyst stage, where much attention is required. Artificial intelligence leads to cognitive intelligence through knowledge, understanding, and decision-making from past experiences. Artificial intelligence is speeding up with a high pace to achieve a technology that enables computers and machines to work smartly to allow the smart industry. The cloud services with IoT devices that can program following the wishes of each user are now on the brink of being satisfied with their performance.

Table 1.3: Comparison of AI on AWS, Azure and GCP

AWS	Azure	GCP
• Machine Learning • Translate • Transcribe	• Machine Learning • Azure Bot Service • Cognitive Services	• Cloud Speech API • Cloud Translation • Cloud Video Intelligent

Table 1.4: Comparison of Networking on AWS, Azure and GCP

AWS	Azure	GCP
• Amazon Cloud Front • Amazon Transit Gateway, Amazon Cloud WAN • Amazon Route 53	• Azure Load Balancing • Azure Service Fabric Mesh • Consul on Azure	• Network Intelligence Center • Cloud VPN • Traffic Director

X. CONCLUSION

Cloud computing is a modern concept that not just speeds up computing and cut costs. However, several challenges still weigh down the technology. Resolving security, storage, Artificial intelligent and Networking problems with cloud computing is one such major challenge. The result of the comparison showed that AWS has a vast global reach and market shares with its flexible and wide range of services, it should appeal to large companies seeking a cloud platform. Microsoft windows azure offers a hybrid solution, easy first time cloud migration, it is suitable for start-ups and the best fit for organizations using Windows. Google App Engine offers a cost effective platform and has huge development prospect, best fits developers of cloud based software and apps.

IX. RECOMMENDATION

This paper is helpful to potential users of cloud platform such as small mid-size enterprises, developers and large companies for selecting suitable cloud platforms that satisfies their specification, as it analyzed the features each cloud offers more quality service even though the choice rests solely on the user.

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