Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Information Engineering

Diploma Thesis

Cloud Computing as a service for small and medium organizations.

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

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Systems Engineering and Informatics
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Thesis title

Cloud computing as a service for small and medium organizations.

Objectives of thesis

The main goals of this thesis are to highlight the concept of cloud computing and the associated database management for small and medium-scale organizations.

Other goals are:

1) Description of Cloud computing and Cloud Computing architecture.
2) Description of Cloud computing infrastructure.
3) Benefits of Cloud applications.
4) Description of different Cloud providers.
5) Definition of advantages of Cloud Computing for SME organizations.

Methodology

A mixed-method research approach will be adapted to realize these objectives. The rationale behind this method is to have a detailed view of the research problem as well as a generalization of the cloud-based service and adoption trend from service providers' and users' perspectives. The researcher will start with a qualitative method for exploratory purposes which will be subsequently followed by a quantitative to provide both detailed and generalized analysis of the research problem. Whiles Qualitative data provided the researcher with in-depth knowledge of cloud service providers and cloud service with respect to database management and database servers, the quantitative data provided a broad generalized trend the SMEs and the use of cloud services.

The proposed extent of the thesis

60-80 pages

Keywords

Cloud Computing, AWS, RDS, Microsoft Azure, Saas, PaaS, SQL, NoSQL, DynamoDB, MongoDB, CassandraDB, AWS, Server,Scalability, Avaiability

Recommended information sources

Cloud Computing Bible – Barrie Sosinsky, Janury 2012. ISBN: 978-0-470-90356-8
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White Paper – Database as a Cloud Service – Scalability Experts – Wolter, R. (2011)

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Declaration

I declare that I have worked on my diploma thesis titled " Cloud Computing as a service for small and medium organizations." by myself, and I have used only the sources mentioned at the end of the thesis. As the author of the diploma thesis, I declare that the thesis does not break the copyrights of any person.

In Prague on 30.11.2021 ______________________________

Sakibul Alom Tanim

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Firstly, I would like to express my gratitude to Ing. Petra Pavlicková, Ph.D. for leading me down the difficult road of cloud computing, encouraging and advising my proposals with her vast knowledge and expertise and very supportive personality, also my parents and my siblings for allowing me to be in this position, and all of my relatives who are praying for me.

Cloud Computing as a service for small and medium organizations.

Abstract

To keep up with the shifting tide, new innovations are needed. Virtualization is used by the majority of businesses to lower their computing costs. The need for lower processing costs has resulted in the development of Cloud Computing. Cloud storage improves computing performance by increasing utilization and reducing management and development costs. Software as a Service (SaaS) and Utility Computing are two types of cloud computing. Database server management and as a cloud-based service is getting famous worldwide because of its easy use and many Advantages. Cloud computing is only in its infancy, and it is a comparatively modern tool for companies. As a result, the great majority of businesses are affected are in a state of flux, unable to embrace it. This thesis will look at the cost and security consequences of this topic for small and medium organizations. I will address the available options for database management, cost and security advantages, disadvantages, and a few facts that an organization can face when adopting Cloud Computing.

Keywords: Cloud Computing, AWS, RDS, Microsoft Azure, SaaS, PaaS, SQL, NoSQL, DynamoDB, MongoDB, Cassandra DB, AWS, Server, Scalability, Availability.

Cloud Computing jako služba pro malou a střední organizaci.

Abstrakt

Abychom drželi krok s měnícím se přílivem, jsou zapotřebí nové inovace. Virtualizaci využívá většina podniků ke snížení nákladů na výpočetní techniku. Potřeba nižších nákladů na zpracování vedla k rozvoji Cloud Computingu. Cloudové úložiště zlepšuje výpočetní výkon zvýšeným využitím a snížením nákladů na správu a vývoj. Software jako služba (SaaS) a Utility Computing jsou dva typy cloud computingu. Správa databázového serveruvse jako cloudová služba celosvětově proslavila díky snadnému použití a mnoha výhodám. Cloud computing je teprve v plenkách a pro firmy jde o poměrně moderní nástroj. Výsledkem je, že velká většina dotčených podniků je ve stavu změny a není schopna ji přijmout. Tato práce se bude zabývat náklady a bezpečnostními důsledky tohoto tématu pro malé a střední organizace. Budu se věnovat dostupným možnostem správy databází, cenovým a bezpečnostním výhodám, nevýhodám a několika faktům, se kterými se může organizace potýkat při zavádění Cloud Computingu.

Klíčová slova: Cloud Computing, AWS, RDS, Microsoft Azure, SaaS, PaaS, SQL, NoSQL, DynamoDB, MongoDB, Cassandra DB, AWS, Server, škálovatelnost, dostupnost.

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1. Introduction

The effect of cloud computing on business and end-users is impossible to overstate: the ubiquitous existence of software that operates on cloud networks has changed many facets of daily life. Start-ups and companies will cut costs and broaden their services by using cloud storage instead of buying and maintaining all of the required hardware and applications. Individual entrepreneurs now have the opportunity to build applications and web utilities that are available worldwide. Researchers will also exchange and interpret data at sizes previously only available to large-scale programs. Furthermore, internet users can easily access applications and storage to build, share, and archive digital media in amounts well beyond their computing capability.

Cloud computing is a model for enabling ubiquitous, 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. This cloud model is composed of five essential characteristics, three service models, and four deployment models. (Grance & Mell, 2011)

Cloud computing represents a real paradigm shift in the way in which systems are deployed. The massive scale of cloud computing systems was enabled by the popularization of the Internet and the growth of some large service companies. (Sosinsky, 2011)

Research Question 1: What are the cloud-based service challenges/risks of moving Database servers into the cloud in SMEs' context ?

Research Question 2: What are the available options for SMEs to move or start as cloud-based Database management and Database servers ?

Research Question 3: Would cloud computing will help users to save money?

Even though cloud computing is becoming more prevalent, many people are unaware of its specifics. What is the cloud, how can one use it, and what are the advantages for companies for using Database management or Database server as a cloud-based service?

2. Objectives and Methodology

2.1 Objectives

The primary objectives of this study are to highlight the concept of cloud computing and the associated database server management for small and medium-scale organizations.

2.2 Methodology

A mixed-method research approach will be adapted in order to achieve these goals. The aim of this approach is to get a holistic view of the study problem as well as a generalization of the cloud-based service and adoption trendfrom service provider's and user's perspectives. The researcher will start with a qualitative method for the exploratory purpose, which will be subsequently followedby a quantitative to provide both detailed and generalized analysis of the research problem. Whiles Qualitative data provided the researcher with in-depth knowledge of cloud service providers and cloud services concerning Database and server management and the quantitative data provided a broad generalized trend of the SMEs and the use of cloud services.

Creswell (1994) defines quantitative research as a type of research that is the practice of gathering numerical data and interpreting it using mathematically based techniques to describe phenomena. In this research, a survey will be used to source data from respondents from small and medium-scale enterprises. Kraemer (1991)Survey analysis, according to the authors, can be used to quantitatively identify particular facets of a population, gather required subjective data from individuals, and use the data collected from the chosen portion of the population for generalization back to the whole population.

3. Literature Review

3.1 Cloud computing

In this section, I will discuss cloud Computing

3.1.1 What is cloud computing

Cloud computing refers to applications and services that run on a distributed network using virtualized resources and accessed by common Internet protocols and networking standards. It is distinguished by the notion that resources are virtual and limitless and that details of the physical systems on which software runs are abstracted from the user. (Sosinsky, 2011) To better describe cloud computing, many cloud types have been defined. In this chapter, we will talk we'll address two types of clouds: those that use the implementation model and those that use the service model. The implementation model specifies where the cloud will be placed and what it will be used for. Deployment models include public, corporate, community, and hybrid clouds. The type of service that the service provider offers is defined by the service model. Software as a Service (SaaS), Platform as a Service (Platform as a Service), and Infrastructure as a Service (the SPI model) is the most well-known service models. The service models draw on each other, defining what a provider is responsible for and what the customer is responsible for. Cloud computing reflects a significant shift in how people work. Applications are distributed. The massive scale of cloud computing systems was enabled by the popularization of the Internet and the growth of some large service companies in a pay-as-you-go, infinitely scalable, and freely accessible method. (Sosinsky, 2011) Cloud computing realizes the long-held dream of utility computing users, can start small and develop large quickly with cloud computing. That is why cloud computing is revolutionary, despite the fact that the technology on which it is based is evolutionary. Both apps prosper from cloud implementation. Latency, transaction control, and, in particular, protection and regulatory enforcement are all issues that need to be addressed.

- **Abstraction:** Cloud computing abstracts the details of system implementation from users and developers. Applications run on physical systems that aren't specified, data is stored in unknown locations, administration of systems is outsourced to others, and access by users is ubiquitous. (Sosinsky, 2011)

- **Virtualization:** Cloud computing virtualizes systems by pooling and sharing resources. Systems and storage can be provisioned as needed from a centralized infrastructure, costs are assessed on a metered basis, multi-tenancy is enabled, and resources are scalable with agility. (Sosinsky, 2011)

3.1.2 Types of cloud computing

There are two types of cloud computing:

- Deployment models – refer to location and management of the cloud's infrastructure.
- Service models – particular types of services that can be accessed on a cloud computing platform.

3.2 AWS Model

Developers and IT teams will rely on what matters most with the AWS Cloud computing model, eliminating undifferentiated activities like recruitment, maintenance, and power planning. . As cloud infrastructure has become more prevalent, a variety of models and implementation techniques have arisen to address the needs of various users. Users have varying degrees of autonomy, flexibility, and management for each cloud provider and implementation process. Understanding the distinctions between Infrastructure as a Service, Network as a Service, and Software as a Service, as well as the different implementation techniques available, will assist users in deciding which range of resources is better suited to the requirements. (Youssef, 2012)

3.2.1 AWS Cloud Computing models

There are three main types of cloud computing. Each model reflects a distinct aspect of the cloud computing system.

Infrastructure as a service (Iaas) - Infrastructure as a ServiceIaaS, or Infrastructure as a Service, is a cloud computing service that usually offers access to networking functionality, computers (virtual or dedicated hardware), and data storage capacity. Infrastructure as a Utility helps it to be as agile as possible, and It is most comparable to current IT resources that many IT departments and developers are familiar with today in terms of security and management control over IT resources. (AWS Cloud Computing Models, 2020)

Platform as Service (PaaS) - Platforms as a service removes organizations' need to maintain underlying technology (usually hardware and operating systems) so the user can concentrate on device deployment and management. This makes it easy for developers to be more creative, so they don't have to think about resource procurement, power preparation, program maintenance, patching, or any of the other undifferentiated heavy lifting that comes with running an application. (AWS Cloud Computing Models, 2020)

Software as Service (SaaS) - As a Service (SaaS) provides users with a final product that the service company runs and maintains. Most of the time, as people talk about Software as a Service, they're talking about end-user apps. Users don't have to worry about how the service is maintained or how the underlying system is operated when they use a SaaS offering; all they just have to do is think about how the user's use will become the particular piece of tech. A typical example of a SaaS program is web-based email, which helps users to send and receive email without needing to handle feature additions to the email product or support the servers and operating systems on which it runs. (AWS Cloud Computing Models, 2020)

3.3 NIST Model

The NIST model is a set of working definitions published by the U.S. National Institute of Standards and Technology. Five basic features, three service models, and four implementation models make up this cloud architecture. (Peter Mell (NIST) & Tim Grance (NIST), 2011)

3.3.1 Essential Characteristics:

On-demand self-service - Without requiring human contact with each service provider, a client may arbitrarily, As required to provide computational services such as server time and network storage.

Broad network access - Capabilities are accessible across the network using common mechanisms that encourage the usage of heterogeneous thin and thick client platforms (e.g., mobile phones, tablets, laptops, and workstations).

Resource pooling - Using a multi-tenant model, the provider's computing services are shared to support many users, with different physical and virtual resources dynamically delegated and reassigned based on customer demand. The consumer has no discretion or understanding of the precise location of the given services but may be able to define area at a higher degree of abstraction (e.g., country, state, or datacentre). Storage, transmission, memory, and network bandwidth are examples of tools.

Rapid elasticity - Capabilities may be provisioned and released flexibly, and in some cases automatically, to scale outward and inward in response to demand. To the user, provisioning capacities always tend to be infinite, and they can be used in any amount at any time.

Measured service - Cloud services use a metering capability at any degree of abstraction suitable to the type of service to automatically manage and maximize resource use (e.g., storage, processing, bandwidth, and active user accounts). Resource use can be tracked, managed, and recorded, giving both the supplier and the user of complete service accountability.

3.3.2 Service Models

Software as a Service (SaaS) - The user is able to access the provider's software that is hosted on a cloud infrastructure2. The programs can be accessed by a thin client interface, such as a web browser (e.g., web-based email), or a program interface, from a variety of client devices. With the potential exception of restricted user-specific device configuration configurations, the client does not handle or monitor the underlying cloud infrastructure, which includes network, servers, operating systems, storage, or even individual application functionality. (Peter Mell (NIST) & Tim Grance (NIST), 2011)

Platform as a Service (PaaS) - The client is granted the freedom to install consumer-created or purchased software into the cloud platform using programming languages, libraries, facilities, and resources provided by the vendor's user does not have control over the underlying cloud infrastructure, such as the network, servers, operating systems, or storage, but does have control over the installed applications and probably the application-hosting environment's configuration settings. (Peter Mell (NIST) & Tim Grance (NIST), 2011)

Infrastructure as a Service (IaaS) - The user is granted the right to provision processing, storage, networks, and other essential computing tools so that they can deploy and run any program, including operating systems and applications. While the user does not maintain or monitor the underlying cloud technology, he or she does have control over operating systems, servers, and deployed software, as well as potentially partial control over such networking elements (e.g., host firewalls). (Peter Mell (NIST) & Tim Grance (NIST), 2011)

Deployment Models:

Private cloud - The cloud architecture is set up for a single company of many users to use exclusively (e.g., business units). It could be owned, maintained, and run by the company, a third party, or a hybrid of the two, and it could be on-site or off-site.

Community cloud - The cloud service is reserved for a select group of customers from businesses with similar interests (e.g., mission, security requirements, policy, and compliance considerations). It could be owned, funded, and run by one or more community groups, a third party, or a combination of them, and it could take place on or off-site.

Public cloud - The cloud infrastructure is provisioned for open use by the general public. It is usually a free system available to the general public via WWW or Internet. A corporation, academic, or government institution, or a combination of them, can own, maintain, and run it. It operates on the cloud provider's premises. Examples of public cloud: Google application engine, Amazon elastic compute cloud, Microsoft Azure.

Hybrid cloud - The cloud infrastructure is made up of two or more distinct cloud infrastructures (private, cooperative, or public) that each exists as separate entities but are linked through structured or proprietary technologies that allow data and device portability.

3.3.3 Cloud computing architecture

Cloud computing is simply a set of levels that work together to build a device in different ways. This scheme is also known as the architecture of cloud computing. The cloud provides a framework where it is possible to pool and partition resources as required. Cloud infrastructure can combine with software that runs in several locations on virtualized hardware to provide users with an on-demand service. Within an organization's infrastructure, a cloud may be built or outsourced to another data center. Typically, cloud services are virtualized resources, so it's easier to change and optimize virtualized resources. To support the staging and store of data, a computing cloud needs virtualized storage. From the point of view of a customer, the services must appear to be infinitely scalable, that the service is measurable and that the price is calculated. (Peter Mell (NIST) & Tim Grance (NIST), 2011)

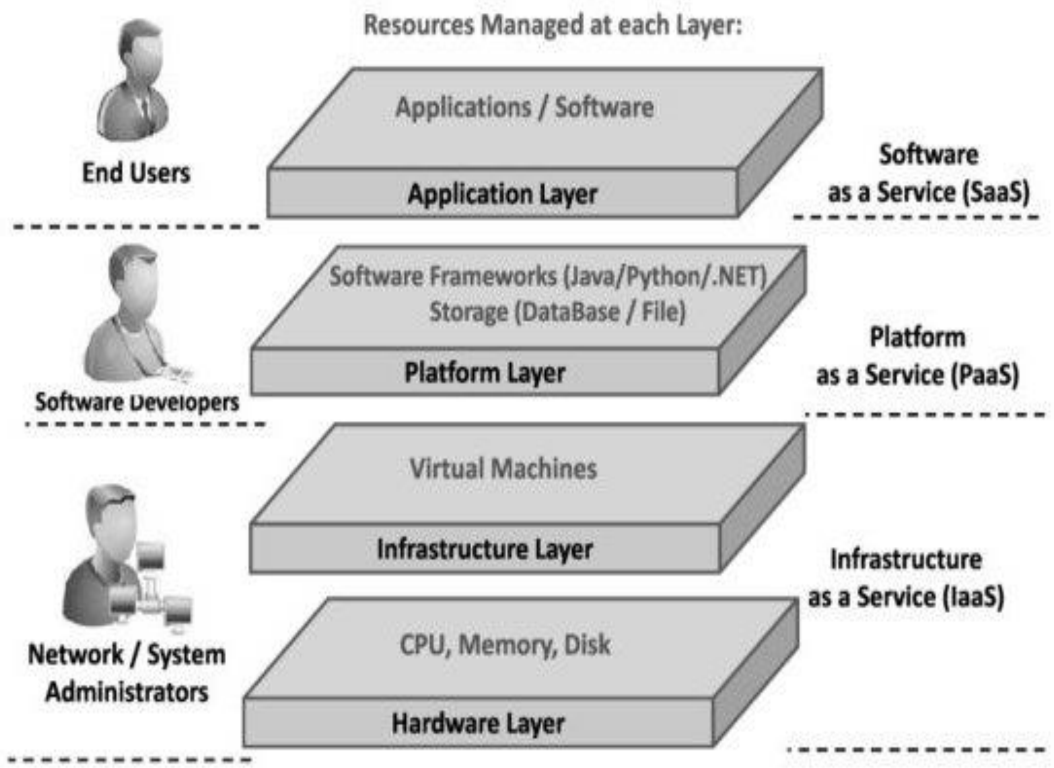

Figure 1: Cloud computing architecture ***[source: Q. Zhang, L. Cheng, and R. Boutaba, 2010]***

The architecture of Cloud Computing consists fundamentally of two parts. The front-end and the back-end are them. The front end is the end used by the user, and the host handles the back end. With the means of the internet, both ends connect.

