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Cloud Computing Services for Mobile Applications

Dr. S. T. Patil, Swarom Muley
Professor, Vishwakarma Institute of Technology Pune, Maharashtra, India
Student, Vishwakarma Institute of Technology Pune, Maharashtra, India

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ABSTRACT
Mobile applications are now dominating the marketplace, and the ease with which users can install and use the applications has also increased. To solve the problem of back-end infrastructure not being to handle high amounts of traffic generated by worldwide audiences, mobile developers now use cloud computing technologies. There are different options available in the market. In this research paper, we will go through the cloud service providers like AWS, Google Cloud, Oracle Cloud, and Microsoft Azure Cloud and compare their offerings.
Keywords— Cloud Computing, iOS, Android, Compute, Storage

I. INTRODUCTION

Due to the massive surge of mobile devices available in the world, there have also been a large number of mobile applications that are being developed for app stores like the Apple App Store and Google Play Store. These available applications are not just working locally but are also connected to servers to retain user information and provide services that users demand. This phenomenon has increased the loads on servers and as a result, traditional data centers fall short of being able to handle such high amounts of traffic.

As a result, there has been an increasing demand for cloud services, where the developers don't need to worry about the underlying infrastructure, like servers, database machines, etc. Instead, third-party vendors like Google and Microsoft can handle that task.

TABLE I
AVAILABLE CLOUD SERVICE PROVIDERS

Serial Number	Provider	Name
1		Microsoft Azure Cloud [1]
2		Google Cloud Platform [2]
3		Amazon Web Services [3]
4		Oracle Cloud [4]

In this paper we will go through the various services provided by these providers that facilitate developers and allow them to build applications, without

worrying about the undifferentiated heavy-lifting which is required for managing software infrastructure.

II. LITERATURE REVIEW

There are different ways to create mobile applications along with ways to create back-end infrastructure to support the applications. We will look at some of the types of mobile applications that are created.

There are two major operating systems for which mobile applications are created the first one is iOS applications and the second one is android applications. iOS applications are developed for the Apple App Store, while on the other hand Android applications are created for the Google Play Store, but users also can side-load the applications on their mobile phones.

A. Android

Android operating system is the open-source operating system introduced by Google on 23 September 2008. The operating system of 2022 is the most popular operating system in the world, with 43% of the market share in the global market [5]. The operating system is based on the Linux Kernel.

Applications to Android can be submitted via the Google Play Store, or as mentioned earlier users can side-load applications to avoid downloading applications through the Play Store, or any other stores present on the machine.

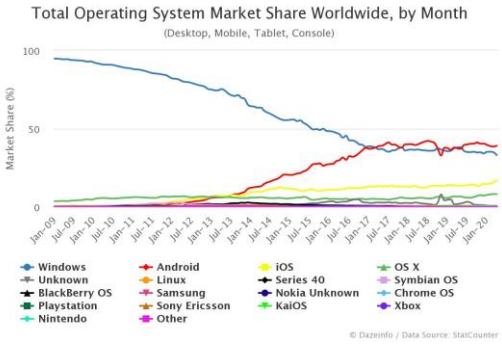

Fig. 1 Market Share of operating systems.

B. iOS

The iOS operating system is a proprietary operating system developed by Apple and introduced to the world on 29 June 2007. The operating system is the 3rd most popular operating system in the world with a 14% market share as of September 2022. The operating system is based on OSX, which is the desktop operating system also developed and managed by Apple.

Fig. 2 iOS initial version.

C. Google Play Store - Apple App Store Comparison

Apple App Store and Google Play Store are two distribution modes for developers to release their apps on mobile devices. It's mandatory to release applications on the Apple App Store for iOS devices, but since Android is open source, there are alternate methods or stores available for distribution. For example, Korean smartphone manufacturer Samsung has its store.

