Cloud Computing: An Overview

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Abstract—**Ever since Amazon launched its first cloud platform in 2006, cloud computing has been a major field in networking nowadays. Many switch to cloud for its multiple uses and benefits. This paper aims to give an insight about the three most popular cloud platforms which are Amazon Web Services, Microsoft Azure and Google Cloud with comparison of each platform. This paper also presents how programming can be done via these cloud platforms.**

Keywords—Cloud computing, Amazon Web Services, Microsoft Azure, Google Cloud

I. Introduction

The growth of technology over the decade has witnessed a rise in the use of cloud computing within the computing industry. Cloud computing (CC) refers to the supply of Information Technology (IT) resources such as databases, storage and power when needed by users [1]. They operate using servers which are located in different parts of the world. Compared to the traditional ways of maintaining these resources in physical where they require space and staff, users only treat them as if they are software. Cloud computing allows users to use and pay for the services up to the amount that is required. Many businesses use cloud to deploy their services via the Internet for wide range of uses, like maintaining a website and storing customers' data in the databases.

Cloud computing has numerous advantages that makes it the choice of most people nowadays. Its flexibility of letting users use only what is needed saves their expense [2]. Users do not need to employ, upgrade and sustain physical hardware, leaving the work to the providers. In this way, users can save on variable expenses, the expenses that change depending on the use of the assets. Next, cloud computing offers a lot of tools and technologies that enable users to build things faster and easier. Just name it – storage, Internet of Things (IoT), analytics – cloud has them all. Furthermore, cloud lets users to allocate only needed number of resources at that time. There is no such thing as under- or over-capacity. As the needs grow, so as the capacity of the resources. Users have the freedom to add or reduce them. Lastly, going global over the Internet is as simple as a click away with cloud. Since the data centers are spread across the world, users' application can be installed and accessed by people around the world.

Despite the strengths of the cloud computing, it is no denying that cloud has its own weaknesses too. As mentioned by S., Eloff and Smith [3], security is the main concern. Many users doubt whether these technologies are as secure as claimed, as the location of data centers in certain countries of the world may cause them to be applied laws regarding the use of the machine. For example, data stored in US computers may be accessed by the American governments due to them being subjected to the jurisdiction of the U.S Patriot Act. Other than that, there has also been multiple instances of cloud services undergoing power outage where the providers become inaccessible. This has happened to large services such as Google and Amazon [4].

This paper presents an overview of cloud computing along with how the programming languages are supported on cloud. The paper also contains examples of cloud programming and a comparison of three most popular cloud platforms; Amazon Web Services (AWS), Microsoft Azure and Google Cloud.

II. Cloud Computing Development Environments

Development environments refer to the implementation of the cloud computing. In this section, we will discuss the three most common types of cloud computing development environments, public, private and hybrid cloud [5]. It is important for users to know the differences between these three environments before deciding to use cloud.

A. Public Cloud

Public cloud allows user to access the services offered using their browsers, as long as there is an internet connection. It is a pay-as-you-go service, which ensures the services to be fully utilized for the cost. Public cloud usually provides huge storage compared to the other types. This offers maximum scalability, letting users match the services with their needs at the moment. However, since it is public, service providers will have full control over them. This may cause security concerns such as information leaks.

B. Private Cloud

Private cloud is usually used by a single organization residing behind firewalls. Organization used it to only permit their authorized users to access it, ensuring complete control over the security. Private cloud is used by many companies as they might need to keep private documents or assets related to the company. Aside from the security freedom, private cloud also allows complete control over the choice of hardware and software [6]. The downside of private cloud is it requires higher cost in terms of set up and maintainability when compared to public cloud.

C. Hybrid Cloud

Hybrid cloud is a combination of public and private cloud in addition to on-premises infrastructure [7]. The integration of these three together will produce a distributed type of computing environment. Two categories of hybrid cloud are available, which are traditional and modern. Traditional hybrid cloud involves converting company's on-premises infrastructures to public cloud and linking them to public cloud providers. Modern hybrid cloud does not require physical facilities much, rather it provides support for work deployment across all platforms.