3.3.4 Front End

The front end is the Cloud Storage client component that uses the user's specifications. The front-end consists of software and interfaces that enable access to cloud computing. Example- A browser or app built by the business itself.

3.3.5 Back End

The back end is a portion operated by the company's delegated authorities, and its back end has massive data storage facilities, virtual machines, security systems, and servers. Along with security monitoring, they are also engaged in traffic management.

3.4 Components of Cloud Computing Architecture

3.4.1 Hypervisor

The hypervisor has often known as the Virtual Machine Monitor. The hypervisor is consists of the software, hardware, and firmware that the virtual machines render and run. The hypervisor offers a platform known as the Virtual Operating Platform for a user. This helps us to use the cloud to control the guest's operating system. In an operating system, this can also be known as the standard kernel word.

3.4.2 Management Software

Management software consists of different plans and techniques that help improve the cloud's efficiency. This program for management offers many features, such as on-time storage delivery, proper security, all-time access, and many other facilities.
This is one of the significant components of the architecture of cloud computing. One of the main features of this is compliance auditing, emergency supervision management, and contingency planning.

3.4.3 Deployment Software

Cloud deployment means starting SaaS, PaaS, and IaaS operations. This provides solutions that can be used by consumers or clients. This deployment is made up of all compulsory cloud deployments and configurations. This comes from the back end and applies until provisioning takes place.

3.4.4 Route Connectivity

It is an integral part of the architecture of Cloud Computing, by which the entire cloud gets connected. The transmission speed depends on the network that is connected to the internet. With the assistance of this virtual path, there are several cloud servers present
that connect. This also provides the user with a facility by allowing the route and protocol to be personalized.

3.5 Cloud computing Infrastructure

Cloud infrastructure provides the same features as physical infrastructure but can offer additional advantages, such as lower ownership costs, greater flexibility, and scalability.

Private cloud, public cloud, and hybrid cloud systems have cloud computing resources available. Cloud infrastructure components can also be leased from a cloud provider through cloud infrastructure as a service (Iaas). Cloud infrastructure systems allow integrated hardware and software and can provide multiple clouds with a single management framework.

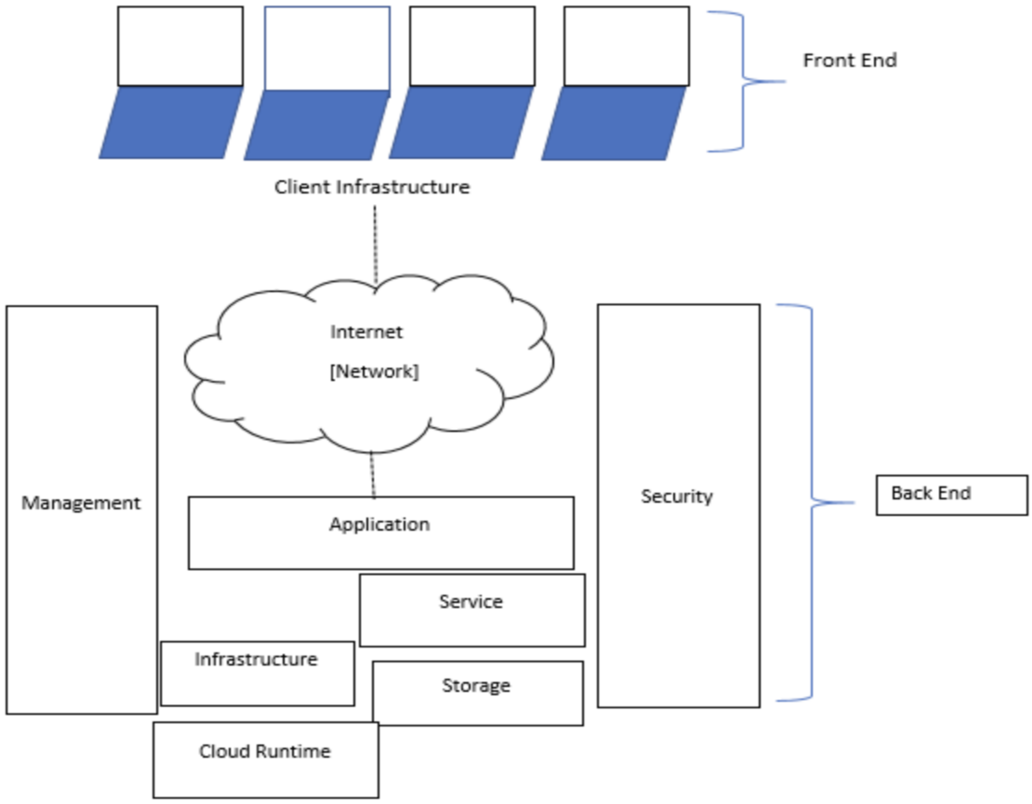

Figure 2:Cloud Computing Infrastructure *[Anusha Dutta, 2017]*

3.5.1 **Platform as service**

The actual cloud computing platform is programming, code, and implemented interfacing systems that help user-level devices (and applications) link to the cloud's hardware and software resources are a cloud computing platform. It is a software layer that is used to build services at a higher level. In the Platform-as-a-Service (PaaS) model, Developers rent everything they need to create an application in the Platform-as-a-Service (PaaS) model, depending on a cloud provider for development resources, infrastructure, and operating systems. This is one of cloud computing's three service models. PaaS significantly simplifies web application development; all backend management takes place behind the scenes from the developer's perspective. There are several important differences between them, although

PaaS has some parallels to serverless computing. PaaS can be accessed through any internet connection, allowing a web explorer to develop an entire application. As this development environment is not locally hosted, developers can operate from anywhere in the world on the application. This helps teams are located globally to work seamlessly without any geographical problem. It also implies that developers have less control over the environment for development, but this comes with much less overhead.

3.5.2 What is included in PaaS

The main offerings included by PaaS vendors are:

- Development tools
- Middleware
- Operating systems
- Database management
- Infrastructure

Different vendors may include other services as well, but these are the core PaaS services. Figure 3 describes core PaaS services. (T, 2020)

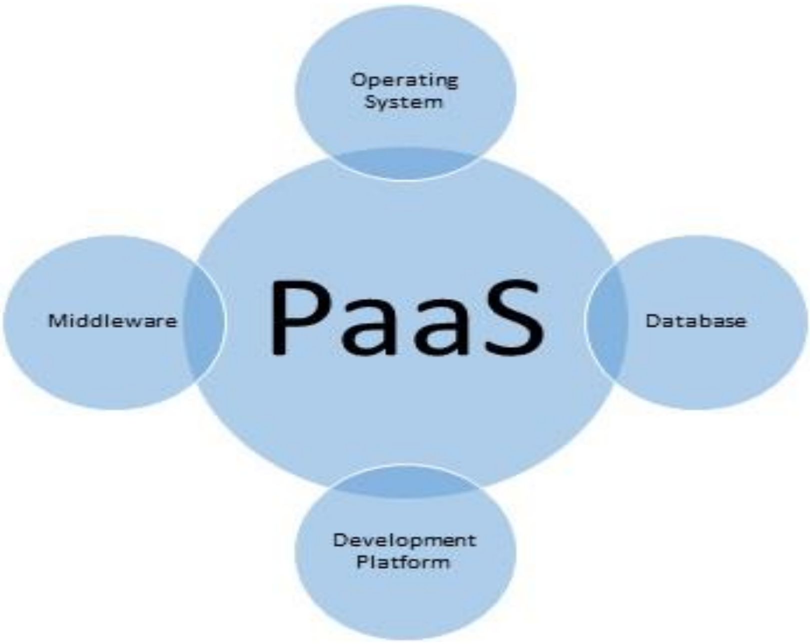

Figure 3:Services for Paas. ***[source: www.mbaskool.com/2015_images/stories/may-images/ash-paas.jpg]***

3.5.3 **Development tools**

PaaS vendors have a range of software development tools, such as a source code editor, a debugger, a compiler, and other required tools. These methods may be combined to form a structure. The resources available can vary depending on the manufacturer, but PaaS should provide all a developer requires to design their app.

3.5.4 **Middleware**

Platforms delivered as a service usually provide middleware, so it does not have to be developed by developers themselves. Middleware is software that sits between user-facing programs and the operating system of the machine; middleware, for example, enables software to access keyboard and mouse inputs. To run an application, middleware is required, but end users don't interact with it.

3.5.5 **Operation systém**

The operating system that developers operate on and the application runs on will be supported and managed by a PaaS vendor.

3.5.6 **Infrastructure**

In the cloud computing service model, PaaS is the next layer up from IaaS, and PaaS also contains everything found in IaaS. A PaaS provider either operates or purchases servers, storage, and physical data centers from an IaaS provider.
There are several different providers of Platform as a Service (PaaS), some of which we will mention:

- Salesforce.com’s Force.com and Databse.com Platforms
- Windows Azure Platform
- Google Apps and Google AppEngine
- Amazon Web services

3.6 Why do developers use PaaS?

3.6.1 Faster time to market

If developers had to worry about designing, configuring, and provisioning their systems and backend infrastructure, PaaS is used to create apps faster than would be possible. With PaaS, all users need to do is write the script and evaluate the software, and the rest is done by the vendor.

3.6.2 One environment from start to finish

PaaS helps developers, all in the same environment, to design, test, debug, deploy, host, and upgrade their applications. This allows developers to make sure that a web application can work properly when it is hosted before it is released and simplifies the lifecycle of application creation.

3.6.3 Price

In certain instances, PaaS is more cost-effective than leveraging IaaS. The overhead is minimized because virtual machines do not need to be operated and supplied by PaaS customers. Furthermore, some vendors have a pay-as-you-go pricing structure in which the vendor charges only for the computing services used by the application, essentially saving money for consumers. Each seller, however, has a slightly different price tag, And a flat fee per month is paid by certain platform providers.

3.6.4 Ease of licensing

All operating system licenses, development software, and everything else used in their platform is managed by PaaS providers

3.7 How is Platform-as-a-Service distinct from computing that is serverless?

PaaS and serverless computing are equivalent in that all a developer has to think about is writing and uploading code for both, and all backend operations are handled by the supplier. When using the two versions, scaling, however, is significantly different. Serverless computing or FaaS-built applications will automatically scale, while PaaS applications will not scale unless they are designed to do so. Start-up times often differ considerably; almost instantly, serverless applications can be up and running, but PaaS applications are more like conventional applications and have to run most of the time or all of the time to be available to users immediately. Another distinction is that, as PaaS vendors do, serverless vendors do not have development instruments or frameworks. And eventually, the two versions are differentiated by pricing. PaaS billing is not nearly as accurate as serverless computing, where payments are broken down to the number of seconds or fractions of a second that each function instance is running.

3.8 Drawbacks of using PaaS

3.8.1 Vendor lock-in

Changing PaaS providers can be challenging, as the application is designed using the software of the vendor and specifically for their platform. Every vendor can have different specifications for architecture. The same languages, libraries, APIs, architecture, or operating systems used to develop and run the application can not be provided by different vendors. Developers can need to either reconstruct or severely alter their applications to move vendors. (Dahiya, 2021)

3.8.2 Vendor dependency

The effort and resources involved in changing PaaS suppliers will make businesses more dependent on their current suppliers. A minor change in the internal processes or infrastructure of the provider may have an enormous impact on the performance of an application built to operate on the old configuration effectively.
Besides, an application can suddenly become more costly to run if the vendor changes its pricing model. (Dahiya, 2021)

3.8.3 Security and compliance challenges

The external provider can store most or all of the data of an application, along with hosting its code, in a PaaS architecture. In certain instances, through an external third party, an IaaS provider, the vendor can directly store the databases. Although most PaaS suppliers are large firms with solid protection in place, This makes it impossible for security measures that secure the application and its data to be thoroughly assessed and checked. Besides, checking the compliance of additional external suppliers would bring further barriers to going to market for businesses that have to comply with stringent data protection regulations.

3.9 Cloud Applications

A software application that includes both cloud-based and local components functions together is a cloud application or cloud app. This model relies upon remote logic processing servers which are accessed via a web browser with a continuous internet connection.

Usually, cloud application servers are located in a remote data center run by an infrastructure provider for third-party cloud services. Email, file storage and sharing, order entry, inventory management, word processing, customer relationship management (CRM), data collection, or financial accounting features can include cloud-based application tasks. (Shore, n.d.)

3.9.1 Benefits of cloud apps

Fast response to company requirements. Cloud apps can be easily downloaded, reviewed, and distributed, giving businesses a speedier time to market and greater agility. This rapidity has the potential to trigger cultural changes in company activities.

Service has been streamlined. Third-party cloud vendors can assist with service maintenance. Scalability is available right away. Usable capacity may be balanced as demand increases or decreases.

Usage of the API. With an application programming interface, third-party data sources and storage facilities may be accessed (API). Through using APIs to hand over data to applications or API-based back-end resources for processing or computational computations, cloud applications can be kept smaller, with the results handed over to the cloud application.

A gradual adoption. Components can be applied on an incremental basis by refactoring legacy, on-site software to a cloud architecture in stages.

Decreased prices. Lower prices have been driven by the size and scope of data centers operated by significant cloud infrastructure and service providers, along with rivalry among providers. Running and managing cloud-based systems can be less costly than installing on-site equivalents.

Enhanced sharing and protection of data. Data stored on cloud storage is open to approved users immediately. Cloud providers can employ world-class security specialists because of their sheer size and introduce infrastructure security measures that can usually only be accessed by large companies. More effectively, centralized data maintained by IT operations staff is backed up daily and restored if disaster recovery becomes necessary.

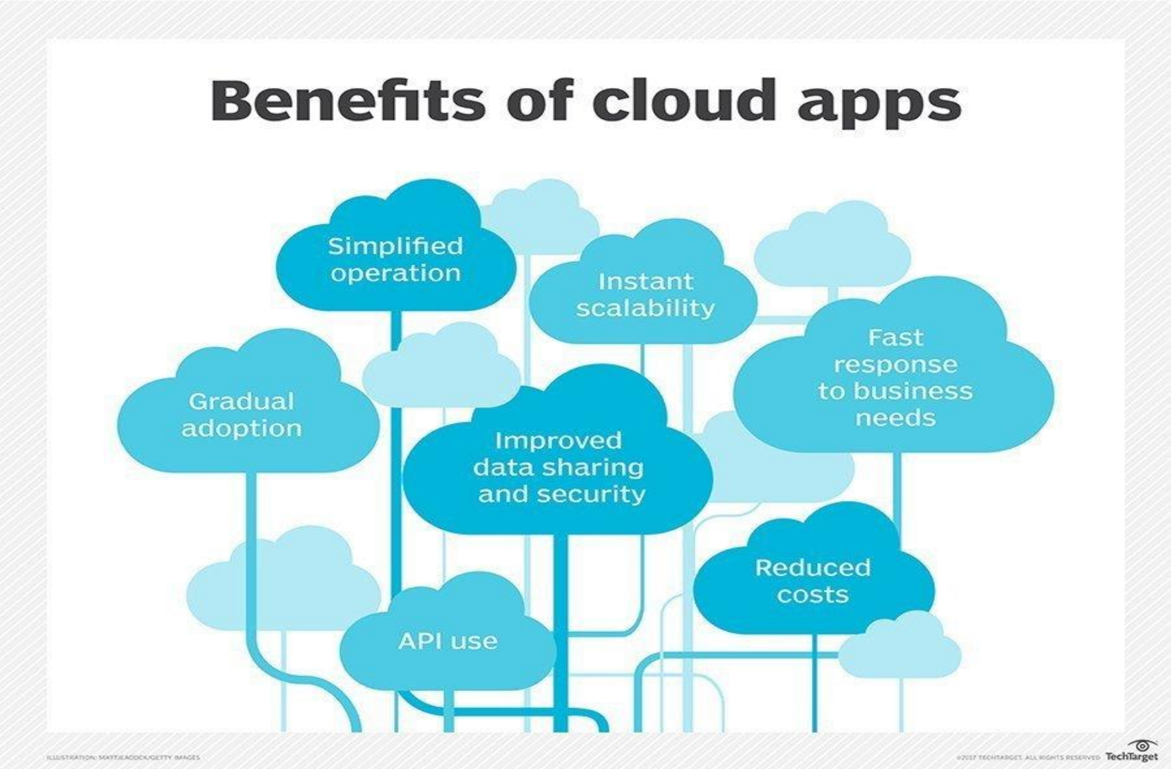

Figure 4: shows the benefits of cloud apps. ***[Source: Joel Shore, 2017]***

3.9.2 How cloud apps work

In a remote data center usually run by a third-party organization, data is stored, and computing cycles occur. A back end guarantees uptime, protection, and integration and supports different methods of entry. Cloud apps have easy responsiveness and do not need to remain on the local computer permanently. They can operate offline, but they can be updated online. Cloud applications do not often use storage space on a server or communications system while they are under continuous monitoring. A well-written cloud application, assuming a relatively fast internet connection. Cloud services, though under continuous supervision, do not always consume storage space on a computer or communication device. A well-written cloud application, assuming a relatively fast internet connection, provides all the interactivity of a desktop app and the portability of a mobile app

3.10 **Web apps vs. Cloud apps**

Clear distinctions between cloud and web apps have blurred with the progress of remote computing technologies. The word cloud application has won great cachet, often leading application vendors to mark them as cloud applications for any online aspect. Data residing on remote storage is accessed by cloud and web applications. Both use the computing capacity of servers that can be located on-site or in a distant data center. Architecture is a rigorous distinction between cloud and web applications. To work, a web application or web-based application must have an ongoing internet connection. Moreover, on a local computer or workstation, a cloud application or cloud-based application carries out computing activities. For downloading or uploading data, an internet connection is primarily necessary. When the remote server is inaccessible, a web application is unusable. If a remote server in a cloud application becomes unavailable, the program installed on a local user computer can still work, but it is unable to upload and retrieve data until the remote server service is restored with two standard productivity tools, email and word processing, the disparity between cloud and web applications can be highlighted. For starters, Gmail is a web application that only needs a browser and an Internet connection. It's possible to open, write and arrange messages through the browser using search and sort capabilities. On the servers of the service provider (Google, in this example), all processing logic occurs through either the HTTP or HTTPS protocols of the Internet. A CRM program accessed under a fee-based software as a service (SaaS) agreement via a browser is a web application. Web apps that don't install software locally are also called online banking and regular crossword puzzles. Microsoft Office 365 from Word is an example of a word-processing cloud program that is mounted on a workstation. On a computer that does not have access to the internet, the program executes tasks locally. When users save work on an Office 365 cloud server, the cloud factor comes into play.