TABLE II

DISTRIBUTION COMPARISION

Serial Number	Logo	Store	Mandatory
1		Apple App Store	Yes
2		Google Play Store	No

III. CLOUD SERVICE PROVIDER COMPARISON

Each Cloud service provider has some basic functionalities that provide developers with infrastructure as a service. These components include

1. Computation
   a. Raw Compute
      i. Virtual Machines
      ii. Bare Metal Machines
   b. Container Management
   c. Functions as a service.
2. Storage
   a. Relational Databases
   b. NoSQL Databases
   c. Blob Storage (Object Storage)
3. Security
   a. Security rules
   b. Virtual VPN
4. DevOps Solutions
   a. Jenkins Management

Fig. 3 Google Cloud Services Overview.

A. Computation

Every cloud service provider has a computing platform through which developers can either rent virtual machines, use bare metal machines, or even directly use functions as a service platform. Functions as a service allow developers to only focus on the code and the cloud service providers manage everything else.

1. Raw Compute

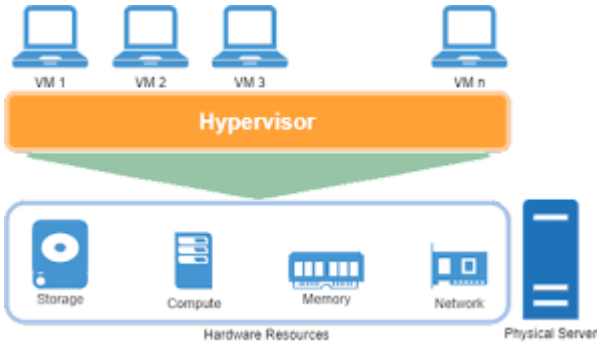

Fig. 4 Virtual Machine Diagram

A Virtual Machine (VM) is a compute resource that uses software instead of a physical computer to run programs and deploy apps. One or more virtual "guest" machines run on a physical "host" machine. Each virtual machine runs its own operating system and functions separately from the other VMs, even when they are all running on the same host.

More recently, public cloud services are using virtual machines to provide virtual application resources to multiple users at once, for even more cost-efficient and flexible computing.

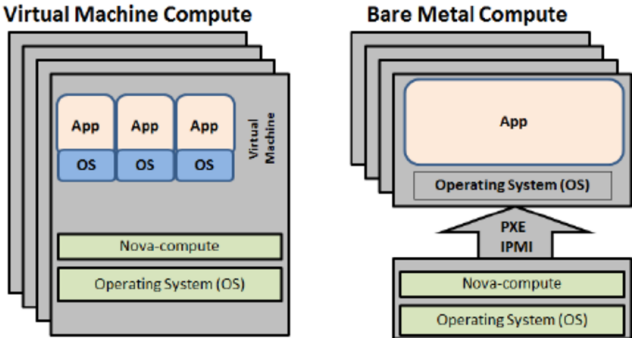

Fig. 5 Bare Metal vs VM Comparison

Bare metal servers are single-tenant servers that avoid virtualization, and clients can directly rent machines instead of having to go through the process of VMs. Bare metal machines have enhanced security because only a single tenant is possible on a single machine. There are no virtual agents on the machine. Bare metal machines are perfect for high-performance, latency-sensitive, specialized, and traditional workloads.

TABLE III

SERVICE OVERVIEW

Virtual Machines	Azure VM's	Compute Engine	EC2	Oracle VM
Bare Metal	BareMetal	Bare Metal Solution	EC2	Oracle BareMetal

2. Container Management

Over the last few years, containers have been increasing in popularity. This is a layer on top of virtual machines. This means on a single virtual machine multiple containers can be running (for example a macOS base machine can run Windows as well as Linux containers).

Docker is a software platform that allows you to build, test, and deploy applications quickly. Docker packages software into standardized units called containers that have everything the software needs to run including libraries, system tools, code, and runtime.

