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Introduction

As a start-up education software company, our client has built a knowledge-sharing application that manages student information and shares documents, books, and videos for students' learning. Its users are from Australia, US, and Europe. Currently, the company uses on-premises IT infrastructure to host a Three-Tier application architecture. They are interested in cloud solutions to improve their performance.

Existing Infrastructure

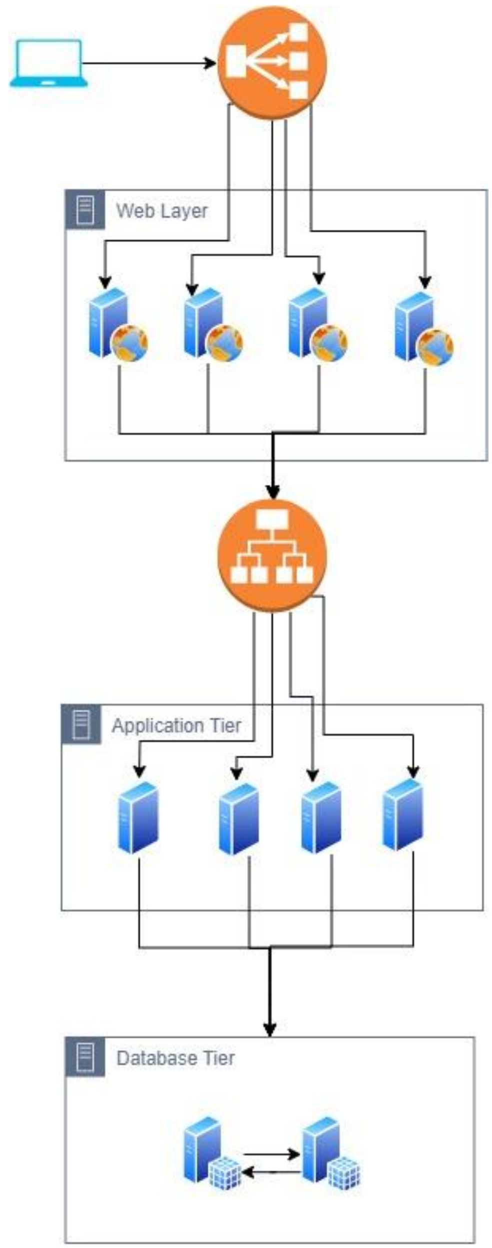

Figure 1: Client's existing IT infrastructure

Assumptions

The following assumptions are based on Business and Technical discussion:

1. Increase in number of students during every academic semester.
2. Less usage during holidays.
3. Minimal downtime due to technical or environmental reasons affecting all users.
4. Potential cyber-attacks from other competitors or cyber thefts.
5. The client has a low budget as the organization is a start-up.
6. The client has less technical expertise

Reasonable Analysis

The gap in the existing solution

Our client's current infrastructure lacks major abilities as below:

1. ***Security***

   No feature to protect the system from malicious online attacks. Attackers can steal data, corrupt the system, and block users from using the web. Users' personal data can be compromised.

2. ***Scalability***

   The client has a fixed number of servers. Instances cannot be increased quickly. Also, it requires extra investment. On the other hand, if there is less usage over the applications, instances cannot be reduced. They remain unused in the system and money is wasted on their purchase.

3. ***Reliability***

   To make a system reliable we should be able to recover work prior to a failure, we should be able to monitor system utilization and make appropriate changes. The current system does not have any application to take care of these agendas.

4. ***High Availability***

   In case the client wants to include a new service, they will need to conduct research into a good product and plan its implementation. Thus, a lot of important time is spent on getting new services.

5. ***Elasticity***

   The current system is not scalable on demand, thus there is no chance of auto-scaling too.

6. ***Pay-on usage benefit***

   The current system is not cost-effective. If servers remain unused, then their investment will be wasted. The current system cannot be halted or re-started on demand. Investment can be reduced by making use of savings plans.

What is Cloud Computation?

Today services like computing, storage and databases can be accessed via the Internet. This is called cloud computing or cloud services. This technology will help businesses to be more reliable and profitable. It is popular because it is accessible on-demand. Based on the requirement of the customer, cloud computing solutions can be private, public or hybrid (AWS, 2022). Further on, services provided by them could be Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS). We have many famous cloud providers like Amazon Web Services (AWS), Microsoft Azure, Google Cloud Platform, Salesforce etc.

