SAFEDEPOSIT PROJECT
FINAL PROJECT REPORT

CSCI5410 – Serverless Data Processing

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Overview

The company DALSoft5410 is working towards building a serverless SafeDeposit that will use a multi-cloud deployment model and a BaaS (Backend-as-a-Service) model. The features like customization of services and additional services offered to authorized users, whereas restricted services to the visitors are offered by the SafeDeposit application being developed. Along with all the above features, SafeDeposit will also provide an online virtual assistant that will assist the users in query resolution and allow authorized users to pass messages among them.

The SafeDeposit application will have three types of authorized users who can access the system via multi-factor authentication. On successful authentication, the user can leave a message for other authorized users and upload pictures of objects. The user authorized to access the SafeDeposit will be notified if certain criteria of the image uploaded are met. The authorized users are also able to withdraw money from the SafeDeposit.

Modules

The SafeDeposit project of DALSoft5410 can be summarized to be composed of seven core components or modules. These modules cover everything from the front-end to the back-end of the SafeDeposit application making it robust and easy to use. Each module is built using either Amazon Web Services (AWS) or Google Cloud Platform (GCP) as a multi-cloud deployment model is used.

Module 1: **User Management**

The User Management module covers registration and login of the authorized and guest user and storing and retrieving their details when needed.

Tasks	Selected Cloud Service
Signup + Login + Validation Tasks	Amazon Web Services (AWS) , Google Cloud Platform (GCP)
Managing + Storing User Details	Amazon Web Services (AWS)

Module 2: User Authentication

The User Authentication module focuses on Multi-Factor Authentication of users. There are three stages of authentication performed to ensure the security of the application. The first-factor authentication is done through ID and Password, whereas the second-factor authentication is done through Question and Answer. Finally, the third-factor authentication is done through Caesar - Cipher.

Tasks	Selected Cloud Service
First Factor (ID-Password)	Amazon Web Services (AWS)
Second Factor (Question-Answer)	Google Cloud Platform (GCP)
Third Factor (Caesar-Cipher)	Amazon Web Services (AWS)

Using a combination of Amazon Web Service (AWS) and Google Cloud Platforms (GCP) for this module is done because of seamless integration and data passing between cloud providers. The main reason for choosing a multi-cloud model for authentication is to enhance security using the best of both service providers.

Module 3: Online Support

The Online Support module focuses on deploying a virtual assistant for all different access type users throughout the application. Though the operations vary from user type to user type, for the guest users, the virtual assistant will guide them with registration difficulties. In contrast, for the authorized users, the assistant will assist them with forgot passwords or even with managing their profiles.

Tasks	Selected Cloud Service
Virtual Assistant for all types of users	Amazon Web Services (AWS)

The reason for choosing GCP for the messaging module is because of the real-time notification requirement, and GCP has an easy-to-use service for the same.

Module 4: Message Passing

As the name suggests, the Message Passing module is a feature that helps authorized users of the same SafeDeposit box communicate and be notified of the changes. This module notifies a user of that particular SafeDeposit box if any other user has carried out any transactions.

Tasks	Selected Cloud Service
SafeDeposit box user's communication	Google Cloud Platform (GCP)

The reason for choosing GCP for the messaging module is because of the real-time notification requirement, and GCP has an easy-to-use service for the same.

Module 5: Machine Learning (ML)

The main focus of the Machine Learning (ML) module is the classification of the uploaded images. The authorized users upload images in the SafeDeposit application, which the system needs to read and classify using ML algorithms and assign an appropriate score using the labels.

Tasks	Selected Cloud Service
Classification of Uploaded Images	Google Cloud Platform (GCP)

The service that we have used is Google's AutoML Vision using Google Cloud Platform. It detects the labels from the images to be compared for the classification and then if all the detected labels in both the compared images are similar then the images are identified to be similar and then user can publish the message to other users. The images that this algorithm gets is uploaded by the user and stored into AWS S3 of which the url is stored along with the user details in AWS dynamoDb. The other images that are compared are fetched from the S3 bucket where other images are stored and then this algorithm proceeds with the classification.