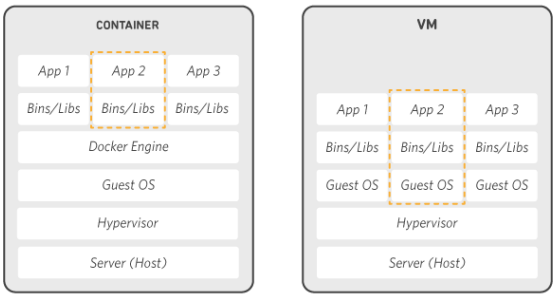

Fig. 6 Kubernetes Architecture

Docker works by providing a standard way to run your code. Docker is an operating system for containers. Similar to how a virtual machine virtualizes server hardware, containers virtualize the operating system of a server.

AWS services such as AWS Fargate, Amazon ECS, Amazon EKS, and AWS Batch make it easy to run and manage Docker containers at scale.

This flexibility allows developers to package applications and various dependencies that they have. But running individual containers is not the most efficient way to accomplish the task. As a result, multiple container orchestration platforms have been

developed. For example, Google has its own internal container orchestration platform called Borg [7] .

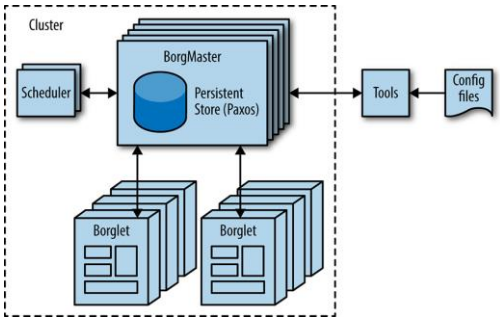

Fig. 7 Google Borg Diagram

Google has also developed an open-source container orchestration platform called Kubernetes which is extremely popular and is adopted by most organizations. As a result, it's also a valuable addition to the Cloud Service Providers.

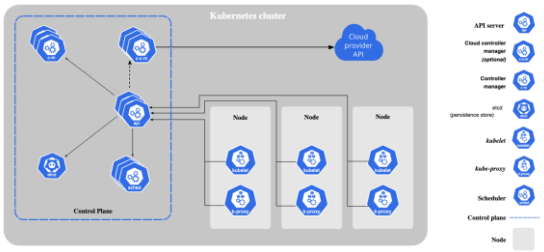

Fig. 8 Kubernetes Architecture

There are multiple managed Kubernetes platforms available, for instance, Amazon has Elastic Kubernetes Service, and RedHat has OpenShift. Microsoft has Azure Kubernetes Service & Google Cloud has Google Kubernetes Engine.

3. Functions As a Service (FAAS)

Functions as a service category of computing were first pioneered by Amazon Web Services when they introduced a service called AWS Lambda. In AWS Lambda developers only need to focus on the code, all the provisioning of appropriate resources will be managed by Amazon. This was essentially the birth of serverless development.

Developers need to select a runtime environment, the available choices for AWS Lambda are Python, Java, NodeJS, Golang, and .NET Core. It's also possible to run containers on Lambda. So developers can directly upload a container image, which will be appropriately evoked when a trigger is called.

Fig. 9 Kubernetes Architecture

Functions as a service or serverless development are useful for the following use cases

1. Processing data at scale
2. Running interactive web and mobile applications.
3. Gaining and enabling powerful machine learning insights
4. Creating event-driven mobile applications.

In 2022 almost all cloud computing service providers including Oracle, Google, and Microsoft provide functions as a service.

B. Storage

1. Relation Databases

It is of course possible to run open-source databases like MySQL, PostgreSQL, or even licensed databases like Oracle in Virtual Machines, this gives you more flexibility with how they operate. But the downside is that they are expensive and harder to maintain. This is why every cloud service provider offers a managed database service for relational databases.

Amazon provides RDS (Relational Database Service), which is a managed database service that can completely alleviate the load of managing, upgrading, and patching databases. RDS offers support for a variety of open-source and licensed databases including

- Open Source
  - MySQL
  - PostgreSQL
  - MariaDB
- Licensed Databases
  - Oracle
  - Microsoft SQL Server
  - Amazon Aurora (MySQL and PostgreSQL compatible) [9]

Similarly, all other cloud service providers have a managed relational database service. Google Cloud also has Cloud Spanner [10], which is highly scalable (unlimited scale), has strong consistency, and has 99.999% availability.