III. Example of Cloud Computing Platforms

There are several leading cloud platforms offered by providers to users.

A. Amazon Web Services (AWS)

Amazon Web Services started its operation in 2006 [8] making it the oldest cloud platform to be available now. Millions of loyal customers have been using AWS as the development of cloud technology has grown more over the past few years. The whole public cloud infrastructures are half accounted by AWS with a massive percentage of 47.8%, compared to their other competitors such as Microsoft (15.5%) and Google (4%) as reported by Stamford [9]. The four key features that distinguish AWS from the other services are flexibility, cost, scalability, security and experience [10]. Firstly, flexible in AWS practically means everything in AWS is allowed to be flexible, from the first stage of planning until the deployment process. Worrying about the cost that may come out as a result of the usage of these cloud services? AWS leaves the matter to its user to wisely decide on the number of resources they want to consume without having to concern about underspending or overspending. The same thing also applies in terms of scalability, where these services can be scaled up and down based on the needs of the user. When it comes to the security of AWS, the platform has always prioritized their users' privacy. Lastly, AWS has a level of experience different from other platforms when it comes to cloud. More than a decade of running the platform has made AWS build top notch infrastructures to satisfy users' needs. Some of the services provided by AWS are:

- Elastic Compute Cloud (EC2). EC2 acts as an instance launcher for application, enabling users to run their resources on cloud. There are many instance types to choose from, ranging from memory to communication. This is a pay only for what resources you use type of service.

- Simple Storage Service (S3). S3 provides storing solution for huge items. It allows write, read and delete function to be made. A bucket is used to store an object and contains a key in order for the object to be retrieved.

- DynamoDB. DynamoDB is a NoSQL-type of database for storing and retrieving data via Solid State Drives (SSDs). It makes a copy of the data and spreads them across three Availability Zones. The service is designed to handle high request and traffic so that it is reliable enough for users.

B. Microsoft Azure

Azure has its datacenter deployed across 19 regions with additional two regions being in China [11]. When using Azure, organizations will only be given hardware by Microsoft, so they do not need to worry about the architecture much. Like AWS, Azure also provides a wide range of services for computing, storing, networking and other functions. Azure can be used for a lot of things [12]. Due to its flexible nature, it can be a disaster recovery tool. Data can be backed up across all platforms in any language and location. If one data center went down, data in other centers will still be accessible. Next, it can be a platform for both web and mobile hosting. Azure provides management for virtual machines so that user does not need to figure out their infrastructures. A built-in feature, AutoScale is also available for managing incoming traffic so that the server would not go down by automatically modifying the resources based on the traffic. Furthermore, Azure also provides solution for

companies implementing IoT. Azure IoT Hub an IoT management solution to keep track of these devices. It is an all-in-one as it also provides security, maintenance and analytics. Some services offered by Azure are:

- Azure Virtual Machines. It is an equivalent of EC2 in AWS where server can be deployed in the datacenter through Virtual Machines. The instance is known as Virtual Machine (VM). User can configure VM by themselves, from installation until maintenance.

- Blob storage. The service lets users to store files of various types such as pictures. These files can then be accessed from anywhere using the provided link, interface or storage client libraries. Block and page blobs are two types of blobs supported by this storage. Block blobs support common file upload for a maximum size of 200 Gigabyte (GB). Page block is for storing random-access files, limited for files under 1 Terabyte (TB) in size only.

- Azure SQL Database. With this service, user does not need to care about physically retaining the database as only logical management is needed. It can perform basic SQL operations such as data entry and retrieval.