3.10.1 **Cloud apps vs. desktop apps**

For each operating system, desktop applications are platform-dependent and need a different version. The need for several versions increases the time and cost of development and complicates the testing, management of versions, and support.

Cloud apps, on the other hand, can be accessed from a range of devices and operating systems and are independent of the network, which usually contributes to substantial cost savings. Each computer in a desktop application requires an installation of its own. Since it's not possible to implement an update if a new version is available, it's impossible to make the same one run by all users. A strain on tech support could be the need to provide support for several versions simultaneously. Cloud apps do not face problems with version control since only the version available on the cloud can be accessed and run by users.

3.11 **Scalability**

Scalability is a beneficial property of a device that demonstrates its ability to either gracefully manage increasing quantities of work or its ability to enhance performance when additional resources (typically hardware) are introduced. A scalable device is said to be a system whose output increases after the hardware is added, proportionally to the power added. Similarly, an algorithm is said to scale, and when applied to significant situations (for example, an enormous input data set or a large number of participating nodes in the case of a distributed system), it is sufficiently efficient and functional. It does not scale if the algorithm fails to work as the resources increase. Through incorporating hardware resources, there are usually two ways in which a device can scale. If the system scales vertically and is referred to as scale-up, the first solution is.

3.11.1 **Vertical scale (or scale-up)**

means adding resources to a single system node, which usually includes adding processors or memory to a single computer. Such vertical scaling of existing systems also helps them to make more productive use of virtualization technology since it offers more resources to share the host collection of operating system and device modules. The increase in the number of Apache daemon processes running is an example of taking advantage of such shared resources. The other way to scaling a device is to horizontally incorporate hardware resources referred to as scale-out. To scale horizontally (or scale out) means to add more nodes to a device, such as adding a new computer to a distributed software application. For example, scaling from one web server system to a system of three web servers may be an example. (Yu, Kim, & Unland, 2011)

3.11.2 **The Horizontal model (Scale-out-model)**

As computer prices fall and demand for performance continues to grow, low-cost "commodity" systems can be used to create shared computer infrastructures for high-performance applications such as web search and other web-based services to be deployed. In a cluster, hundreds of small computers can be programmed to obtain aggregate processing power that often exceeds that of single conventional supercomputers based on RISC processors. The availability of high-performance interconnects has further fuelled this model. The scale-out model also creates an increased demand for shared data storage with very high I/O efficiency, especially where large quantities of data are needed to be processed. The scale-out model has traditionally served as the basic architecture paradigm for today's large-scale data-centers. (Yu, Kim, & Unland, 2011)

3.12 **Elasticity**

One of the major factors for the success of the cloud as an IT infrastructure is its pay-per-use pricing model and elasticity. For a DBMS deployed on a pay-per-use cloud infrastructure and the added goal is to optimize the system's operating cost. Elasticity, i.e., the ability to deal with load variations by adding more resources during high load or consolidating the tenants to fewer nodes when the load decreases, all in a live system without service disruption, is therefore critical for these systems. Even though elasticity is often associated with the scale of the system, a subtle difference exists between elasticity and scalability when used to express a system's behavior. (Yu, Kim, & Unland, 2011) Scalability is a system's static property that describes how it behaves under a static setting. A device architecture, for example, may scale to hundreds or even thousands of nodes. Elasticity, on the other hand, is a good thing as a dynamic property that allows the system's scale to be increased on-demand while the system is operational. For instance, a system design is elastic if it can scale from 10 servers to 20 servers (or vice-versa) on-demand. A system can have any combination of these two properties. (Yu, Kim, & Unland, 2011) The elasticity of large-scale structures is a desirable and essential property. Elasticity is essential for a scheme implemented on a pay-per-use cloud service, such as the abstraction of Infrastructure as a Service (IaaS), to reduce operational costs while maintaining good efficiency during heavy loads. It makes it possible to simplify the system to consume fewer resources and thereby reduce running costs during low load times while allowing it to scale up its size dynamically as the load decreases.

Enterprise infrastructures, on the other hand, are also statically provided. In such cases, elasticity is also ideal, where it enables the realization of energy efficiency. Although the infrastructure is statically provisioned, by consolidating the system in such a way that certain servers can be shut down, reducing the cost of power use and cooling, considerable savings can be achieved. However, this is an open research subject in its own right, as powering down random servers does not inherently decrease the use of resources. To choose servers to power down, careful planning is necessary so that entire racks and alleys in a data center are powered down so that substantial cooling savings can be achieved. The effect of reducing supply must also be considered. For example, consolidating the system into a collection of servers all within a single failure point (for example, a switch or a power supply unit) can lead to a total service interruption resulting from a single failure. Besides, it is more costly to bring up powered-down servers, so the penalty for a miss-predicted power-down operation is greater. Finally, we can say elasticity allows users and providers to offer and take advantage of more with minimum facilities.

4. Practical Part

4.1 AWS (RDS)

The Amazon Relational Database Service (Amazon RDS) makes a relational database in the cloud simple to set up, run, and scale. Although time-consuming administrative activities like hardware provisioning are automated, database configuration, patching, and backups, it offers a cost-efficient and resizable ability. It helps the user to concentrate on their apps so that they can provide them with the fast efficiency, high availability, protection, and usability they need.

Amazon RDS is available for many types of database instances - tailored for memory, performance, or I/O - and offers six familiar database engines to choose from, including Amazon Aurora, PostgreSQL, MySQL, MySQL, Oracle Database, MariaDB, and SQL Server. To conveniently move or clone current databases to Amazon RDS, users can use the AWS database migration service.

4.1.1 The architecture of Amazon RDS/features

- **RDS Configuration** – The architecture diagram above displays the proposed Enterprise Web Applications AWS Architecture**.**

- **VPC-** AWS proposes to have the application within a VPC (Virtual Private Cloud). It is advisable to provide a private and public subnet within the VPC for a multi-tiered web application to be isolated and protected. The database server should be launched on a private subnet. Web servers are expected to be launched on the public subnet. It is essential to configure protection and routing so that only web servers can communicate within the private subnet with the database servers. There will be an internet route designed for the public subnet, as the web application is public.

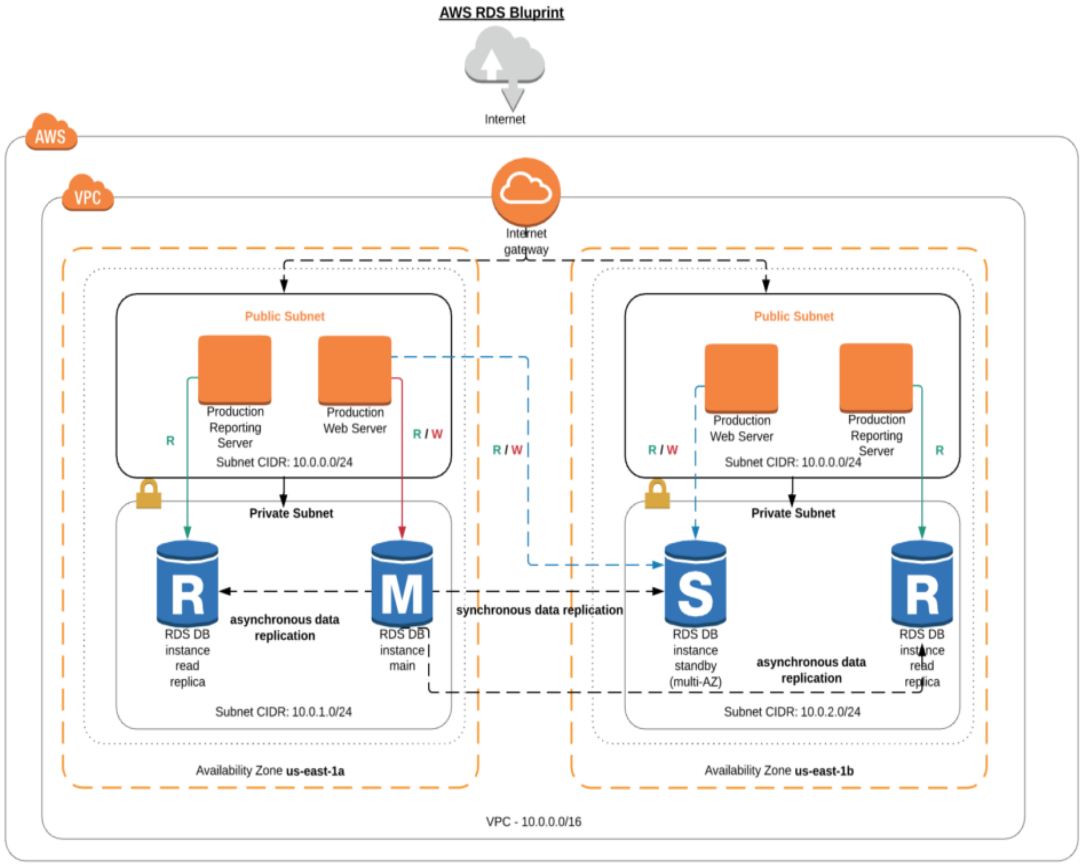

Figure 5: Amazon RDS architecture. ***[Source: dbsSeer, 2018]***

- **Multi-AZ Deployment -** To support high availability and reliability, AWS RDS enables multi-AZ deployment. With this function, a synchronous standby replica in a different availability Zone is automatically supported and maintained by AWS.AWS replicates the data synchronously from the primary instance to the secondary database instance. If, for whatever cause, the main database instance goes down, AWS will immediately fail to move to the secondary database instance.
- **Read Replicas -** Reading Replicas will help users scale-out read-heavy database workloads beyond the ability of single database deployment. Updates made to an instance of the source DB are copied asynchronously to the Read Replica. If the user has a web application and a reporting application all using the same instance of the database, this function will be very useful. All read-only traffic will be redirected to the read replicas in this case. The primary database will be used for the web application's read and write traffic.
- **Backup and Maintenance -** AWS generates backups of an RDS instance automatically. Amazon RDS provides a snapshot of the Database instance's storage space, backing up the entire DB instance. When application use is limited, backups and maintenance should be designed to reduce performance effects
- **Simplicity -** To access the functionality of a production-ready relational database in minutes, the user can use the AWS Management Console, the Amazon RDS Command Line Interface, or quick API calls. The instances of the Amazon RDS database are pre-configured with parameters and settings suitable for the selected engine and class. A database instance can be launched, and the application can be linked within minutes. DB Parameter Groups offer database granular control and fine-tuning.
- **Automatic software patching-** Amazon RDS will ensure that with the new updates, the relational database software running the deployment stays up to date. The user will exercise optional control over when and where an instance of the database is patched.
- **Recommendations from best practice-** By reviewing configuration and utilization metrics from database instances, Amazon RDS provides best practice guidance. Recommendations include areas such as variations of a database engine, storage,

types of instances, and networking. Users may quickly browse the available recommendations and execute the suggested action, schedule it for their next maintenance window, or entirely dismiss it.

- **Metrics and Tracking-** For DB Instance deployments, Amazon RDS supplies Amazon CloudWatch metrics. The AWS Management Console is a tool that can be used to manage monitor key DB Instance deployment operational metrics, including the use of compute/memory/storage capability, I/O behavior, and DB Instance connections.
- **Database snapshots -** Database snapshots are user-initiated backups that are held until the user directly deletes an instance stored in Amazon S3. Whenever users wish, they can construct a new instance from a database snapshot. While database snapshots act as complete backups operationally, users are only billed for incremental storage usage**.**

4.1.2 Amazon RDS Scalability

Amazon RDS manages the scaling of users' applications. The relational database is a managed service so that databases can keep up with the rising requirements of client applications or applications. The client can scale vertically to handle an application that uses an approximately equal number of reads and writes to satisfy the increasing requirements. Or, for read-heavy applications, the client can scale horizontally.

4.1.3 Vertical Scaling

Just pressing a button can vertically scale up the master database to accommodate a higher load in the database. Currently, when resizing RDS MySQL, PostgreSQL, MariaDB, Oracle, or Microsoft SQL Server instances, there are on top of 18 instance sizes that users can choose from. There are five memory-optimized instance sizes available for Amazon Aurora to choose from. The extensive range of instance types allows the best resource and expense for the database server to be selected.

4.1.4 Horizontal Scaling

In addition to vertically scaling the master database, using read replicas to horizontally scale the database would also increase the efficiency of a read-heavy database. There can be up to 5 read replicas on RDS MySQL, PostgreSQL, and MariaDB, and up to 15 read replicas on

Amazon Aurora. Read-only replicas allow the production of read-only copies synchronized with the master database. Also, for better results, position read replicas closer to users in a different AWS area. Read replicas to boost database availability by encouraging a read replica to a master for fast recovery in the event of a disaster. Read replicas are not, however, a substitute for the high availability and automatic failover capabilities offered by Multi-AZ. RDS read replicas are currently assisted by transparent load balancing of queries or connections. Each replica has a specific Domain Name Service (DNS) endpoint so that, by connecting to the replica endpoint, an application can enforce load balancing. Let's look at the possibilities for how applications can be made aware of RDreadng replicas. There are MySQL Connectors that allow read/write splitting and read-only endpoint load balancing without a significant change to the application if the application uses the native MySQL driver. For instance, if the PHP application can use the PHP MySQL Nd Replication and Load-Balancing plugin of the MySQL native driver. Users can install a load balancer between the application and the database servers, in addition to using the MySQL Connector. Make this add-on so that the program is met with a single database endpoint. This method creates a more dynamic environment. in which read replicas behind the load balancer are transparently added or removed without continuously updating the application's database connection string. A personalized health review can also be done using scripts.

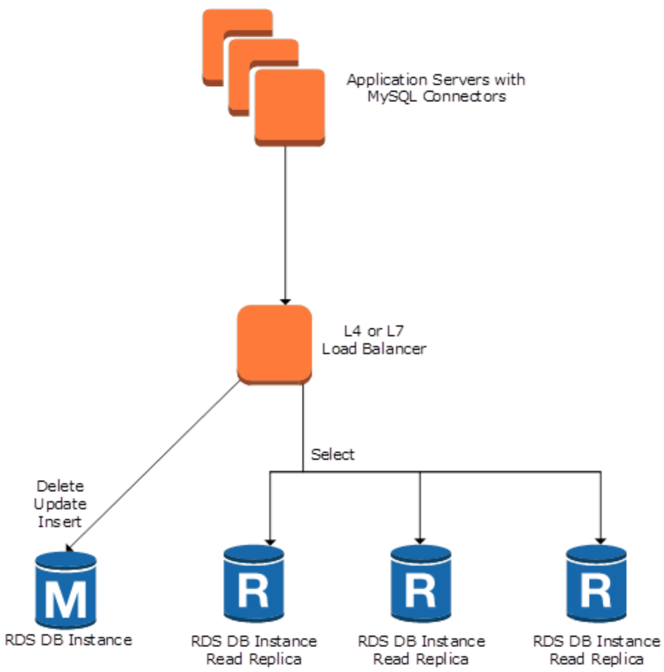

Figure 6: AWS Horizontal scaling. ***[Mary Yap, 2016]***

As seen in the diagram, along with the MySQL Connector, a transport or layer four load balancer can be used. The Elastic Load Balancing (ELB) load balancer currently does not support traffic routing to RDS instances. Other solutions, such as HAProxy, which is an open-source load balancer based on software that many people use, may also have to be considered. With this solution, HAProxy can be configured to listen to read queries on one port and write queries on another. Another alternative is to use a layer 7 SQL-aware load balancer, which enables the use of complex rules to forward queries to databases. This type of load balancer has a more advanced ability to understand how great d/write splits on multi-statements can be done properly than a MySQL Connector does. In a distributed database environment, this approach handles the scaling problems, so users don't have to tackle scaling on the application layer, resulting in little or no change to the application itself. There are several open-source solutions (such as MaxScale, ProxySQL, and MySQL Proxy) as well as commercial solutions to achieve this, some of which can be found in the AWS Marketplace. (Yap, 2016)

Scaling up or out of RDS configuration to meet the rising needs of applications. RDS takes care of the heavy lifting in the scaling database so that application or applications can concentrate more on it.