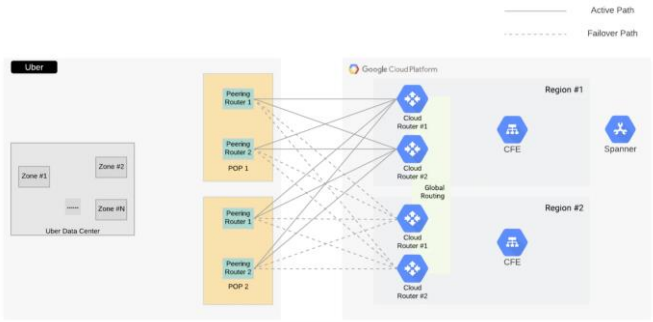

Fig. 10 Cloud Spanner Uber use case [11]

Uber handles millions of transactions per second, and it needs to have highly consistent data, hence they leverage the Google Cloud Spanner database, which allows them to run high-performance transactions with strong consistency across regions and continents. They are also able to manage zero scheduled downtime and the table schema can be changed live in production (online)

2. NoSQL Databases

NoSQL databases have been increasing in popularity over the last decade due to their flexibility and fewer restrictions on the schema because they have an unstructured schema.

Every cloud provider has it's own separate offering of managed NoSQL databases and some also offer some open source alternatives like MongoDB.

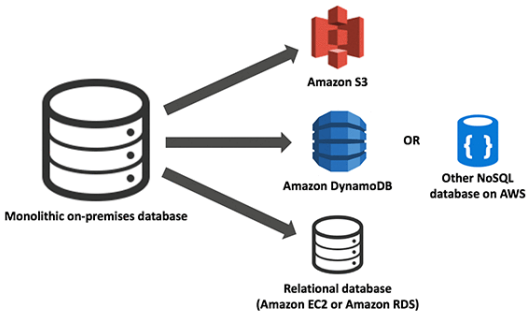

Fig. 11 AWS Database services example [12]

AWS offers it's own highly scalable global NoSQL database called DynamoDB. Google offers two NoSQL databases they are Google Cloud Firestore and Google Cloud Datastore.

3. Blob Storage (Object Store)

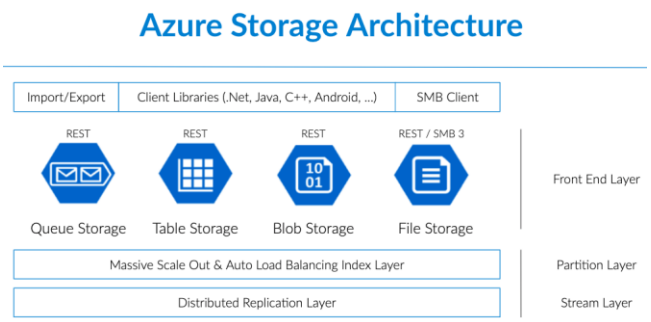

Fig. 11 Azure Storage Architecture

Blob storage or object store is ideal for storing unstructured data. For example, a developer might need to store video or image data for an application. Traditional SQL or NoSQL databases are not ideal for storing this type of data. Hence cloud service providers offer a service called object storage. Every cloud service provider has this offering, for example, AWS has S3 Object Store and Microsoft Azure has Blob Storage. There are additional services built on

top of these offerings like the capability to create Data Lakes to analyze data.

In object storage, there are different types of tiers available for storing hot or cold data. For instance, think of an application that simply backs up a user's files on a mobile phone. Files get uploaded and synced at regular intervals (frequently) but the data retrieval rate is a lot lower. Hence it might make sense to make use of storage services like AWS Glacier archival tier, which costs $1 per Terabyte per month. [13]

IV. Conclusion

For mobile developers, there are now multiple choices for IAAS (Infrastructure As A Service) and even PAAS (Platform As A Service). Every cloud service provider can provide developers with the resources such that they can safely develop and deploy applications and let organizations like Amazon Web Services or Google Cloud Platform handle the undifferentiated heavy lighting.

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