Module 6: Web Application and Hosting

To build a robust and real-time rendering web application, we will use React.js and Node.js as both are easy to use, flexible, easily integrable, and lightweight.

Tasks	Selected Cloud Service
Application Hosting	Google Cloud Platform (GCP)

Programming Languages:

Front-End Technologies: React.js

Back-End Technologies: Node.js + Express.js

Module 7: Visualization

The Visualization module focus on the statistics of the application. The GCP provides services for visualizations.

Tasks	Selected Cloud Service
Visualizations	Google Cloud Platform (GCP)

Architecture

Figure 1 displays the architecture of the SafeDeposit application. The application consists of a frontend that will be built using the React.js framework and a backend built using Express.js, Node.js along with various Amazon Web Services (AWS) and Google Cloud Platform (GCP) Services.

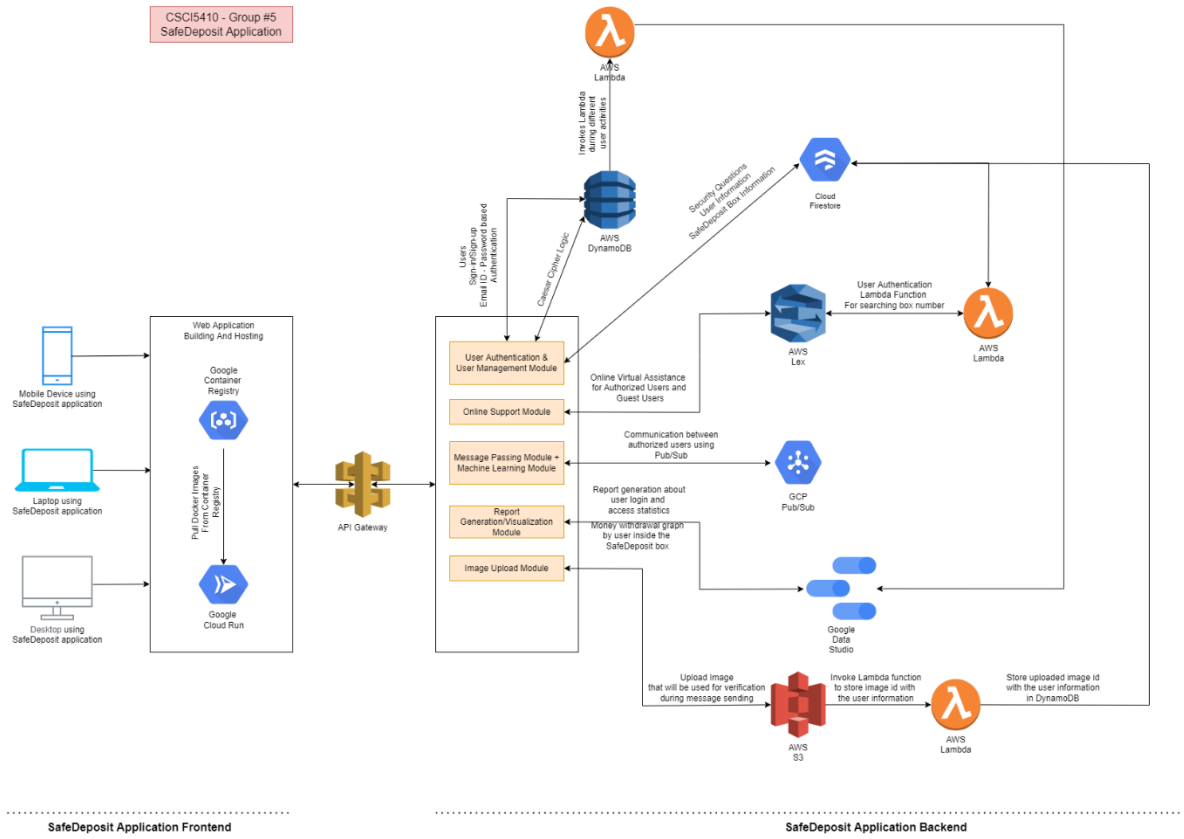

Figure 1 SafeDeposit Application Architecture

Figure 2 below shows the flow of the application DalSoft5410 – SafeDeposit.

