BAIT3273 Cloud Computing
(202405)
(PRACTICAL ASSIGNMENT (50%))

Objective	To fulfilled the coursework requirements for students who are taking the course BAIT3273 Cloud Computing.
Learning Outcomes Being Assessed	CLO 2: Propose solutions by analysing and applying the service models of cloud computing. (C5, PLO2), MQF Cluster: C2 CLO 3: Communicate in a team to explore the cloud computing services. (A2, PLO5), MQF Cluster: C3C
Submission Deadlines	Week 12 Friday
Assessment	This is a group assignment with 4-6 students per group. This assignment contributes **50%** to the overall coursework marks for the coursework. The assessment criteria are as in Form 2.
Assignment Report Content	The assignment report should consist of the following components: 1. Cover sheet 2. Assignment Report Assessment Criteria. Below, use "**Academy_Lab_Projects_Showcase_template.pptx**" and convert it to a PDF attached to the assignment. 3. Acknowledgement 4. Table of contents 5. Introduction (brief description on the system) 6. Content: - Web Page URL - Screenshot of resources deployed - List and briefly explain of services used - Snippet of Web page(s) and database table, field, and records. 7. Conclusion 8. Formatted References (APA)
Submission	1) A report using .pdf 2) URL during presentation

Reminder	Tips has be given to guide students in developing the Web app independently with minimal Lecturer guidance. Also, to score *"Able to analyze, configure, troubleshoot and work independently with minimal guidance"* criteria in the marking scheme.
Learning	As a bachelor student, emphasis will be upon you to direct your learning, guided by the teaching schedule and feedback from the various activities and assessments throughout the module. There is a lot of low-level detail related to the tools and frameworks we use. You will be expected to seek out and learn this material for yourself. It is your responsibility to identify what you must learn. Lecture sessions will be used to explore and discuss the subject area, and to practice the cognitive skills of analysis and design. You will be responsible for developing your knowledge base from the many texts and research papers available in the subject area.
Help and Support	Announcements to all students will be made through Google Classroom; therefore, it is important that you check it regularly. Practical sessions will be the primary vehicle for academic support. You should be prepared with your questions and ask them at an appropriate opportunity. You are required to work as a member of a team in this module. Teamwork (and assessment) always creates anxiety. It is important, and required, that you engage with your team.
Late Submission	As per GUIDELINE ON LATE SUBMISSION OF COURSEWORK: Penalty for late submission of coursework shall be imposed after submission deadline / extended submission deadline: i) Late submission within 1 - 3 days: total marks to be deducted is 10 marks. ii) Late submission within 4 - 7 days: total marks to be deducted is 20 marks. iii) Late submission after 7 days: reject coursework and zero mark shall be awarded.

Building a Highly Available, Scalable Web Application

Overview and objectives

Throughout various AWS Academy courses, you have completed hands-on labs. You have used different AWS services and features to create compute instances, install operating systems (OSs) and software, deploy code, and secure resources. You practiced how to enable load balancing and automatic scaling, and how to architect for high availability to build simple, lab-specific applications.

In this project, you're challenged to use familiar AWS services to build a solution *without* step-by-step guidance. Specific sections of the assignment are meant to challenge you on skills that you have acquired throughout the learning process.

By the end of this project, you should be able to do the following:

- Create an architectural diagram to depict various AWS services and their interactions with each other.
- Estimate the cost of using services by using the AWS Pricing Calculator.
- Deploy a functional web application that runs on a single virtual machine and is backed by a relational database.
- Architect a web application to separate layers of the application, such as the web server and database.
- Create a virtual network that is configured appropriately to host a web application that is publicly accessible and secure.
- Deploy a web application with the load distributed across multiple web servers.
- Configure the appropriate network security settings for the web servers and database.
- Implement high availability and scalability in the deployed solution.
- Configure access permissions between AWS services.

The lab environment and monitoring your budget

This environment is long lived. When the session timer runs to 0:00, the session will end, but any data and resources that you created in the AWS account will be retained. If you later launch a new session (for example, the next day), you will find that your work is still in the lab environment. Also, at any point before the session timer reaches 0:00, you can choose **Start Lab** again to extend the lab session time.

