AI-Enabled Extension for Online Meeting Tool (Zoom/GTM) for Remote Areas Having Low Internet Bandwidth

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ABSTRACT

This project revolves around the development of a Zoom extension focused on achieving efficient bandwidth utilization during video calls. The primary objective is to minimize bandwidth consumption while maintaining a video communication experience. To accomplish this, the extension introduces several key functionalities. It enables users to initiate video calls and employs advanced frame similarity analysis to identify and hold frames with significant resemblances, thus reducing redundant data transmission. Users can manually adjust frames per second (FPS) rates to further fine-tune bandwidth usage. Leveraging artificial intelligence, the extension forecasts future bandwidth requirements, allowing users to optimize the frame similarity threshold for optimal performance. Through these features, the project aims to significantly enhance bandwidth efficiency without compromising video call quality.

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CHAPTER 1

SOFTWARE PROJECT MANAGEMENT PLAN (SPMP)

Software Project Management Plan

1.1 Introduction

During Covid-19, many work tasks were performed remotely through online meetings using ZOOM/TEAMS. These work tasks targeted various sectors such as education, business etc. People across the world were connected through various software to perform their daily routine tasks. This project aims to provide extensions in online meeting software so that they can work smoothly even in remote areas where internet connectivity is poor.

1.1.1 Project Overview

The purpose of the Zoom extension project is to optimize the video call experience for users with limited bandwidth. The project aims to achieve this by utilizing AI-based algorithms to forecast future bandwidth, adjust the similarity rate, and optimize the transmission of video frames. The project's primary goal is to enhance the video call experience for users with low bandwidth while ensuring smooth video call. The project's success will be measured based on the improvements in video quality, reduction in network congestion, and overall user satisfaction.

1.1.2 Project Deliverables

There are 3 deliverables of my project:

- SPMP and SRS of the project.
- Complete documentation of the project.
- Implementation of the project with complete documentation

1.2 Project Organization

Project organization consists of software process model, roles and responsibilities and Tools and Techniques.

1.2.1 Software Process Model

Incremental model as a software model for the completion of project due to the following reasons:

- Implementation is done in parts, so it is easy to check the progress.

- Design, implementation and testing incrementally (a little more is added each time) until the product is finished.
- Prototyping of activity and interfaces.

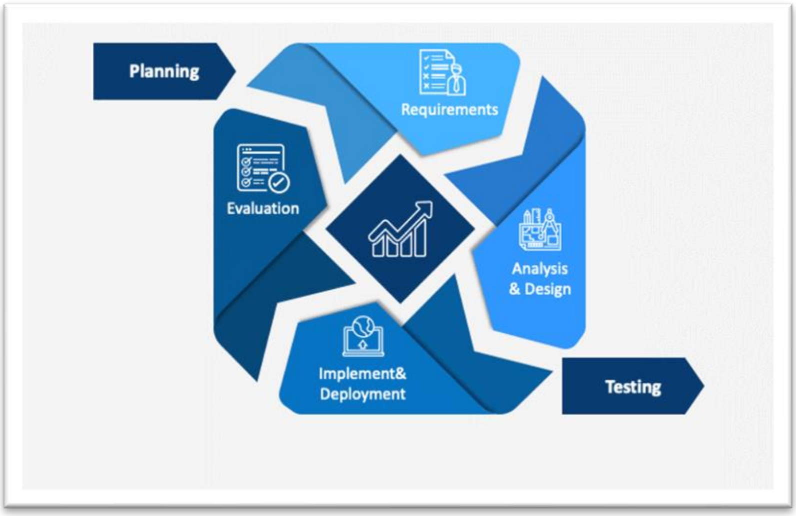


Figure 1: Incremental Model

1.2.2 Roles and Responsibilities

Roles

I am going to develop this system and my supervisor will guide me about the algorithms related to computing Frames Similarity, bandwidth forecasting, and requirements of the system.

Responsibilities

- Correct Understanding of the system.
- Gathering information.
- Understanding the Workflow of the system.