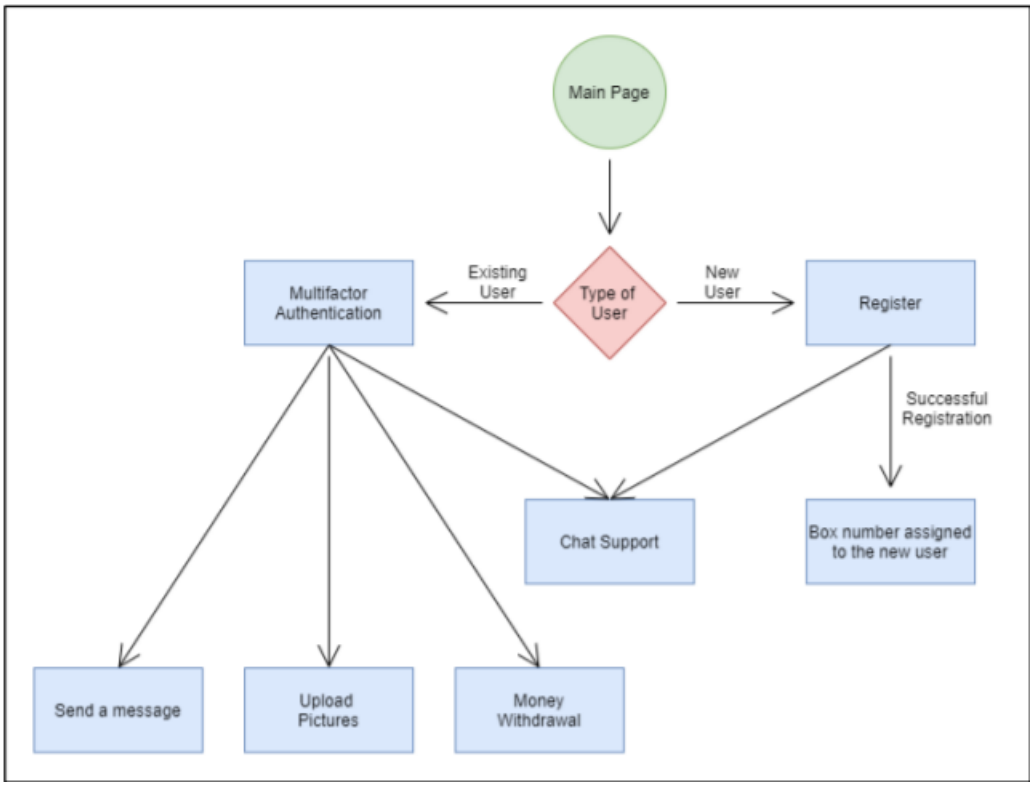

Figure 2 Flow of SafeDeposit application

The SafeDeposit application is a multi-cloud based serverless security deposit box that consists of a frontend built using React.js framework and a backend built using Express.js, Node.js along with various cloud-based services from AWS and GCP. The final application will be deployed to the Google Cloud Run (GCR). This application provides numerous features to the authorized users such as money withdrawal from the safe deposit, message sending to other authorized users, safe deposit box number searching based on a clue provided. Also, it provides a few features to the guest users such as virtual assistance for navigation. The final application will contain the below modules and will be built using the following services:

The architecture is explained in detail in the given section:

1. User Management Module:
    - This module mainly covers the User Registration part of the application along with dynamically assigning the User to a SafeDeposit Box and also securely storing and maintaining the user details. The application initially will display the home page where the user will either login to the application or can register themselves.
    - If the user chooses to register themselves then the application will ask user for details like Full Name, Email ID (It will be a unique User ID), Password and Three Predefined Security Questions. There will be on-the go validations done for the details entered by the user like for a valid email or for a strong password.
    - SafeDeposit Box Logic:
        - So, initially at the very beginning when there are no users registered within the application there are Zero SafeDeposit boxes created or available. When first user registers with the application, the system checks if there are any SafeDeposit boxes already created if no, then the very first SafeDeposit Box is created, and the user gets added to that SafeDeposit Box.
        - As each SafeDeposit Box can contain up-to 3 users, so for the next two users that registers with the application will be added to the first SafeDeposit Box that was created.
        - Now, if a fourth User registers with the application, then the application checks if there is any SafeDeposit Box available to add a new User, if no then a new SafeDeposit Box gets created and respectively an entry is made in the AWS DynamoDB database.
        - To achieve this, we will be using in-code checks using AWS DynamoDB and AWS Lambda function to dynamically add User to respective SafeDeposit Boxes and create new SafeDeposit Boxes.
    - Now, all the information entered by the User, all the Security Questions and also the SafeDeposit Box Information is stored securely in the AWS DynamoDB.
    - Another thing that the user needs to do is upload an image that will be stored against that User and will be used as verification for the Message Passing between authorized users. The details of this are covered in the Image Upload Module.
2. User Authentication Module:
    - In this module the Registered Users are authenticated by using a three-factor authentication module. The three-factor authentication includes the ID-Password, Security Question and Caesar Cipher.
    - We are using AWS Cognito in our application for Email ID – Password authentication, whereas for Security Question authentication we are using AWS DynamoDB that has each User's Security Question and Answers stored. For Caesar Cipher we are using an AWS Lambda Function.

- For Caesar Cipher we will provide user with the Caesar Cipher and the Key, the user will be required to decode the Caesar Cipher using the Key and enter the decoded message.

3. Online Support Module:
    - The Online Support Module is basically an Online Virtual Assistant that both Authorized and Guest Users can use. As, we are using React.js for frontend of our application, we can seamlessly integrate the AWS Lex and React.js.
    - For Online Virtual Assistant we are using AWS Lex along with AWS Lambda Function. The flow is as follows:
        - The user either a guest or an authorized user interacts with the Virtual Assistant, if the user is a guest, then he/she will only be shown navigation and normal application features.
        - If the user is an authorized user, then he/she will be asked for authentication first by invoking an AWS Lambda function which will communicate with the AWS DynamoDB that will have the user's details stored.
        - If, the authentication is successful then the user can access various features via the Virtual Assistant like Searching his/her SafeDeposit Box number, User details and much more.
4. Money Withdrawal Process
    - The money withdrawal module is the part where the registered users are able to log in to the application via the three-factor authentication and then lands on the main homepage of the application where the user is able to see the visualizations, the message passing module and the money withdrawal process. Each safedeposit box has at max 3 users so only those users can withdraw money from the safedeposit box to which they are assigned. The balance gets updated on withdrawal.

5. Message Passing Module + Machine Learning Module:
    - In the Message Passing Module the main service that is being used is the GCP Pub/Sub service that enables the authorized users to send and receive messages to other authorized users using the application. These messages are stored in the AWS DynamoDB Database.
    - For the Machine Learning Module, we are going to use the GCP built-in image classification algorithm which is the GCP AutoML Vision service that will help us in validating and comparing the images and then allowing the user to send message.
6. Image Upload Module:
    - When user wants to send a message to another authorized user, he/she has to upload an image for sending the message and that image needs to be verified with the recipient's image in order to successfully send the message and the receiver can receive the message. The image would be stored into storage service provided by AWS S3. Whenever user sends a message lambda function is triggered to store the image id and verify it with the user information stored during registration into the

DynamoDB. If the image match is successful then it is verified and user can send message successfully.

- This is an add-on module where user can upload an image in order to update their original uploaded image while registration. User will get an option to upload an image in the user interface which will take them to another dialog box or page to upload the image. This image will be stored into AWS S3 and then it will be updated in the DynamoDB for the user id associated with the user and original image will be replaced. A lambda function will be triggered when user uploads an image which does the storing of the image in DynamoDB.