4.1.5 Amazon RDS Availability

There are two easy solutions for Amazon Relational Database Service (Amazon RDS) to ensure that the relational database is highly accessible, user can use Amazon RDS Multi-AZ deployments for MySQL, MariaDB, PostgreSQL, Oracle, and SQL Server database (DB) instances. Amazon RDS automatically generates a primary DB instance when the user has a Multi-AZ (Amazon RDS High Availability, n.d.) separate Availability Region (AZ). Amazon RDS conducts an automated failover to the Standby DB instance in case of an infrastructure failure. Since the endpoint for y DB instance remains the same after a failover, without the need for manual administrative intervention n, the application will resume operation of the database. (Amazon RDS High Availability, n.d.) Additional high-availability solutions include the Amazon Aurora PostgreSQL and Amazon Aurora MySQL engines. Amazon Aurora improves flexibility even with a single database instance by replicating the data six ways across three Availability Zones. This means the DB cluster can withstand an Availability Zone failure without any data loss and just a brief service interruption, in an Amazon Aurora DB cluster, the user can opt to run one or more Replicas. If the initial instance in the DB cluster fails, automatically RDS prompts the new primary instance of an existing Aurora Replica and updates the endpoint of the server so that the application can resume operation without any manual interference. If no replicas have been provisioned, when a failure is found, RDS will automatically generate a new replacement DB instance for the user. When running Multi-AZ deployments, a user also benefits from increased database availability. If an Availability Zone or a Database Instance fails, the availability effect is limited to the time it takes to complete the automated fail-over, which is usually less than a minute for Amazon Aurora and one to two minutes for other database engines. (Amazon RDS High Availability, 2020) For Multi-AZ deployments, when operations such as DB Instance scaling or device updates such as OS patching are initiated, they are first applied on standby before theorematic failover. As a result, the effect of availability is limited only to the time needed to complete the automated failover.

4.1.6 Amazon RDS Pros and Cons

Advantages	Disadvantages
Automated Patching	Patching forces a downtime
Automated Backups	No scale-out for write workloads
Encryption at rest and in-transit	Downtime required for scaling operations
Sia significant improvement over on-premises databases	No automated performance tuning
Connected to the rest of the Amazon Web Services ecosystem	Not a zero-administration database
No hardware maintenance needed	No automated partition management

Simplified scaling in comparison to on-premises databases	No native support as a read replica for on-premises Databases
Automated additional storage allocation	CPU and Storage performance is not guaranteed
the point time recovery	Zero data loss is not guaranteed

Table 1:Amazon RDS Pros and Cons

4.1.7 **Cost for using Amazon RDS service**

There's a free Amazon RDS to try. Just pay for what users are using. No minimum fee is applicable. Amazon RDS may be compensated for by using On-Demand or Reserved Instances.

- **Amazon RDS Reserved Instances** Amazon RDS Reserved Instances offer the option to reserve a DB instance for a period of one or three years and, in exchange obtain a substantial discount relative to the DB instance's On-Demand Instance pricing. When acquiring a Reserved Case, there are three payment options. Pay for the entire Reserved Instance with one upfront payment with the All Upfront option. About On-Demand Instance pricing, this alternative offers the most considerable discount. Make a low upfront payment with the Partial Upfront option, and then a reduced hourly rate is paid for the term of the Reserved Case. The No Upfront alternative does not require any upfront cost and offers the length of the contract with a reduced hourly rate. For Aurora, MySQL, MariaDB, PostgreSQL, Oracle, and SQL Server database engines, all Reserved Instance types are open.
- **Amazon RDS on-demand** Depending on the class of the DB instance, DB instances are billed (for example, DB.t2.small or DB.m4.large). For a DB instance, billing begins as soon as the DB instance is available. Pricing is listed on a per-hour basis, but bills are measured in the decimal form down to the second and display times. Use of Amazon RDS is billed in intervals of one second, with a minimum of 10 minutes. In the event of a checkable configuration adjustment, such as compute scaling or storage capacity, users will be charged a minimum of 10 minutes. Billing lasts until the instance of the DB stops, which happens uninstalling all the instances of the DB

or if the instance of the DB fails if the user does not want to be paid for DB instance anymore, must stop or uninstall it to prevent additional DB instance hour from s being charged.

4.2 Microsoft SQL Azure

Microsoft's public cloud platform is Azure. For example, Platform as a Service (PaaS), Infrastructure as a Service (IaaS), and Managed Database Service capabilities, Azure provides a wide collection of services. Azure depends on a technology known as virtualization, like other cloud services. In software, most computer hardware can be emulated since most computer hardware is simply a series of instructions encoded in silicon permanently or semi-permanently. Virtualized hardware will run on software as if it were the actual hardware itself, using an emulation layer that maps software instructions to hardware instruction. A cloud is a group of physical servers in one or more datacentres that, on behalf of clients, perform virtualized hardware. Each instance of the fabric controller is connected, usually known as a front end, to another collection of servers running cloud orchestration software. Web services, RESTful APIs, and internal Azure databases used for all operations performed by the cloud are hosted on the front end. Azure is a large array of servers and networking hardware that runs a complex set of distributed applications to orchestrate the virtualized hardware and software setup and activity on those servers. As users are no longer responsible for maintaining and updating hardware because Azure does all this behind the scenes, it is this orchestration that makes Azure so effective.

4.2.1 SQL Azure architecture

Each SQL Azure database is associated with its subscription. From the subscriber's perspective, SQL Azure provides logical databases for application data storage. In reality, each subscriber's data is replicated across three SQL Server databases that are distributed across three physical servers in a single data center. Many subscribers may share the same physical database, but the data is presented to each subscriber through a logical database that abstracts the physical storage architecture and uses automatic load balancing and connection routing to access the data. The logical database that the subscriber creates and uses for database storage is referred to as a SQL Azure database. (Jennings, 2009)

4.2.2 **Scalability with Microsoft Azure**

Azure SQL Database is a flexible Platform as a service database that can be easily scaled to fit user's needs. Users can add more compute or storage to satisfy performance requirements without waiting for new hardware or migrating data to more powerful machines. Azure enables to change the performance characteristics of a database on the fly and assign more resources when needed or release the resources when they are not needed to decrease the cost. (Jovan, 2018)

There are two forms of scaling available in Azure SQL Database:

- **Vertical scaling** By adding more computational power, the user will scale up or down the database.
- **Horizontal scaling** Users can add more databases and share their data into multiple database nodes.

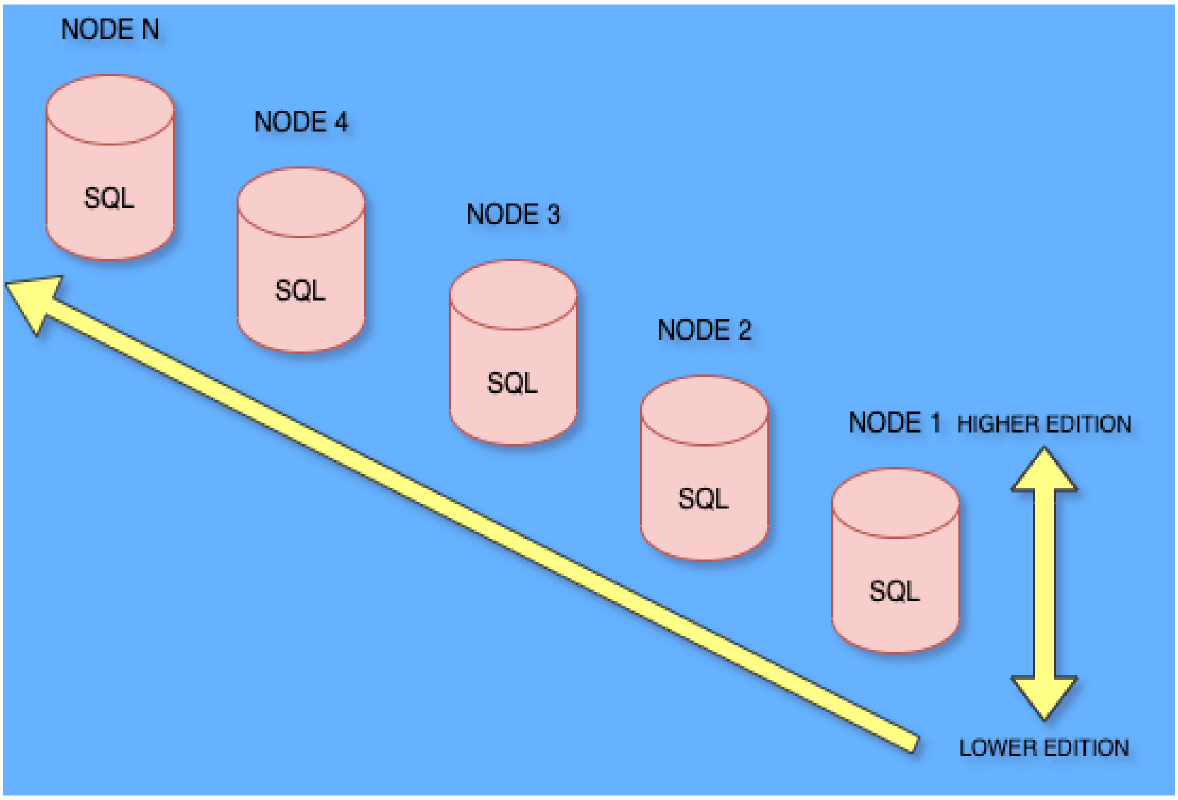

Figure 7:Microsoft Azure Horizontal and vertical scaling

Performance problems that can't be fixed with conventional database optimization techniques like query updates, indexing, and so on, Solution can be quick to address them and need to scale up the database. Vertical scaling is helpful if any spikes in the workloads where the current output level is unable to meet all demands. One can easily manage the peak workload by adding more resources and then returning to the original state when the resources are no longer needed. If even at the highest output level, users can't get enough resources, consider horizontal scaling. Horizontal scaling helps to divide the data into different databases (shards), each of which can be scaled up or down independently.

Scaling up or down:

Scaling up is the method of growing the database's resources to increase efficiency.

If users find that their workload is reaching a performance cap, they can scale up their database (e.g., CPU or IO). Users should choose the number of CPUs they want. To use and how much storage they need with Azure SQL Database, and they can change these parameters dynamically at any time. If their current resources can't support the workload, they can easily add more Processor power or storage. For example, they can build an Azure SQL Database with 16 cores and 500GB storage and then increase or decrease these numbers as needed. Changing CPU or storage in an instance can be done via the Azure portal using a simple slider. Any adjustment users would be almost instantaneous. Provisioning, disk attachments, and other tasks are not needed. The database will be reconfigured based on the values users enter in the slider, and Azure SQL Database will obtain additional resources right away.

DTU-based model:

Another model is the DTU-based model, in which the database is placed in a pre-defined output class (for example, 100DTU, 200DTU, etc.) Every DTU class is a resource bounding box where users get the most CPU, memory, and IO resources. The following are the read and write operations for that class. The CPU/memory/read/write ratio has been balanced and optimized for generic workloads using Azure SQL Database benchmarks. The number of resources specified in the DTU class will always be available in Azure SQL Database. Users' workload can be run on the selected DTU class without scaling up the database as long as none of the measurements in the DTU bounding box exceed the limit. If the user reaches their limit, the user needs to move to a higher class. Changing the service tier from Standard/General Purpose to Premium/Business Essential is another way to scale up or down. Standard/General Purpose infrastructure comes with data stored on Azure premium disks, while Premium/Business Essential infrastructure comes with data stored on local SSD. If users decide that standard architecture cannot fulfill their latency requirements, moving between these tiers is typically a long-term decision.

Read scale-out:

If the workload exceeds the available resources and the ser is unable to scale up the database to address the problem, another alternative is to redirect some of their workloads to another database node. Premium (DTU-based model) and Business Critical (vCore-based model) databases have several replicas to ensure high availability. These replicas usually collect data from the primary node, make adjustments, and trigger if the primary node fails. The Read Scale-Out function lets users use the read-only replicas' ability for read-only queries. The read-only workload will be segregated from the main read-write workload, and its output will be unchanged. The function is designed for applications that have logically isolated read-only workloads, such as analytics, which will benefit from the additional capacity at no extra cost.

The main benefits of RreadingScale-Out are:

1. the primary database node will not spend resources on the read-only/analytic queries because they are not sent to the primary node anymore. Saved resources might be used to improve the performance of the table workload. (Jovan, 2018)
2. Users can use resources on secondary nodes to handle heavy reports and analytical queries. (Jovan, 2018)

It's simple to route read-only/analytical queries to secondary replicas. Once read scale-out is allowed, users may add the ApplicationIntent=ReadOnly; property to the inked string for analytic queries, and these queries will be sent to the secondary replica. It's worth remembering that the data in the secondary replica may not be the same as the data in the primary database. Since the method of transferring changes from primary to secondary nodes is asynchronous for performance purposes here, the user can not see the most recent data in the secondary node. If users plan to run some analytic reports that don't need precise/up-to-date data (e.g., monthly/weekly reports), use secondary read-only replicas.

4.2.3 **Microsoft Azure Database**

Azure SQL Database is a platform as a service (PaaS) database engine that is completely managed and automates most database maintenance activities such as upgrading, patching, backups, and monitoring. Azure SQL Database has a 99.99 percent uptime since it operates on the most recent stable version of the SQL Server database engine and a modified operating system. The built-in PaaS capabilities of Azure SQL Database enable to focus on business-critical domain-specific database administration and optimization tasks. Users can build a highly accessible and high-performance data storage layer for Azure applications and solutions using Azure SQL Database. Since it can process both relational data and non-relational constructs like graphs, JSON, spatial, and XML, SQL Database is a good fit for several modern cloud applications. (What is Azure SQL Database, n.d.)

Azure SQL Database is built on the Microsoft SQL Server database engine's most recent stable version. Advanced query processing capabilities, such as high-performance in-memory technology and intelligent query processing, are available. In reality, SQL Server's newest features are released first to SQL Database, then to SQL Server itself. Users get the most recent SQL Server features without the hassle of patching or updating, and they've been thoroughly checked across millions of databases.

With SQL Database, users can easily describe and scale output in two different purchasing models: vCore-based purchasing and DTU-based purchasing. SQL Database is a completely managed service with high availability, backups, and other standard maintenance features built-in. Microsoft is in charge of both SQL and operating system patching and updates. Users don't have to worry about the infrastructure.

4.2.4 Microsoft Azure Logical server

A server is a conceptual construct in Azure SQL Database and Azure Synapse Analytics that serves as a central administrative point for a set of databases. Users can manage logins, firewall rules, auditing rules, threat detection policies, and auto-failover groups at the server level. A server's resource group can be in a different area. Before users can build a database in Azure SQL Database or a data warehouse database in Azure Synapse Analytics, users must first create the server. A single server's databases are all created in the same region as the server.

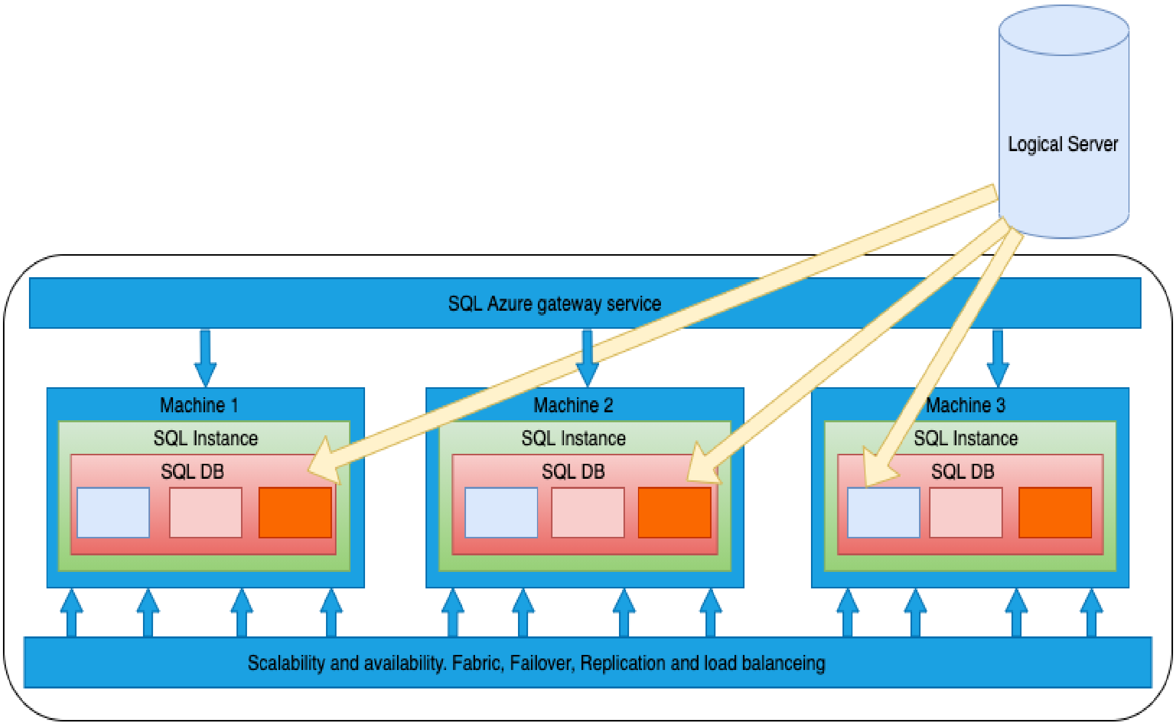

Figure 8:Logical server and database distribution in the cluster

- Failure detection: notes when a primary or secondary replica becomes unavailable so that the Reconfiguration Agent can be triggered.
- Reconfiguration Agent: manages the re-establishment of primary or secondary replicas after a node failure.
- PM (Partition Manager) Location Resolution: allows messages to be sent to the Partition Manager. (Jennings, 2009)
- Engine Throttling: This feature guarantees that only one logical server is used a disproportionate amount of the node's resources or exceeds its physical limits. (Jennings, 2009)
- Ring Topology: manages the machines in a cluster as a logical ring so that each machine has two neighbors that can detect when the machine goes down. (Jennings, 2009)

In Figure *8*, the logical server contains three databases: DB1, DB2, and DB3. The primary replica for DB1 is on Machine 1, and the secondary replicas are on Machine 3 and Machine 2. For DB3, the primary replica is on Machine 3, and the secondary replicas are on Machine 2 and another machine not shown in this figure. For DB4, the primary replica is on Machine

2, and the secondary replicas are on Machine 6 and another machine not shown in this figure. Note that this diagram is a simplification. Most production Microsoft SQL Azure data centers have hundreds of machines with hundreds of actual instances of SQL Server to host the SQL Azure replicas, so it is extremely unlikely that if multiple SQL Azure databases have their primary replicas on the same machine, their secondary replicas will also share a machine. (Jennings, 2009)

This server is not the same as a SQL Server instance users might be familiar with from an on-premises environment. There are no assurances on where the databases or data warehouse databases would be located concerning the server that handles them. Furthermore, neither Azure SQL Database nor Azure Synapse provides access or functionality at the instance level. The instance databases in a controlled instance, on the other hand, are all physically co-located in the same way as SQL Server is in the on-premises or virtual machine environment. When users create a server, they give it a login account and password that has administrative access to the server's master database as well as all databases it creates. This is a SQL login account for the first time. SQL authentication and Azure Active Directory authentication are supported by Azure SQL Database and Azure Synapse Analytics. See Managing Databases and Logins in Azure SQL Database for more detail on logins and authentication. Using Windows Authentication is not an option. Each relation is tied to a single database, not a single instance of SQL Server, due to the physical distribution of databases that are all part of one logical instance of SQL Server.