C. Google Cloud

Google launched its first cloud service in the form of Platform as a Service (PaaS) in April 2008, known as App Engine [13]. It is a platform for building web and mobile application. At first, App Engine does not support many programming languages, however as it continuously develops, most programming languages are now allowed. A wide array of services is also offered for different functions. There are a lot of services by Google Cloud for the benefit of users, and here are some of the most popular ones:

- Compute Engine. An Infrastructure as a Service (IaaS) type, Compute Engine lets user set their virtual machines on cloud to run their resources. This includes designing the architectures such as auto scaling and load balancing the application [14].

- Cloud SQL. Cloud SQL is a relational database management solution for data storage and retrieval tasks. Similar to Azure's SQL database, user only needs to handle the logical part and leaves the rest to the platform for configuration.

- Cloud Endpoints. This service is used for generating RESTful services for clients to access it, specifically Android, iOS and JavaScript. Other Google Cloud built in services such as OAuth 2.0 support is also integrated.

IV. EXAMPLE OF CLOUD PROGRAMMING

In this part, we will take a look at some examples of cloud programming that can be done using the cloud platforms services.

A. Using AWS

For first time beginners programming using AWS, Lambda console is a good start for creating simple code, such

as a Hello World program. The steps to create a Hello World program would be as followed [15]:

1. Inside the AWS console, search Lambda. Lambda will be used to create a function.

2. Click on the Lambda function and a list of blueprint options will appear as shown in Figure 1. These blueprints provide design plan for users to decide on the functionalities and vary according to the chosen programming languages of user.
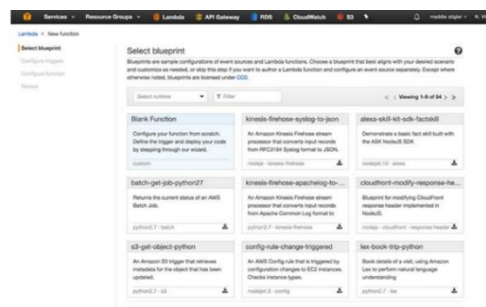

Figure 1. List of blueprint options

3. Select a blank function to be configured. The name, description, runtime, handler and role will be decided by user. Once assigning the first three items, the configurations will look like Figure 2 below:
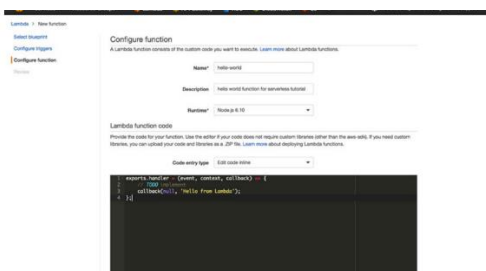
Figure 2. Function configuration

4. Set handler and role to index.handler and lambda_basic_execution, respectively.

5. The handler and role should look like Figure 3 below:
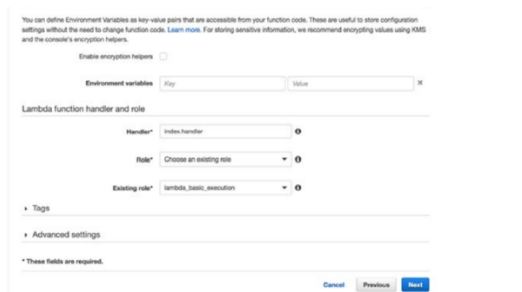
Figure 3. Handler and role

6. Before executing the function, it needs to be tested. Firstly, the test event (e.g keys) needs to be configured. A sample is also provided by AWS as displayed in Figure 4 below:
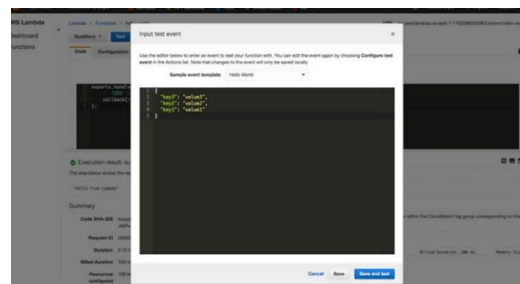