7. Report Generation/Visualization Module:
   - In the Visualization Module we are using the GCP Data Studio service that is one of the best out there to generate various interesting and interactive reports that depict the statistics of various application related data. The GCP Data Studio can integrate with various third part services to create data stores and then use them to generate various reports. The GCP Data Studio generates user statistics report or transaction reports in a pie chart or bar charts. The data is stored in the AWS DynamoDB and GCP FireStore that is being mainly used to generate the interactive reports.

Challenges

The course project work focuses on working with various components of any application such as authentication, profile management, information delivery, record maintenance, etc. The implementation of these components involves development of these using the libraries and frameworks in the MERN stack, object-oriented concepts, Amazon Web Services (AWS) services and their integration with SDK to be implemented using Java. Based on the implementation requirements, following are the challenges that need to be addressed:

- Shortcomings in the usage of AWS and GCP: The services and tools offered by AWS and GCP help in building value-based solutions. However, these services are provided with certain limits such as services offered based on regions, account type like student.
- Pricing of plans and services included in them: The various services offered by AWS and GCP are accessible with a wide range of plans but each plan covering very less number of services.
- Skill enhancement: Team members are not as skilled in the technology stack used for the project and hence this can consume a lot of time to arrange for their learnings and hands-on experience in the same.
- Regulations and policies of the cloud service providers: The service providers focus on maximizing the profit and hence have restricted the use of these services in the plans utilized for the project

Github Link for the project:

Front end: https://git.cs.dal.ca/dashah/safedeposit-frontend-group5.git

Back end: https://git.cs.dal.ca/dashah/safedeposit-backend-group5.git

Meeting Logs

Meeting 1

Meeting title – Introduction and Task Division

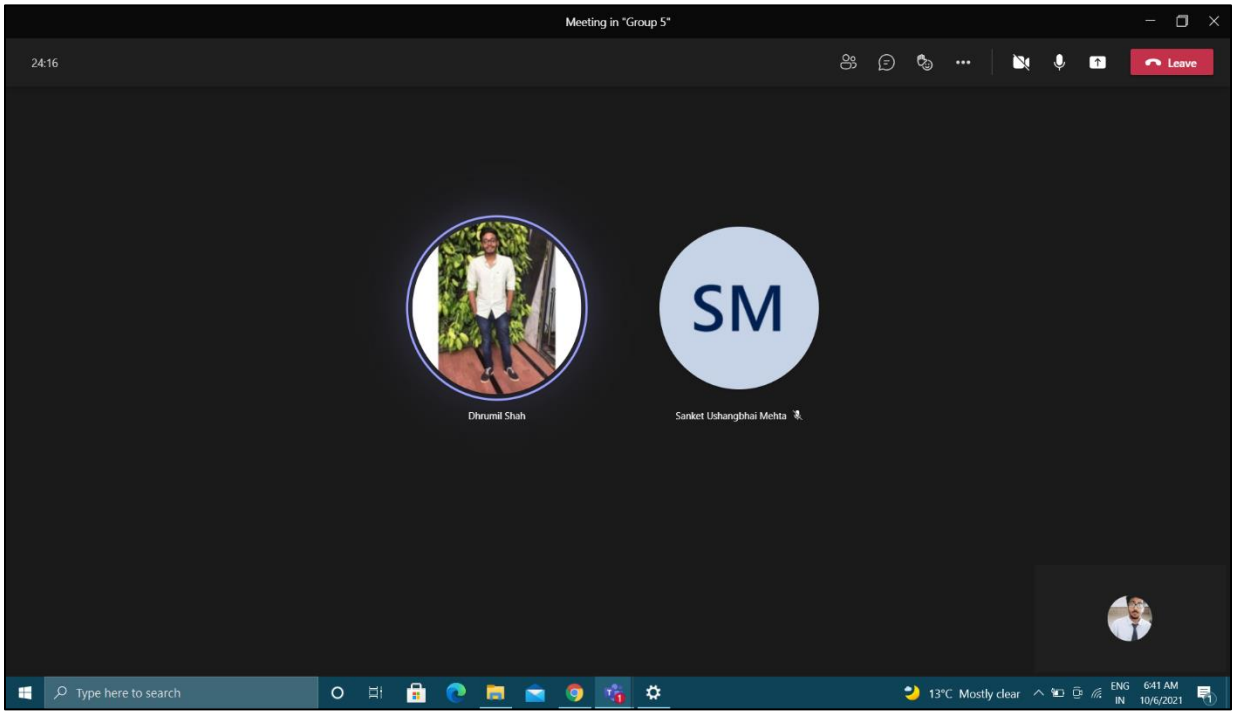

Figure 3 - Meeting 1 - Introduction and Task Division on Tuesday, October 5, 2021