Following is a comparison of on-premises IT and Cloud Infrastructure (Cloud vs On-Premises: Pros and Cons for Your Business | Solid Systems, 2021):

SR No.	On-premises Solution	Cloud Solution
1	Large initial investment.	Low investment as payment is monthly based and it is cheap.
2	Maintenance, updates, and upgrades are responsibility of the organization.	Maintenance, updates, and upgrades included in monthly fees.
3	On-site expertise required for support.	Cloud expertise is accessible from anywhere in the world.
4	Security needs in-house experts.	Cost-effective security.

Given the above analysis, it can be stated that Cloud Infrastructure is best suited for the client and will help incorporate all the features required for a well-performing and reliable business in a cost-effective manner.

There are several major cloud service providers like Azure, AWS (Amazon Web Services) and Google Cloud. AWS has a lot of features readily available with free options / cheap costs. Thus, AWS can be used as a starting point for this startup organization to transition to cloud infrastructure.

Proposed Solution

About AWS

Amazon Web Services (AWS) is an on-demand cloud computing platform. It provides computing, database, networking and content delivery, security compliance, storage and many more services via the Internet. These services are charged based on usage. It is used in several industries such as media and entertainment, travel and hospitality, manufacturing, retail, education, aerospace and satellite and automotive (Amazon Web Services, 2023).

About Proposed Architecture

Our cloud solution is a three-tier (Web, Application and Database) application in Amazon VPC. The solution will be deployed in 3 regions (US, Europe and Australia). US and Europe regions will have 3 Availability Zones (AZ) due to their large geographical area, whereas Australia will have 2 AZs. The user's request will be mapped to the application via Amazon Route 53. Amazon Content Delivery Network is used to deliver content to users at low latency. Web and Application will run on Amazon EC2 and Database will run on Amazon Dynamo DB. Amazon S3 plays a key role in streaming videos and showing information that is crucial for the customer's EdTech application. Along with this, we also have the Amazon S3 Glacier which will store documents and pictures at a very low cost for five years based on the requirement specified by the customer. The overall traffic will be managed by Amazon Elastic Load Balancer to ensure that the overall architecture continues to perform well.

Architecture Diagram

(*An AWS Cloud Architecture for Web Hosting - Web Application Hosting in the AWS Cloud: Best Practices*, n.d.)