Important: Monitor your lab budget in the lab interface. When you have an active lab session, the latest known remaining budget information displays at the top of this screen. This data comes from AWS Budgets, which typically updates every 8–12 hours. Therefore, *the remaining budget that you see might not reflect your most recent account activity*. **If you exceed your lab budget, your lab account will be disabled, and all progress and resources will be lost**. Therefore, it's important for you to manage your spending.

AWS service restrictions

In this lab environment, access to AWS services and service actions might be restricted to the ones that are needed to complete the lab instructions. You might encounter errors if you attempt to access other services or perform actions beyond the ones that are described in this lab.

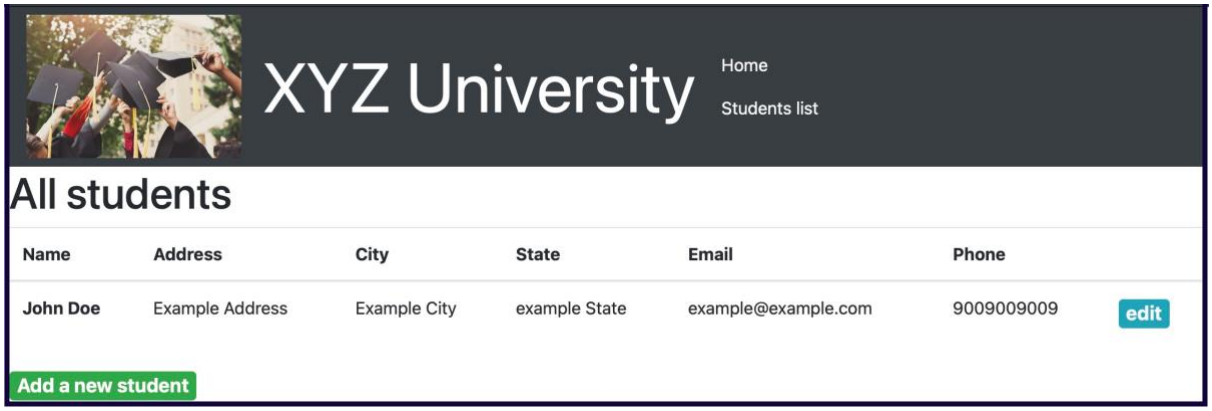
Scenario

Example University is preparing for the new school year. The admissions department has received complaints that their web application for student records is slow or not available during the peak admissions period because of the high number of inquiries.

You are a cloud engineer. Your manager has asked you to create a proof of concept (POC) to host the web application in the AWS Cloud. Your manager would like you to design and implement a new hosting architecture that will improve the experience for users of the web application. You're responsible for building the infrastructure to host the student records web application in the cloud.

Your challenge is to plan, design, build, and deploy the web application to the AWS Cloud in a way that is consistent with best practices of the AWS Well-Architected Framework. During the peak admissions period, the application must support thousands of users, and be highly available, scalable, load balanced, secure, and high performing.

The following image shows an example of the student records web application. The site lists records of students who have applied for admission to the university. Users can view, add, delete, and modify student records.



Solution requirements

The solution must meet the following requirements:

- **Functional:** The solution meets the functional requirements, such as the ability to view, add, delete, or modify the student records, without any perceivable delay.
- **Load balanced:** The solution can properly balance user traffic to avoid overloaded or underutilized resources.
- **Scalable:** The solution is designed to scale to meet the demands that are placed on the application.
- **Highly available:** The solution is designed to have limited downtime when a web server becomes unavailable.
- **Secure:**
    - The database is secured and can't be accessed directly from public networks.
    - The web servers and database can be accessed only over the appropriate ports.
    - The web application is accessible over the internet.
    - The database credentials aren't hardcoded into the web application.
- **Cost optimized:** The solution is designed to keep costs low.
- **High performing:** The routine operations (viewing, adding, deleting, or modifying records) are performed without a perceivable delay under normal, variable, and peak loads.