4.2.5 Microsoft Azure Network Topology

The client layer, the applications layer, the platform layer, and the infrastructure layer are the four layers that make up the client layer. There are four different abstraction layers that work together to provide the logical database for the subscriber's application to use. The relationship between these four layers is depicted in Figure 9. The client layer is the layer that is nearest to the application and allows it to communicate directly with SQL Azure. The client layer may either be hosted on-premises in a data center or Windows Azure. Any protocol capable of producing TDS over the wire is supported. Since SQL Azure uses the same TDS interface as SQL Server, familiar tools and libraries can be used to create client applications for cloud-based data. The infrastructure layer is responsible for managing the physical hardware and operating systems that allow the services layer to function.

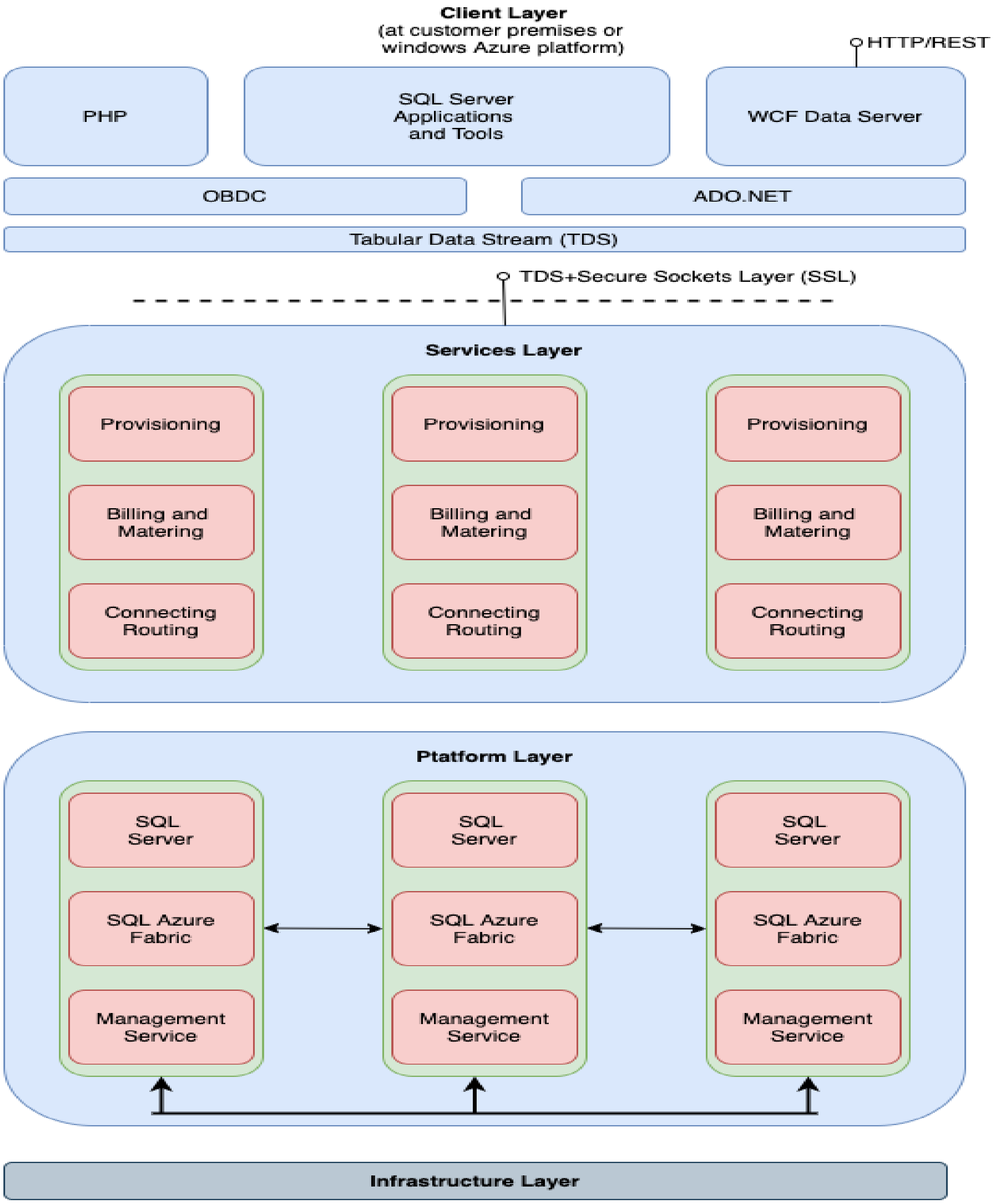

Figure 9: The SQL Azure logical database is provided to a client application across four layers of abstraction

4.2.6 Microsoft Azure Failure Detection

Datacenter management must be able to detect not only total system failure but also situations under which computers are slowly degrading and contact with them is disrupted. These requirements are addressed by the principle of quorum commit, which was previously discussed. For starters, a transaction isn't deemed committed until the primary replica, and at least one secondary replica can both agree that the transaction log records were successfully written to disk. Second, if both the primary and secondary replicas must report success, minor errors that do not prohibit a transaction from committing but indicate a larger issue can be identified.

4.2.7 Microsoft Azure Availability

As previously mentioned, Microsoft SQL Azure aims to achieve 99.9% availability. Because of the way database replicas are spread through several servers and the powerful algorithms for promoting secondary replicas to main, the data center's availability can be assured even though 15% of the machines are down.

Standard availability: a computing and storage model focused on the separation of computing and storage. It is reliant on the remote storage tier's high availability and reliability. This architecture is designed for cost-conscious business applications that can withstand some performance degradation during maintenance.

Premium availability: A model based on a group of database engine processes. It is based on the assumption that there is always a quorum of database engine nodes open. This architecture is designed for mission-critical applications that require high IO efficiency and transaction rates, and it ensures that maintenance activities have minimal performance effects on workload.

4.2.8 Microsoft azure pricing

There are two pricing models to consider for Azure SQL: the Database Transaction Unit (DTU) model and the vCore model, in addition to a wide range of deployment options.

DTU Pricing Model: Users can use a DTU calculator provided by Azure to determine how many DTUs each database needs. Users can then choose from a variety of instance forms and pool sizes (for the elastic pool deployment option). Each type has a specific number of DTUs (processing power) and storage capacity.

Database Transaction Units (DTU) is a way of measuring compute resources required to run SQL databases. Below we show DTU pricing for Azure SQL using the General Purpose/Standard service tier, for a Single Database deployment, in the West US 2 region.

Instance Type	DTUs	Maximum Storage Allowed*	Price for DTUs and Included Storage
S0	10	250 GB	$0.0202
S1	20	250 GB	$0.0404
S2	50	250 GB	$0.1009
S3	100	1 TB	$0.2017
S4	200	1 TB	$0.4033
S6	400	1 TB	$0.8066
S7	800	1 TB	$1.6130
S9	1,600	1 TB	$3.2260
S12	3,000	1 TB	$6.0488

Table 2: Microsoft Azure DTU Pricing Model. ***[Source: azure.microsoft.com]***

Where all options come with minimal included storage of 250GB.

- If someone needs to use extra data storage beyond the included storage, the price is $0.17 per GB-month.
- For long-term retention of data using RA-GRS blob storage, the price is $0.05 per GB-month.

vCore Model Pricing: For more extensive databases, a vCore model is appropriate. It allows the creation of a net number of virtual SQL servers in Azure. Users may choose vCores with specific physical hardware characteristics (CPUs, number of cores, RAM, and so on) as well as a particular amount of data storage, log storage, and connected backup storage. Users can move all current SQL Server licenses from their on-premise database servers to their Azure SQL vCores, which is a significant advantage of the vCore model. This allows the user to take advantage of Azure Hybrid Benefit, a program in which Azure covers the cost of Microsoft software as part of the VM cost. If they use existing licenses, Azure Hybrid Benefit allows users to save up to 55 percent on vCore prices.

When evaluating vCore pricing, there are two options users must consider — serverless compute and provisioned compute.

Serverless Compute Optionusers user chooses serverless compute, they can dynamically select between 0.5 and 16 vCores, with between 2.02 GB and 48 GB of memory.

The price is $0.5218 per vCore hour and $0.115 per GB-month.

Additional data charges:

- Point-in-time restore, charge $0.20 per GB-month for backup storage
- Long-term retention, charge $0.05 per GB-month

Provisioned Compute Option

- Users must have several of vCores in the provisioned compute option, and their ability and prices will be calculated accordingly. There's a default vCore price that includes the Microsoft software license and an Azure Hybrid Benefit price that's cheaper if the user passes their current SQL Server licenses to vCores. The Azure Hybrid Benefit discount is 40% in this case.

- Below we show vCore pricing for Azure SQL using the General Purpose/Standard service tier, for a Single Database deployment, in the West US 2 region

vCores	Total Memory (GB)	Price Per Hour Including License	Price Per Hour with Azure Hybrid Benefit
2	10.2	$0.5044	$0.3045
4	20.4	$1.0088	$0.6089
6	30.6	$1.5131	$0.9134
8	40.8	$2.0175	$1.2178
10	51	$2.5219	$1.5222
12	61.2	$3.0262	$1.8267
14	71.4	$3.5306	$2.1311
16	81.6	$4.0350	$2.4355
18	91.8	$4.5393	$2.7400
20	102	$5.0437	$3.0444
24	122.4	$6.0524	$3.6533
32	163.2	$8.0699	$4.8710
40	204	$10.0874	$6.0887
80	396	$20.1747	$12.1774

Table 3:Microsoft Azure Vcore Pricing model. ***[Source: azure.microsoft.com]***

Additional storage charges:

- The vCore prices above the only cover compute. Users are charged separately for storage, using the Premium tier of the Azure Blob Storage service, for $0.115 per GB/month.
- Point-in-time recovery, charge $0.20 per GB-month.
- Long-term retention, charge $0.05 per GB-month

4.3 Google Cloud SQL

Customers will use the Google cloud platform to access flexible cloud computing services. The services offered use the same technology as the company's other services, such as Gmail, Google Suite, Youtube, and so on. Google Cloud SQL, on the other hand, is a fully-managed database service that assists with the setup and management of relational databases on the GCP (Google Cloud Platform).

Simply put, Google Cloud SQL gives the user the freedom to set up database infrastructure after they finish developing their cloud app. Users can easily migrate existing databases to Cloud SQL if they're running on MySQL, SQL Server, or PostgreSQL BETA.

4.3.1 Advantages of Google Cloud SQL

Less maintenance: Users won't have to think about keeping the application data up to date if it's labeled as fully-managed. This allows focusing on developing the cloud applications and framing tactics that will give an organization a competitive advantage

Ensure Business Continuity: Data backup and recovery are guaranteed with Cloud SQL. In the event of a catastrophe, users can quickly recover application data and resume operations without interruption.

Ensures Security and Compliance: Data encryption and firewall support are provided by Cloud SQL. It's a secure RDBMS service that focuses on providing private connectivity through authentication and network access managed by the user. The Google service is SSAE 16, ISO 27001, PCI DSS, and HIPAA compliant.

Easy-Setup: Users can set up their first Google database app in minutes using regular link drivers and migration software. The simple-to-use SQL service from Google ensures a painless first-time experience.

Automated Tasks: Cloud SQL includes automated task management so the user can concentrate on growing their company while on the go. Storage management, backup and redundancy management, updates, power management, and data access are all available via the Google service.

Easy Integration: Google offers quick access to cloud SQL instances and guarantees that Kubernetes Engine, App Engine, and Compute Engine are all easily integrated. It also aids in the development of analytics capabilities and allows users to use Big-Query to perform SQL queries on databases.

4.3.2 **Pricing for Google Cloud SQL**

Google Cloud SQL, MySQL Pricing

Use case	Configuration details	Monthly cost
Test instance	• 1 CPU • 614 MB memory • 10 GB storage • No backup storage • No commitment term • Not highly available • `us-central1` region	$9.37
Highly available production database	• 4 CPUs • 24 GB memory • 60 GB storage • 80 GB backup storage • 3 year commitment term • Highly available • `us-central1` region	$273.55
Higher performance, highly available production database	• 32 CPUs • 208 GB memory • 10,230 GB storage • 1,000 GB backup storage • 3 year commitment term • Highly available • `us-central1` region	$5,532.26

Table 4: Google MySQL pricing Example. ***[Source: azure.microsoft.com]***

Google Cloud SQL, PostgreSQL Pricing example

Use case	Configuration details	Monthly cost
Test instance	• 1 shared CPU • 0.6 GB memory • 10 GB storage • No backup storage • No commitment term • Not highly available • `us-central1` region	$9.37
Highly available production database	• 4 CPUs • 24 GB memory • 60 GB storage • 80 GB backup storage • 3 year commitment term • Highly available • `us-central1` region	$260.31
Higher performance, highly available production database	• 32 CPUs • 208 GB memory • 10,230 GB storage • 1,000 GB backup storage • 3 year commitment term • Highly available • `us-central1` region	$5,504.74

Table 5:PostgreSQL pricing example. ***[Source: azure.microsoft.com]***

Each database instance is given the amount of RAM indicated above, as well as an acceptable amount of CPU. The filespace used by the MySQL database, PostgreSQL database, and SQL server is calculated in storage. Bills are sent out every month, depending on the number of days the database was active.

Google Cloud SQL, SQL server pricing example

Use case	Configuration details	Monthly cost
Test instance	• 1 CPU • 3.75 GB memory • 20 GB storage • No backup storage • No commitment term • Not highly available • Standard license • `us-central1` region	$432.31
Highly available production database	• 4 CPUs • 24 GB memory • 60 GB storage • 80 GB backup storage • 3 year commitment term • Highly available • Standard license • `us-central1` region	$646.31
Higher performance, highly available production database	• 32 CPUs • 208 GB memory • 10,230 GB storage • 1,000 GB backup storage • 3 year commitment term • Highly available • Standard license • `us-central1` region	$8,621.54

Table 6:Google Cloud SQL, SQL server pricing example. ***[Source: azure.microsoft.com]***

4.4 **RDBM as service overview**

The ability to generate useful information by joining tables is the primary advantage of the relational database approach. Understanding the relationships between the data or how the tables relate can be accomplished by joining tables. SQL supports counting, adding, grouping, and combining queries. Basic math and subtotal functions, as well as logical transformations, are available in SQL. The results can be sorted by date, name, or any column.

Flexibility: Data Definition Language is a built-in language in SQL for constructing tables (DDL). While the database is being used and queries are being run running, DDL users can add new columns, tables, rename connections, and make other changes. Users can adjust the schema or the way users model data on the fly with this function**.**

Reduced redundancy: Data redundancy is eliminated for relational databases. A single customer's information is included in a single entry in the customer table. Only a connection to the customer table is required in the order table. Normalization is the process of separating data to prevent duplication. During the design process, progressive database designers ensure that the tables are normalized**.**

Ease of backup and disaster recovery: Transactional databases guarantee that the state of the whole system is consistent at all times. Most relational databases have simple export and import capabilities, making backup and restore a breeze. These exports will take place even when the database is running, making it simple to recover in the event of a failure. Continuous mirroring is possible for modern cloud-based relational databases, resulting in data loss on restore calculated in seconds or less. Most cloud-managed services, such as IBM Cloud Databases for PostgreSQL, allow building Read Replicas. Users can store a read-only copy of the data in a cloud data center with these Read Replicas. For disaster recovery, replicas may also be promoted to Read/Write instances.