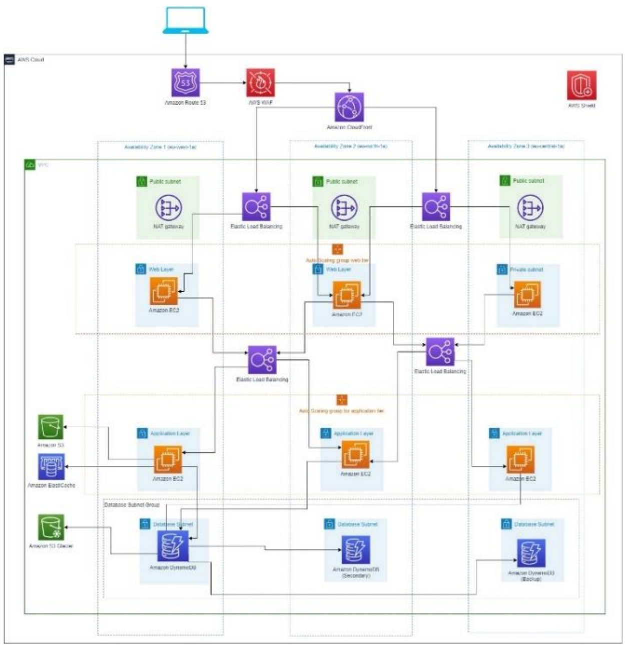

Figure 2: Cloud Architecture for Europe

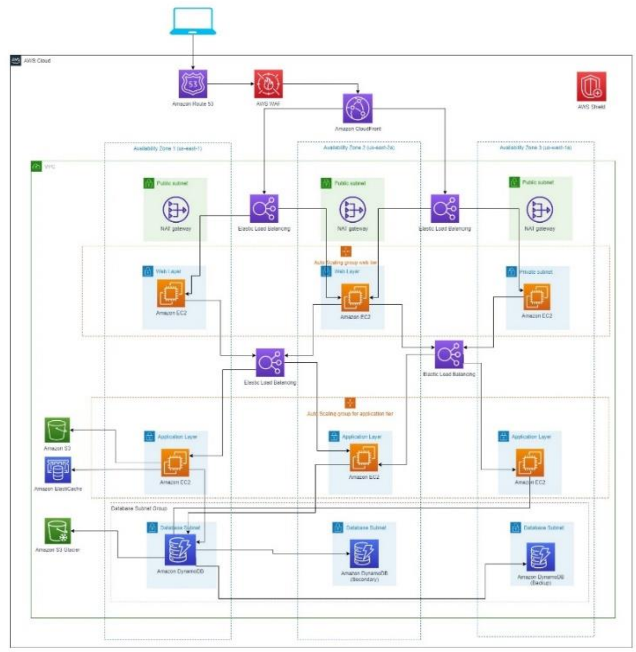

Figure 3: Cloud Architecture for US

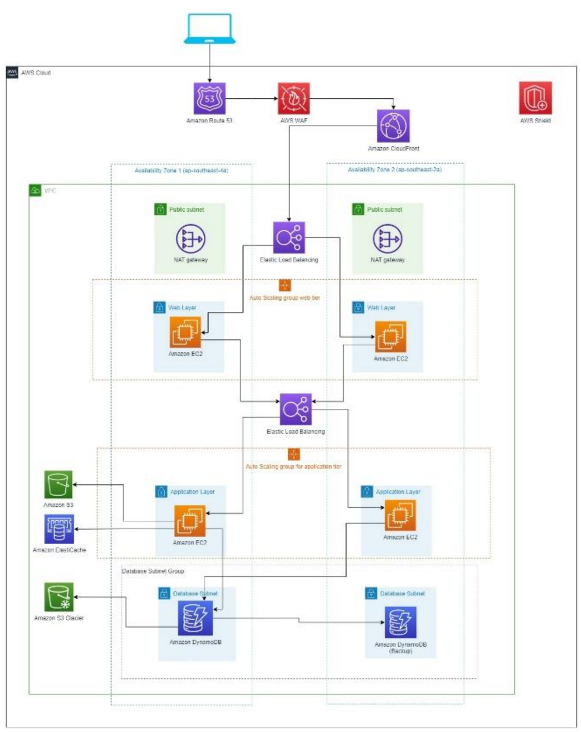

Figure 4: Cloud Architecture for Australia

AWS Resources

Our resources are split into (What is AWS cloudformation? - AWS Cloudformation, n.d.):

1. Network solution details
2. Web Tier, application tier, database tier and storage solution details
3. Security solution details
4. Resilience and High Availability

Network solution details

Amazon Route 53

Amazon Route 53 serves as a crucial component in our cloud solution, enabling the smooth routing of all students' requests to our cloud solution. It converts domain names such as www.edtech.com into a numeric IP address 10.0.1.2, which is how the end user connects to AWS EC2.

Amazon CloudFront

As the students are based all over US, Europe, and Australia there could be latency issues due to large geographical regions. CloudFront is used to deliver videos to students over large geographical regions. It will provide us with proxy servers to cache content and distribute videos with low latency.

NAT Gateway

We have used NAT Gateway so that instances in our private subnet can connect to the internet and get necessary updates. At the same time, NAT Gateway will help us avoid connection requests from unauthorized external services.

Subnet

A range of IP addresses in VPC.

1. **Public Subnet**
   The public subnet allows resources within it to have direct connectivity to the public internet. The elastic load balancer is in the public subnet. It gets requests from the public internet, which are then carried to resources in private subnet based on security group conditions.
2. **Private Subnet**
   Resources in private subnet connect to the public internet via NAT. In our solution sensitive resources such as Web servers, App servers and DB servers are included within private subnets to protect them from security risk. This vital network component acts as a protective barrier, keeping our system's sensitive assets safe and secure.

Web tier, application tier, database tier and storage solution details

The Web Tier is responsible for handling client requests and serving the application's frontend. Logical operations happen in the Application tier. Information processed in the application layer is stored and retrieved from the database tier.

Amazon EC2

Amazon Elastic Cloud Compute (EC2) are virtual computers that we have used to run our application. EC2 instances are deployed across multiple availability zones and the number of instances will be scaled up/down when needed. This will ensure fault tolerance and high availability.

Amazon S3

Amazon S3 is a scalable, durable, and cost-effective object storage service. It provides secure and reliable storage for any type of data, with high accessibility and integration capabilities. Amazon S3 can be utilized for storing and serving documents, books, videos, and other media files. Infrequent access storage classes like S3 Glacier or S3 Intelligent-Tiering can be used to optimize costs for rarely accessed files and are a good fit for an education software company.