Assumptions

This project will be built in a controlled lab environment that has restrictions on services, features, and budget. Consider the following assumptions for the project:

- The application is deployed in one AWS Region (the solution does not need to be multi-Regional).
- The website does not need to be available over HTTPS or a custom domain.
- The solution is deployed on *Ubuntu* machines by using the JavaScript code that is provided.
- Use the JavaScript code as written unless the instructions specifically direct you to change the code.
- The solution uses services and features within the restrictions of the lab environment.
- The database is hosted only in a single Availability Zone.
- The website is publicly accessible without authentication.
- Estimation of cost is approximate.

Disclaimer: A security best practice is to allow access to the website through the university network and authentication. However, because you are building this application as a POC, those features are beyond the scope of this project. You are encouraged to implement this additional functionality.

Approach

Recommendation: Develop your project solution in phases. This will help you ensure that basic functionality is working before the architecture becomes more complex. After the application is working, you are encouraged to enhance the solution with additional requirements.

Phase 1: Planning the design and estimating cost

In this phase, you will plan the design of your architecture. First, you will create an architecture diagram.

Next, you will estimate the cost of the proposed solution, and present the estimate to your educator. An important first step for any solution is to plan the design and estimate the cost. As necessary, review the various components in

the architecture to adjust the estimated cost. Cost is an important factor when building a solution because cost can help to determine the components and architecture pattern to use.

Note: You don't need to use the lab environment for this phase of the project, but you might want to use it to refer to AWS services and features as you plan your design.

Task 1: Creating an architectural diagram

Create an architectural diagram to illustrate what you plan to build. Consider how you will accomplish each requirement in the solution.

References

- AWS Architecture Icons: This site provides tools to draw AWS architecture diagrams.
- AWS Reference Architecture Diagrams: This site provides reference architecture diagrams for a variety of use cases.

Task 2: Developing a cost estimate

Develop a cost estimate that shows the cost to run the solution in the us-east-1 Region for 12 months. Use the AWS Pricing Calculator for this estimate.

If required by your instructor, add your architectural diagram and cost estimate to presentation slides. Your educator might want to evaluate this information as part of assessing your work on this project. A presentation template is provided.

References

- What Is AWS Pricing Calculator?
- PowerPoint presentation template

Phase 2: Creating a basic functional web application

In this phase, you will start to build the solution. The objective of this phase is to have a functional web application that works on a single virtual machine in a virtual network that you create. By the end of this phase, you will have a POC to demonstrate hosting the application on the AWS Cloud. You can then build upon your work in later phases.

Task 1: Creating a virtual network

Create a virtual network to host the web application.

Tip: Create networking resources such as a virtual private cloud (VPC) and subnets.

Reference

- AWS Academy Cloud Architecting – Lab: Creating a Virtual Private Cloud

Task 2: Creating a virtual machine

Create a virtual machine in the cloud to host the web application.

To install the required web application and database on the virtual machine, use the JavaScript code from the following link: SolutionCodePOC

Tips:

- Use a compute service such as Amazon Elastic Compute Cloud (Amazon EC2).
- Use the latest Ubuntu Amazon Machine Image (AMI).

Task 3: Testing the deployment

Test the deployment of the web application to ensure it is accessible from the internet and functional. Perform a few tasks, such as viewing, adding, deleting, or modifying records.

Tip: To access the web application, use the IPv4 address of the virtual machine.

Phase 3: Decoupling the application components

In this phase, you will continue building. The objective is to separate the database and the web server infrastructure so that they run independently. The web application should run on a separate virtual machine, and the database should run on the managed service infrastructure.

Task 1: Changing the VPC configuration

Update or re-create the virtual network components that are necessary to support hosting the database separately from the application.

Note: You need private subnets in a minimum of two Availability Zones.

Reference

- AWS Academy Cloud Architecting – Lab: Creating a Virtual Private Cloud

Task 2: Creating and configuring the Amazon RDS database

Create an Amazon Relational Database Service (Amazon RDS) database that runs a MySQL engine. You can choose to create a provisioned instance or run it serverlessly.

Notes:

- Allow only the web application to access the database.
- Don't enable enhanced monitoring.

Reference

- AWS Academy Cloud Foundations – Lab: Build Your DB Server and Interact With Your DB Using an App

Task 3: Configuring the development environment

Provision an AWS Cloud9 environment to run AWS Command Line Interface (AWS CLI) commands in later tasks.