4.5 What is NoSQL Database

When people say "NoSQL database," they're generally referring to some non-relational database. Some people say "NoSQL" means "non SQL," while others say it means "not just SQL." In any case, most people believe that NoSQL databases are databases that don't use relational tables to store data. It's a popular misconception that non-relational databases, or NoSQL databases, can't store relationship data well. Relational databases can store relationship data, but NoSQL databases store it differently. Because there is no need to separate relevant data between tables, many people believe that modeling relationship data in NoSQL databases is simpler than modeling relationship data in SQL databases. In NoSQL data models, related data may be nested within a single data structure. As the cost of storage dropped drastically in the late 2000s, NoSQL databases appeared. Gone were the days when eliminating data duplication necessitated the development of a complex, difficult-to-manage data model. Since developers were becoming the primary cost of software development (rather than storage), NoSQL databases were designed to improve developer productivity.

4.6 Amazon DynamoDB

Amazon DynamoDB is a NoSQL database that can store both key-value and document data. DynamoDB allows developers to create modern, serverless applications that can scale globally to support petabytes of data and tens of millions of read requests per second. DynamoDB is built to run high-performance, web-scale applications that might otherwise overwhelm standard relational databases. (Amazon DynamoDB features, 2020) In addition to DynamoDB is supported by AWS Glue Elastic Views as a source for continuously combining and replicating data through multiple databases near-real timeline. To query, insert, edit, and delete table data in DynamoDB, use PartiQL, a SQL-compatible query language. To capture item-level changes in DynamoDB tables, use Amazon Kinesis Data Streams for restoring DynamoDB is faster now. A, so Use other AWS services like Amazon Athena to review the data and extract actionable insights after exporting data from DynamoDB to Amazon S3.

4.6.1 Amazon DynamoDB Performance

DynamoDB is a horizontally scalable key-value and document database that can handle tables of almost any size. Over petabytes of storage, DynamoDB can scale to more than 10 trillion requests a day, with more than 20 million requests per second have been recorded at times.

Key-value and document data models: Both key-value and document data models are supported by DynamoDB. This allows DynamoDB to have a versatile schema, which means that each row can have any number of columns at any time. This makes it simple to adapt the tables when the business needs shift, rather than having to rewrite the table schema as might in relational databases.

Microsecond latency with DynamoDB Accelerator: DynamoDB Accelerator (DAX) is an in-memory cache that allows users to use a completely controlled in-memory cache to deliver quick read performance for the tables at scale. Users can boost the read output of their DynamoDB tables by up to ten times with DAX, reducing read times from milliseconds to microseconds, even when processing millions of requests per second.

Automated global replication with global tables: DynamoDB global tables automatically duplicate the data across the AWS Regions of preference and scale capability to meet the workloads. The globally distributed applications can access data locally in the selected regions using global tables, resulting in reading and write output in the single-digit millisecond range. (Amazon DynamoDB features, 2020)

Advanced streaming applications: As a Kinesis data source, Amazon Kinesis Data Streams for DynamoDB captures item-level changes in the DynamoDB tables. Users can use this function to create advanced streaming applications, including real-time log aggregation, real-time business analytics, and data collection from the Internet of Things. Amazon Kinesis Data Streams for DynamoDB collects item-level changes in DynamoDB tables as a Kinesis data source. Advanced streaming applications, such as real-time log aggregation, real-time business analytics, and data collection from the Internet of Things can be created using this feature. (Amazon DynamoDB features, 2020)

4.6.2 Amazon DynamoDB Serverless

There are no servers to provision, repair, or handle and no program to install, maintain, or run while using DynamoDB. DynamoDB scales tables automatically to compensate for capability and retains efficiency with no manual intervention. Availability and fault tolerance are built-in, so users won't have to worry about architecting the applications to accommodate these features.

Read/write capacity modes: Each table in DynamoDB has two power modes: on-demand and provisioned. On-demand power mode manages the capacity, and the user just pays for what they consume, which is ideal for workloads that are less reliable and for which users are uncertain that they will have high usage. Users must set read and write capacity for tables that use provisioned capacity mode. When users are sure that they will use the provisioned capacity users specify, the provisioned capacity mode is more cost-effective.

On-demand mode: DynamoDB immediately accommodates the workloads as they ramp up or down to any previously achieved traffic level for tables using on-demand capacity mode. If the traffic level of a workload reaches a new high, DynamoDB adjusts quickly to handle the workload. Users can use on-demand capacity mode for both new and existing tables, and they don't have to change the code to use the existing DynamoDB APIs.

Auto Scaling: DynamoDB automatically scales throughput and storage for tables with provisioned space based on their previously defined capacity by tracking the output consumption of the application. If the application's traffic expands, DynamoDB scales up its throughput to keep up. DynamoDB scales down as their application traffic decreases, so they pay less for unused space.

Change tracking with triggers: AWS Lambda and DynamoDB work together to provide triggers. When changes at the item level of a DynamoDB table are discovered, triggers can be used to automatically execute a custom feature. Users can use triggers to create applications that respond to data changes in DynamoDB tables. Any action they specify, such as sending a notification or starting a workflow, can be performed by the Lambda function.

4.6.3 Amazon DynamoDB Data Model

Partition key: Let's look at a table called "Landmarks" that has the following data structure as an example.

Hotel_id	City	Landmark	Description
1	London	Museum	National Gallery
.	.	.	.
.	.	.	.
10001	Manchester	Arena	Etihad Stadium
.	.	.	.
.	.	.	.
20001	Liverpool	Monument	Beatles Statue
.	.	.	.
.	.	.	.
30001	Edinburg	Architecture	Edinburgh Castle
.	.	.	.
.	.	.	.
40001	Cardiff	Park	Bute Park
.	.	.	.
.	.	.	.
50001	Bristol	Architecture	Clifton Bridge

Table 7:Amazon DynamoDB table for example. ***[Sasidhar Sekar, 2018]***

The table shows hotels in major UK cities, as well as prominent landmarks near the hotels. Assume the table contains 60000 objects, and every 10000 records represent a data volume of 10 GB. The table's total size is 60 GB. Users must select an attribute as the table's Partition Key while building a DynamoDB table. Based on the Partition Key, DynamoDB will break the entire table data into smaller partitions. If Hotel ID is chosen as the table's Partition Key, the table will be divided into partitions as shown below.

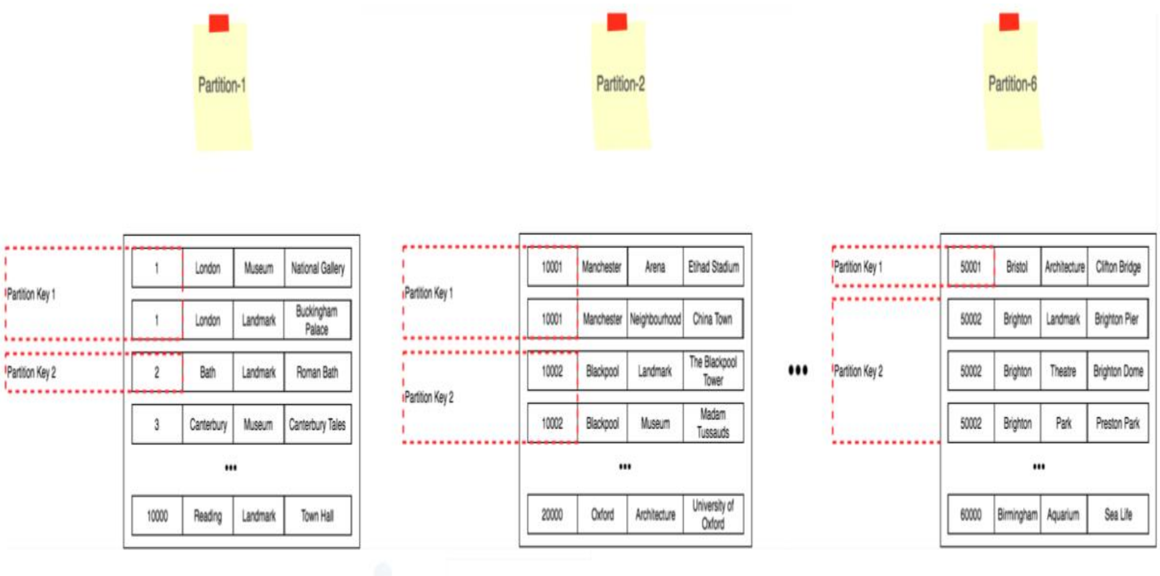

Figure 10: Amazon DynamoDB Partitions on the Sample Table. ***[Sasidhar Sekar, 2018]***

Assume users have a read operation identical to the one shown below.

```
aAWSdynamodb get-item --table-name Landmarks --key file://key.json
```

The arguments for get-item are saved in the “key.json” JSON format. The following is the output of that file:

```
{ "Hotel_ID": {"N": 1},"Description": {"S": "National Gallery"} }
```

This operation's read direction will be similar to the one shown below

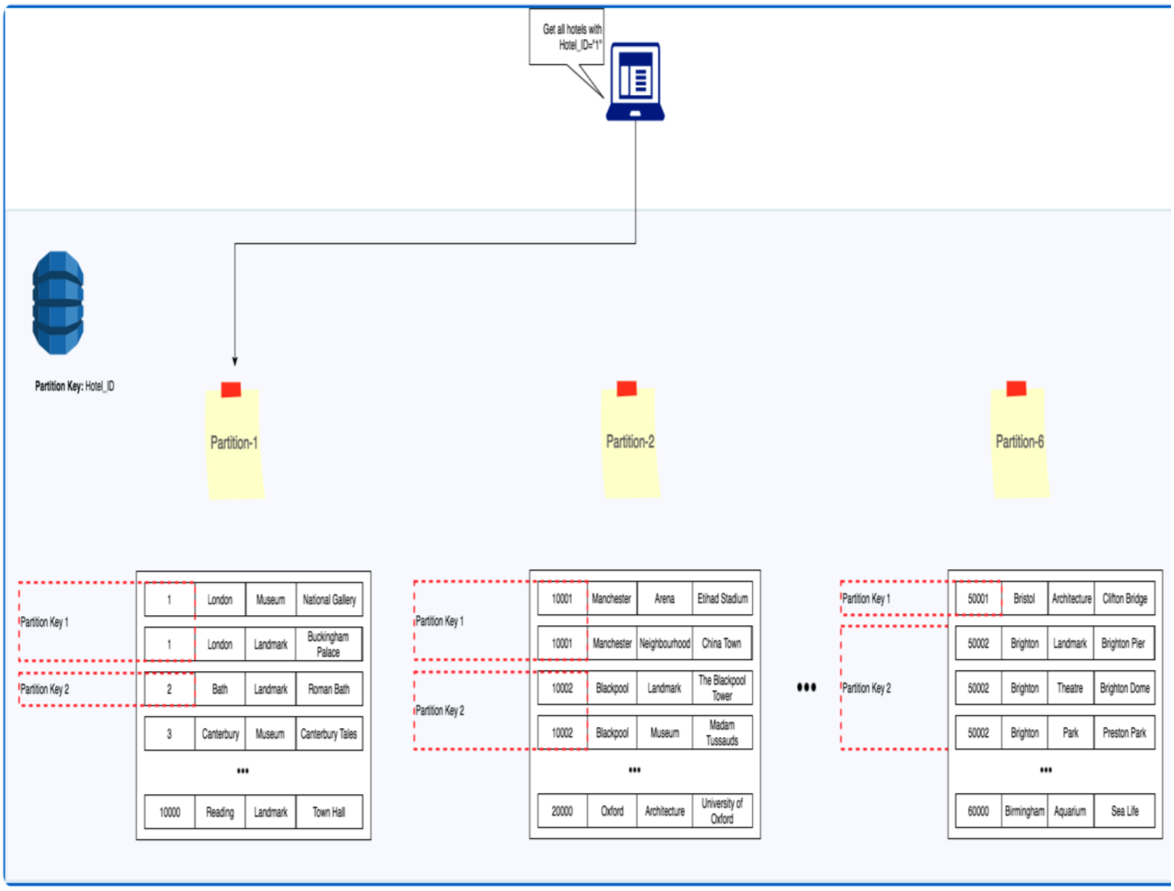

Figure 11: Amazon DynamoDB: Read Path on the Sample Table. ***[Sasidhar Sekar, 2018]***

As can be seen in the example above, DynamoDB directs the request to the exact partition containing Hotel ID 1. (Partition-1, in this case).

How does it do this? DynamoDB divides table data into partitions based on the Partition Key, as previously mentioned. This occurs in a series of steps.

Step 1: Each unique Partition Key (Hotel_ID here) is passed through a hashing algorithm

Step 2: The entire table data is split into several "hash ranges," based on Data size and Provisioned read/writes.

Step 3: Each "hash range" contains data corresponding to one or more Partition Keys.

When there is a read request, the following happens.

Step 1: The client sends a read request to DynamoDB.

Step 2: DynamoDB hashes the Partition Key specified in the request.

Step 3: DynamoDB looks up the Partition that is responsible for this hash.

Step 4: DynamoDB routes the request to that specific Partition.
Step 5: Data is returned to the Client.
This is the perfect situation, and each request should try to reach just one partition. (Sasidhar, 2018)

4.6.4 **Amazon DynamoDB Pricing**

Assume users are creating a new table in the United States' East (North Virginia) Area. They don't know what the traffic patterns would be because this table is for a new program. Assume that every time a user communicates with the website, their application, one 1 KB write and one 1 KB strongly consistent read is performed. They get very little traffic to the application for ten days, resulting in 10,000 reads and 10,000 writes on their table each day. However, on day 11, the app gains traction on social media, resulting in a surge in traffic of 2,500,000 reads and 2,500,000 writes. DynamoDB scales to have a consistent user interface. By the end of the month, the application falls into a more normal traffic pattern, averaging 50,000 reads and 50,000 writes every day. The table below shows the cumulative consumption for the month.

Timeframe (Day of Month)	Total Writes	Total Reads
1–10	100,000 writes (10,000 writes x 10 days)	100,000 reads (10,000 reads x 10 days)
11	2,500,000 writes	2,500,000 reads
12–30	950,000 writes (50,000 writes x 19 days)	950,000 reads (50,000 reads x 19 days)
Monthly total	3,550,000 writes	3,550,000 reads
Monthly bill	**$4.44 ($1.25 per million writes x 3.55 million writes)**	**$0.89 ($0.25 per million reads x 3.55 million reads)**

Table 8:Amazon DynamoDB pricing example. ***[Source: aws.amazon.com/dynamodb]***

Data storage: Assume the table starts with 25 GB of storage and rises to 29 GB by the end of the month, averaging 27 GB based on DynamoDB continuous monitoring. (Amazon DynamoDB Pricing, 2020) The AWS Free Tier includes the first 25 GB of storage. The remaining 2 GB of storage is charged at $0.25 per GB for a monthly table storage cost of $0.50. The overall bill for the month will be $5.83, with $5.33 for reads and writes and $0.50 for data storage.

4.7 Migration process of on-premise dtabase server to AWS EC2

In the last few decades, many startup companies such as the Twitter and Animato have been observed to use the cloud computing services and build their systems which are scalable. (Elbahri et al., 2019). The services of cloud computing not only attracts the startups but it has been used by the large businesses in the form of cloud providers to market their services to the various in-house data centers.

The company which has been chosen in the current case is the SME which is based in UK that gives the various IT solutions for the industry of Oil and Gas. They have approximately thirty workers with different branches in the United Kingdom and the Middle East. They have the structure of an organization on the basis of their functions which includes the Administration, Engineering and support.

The migration includes the viability of the movement of the main service which is provided by an organization i-e the quality monitoring and data acquisition to Amazon EC2 (Wan, Duan and Wang, 2017). This comprised of three companies and their anonymous description is as follows; Company C is the small oil and Gas Company and they own some of the outsourced strengths in the oilfields of the North Sea. They need a data system which enables them to supervise their operation occurring at outsource to monitor their data from their assets in every single minute. Whereas the assets of company C is dependent on the production solutions and potentials of company A which is considered to be a major Oil Company. Hence the data comes from the company A with the help of communication links from the company A. But the company C cannot make their own systems of information technology because they lack behind in having the efficient systems. Therefore Company C has offshored their creation and supervision of their systems to the B which is considered to be an information technology solution and they have small data center.

4.7.1 **Overview of the current system**

The system which is uses in the cloud contains two servers which are mentioned below;

- A database server which is used to store and records it that comes from outsource into the DB storage system. Further the tape drive is being utilized to take the backups on a daily basis of the various databases.
- An application server which is hosting the data in a huge amount that is communicating and observing various applications. The customers of the organization C have the significant approach to the applications by utilizing the remote desktop customer with the help of internet.

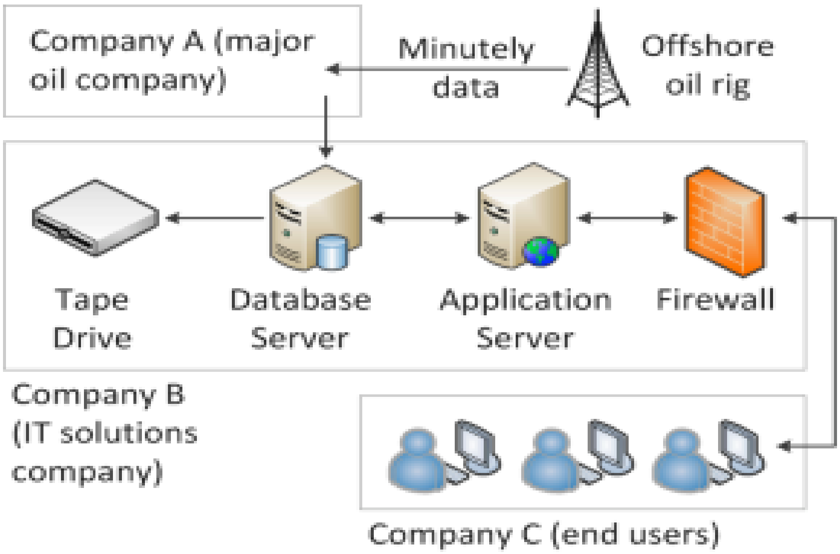

Figure 12: Overview of the system

The main challenge which occurs in shifting an enterprise systems to the cloud is the migration of their number of provisions and services. Migration of a large relational database from the physical infrastructure to the cloud includes a lot of problems and challenges such as the downtime system management, selection of a suitable infrastructure for the cloud, and selecting a cloud provider which best fits the system (Ahmad, Naveed and Hoda, 2018). The database can be developed and deployed on the cloud by choosing one of the service provider which is installed and configured virtually on the system.