AWS DynamoDB

We have access to a robust NoSQL database system intended for managing massive volumes of data effectively with AWS DynamoDB. Its flexible and schema-free data architecture is ideal for our less organized data. DynamoDB provides great performance and scalability, allowing us to store and retrieve data quickly even as our data volumes expand. It's key-value and document data structures enable us to adapt to changing data requirements and readily retrieve information based on the demands of our application.

Amazon S3 Glacier

With AWS Glacier we can store your data at a low cost and ensure its durability and security. It is particularly useful for us as we have large volumes of data that they want to keep for a long time, such as archives and backups. It is a cost-effective way to store data long-term that doesn't require frequent access.

Security solution details

The cloud solution is accessible via the internet which could expose it to multiple security risks. We need to protect our clients from these security risks. By using the following services, we are isolating the resources, introducing protection and controlling traffic from users.

Amazon VPC

Our solution is created within a virtual private cloud (VPC) to secure our network. The VPC provides a dedicated and isolated virtual network environment for the application. By utilizing VPC, we protect our servers from attacks originating from the public internet.

AWS WAF

It is employed to safeguard applications running in our cloud solution. We use it to monitor incoming traffic and block malicious requests based on predefined conditions.

AWS Shield
Distributed Denial-of-Service (DDoS) attacks are common methods used to disrupt normal traffic to targeted servers. We employ Shield to dynamically detect DDoS attacks and automatically initiate countermeasures, reducing downtime for the educational application.

AWS Security Group
Security Groups are implemented to control inbound and outbound traffic to the EC2s and DB. It ensures that the Web Tier allows traffic only from the ELB, the Application Tier permits traffic only from the Web Tier/ELB, and the Database Tier allows traffic only from the Application Tier.

Resilient and high-availability design
This AWS architecture focuses on high availability and resilience to ensure business continuity. This approach enhances fault tolerance and mitigates the impact of infrastructure failures. Auto Scaling and ELBs are implemented to handle peak traffic loads, ensuring application performance during high-demand periods.

Availability Zone

Availability Zones (AZs) are isolated data centers within an AWS region. Multiple availability zones are utilized to ensure the failure of one data center does not affect everyone and provide alternate resources in case of heavy traffic or some kind of failure in one zone. AZs provide redundancy, fault tolerance, and high availability for applications and services. For our architecture, we have 3 availability zones in the US, 3 availability zones in Europe and 2 availability zones in Australia.

<u>Our AZs in Europe</u>: eu-west-1a, eu-north-1a, eu-central-1a

<u>Our AZs in Australia</u>: ap-southeast-4a, ap-southeast-2a

<u>Our AZs in the US</u>: us-east-1a, us-east-2a, us-west-1a

Amazon Elastic load balancer
We use elastic load balancer as it helps evenly distribute incoming network traffic across multiple instances, improving the performance and reliability of our architecture. The ELB is there to support HTTP, HTTPS, and TCP protocols. It performs health checks on instances and automatically adjusts traffic routing to maintain high availability.

Amazon Elastic Cache
We have used this service to improve the performance of the web application by retrieving recent data from in-memory caches, instead of relying on a slower database.

Auto Scaling group

Auto Scaling groups make it easier to manage EC2 instances. The Auto Scaling group may easily add or remove instances as needed by dynamically altering the number of instances in response to workload variations. Furthermore, it actively checks instance health and quickly removes any problematic instances. We can easily handle variations in workload, automate the scaling process, and assure the continuing health of our instances by utilizing an Auto Scaling group.

Implementation

We are using AWS CloudFormation to model our cloud solution. The resources will be defined using JSON. Once the client accepts the solution, we will be able to deploy the same in other regions. This will improve the consistency of the configuration and if any update is needed it could be done without hassle.

Conclusion

Our educational start-up company's analysis and solution report highlights the limitations of the existing on-premises infrastructure and proposes a comprehensive AWS cloud solution. This solution addresses the company's scalability, reliability, high availability, security and cost-effectiveness requirements. By leveraging the capabilities of AWS services and features, the company can now focus on delivering its educational program with enhanced performance and user experience.

Future Work

In terms of future work, we will:

1. Create JSON template for US and Europe region on AWS CloudFormation
2. Study cloud migration in Australia region. If everything works out to be fine, then also carry out the migration process in US and Europe regions.

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