Figure 4. Sample test event

7. The test event is used to get the Hello World response. Click on Save and Test. Then, the result will be shown as below in Figure 5. Since the code is written to execute 'Hello from Lambda', then the output will be 'Hello from Lambda' as well:
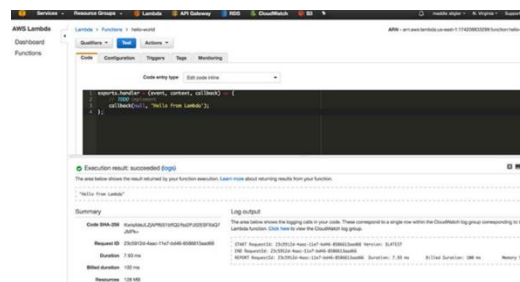

Figure 5. Test result

B. Using Microsoft Azure

The Hello World function will also be built using Azure services to demonstrate programming on Azure cloud. Through the Azure portal, do the following [15]:

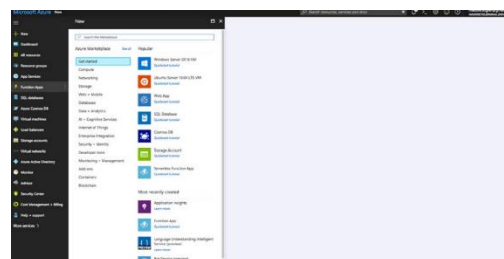1. Click "New" button, choose Compute then navigate to Function Apps, and click any subscription.

Figure 6. Function Apps in Azure

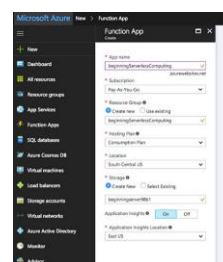2. Fill out the form with details such as in Figure 7 below and click Create:

Figure 7. Function example

3. User will be redirected to the Function Apps page, however when clicking on Functions, the function created before does not appear:
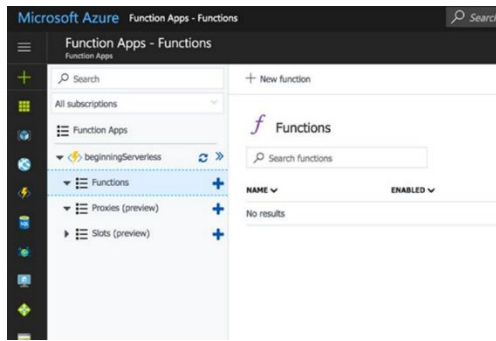

Figure 8. Function Apps page

4. Click on the "+" button to create resources for the function for it to appear. Select WebHooks and API template for creating a function and JavaScript as the runtime. The function will appear and look like Figure 9 below:
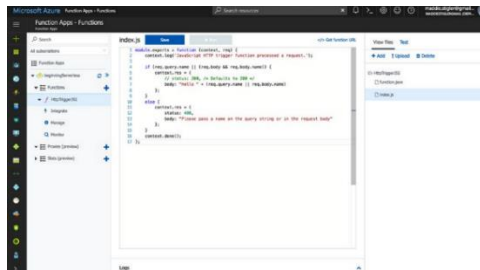

Figure 9. Function in Azure

5. The function takes a POST request as of now. Click Integrate in the function options and a form will appear to display the trigger configuration for HTTP request as shown in Figure 10 below:
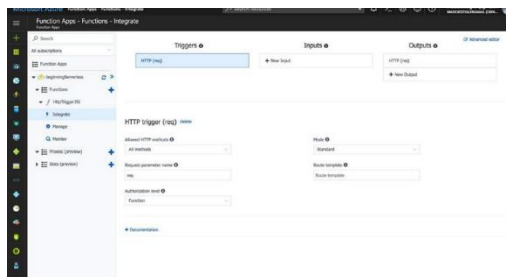