Notes:

- Use a t3.micro instance for the AWS Cloud9 environment.
- Use Secure Shell (SSH) to connect to the environment.

Reference

- Creating Cloud9 Environment

Task 4: Provisioning Secrets Manager

Use AWS Secrets Manager to create a secret to store the database credentials, and configure the web application to use Secrets Manager.

Use *Script-1* from the following link to create a secret in Secrets Manager by using the AWS CLI: AWS Cloud9 Scripts

Note: This .yml file also contains scripts that you will use in later tasks.

Reference

- create-secret in the AWS CLI Command Reference for AWS Secrets Manager

Task 5: Provisioning a new instance for the web server

Create a new virtual machine to host the web application.

To install the required web application on the virtual machine, use the JavaScript code from the following link: Solution Code for the App Server

For the AWS Identity and Access Management (IAM) profile on the EC2 instance, attach the existing *LabInstanceProfile* profile. This profile attaches an IAM role called *LabRole* to the instance so that it can fetch the secret securely.

Note: Optionally, you can continue to use the existing virtual machine for the web application. However, you will need to reconfigure the application to connect to Amazon RDS.

Reference

- AWS Academy Cloud Foundations – Lab: Build Your DB Server and Interact With Your DB Using an App

Task 6: Migrating the database

Migrate the data from the original database, which is on an EC2 instance, to the new Amazon RDS database.

Use *Script-3* from the AWS Cloud9 Scripts file (cloud9-scripts.yml) to migrate the original data into the Amazon RDS database. Recall that you used a script from this file earlier to create the secret in Secrets Manager.

Reference

- AWS Academy Cloud Architecting – Lab: Migrating a Database to Amazon RDS

Task 7: Testing the application

Access the application and perform a few tasks to test it. For example, view, add, delete, and modify student records.

Phase 4: Implementing high availability and scalability

In this phase, you will complete the design and fulfill the remaining solution requirements. The objective is to use the key components that you created in earlier phases to build a scalable and highly available architecture.

Task 1: Creating an Application Load Balancer

Launch a load balancer. The endpoint will be used to access your web application.

Tip: Use a minimum of two Availability Zones.

Reference

- AWS Academy Cloud Architecting – Lab: Creating a Highly Available Environment

Task 2: Implementing Amazon EC2 Auto Scaling

Create a new launch template, and use an Auto Scaling group to launch the EC2 instances that host the web application.

To accomplish this, you can create an AMI from the running instance, or create a new AMI and install the necessary packages and application code. Then, configure an Auto Scaling group to use the load balancer.

Tips:

- Use a Target tracking policy.
- Set the Auto scaling group size according to your estimated requirements.
- You can use the default values (for example, for group size and CPU utilization) initially and then adjust them later as needed.

Reference

- AWS Academy Cloud Architecting – Lab: Creating a Highly Available Environment

Task 3: Accessing the application

Access the application and perform a few tasks to test it. For example, view, add, delete, and modify student records.

Task 4: Load testing the application

Perform a load test on the application to monitor scaling.

Use *Script-2* from the AWS Cloud9 Scripts file (cloud9-scripts.yml) to perform the load test. Recall that you used scripts from this file in previous tasks.

Notes:

- Access the web application from the browser by using the load balancer URL.
- Use AWS Cloud9 to run the load testing scripts against the load balancer.

Reference

- loadtest Tool Repository on GitHub

Ending your session

Reminder: This is a long-lived lab environment. Data is retained until you either use the allocated budget or the course end date is reached (whichever occurs first).

To preserve your budget when you are finished for the day, or when you are finished actively working on the assignment for the time being, do the following:

1. At the top of this page, choose **End Lab**, and then choose **Yes** to confirm that you want to end the lab.

   A message panel indicates that the lab is terminating.

   Note: Choosing **End lab** in this lab environment will *not* delete the resource you have created. They will still be there the next time you choose Start lab (for example, on another day).

2. To close the panel, choose **Close** in the upper-right corner.

TUNKU ABDUL RAHMAN UNIVERSITY OF MANAGEMENT AND TECHNOLOGY

Faculty of Computing and Information Technology

BUILDING A HIGHLY AVAILABLE, SCALABLE WEB APPLICATION

(Programmed Title and tutorial group)

Practical Assignment

BAIT3273 Cloud Computing (202401)

LECTURER: LOW CHOON KEAT

Name **(Block Capital)**	**Registration No.**

Building a Highly Available, Scalable Web Application

Grading Rubric

You can use the following rubric to assess students' solutions.