Meeting **2**

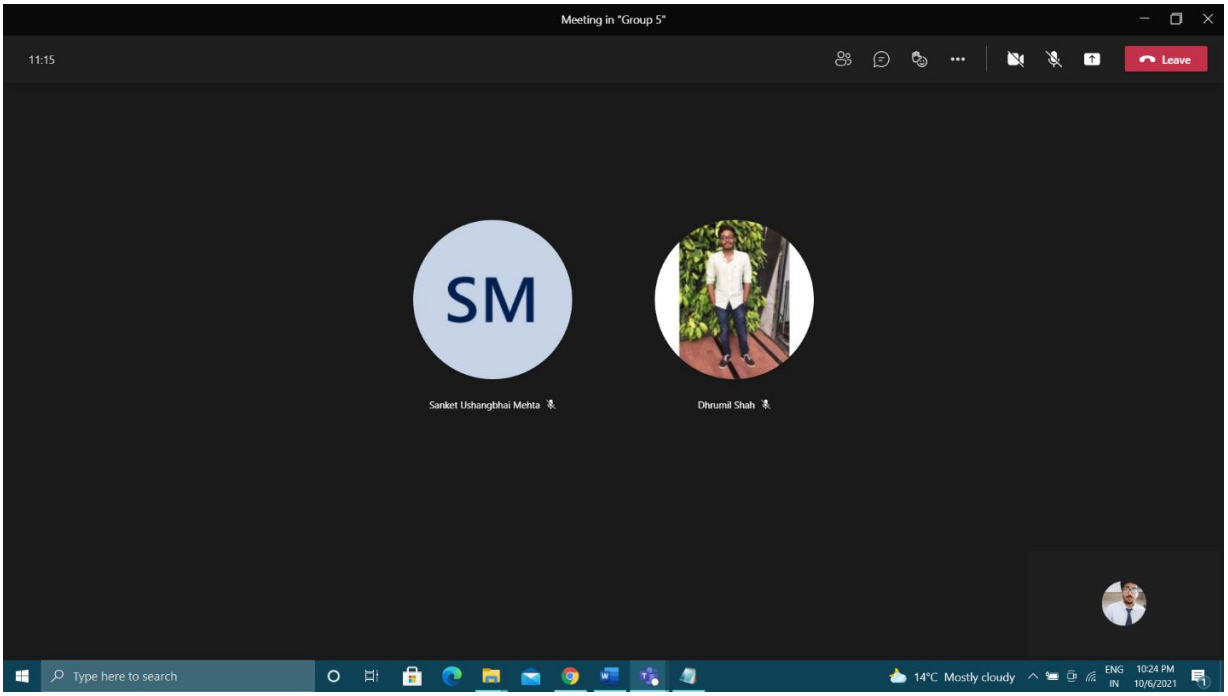

Figure 4 – Meeting 2 – Analysis of the services on Wednesday, October 6, 2021

Meeting **3**

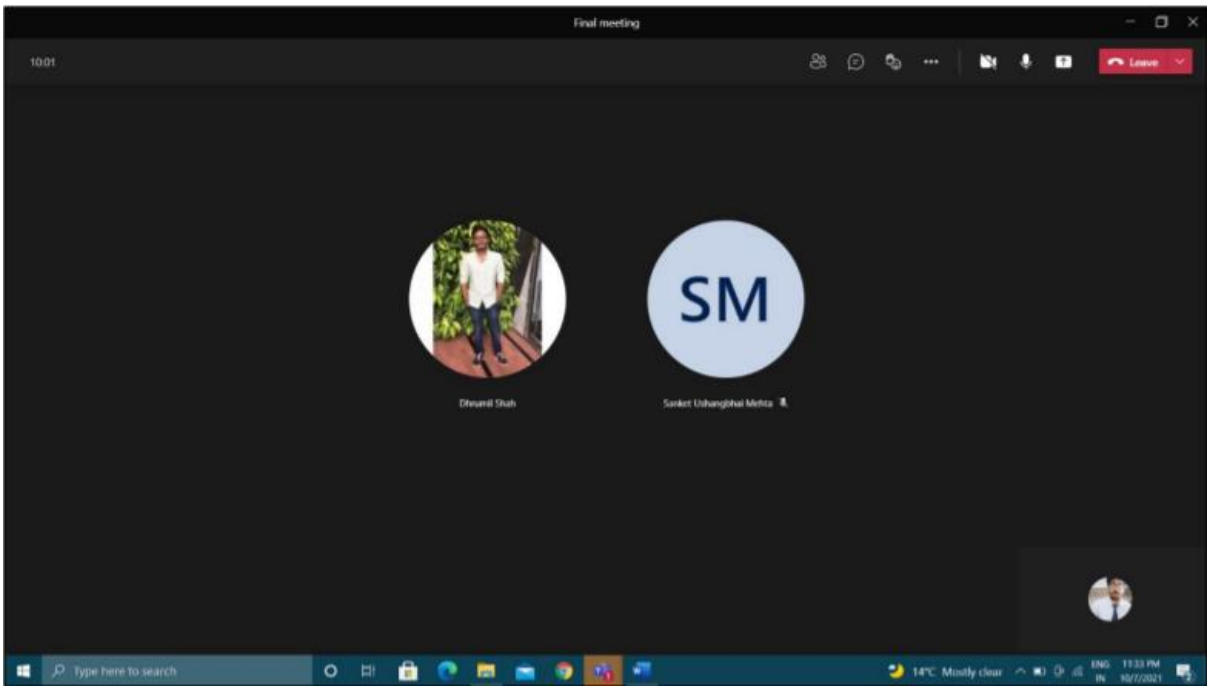

Figure 5 Final Reoprt Analysis

Meeting 4

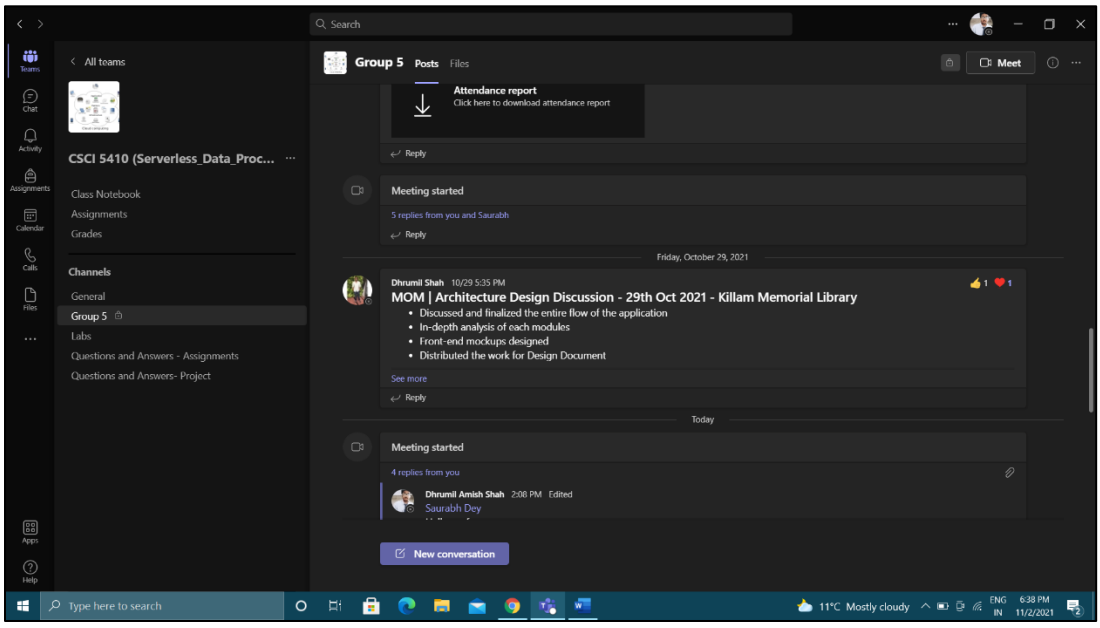

Figure 6 - Meeting regarding Architecture Design Discussion at Killam Memorial Library on 29th Oct 2021

Meeting 5

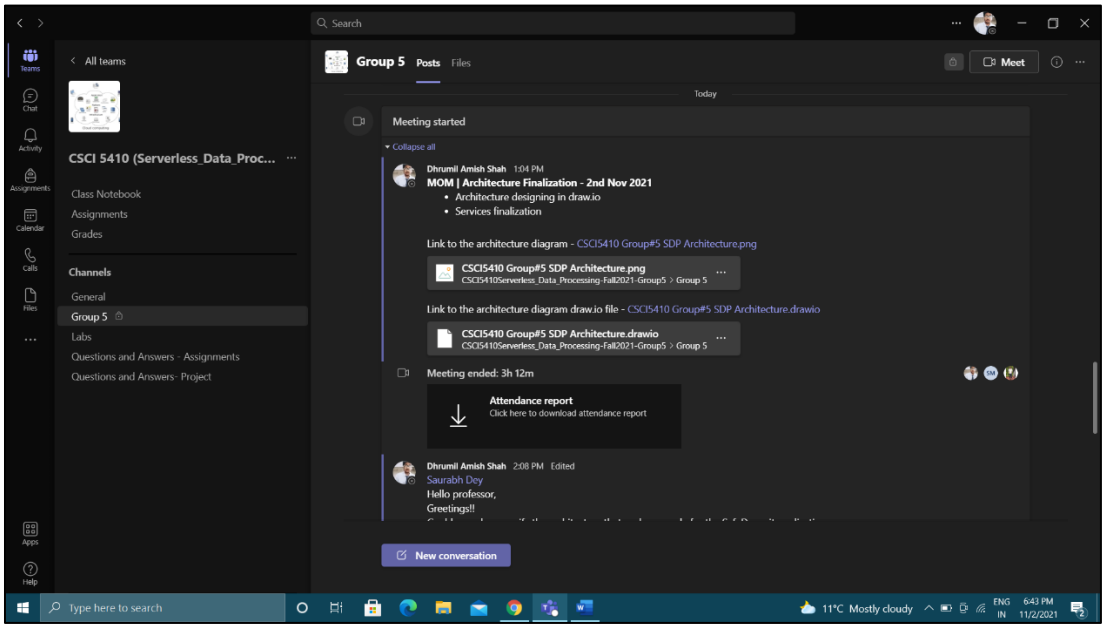

Figure 7 - Meeting regarding Architecture Finalization done Online on 2nd Nov 2021

Meeting 6

Date: 20th November, 2021

Place: Killiam Library

Agenda: Work distribution

Meeting 7

Date: 28th November, 2021

Place: Killiam Library

Agenda: Progress on application development meeting 1

Meeting 8

Date: 3rd December, 2021

Place: Killiam Library

Agenda: Progress on application development meeting 2

Meeting 9

Date: 12th December, 2021

Place: Online meeting

Agenda: Final meeting

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