Figure 10. HTTP request for trigger function form

6. Testing can now be done. Click on the function name. Test blade will appear on the right along with the output.
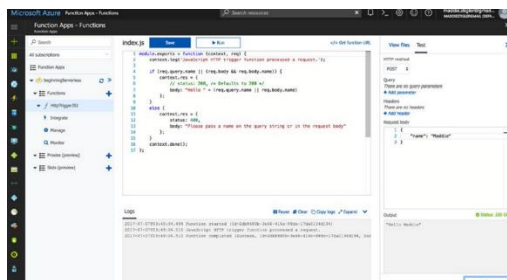

Figure 11. Test result

C. Using Google Cloud

Writing codes on Google Cloud can be done through the Google Functions. The steps to code a simple Hello World program would be as following [15]:

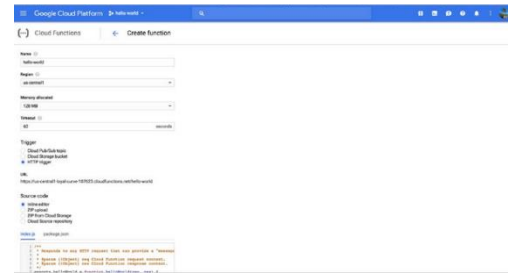1. From the dashboard, navigate to Functions and create a new function called hello-world.

Figure 12. Function configuration in Google Cloud

2. Select an HTTP trigger. This HTTP trigger provides a URL to trigger the function to test and run it.

3. The function will appear in the list.
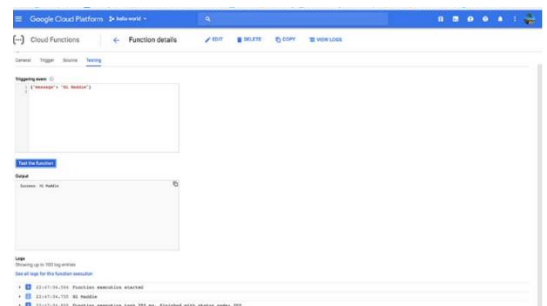
4. Create a test event to show the results.

Figure 13. Test event

V. DISCUSSION & COMPARISON

In this section, we will be discussing two things. The first discussion involves the comparison between the services offered by the three cloud platforms; AWS, Azure and Google Cloud. The second one discusses how programming can be supported in cloud.

A. Comparison between cloud service platforms

Table shows the comparison of services between AWS, Azure and Google Cloud in terms of their functionalities [16]:

Table 1. Comparison between AWS, Azure and Google Cloud

Functionalities	AWS	Microsoft Azure	Google Cloud
Compute	Elastic Compute Cloud (EC2)	Virtual Machines	Compute Engine
Storage	Simple Storage Service (S3)	Blob Storage	Cloud Storage

Archive Storage	Amazon Glacier	Archive Storage	-
Relational Database	Amazon Relational Database Services (RDS)	SQL Database	Cloud SQL
NoSQL Database	DynamoDB	Cosmos DB	Cloud Datastore

B. How programming is supported on cloud

In this section, we are going to have a look on how programming is supported on cloud using AWS services as example.

As mentioned before, AWS has multiple services for cloud programming. One of them is Elastic Multiple Cloud (EC2). EC2 provides user the freedom to set up their development environment including the operating system, memory and subnets. EC2 also provides sufficient security through the use of security groups and access control lists (ACLs).

AWS also offers Elastic Beanstalk, a specialized service for user to deploy their application [10]. This service supports a huge array of programming languages such as Java, Python and Ruby. All user needs to do is just upload their application via Beanstalk and AWS will handle the rest, such as the auto balancing and load scaling.

VI. CONCLUSION

In conclusion, cloud computing has been a crucial part in technology development nowadays. This paper provides a brief introduction to cloud computing and the available service platforms for user to check out. The current biggest cloud service providers, Amazon Web Services, Microsoft Azure and Google Cloud are all unique in their own ways. It is important for users to know their needs before deciding on which one to use.

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