Criteria	Unsatisfactory	Needs Improvement	Good	Excellent
Functional	The web server wasn't accessible from the internet.	The web server was accessible from the internet, but the application webpage didn't display.	The application was accessible from the internet, and all operational tasks (querying, adding, and removing records) could be performed successfully. Migrated data wasn't available.	The application was accessible from the internet, and all operational tasks (querying, adding, and removing records) could be performed successfully. Migrated data was available.
Load Balanced	Load balancing wasn't implemented.	Load balancing was implemented partially. Application traffic was directed to one Availability Zone instead of multiple Availability Zones.	The application traffic was distributed across multiple Availability Zones, but instances were carrying variable load.	The application traffic was distributed evenly across two Availability Zones and across the instances in those Availability Zones. All instances were evenly loaded at peak user load.
Scalable	Automatic scaling wasn't implemented at the application layer.	Automatic scaling was implemented at the application layer. However, scaling was delayed or didn't occur.	Automatic scaling was implemented at the application layer. However, the automatic scaling configuration could be improved by adjusting the scaling policy and the minimum and maximum capacities.	The automatic scaling configuration was optimal, staying within the scaling range, without reaching the maximum limit frequently. The application layer scaled in and out according to application demand and in a timely manner.

Criteria	Unsatisfactory	Needs Improvement	Good	Excellent
Highly Available	A single web server instance hosted the application and database. There was only one public subnet. Managed services, such as Elastic Load Balancing (ELB) and automatic scaling, weren't implemented.	Multiple web server instances were in one Availability Zone, and the application wasn't architected to be highly available.	Web server instances were spread across two Availability Zones. The architecture had public and private subnets in each Availability Zone. Managed services, such as AWS Secrets Manager and ELB, were used.	Web server instances were spread across two Availability Zones. The architecture had public and private subnets in each Availability Zone. Managed services, such as Secrets Manager and ELB, were used. Database backup was enabled for recovery.
Secure	The solution didn't consider any security best practices.	The solution didn't consider any security best practices explicitly, except for using Secrets Manager, as provided in the guidance.	The solution considered security best practices for only a few resources: • Amazon Elastic Compute Cloud (Amazon EC2) instances were locked down to port 80, but port 22 was accessible from anywhere. • The DB instance was in a private subnet, and the web server could access the DB. However, the DB security group wasn't restricted to database port 3306.	The solution followed security best practices: • All EC2 instances were locked down to port 80 and port 22. • Access to EC2 instances through port 22 was limited to an IP range that AWS provided. • The DB instance was in a private subnet. • The web server instances could only access the DB on port 3306. • The DB credentials were stored securely in Secrets Manager. • The load balancer was protected, with security groups having access only on port 80.
Cost Optimized	The Auto Scaling group size and instance sizing weren't considered explicitly, and only default sizing was used.	The Auto Scaling group size wasn't considered; for example, the minimum, maximum, and desired configurations were kept the same.	EC2 instances were oversized or undersized. The Auto Scaling group minimum configuration was high. The DB instance was oversized or undersized.	All EC2 instances were properly sized to handle the traffic. The Auto Scaling group minimum configuration supported the minimum expected traffic. The DB instance was optimally sized to handle normal and variable user load.

Criteria	Unsatisfactory	Needs Improvement	Good	Excellent
High Performing	The application was accessible intermittently under a normal user load. The application failed to serve users (timed out) for a higher user load.	The application was accessible and functional under a normal user load. However, the application failed to serve users (timed out) for a higher user load.	The application was accessible and functional under a normal user load and a higher user load without any deterioration in response time. However, response time deteriorated during the maximum load.	The application was accessible and functional under a normal user load and a maximum load without any deterioration in response. All operations (query, adding, and removing records) finished within the expected time.

Demonstration Session and Student Effort (30 marks)

Student Name ***Score*** ***Total***

1.
2.
3.
4.
5.
6.