4.7.2 **Methodology**

With the inclusion of logs and schema of the database, the database modeling level includes the workload model which well suits with the Structured Metrics Metrics model (SMM), structure model which is associated with the knowledge discovery model (KDM) (Khajeh et al.,2010). The case study includes the fieldwork which can be described in two stages as follows;

Stage 1: The infrastructure cost of the system are measured with the help of reports and invoices of the various projects. Then the comparison of this cost are done to the cost of the infrastructure of the similar setup on the Amazon EC2.

Stage 2: The problems of the system related to the maintenance and support are stored in the database of company B that the current system of company B supports. The database of the company B has been research manually and their support calls which have the potential to be affected by the migration is identified and examined.

Stage 3: The results from the above two stages are obtained to make a poster which is then distributed to the employees of the "B" Company to get views on Amazon EC2 as they are the only one who are familiar with the migration and technology which is used for that purpose. This is called the stakeholder analysis. This process is used to identify the valuable sources of several advantages and risks from the perception of the stakeholders. It consists of several steps which are mentioned below;

1- Identification of stakeholders
2- Identification of changes in various tasks which they need for the purpose of performing and how the performance would be done.
3- Identification of the consequences resulted from the changes with respect to the time of stakeholders, resources, abilities, values and satisfaction of the stakeholders.
4- Analysis of the changes by considering it in the wider context of various related factors which includes the association between every group and different person which is somehow connected or related to the stakeholder.

4.7.3 **Essential features of the cloud**

Cloud computing is the model which enables many on-demand network access to the pool which contains the number of resources such as the networks, servers, storage, applications and services. The typical cloud resources and their functionalities includes the storage, processing, bandwidth of network and virtual machines. According to the study Alruwaili and Gulliver (2018), it provides the number of characteristics which are mentioned below;

Broad network access- One of the most attractive characteristic include that the cloud resources are available everywhere in the comparatively reasonable prices and users have the access with any computing device.

Rapid elasticity- Cloud computing provides an appealing option which includes that the cloud provides an easy to use features and the resources lasts as long as the user needs them. It has enabled the users to scale their resources up and down in a short period of time, and it can be done automatically. This feature is not included in the traditional and any IT model which includes the hardware.

Resource pooling- due to the large pool of resources which the cloud provides users can easily share with other users of the cloud. The most preferable option for the pooling and sharing is to buy an entire server and then use the small fraction of the total capacity of the server.

On-demand- this feature implies that the user can provide the resources and they do not need to wait for the vendors to provide/ship the hardware. Many resources are available whenever the user needs such as the Storage, computing power, memory etc.

4.7.4 **Benefits of migration:**

Many organizations has migrated their traditional databases to the cloud and it benefits them in a lot of ways which includes that it gives them the opportunity to manage their income and outgoings for the staff and customers as well (Mhouti, Erradi and Nasseh,2018). The cloud infrastructure which is included in the migration as a third party provides facility of easy handling of resources to the finance analyst because the service model of the cloud involves the least cost and reduces the disbursement which was previously done on electricity. Cloud computing provides the benefit of giving enhanced flexibility and elasticity. Any new instance can be easily build using the sufficient resources to meet the requirements and demand of the customer. If the demand of the user exceeds the capacity which is given by the single machine then another machine is built in order to support it.

The cloud computing services has been largely used to control the disasters and achieve a useful strategy for the disaster recovery. With the help of cloud computing the whole virtual server can be used as a backup or it can be imitated to an off-site data center. The virtual server can be used to run on any virtual host within a span of few minutes (Ali, Harper and Mohamad, 2018). This provides the benefit that the data can be transferred in an accurate and safe manner in between the data centers and it does not even require the reloading of each and every server on an individual manner. Hence the disaster recovery is considered to be the cost-effective solution as well. In 2014, the Harvard Business review has conducted the survey which has shown that the business agility is the main factor in the businesses. It enables the businesses to respond to the demand of customers with high speed and accuracy which enhances their overall service. Thus they form the most satisfied customer base and reputation for the purpose of reliability and scalability.

4.7.5 Cloud architecture for migration

Cloud computing is nothing more than a collection of layers that work together to create a device in a variety of ways. The architecture of cloud computing is another name for this concept. The cloud provides a framework in which resources may be pooled and partitioned as needed. To provide consumers with an on-demand service, cloud infrastructure can be combined with software that operates in many locations on virtualized hardware (Portella 2019). A cloud can be established within an organization's infrastructure or outsourced to another data center. Cloud services are often virtualized resources, making it easier to adapt and improve them. A computer cloud requires virtualized storage to facilitate data staging and storage. Customers must believe that the services are infinitely expandable, that the service is measured, and that the pricing is calculated.

One of the most significant and popular areas of cloud computing is database management. Due to the massive growth of data, enterprises are facing issues such as resource optimization, coping with complex concurrency demands, addressing rapid storage growth needs, cost management, and a lack of support for underlying infrastructures that can dynamically distribute the necessary computing and storage capital for Enterprise's Bigdata (Iqbal 2019). As a result, the only realistic choice for a company is to deploy new technology. After demonstrating the various benefits of Database management as a service in cloud computing, memory and processing power are dispersed based on the computational capability available at the moment in elastic clouds. Many businesses are still unsatisfied with their security difficulties, and other businesses will have access to their information. There are several enhancements that may be implemented., in my opinion, but now is the appropriate moment to migrate to cloud computing. Many organizations, including some of the world's most prominent multinational corporations, have migrated to cloud computing because it is less expensive, more powerful, and more nimble than on-premise IT systems.

With the AWS Cloud computing paradigm, developers and IT teams can focus on what matters most, removing undifferentiated tasks like recruitment, maintenance, and power planning. As cloud infrastructure has grown in popularity, a wide range of concepts and implementation methodologies have emerged to meet the demands of different users (Sarah 2018). For each cloud provider and installation procedure, users have varied degrees of autonomy, flexibility, and administration. , Network as a Service and Software as a Service, as well as the many implementation methodologies available, may help users choose which set of resources is most suited to their needs.

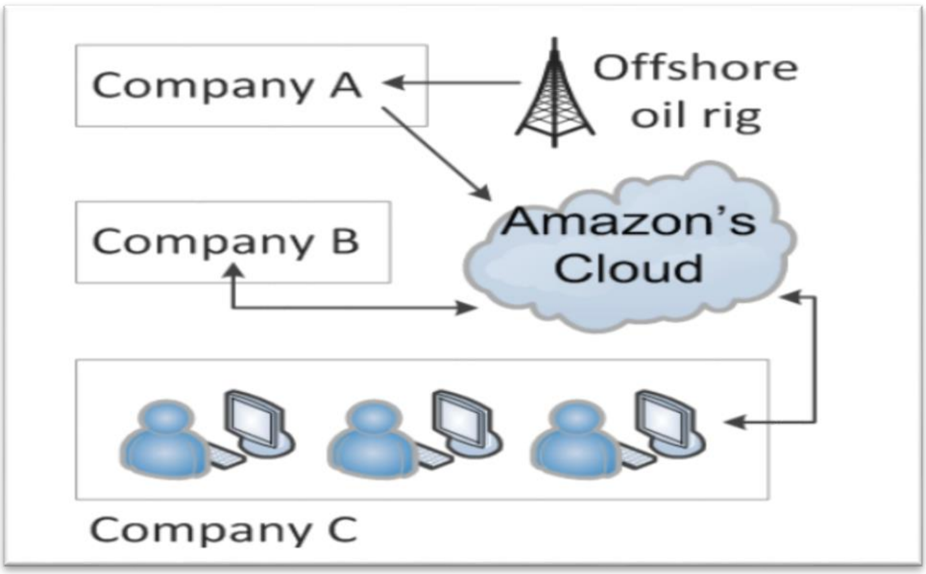

Figure 13: System Deployed in the Cloud

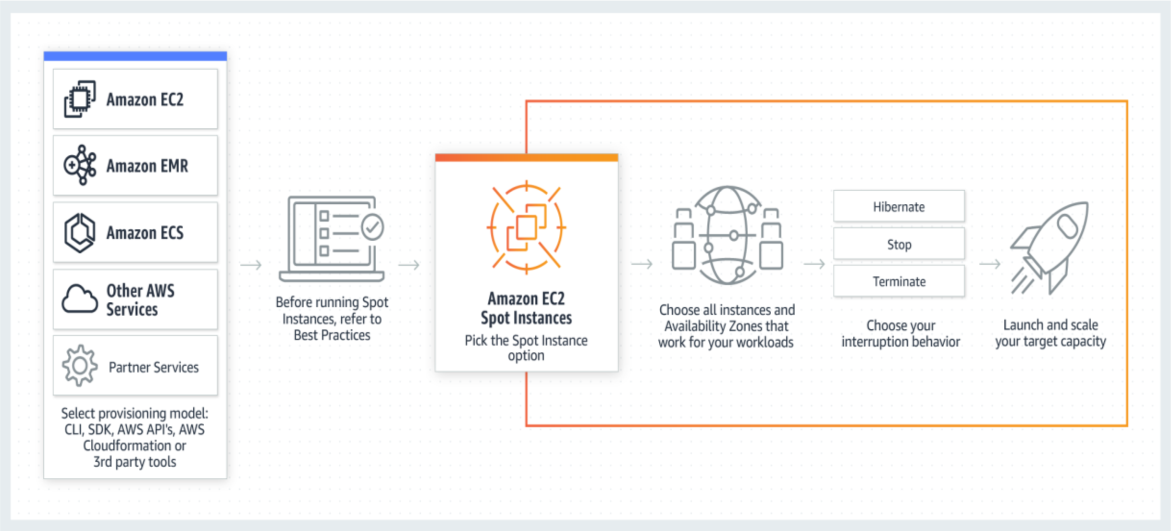

Figure 14: Overview of the system in AWS EC2

Including over 400 examples and a variety of computers, memory, connectivity, software platforms, and pricing models, Amazon Elastic Compute Cloud (EC2) is the most comprehensive and comprehensive compute platform available. Using Ec2 Instances reduces the requirement for upfront hardware investment, allowing one to create and deploy apps more quickly. Amazon EC2 allows users to create however many or as little virtualized resources as per the requirements, as well as establish safety and connectivity and process large amounts of data. Users can scale up or down on Amazon EC2 to manage variations in demand or traffic spikes, decreasing the need to anticipate traffic.

The situation is defined in the following way; Company C is a minor petroleum & energy firm with offshore holdings in the North Atlantic oil wells. Company C required a data capture system for managing their overseas activities by tracing from their facilities on a minute-by-minute schedule. Because Firm C's facilities rely on Company A's (a large oil company) manufacturing plants, the data is brought ashore via Company A's communication lines. Because Company C lacks the resources to construct its own IT infrastructure, it contracted the system's creation and management to Company B, an IT services firm with a modest data center.

The above figure shows that a database server stores data into the database which is received from the offshore oil rig. As seen a drive is used to store and backup data. The application server consists of data reporting and monitoring interfaces that the users use to operate the system. These applications are controlled by company C operatives to access data for monitoring.

The following figure shows the same process been done but this time cloud servers are used to develop and execute the same system using the cloud servers. All four processes from tape drive to the firewall are now done on the cloud server which enables efficiency and better performance.

4.7.6 Stages:

4.7.6.1 Stage 1: Infrastructure Cost

In the year 2005, company "C" has paid almost £104,000 to the company "B" for the purpose of establishing the system. Out of the total amount, 19,400 was used for the infrastructure of the system and the remaining amount was being utilized for the purpose of development of the system. The infrastructure of the system contained two servers and each server had two processors of Intel Xeon 3.4GHz, RAM of 2GB capacity, 6 hard drives of each 72GB in the RAID 10 array which provided the storage of about 200GB. The 2003 Operating system on the window system was used. Further the infrastructure of the system included the tape drive, tools and equipment for the network, rack of servers and various shelf spares. Moreover the "B" was receiving £43,000 amount by the company "C" for the purpose of maintenance and support. Out of which the running cost was approximately around £3,600 which was used for the infrastructure of the system. In the time period of 5 years, the total cost which was used for the infrastructure of the system was calculated to be £37,400 = 19,400 + (5*3,600). The company has noticed that some change was seen in the performance of hardware since 2005 and the perception was made that the cost should be minimized but in reality the cost remain the same over the time span. For instance the cost which was being utilized by the server in the "C" company had approximately cost around £4,525 in the year 2005. These servers cost around £4,445 in the year 2009 in the similar project.

Amazon EC2 has an option which gives the user to choose between the small and large instances of server on the basis of the power of CPU and RAM amount needed. In the initial phase the system can run on two small instances in the form of application and the database server do not appear to be used in the heavy load. But if the performance is not acceptable then this can be altered in the case of large instances. In the future this is not achievable with the help of already used approach because all the hardware should be purchased before the deployment of the system.

The below table shows the comparison of the cost used for the system structure in between the cloud and the data center of "B" company. The features which were utilized for the purpose of calculation of the costs of the system in running condition on AWS includes the on-demand instances of Microsoft windows was also running the whole time i-e 24 hours for 7 days. Further it includes data transfer which was entering and going out at 20GB, 200GB storage which was referred to be the storage used on the existing servers, I/O request of 100 million of EBS, snapshot storage at 30GB, GET request of 10 snapshots and PUT request for 30 snapshots.

Period	Amazon Server Instances			Cmpny B
	2 small	1 small + 1 large	2 large	
1 Month	£200	£390	£590	£620
1 Year	£2,400	£4,680	£7,080	£7,440
5 Years	£12,000	£23,400	£35,400	£37,200

Table 9: Comparison of cost between the cloud and data center of company

From the perspective of the "B", the cloud provides the good option to take the new orders and projects and they do not need to worry about the space available in their data centers because they do not have rack space and it is considered to be extremely expensive if they have to build the whole new building for their data centers. From the above table it can be seen that the company B can propose an alternative which is comparatively cheaper for the purpose of deployment in their in-house data centers for the customers.

On the other the "C" company, also called as the end-users or the clients they have the perception by looking into the data which is presented in the above table that the cost that is used to run the system in the cloud is comparatively cheaper than the data center of "B". For instance, in the future it would be cheaper by 37% in the cloud for the deployment of the system by assuming that both instances are involved. Moreover any type of capital is not needed in the cloud for the infrastructure system because users are paying money per month. However the valuable cost minimizations can be noticed at the significant level but the migration impact on the system's support and maintenance should have to be considered.

4.7.6.2 Stage 2: Support and maintenance:

Currently, the support and maintenance of the system are done by the support department of Company B and they perform the regular checks to check that the system is performing as per the expectations. Further the health check includes logs of error, logs of backup, levels of server loads, links of communication and many more. The “B” company checks the database of the support calls, and those calls were received through different medium such as the telephone and the emails. The calls can also be received from the customers or from the engineers which were executing the health checks on a daily basis. When the system was made live in the year 2005, 218 calls support calls were received related to the system operations. The majority of the calls were related to the problems regarding software but the title of the calls was recorded and 112 calls was selected for the investigation purposes. After the investigations, it was determined that below mentioned calls were received regarding the infrastructure of the system which is approximately 45 in number.

- Out of those 45 calls, 38 calls were associated with the problems related to the backup in between the server of database and tape drive. The most common issues which was noticed were the faulty tapes, number of attempts which was failed on the backup, and loose cables. The reason behind the loose cables was considered to be the continuous in and out of the tapes from the drive. However, these issues were fixed by removing the tapes, rebooting the tape drive and run the scripts of backup again. But sometimes, no backup was taken for the particular day.
- Then the 5 calls were associated with the problems related to the network. Out of those 5 calls, one call was about the need to reboot the router and the other call was about the wrong way of plugging the power cable.
- The 2 calls were associated with the power outages at the data center of “B” Company.

The calls which were previously mentioned had the potential to be eliminated if the deployment of the system can be done in the cloud because the Amazon would then be responsible for any problems related to the hardware.

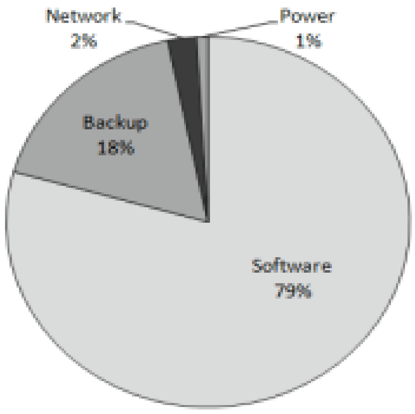

Figure 15: Support calls' overview

The above picture shows the results was approximately around 21% of the support calls. However, the additional calls can come from the results of the migration to the cloud. The problems associated with the cloud includes power shortages at the data centers of Amazon or the problems in delay of network. But the most significant point is that the Amazon would be responsible to dealt with all the problems. This is considered to be the biggest benefit from the perspective for the support department of “B” because it enables them to pay attention on the problems of software which is the main concern of the end users.

4.7.6.3 Stage 3: Impact analysis of stakeholders

The information from the interview suggest that the migration of cloud, which is currently proposed would be beneficial from the perception of development functions of the businesses and for the junior information technology support functions as well. However it would not provide any advantage to the project management and management functions of support of the venture. Further the technical manager and the support engineer had recognized the negative advantage.

The impact analysis of stakeholder put forward the several benefits but it also suggests some risk and challenges which are related to the migration of cloud system. As per the analysis, the biggest advantage which is derived from the cloud provides a chance to manage the income and outgoing in the new way. This has opened up the new opportunities which are used to offer new services/products, enhanced status of jobs, and elimination of monotonous tasks. The biggest source of challenge/risk will be resulted from the decline of client’s care and service quality, enhanced dependence on the 3rd party, reduction in fulfilling the work and enhancement in workload.

Benefits	#
Opportunity to manage income & outgoings	3
Opportunity to offer new products/services	2
Improved status	2
Removal of tedious work	2
Improve satisfaction of work	1
Opportunity to develop new skills	1
Opportunity for organizational growth	1

Table 10: Sources of benefit

Risks	#
Deterioration of customer care & service quality	3
Increased dependence on external 3rd party	3
Decrease of satisfying work	3
Departmental downsizing	2
Uncertainty with new technology	2
Lack of supporting resources	1
Lack of understanding of the cloud	1

Table 11: Sources of Risks

4.7.7 **Risks:**

It has been analyzed from the interviews that the infrastructure solutions provided from the third party gives the risk in terms of customer care and service quality. These risks were identified for the support managers, engineers and the staff of customer care. The high risk was identified in the support engineers and managers to be solely dependent on the provider of cloud services which they cannot control and they can need other various resources for the migration purposes. Further they have to deal with the various problems that comes from the migration such as the limitations in the operations of the cloud from the results of the tasks that are taking more time than usual to complete.

Moreover, the support engineers due to the limited knowledge requires more time to understand the process in order to perform the tasks in the environment of cloud and as a result it could influence the service quality and services of customers. The staff of customer care are also considered to be at risk because they are not being able to offer the services at the right time to the customers. The main reason behind is that it takes more time to solve the issues of customers because it is necessary to cooperate with the external providers of services. This has been identified as the risk as the response time to consider the issues of customer is increased and as a result back-logs occurs. Ultimately this will impact the satisfaction of the customer. Further while switching to external hosting reduces the possibility of customer lock-in in relation to the contracts of software support because now the hardware is managed at the external levels. So the company cannot offer the maintenance at one place and now they have to deal with multiple contracts.

4.7.8 **Summary:**

Cloud computing is considered to be the technology that is largely evolving in changing the deployment process of information technology systems as they are cheap and provides the scalable solution. In the above case study IaaS structure has been used and the results shows that the cloud computing is considered to be a comparatively cheaper solution as compared to the purchasing and management of the whole infrastructure system in-house. Further the cloud migration can resolve various problems related to the support because the cloud has no physical infrastructure which needs maintenance. The case study shows that 37% less cost would be seen over the time span of 5 years on Amazon EC2 and 21% of the support calls would be eliminated by adopting the cloud computing. It has several practical insinuations for the industrial associates by examining the number of advantages of the external infrastructure of the cloud for the businesses.

5. What are the advantages of cloud database and cloud computing bringing for all small and medium organizations?

Small and medium-sized business owners must save money and effort wherever possible to succeed. If the user a newcomer or a well-established company, cloud computing and services, in general, will help the user to save money and focus on their core competencies. While the benefits of cloud computing for small companies are enticing, this does not mean that it is without pitfalls or that it is suitable for all businesses. There are many cloud database service offerings to choose from, and when the user factor in all of the other cloud resources available, selecting the best vendor and services for user business needs is not an easy job. I'm referring to cloud computing in general because the advantages of DBaaS solutions are included in the cloud computing benefits. I'll start with the most important Benefits.

5.1 Benefits for small and medium organizations

Cloud computing saves time and resources for companies by increasing efficiency, enhancing teamwork, and encouraging creativity. Below further advantages that cloud infrastructure technologies will offer to small and midsize businesses.

- **Data accessibility:** Businesses use cloud storage to view information from any computer that can connect to the internet. Cloud computing collects data on the internet rather than on that computer or a disk in the office. Information is accessible via a single web-based hub, which allows those with appropriate credentials to access it from anywhere with an internet connection.

- **Cost-effective:** Buying and servicing server equipment necessitates time, expertise, and money. Rather than trying to handle the data on the user's custom device, which may be vulnerable to downtime, a cloud computing provider handles it for clients and eliminates any of the costs. Business-oriented cloud service prices are still a monthly expense, but they can be handled in a variety of ways.

- **Users have a consistent experience:** When a large number of individuals are working on the same digital material, it's simple for mistakes to occur. Data is quickly synchronized across all machines since cloud-hosted files are kept in the same central place, ensuring that users have access to the most recent version of information.

- **Remote programming is possible:** Businesses use equipment that is not widely used at home. Cloud storage helps users to view all kinds of files and programs as if they were in the workplace since advanced software is often mounted on business machines in the office. Cloud computing takes the workplace to the kitchen table by eliminating the obstacle of access for staff to use the services they're familiar with, regardless of where they are physical. (Iqbal S. , 2021)

- **Easy data backup:** Data failure that is catastrophic will occur at any moment. Businesses are more likely to declare bankruptcy in the same calendar year if data loss is caused by natural catastrophes, power outages, or hardware breakdowns. Despite the fact that most businesses have disaster plans in place, It is advantageous to have additional contingencies in place. When you keep sensitive material in the cloud, you need to be careful. Even if their hardware breaks, business owners can be confident that they will be safeguarded.

- **Staff savings:** People won't need to hire and maintain an in-house team to install and upgrade applications, manage email and file servers, or perform backups. The most important advantage of cloud computing simply pays a nominal monthly fee, and the cloud provider is responsible for running the service or program.

- **Hardware space savings:** People no longer have to handle their own network's program upgrades. Instead, they should store company data in the cloud and have confidential data on their hardware. In comparison, the machine can run more smoothly and effectively.

- **System hardware cutbacks:** On servers and laptops, file management, data backup, and software programs all take up a lot of room. Instead, for cloud storage, save the data on the vendor's servers.

- **Time savings:** Users don't have to waste time and resources updating cloud computing systems because they are maintained daily. This provides the advantage of still providing the most up-to-date capabilities and functionality of an application.

- **Less investment:** To begin using the cloud, all that is required is a computer and an Internet connection; most cloud services can be used without the need for new computers, advanced applications, or additional personnel. This is one cloud computing 63 benefit that appeals to everybody, regardless of sector or form of business. This encourages businesses, especially startups, to invest in new ventures and ideas without risking a significant loss.

5.2 Disadvantages of Cloud Computing

Although the advantages of cloud computing are self-evident and simple to comprehend, there are a few drawbacks that should be carefully considered.

Downtime: The fact that cloud computing creates downtime is one of the most prominent critiques. Since cloud computing services are internet-based, service outages are often a risk that can happen for a variety of reasons. (Turnbulle, 2021)

Security and privacy: Despite the highest security practices and industry certifications introduced by cloud service providers, storing data and essential information on external service providers still presents a risk. Any discussion of data must include protection and privacy considerations, particularly when dealing with sensitive data.

Security Threat in the Cloud: Another drawback to using cloud storage platforms is the security risk. Users should be mindful that once they use cloud storage, it will be exchanging all of the company's proprietary data with a third-party cloud computing service provider. This knowledge could be used by hackers.

Limited control and flexibility: Since the service provider owns, manages, and monitors the cloud resources, the user has very little leverage over them.

Cloud users can find that they have less control over the function and execution of services within a cloud-hosted infrastructure to varying degrees (depending on the service). The end-user license agreement (EULA) and management policies of a cloud provider may place restrictions on what customers may do with their deployments. Customers maintain control over their software, files, and resources but do not have as much control over their backend infrastructure.

Internet Connectivity: In cloud storage, secure Internet access is key. Users can't use the cloud if they don't have access to the internet. Furthermore, there is no other way to collect data from the cloud.

Lower Bandwidth: Many cloud storage service providers restrict their customers' bandwidth use. As a result, if the company exceeds the allotted budget, the extra costs may be substantial.

5.3 Things to consider when switching to cloud computing

Moving to cloud computing is very easy. Most of the service provider has thein way to help the client to start using to their service, including transforming to the new environment. Because nowadays there are many options for clients, few things must have to consider before moving to cloud computing.

Business Impact Analysis: To decide how this migration will affect the business, users must perform a business effect review of the program, if not the whole infrastructure. Starting with an application on which the company is heavily based is not a smart idea. Users must prepare for a shifting workload. Place the least important company program on cloud-first to obtain expertise. Email servers, intranets, and departmental software, for example maybe be the first to move to the cloud.

Performance matters: Users should avoid transferring any environment that requires a lot of data processing or applications that are extremely performance-sensitive. It's because if they have a problem with these demands, such as a longer answer time, the user will lose the company.

Security: Before transitioning to the cloud, make sure that the cloud service provider has appropriate security protocols in place. Are there any regulations or data protection restrictions that cloud service providers should adhere to?

Future Migration Needs: Consider what will happen if the user decides to relocate the environment to a new cloud server vendor in the future. Moving from one cloud system to another is not as easy as relocating a physical office.

Internet Bandwidth and Reliability: The internet bandwidth standards and service efficiency are two of the most important yet mostly underestimated facets of cloud migration. It's vital because once users transfer their IT technology to the cloud, the user will become fully reliant on the cloud service provider. As a result, the dependability of the cloud service provider is essential. To assess a service provider, users must consider the number of users in the business, the quality of the job, and their position. To use the service, they must inquire with the Cloud service provider about availability and bandwidth requirements.

Cost and Return on Investment: A well-thought-out cloud migration should still be focused on the cost of migration, which should require vendor costs for the first three years. However, users must first examine their infrastructure so they might be able to cram diligent life augmentation or third-party guarantees into the budget, allowing the company to properly plan for the future and prepare for relocation**.**

Business Continuity and Disaster Recovery: Before starting the cloud transformation, think about the disaster recovery plan to maintain business continuity.

- What is a good contingency plan if a life cloud service goes down or suffers a disaster?
  What is the approach for coming out of the crisis it sss important User must understand an outage and when financial sanctions can be imposed in such a situation? Many of these details should be covered in the service-level agreements (SLAs).

Licensing: Users must analyze the vendor's cloud to decide if moving from this dedicated model will be expensive in the future. Vendors and cloud service providers can have different licensing and user terms and conditions. As a result, In the case of an emergency, it can still verify if the distributor requires them to run several copies under the same license.

Check for hidden costs: With so many products available today, it's difficult to normalize the choices and make a reasonable distinction. With a little analysis and evaluation tools like those on Compare the Cloud, users can compare features and capabilities. However, providers vary not just in technology but also in prices and ling processes.

5.4 Would cloud computers will help users to save money?

Small to medium businesses face fierce competition in the global sector as technology progresses and multinational corporations expand. Companies must make the most use of their resources to succeed in this dynamic environment. Applying their savings in such a way that they can preserve the consistency of their goods or services while paying as little resources as possible, and a new estimate to reduce these costs, With that to provide services as physical computational infrastructure in company, first and foremost, energy, maintenance, updating, and security costs, as well as mobility to use or service from any location, being sufficient for internet communication, and paying only for the hair to wear. Cloud computing has the potential of lowering hardware costs. Rather than purchasing hardware in-house, hardware requirements are left to the vendor. For firms that are fast developing, new hardware may be a large, costly, and uncomfortable investment. Since data can be acquired rapidly and conveniently, cloud computing addresses these challenges. Far further, the cost of equipment maintenance or upgrade is passed down to the vendors. Off-site hardware reduces internal electricity costs and saves space in addition to the sales price. Large data centers will use a lot of office space and generate a lot of heat. Moving to cloud apps or storage will help save space while still lowering energy costs. Cloud systems can also reduce labor and infrastructure costs significantly. There is less demand for in-house IT workers as a result of suppliers owning the hardware and keeping it off-site. The vendor must fix or update servers or other hardware, and it does not cost the business any time or money. Routine maintenance can be removed, allowing IT employees to focus on more important activities and development. This may also indicate a reduction in the number of staff in some cases. Companies who do not have the financial resources to engage an in-house IT team will profit from the cloud, which will save them money on third-party hardware upkeep. Cloud computing can be particularly cost-efficient- due to the growth in staff efficiency, and in addition to the direct labor, Cloud computing rollout is much easier than standard software installation. Instead of taking weeks or months to install applications, Employees will be able to spend less time waiting and more time working as a result. Cloud systems also reduce the time it takes to adopt them. SaaS programs are usually accessed via a web browser and are simple to read. A whole organization, cloud software can be installed in a matter of hours. Finally, with an internet connection, most cloud computing and web systems are accessible from everywhere. This is fantastic news for companies that have developed travel or telecommuting strategies. Loud systems are usually available on a pay-as-you-go basis. In a lot of ways, this format saves money and allows users more choices. First and foremost, the business is not obligated to pay for equipment that isn't being used. Unlike a traditional license, cloud computing is usually charged per account. Furthermore, pay-as-you-go apps can be canceled at any time, lowering the financial cost of software failure. Finally, the cloud has a smaller initial cost than in-house solutions. Cloud platforms have great versatility for enterprises who need top-tier goods but don't have a lot of cash on hand right now.

6. Conclusion

Database and server management is one of the important part and most popular aspects of cloud computing. Enterprises are facing problems such as optimizing resource allocations, coping with complex concurrency demands, addressing rapid storage growth needs, cost management, and a lack of support for underlying infrastructures that can dynamically distribute the necessary computing and storage capital for Enterprise's BigData due to the massive growth of data. Because of that, the only viable option is for an enterprise to implement emerging technology. Database management in Cloud computing is one field that is having a significant effect on how BigData is handled, deployed, and used. Cloud computing offers a modern way to deploy BigData in the enterprise. It provides an Enterprise with technology that is dependable, scalable, cost-effective, self-regulating, and QoS assured. Infrastructure as a Service (IaaS), Application as a Service (PaaS), and Software as a Service are both open to companies today (SaaS). Memory and processing power are distributed depending on the computational capacity available at the time in elastic clouds, after proving many advantages of Database and server management as a service in cloud computing. Many businesses are still unhappy with their security problems, and other companies will have access to their data accessibility of data. There are still a lot of them, in my opinion, improvements that are not done, but this is the right time to move to cloud computing. Many businesses, including some of the world's largest multinational firms, have also switched to cloud computing because it is less expensive, more powerful, and more agile than onsite IT systems. As a result, small and medium-sized companies would follow suit. If cloud computing has proved to be effective for these large corporations, it will undoubtedly be successful for small and medium businesses.

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8. Appendix

8.1 Amazon RDS – Case study

Blackboard provides cutting-edge education technologies and services that allow millions of people to learn in classrooms, universities, and businesses around the world. Blackboard Learn, the company's flagship offering, is a robust learning management system that comes in three flavors: on-premises, hosed and professionally operated software as a service (SaaS).

That’s why it chose to migrate to the open-source PostgreSQL database running on Amazon Relational Database Service (Amazon RDS). This required an initial investment to carry over optimizations from one platform to another, but the company expects the move to pay off by eliminating licensing fees and reducing management overhead. “In a managed-hosting environment, when the database goes down, it requires manual intervention, and it’s a major event,” says Reinhold Staudinger, chief architect at Blackboard. “With Amazon RDS, it’s handled automatically. That will drive our total costs down significantly over time.” (Staudinger, n.d.)

Adopting Amazon RDS has provided additional advantages beyond cost savings. When the company wanted to offer customers read-only access to real-time data, it found that Amazon RDS already had the feature built-in. Staudinger says, “Using Read Replicas in Amazon RDS, we empower customers to access transactional data without significantly increasing our computational workload.” (Staudinger, n.d.)

8.2 Microsoft AZURE – Case study

Xerox Corporation ported an on-premise enterprise print capability to a public cloud environment. This capability allowed mobile users to find printers with their smartphones and route printouts. As the on-premise version leveraged Microsoft SQL Server for the database component, Xerox selected Microsoft SQL Azure for cloud storage. This approach allowed them to reuse their prior investments in SQL Server-based technology and .NET and minimize the technical challenges of porting a cloud-based environment.38 They were also able to minimize their skills-based challenges because the development team was trained on Microsoft products. Xerox used SQL Azure for “user account information, job information, device information, print job metadata, and other such data," but the actual print files were stored in Azure Blob Storage, not SQL Azure.39 Azure Blob Storage had different pricing and characteristics than SQL Azure. For example, unlike SQL Azure, Blob Storage was not limited to 10 GB (Web edition) or 50 GB (Business edition). (The family of SQL cloud databases providing flexible options for application migration, modernisation and development, 2020)

8.3 MongoDB- Case study

Barclays is a transatlantic consumer, corporate, and investment bank offering products and services across personal, corporate, and investment banking, credit cards, and wealth management. To replace three decades of relational databases in numerous use cases throughout the bank, Barclays built a Centre of Excellence for its non-relational database of choice: MongoDB. The CoE was created in a strategic partnership with MongoDB to help to drive adoption and define best practices across its global organization. Barclays already sees increased agility, scalability, and cost-efficiencies from this transformative project. (MongoDB, 2018)

8.4 Amazon DynamoDB – Case study

"When IMDb launches features to our over 110MM monthly unique users worldwide, we want to be prepared for rapid growth (1000x scale) and for customers to use our software in exciting and different ways," said H.B. Siegel, CTO, IMDb. "To ensure we could scale quickly, we migrated IMDb's popular 10 star rati1startedem to DynamoDB. We evaluated several technologies and chose DynamoDB because it is a high-performance database system that scales seamlessly and is fully managed. This saves us a ton of development time and allows us to focus our resources on building better products for our customers while still feeling confident in our ability to handle growth." (Fast, flexible NoSQL database service for single-digit millisecond performance at any scale, 2020)