1.2.3 Tools and Techniques

Following tools are used in this project:

Tools	**Purpose**
Microsoft Word	For creating the document file for the project.
Project Libre	For creating Timeline and Gantt Chart for the project
Drawio	For drawing UML diagrams for the project
Visual Studio Code and Jupyter Notebook	As code editor
Python	For detecting training model, detecting bandwidth, calculating Frames Similarity and tunning threshold rate.
OBS Virtual Camera	For capturing incoming video from user's camera and sending it to Zoom after processing.

Table 1 : Tools and Technique

1.3 Project Management Plan

Following the description of project management plan for this project. It explains how time and resources managed throughout the lifecycle of this project.

1.3.1 Tasks

The project plan is divided into two phases: the requirements and analysis phase and the design phase. During the requirements and analysis phase, the major tasks include identifying the project scope, defining the requirements, creating a feasibility report, developing use cases, creating an analysis model, developing the SRS, and reviewing the SRS. In the design phase, the major tasks include developing a design using an Object-Oriented Approach.

1.3.2 Description

Description of the major tasks of both analysis and design phases:

Requirements and Analysis Phase

- **Identify Requirements**

The main goal is to review case study and define requirements.

- **Feasibility Report**

The main goal of this report is to check if the project is feasible or not.

- **Define Use Cases**

Define use case make use case diagram, and often analysis models.

- **Develop SRS**

Define functional and non-functional requirements and develop software requirement specification document. It includes all others details of product like scope, purpose, and introduction.

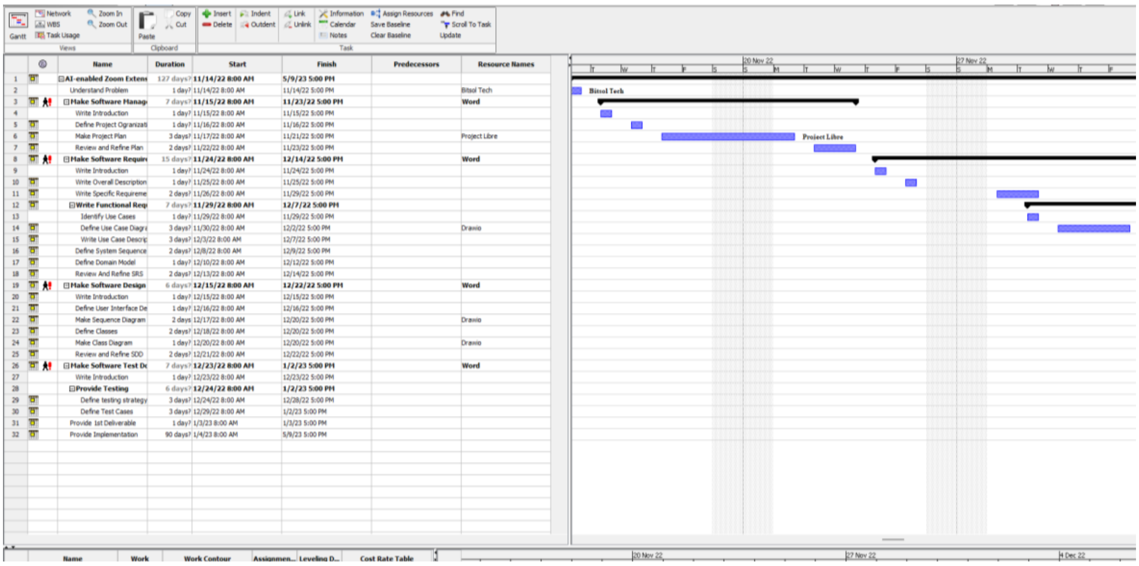
Design Phase

- **Make Sequence Diagram**

Illustrate how objects interact with each other and in what order during a specific scenario of a use case. It shows the flow of messages between objects, including their sequence and the order in which they occur, and can be used to visualize the dynamic behavior of a system.

- **Make Class Diagram**

Describe the attributes and operations of each entity associated with the system and the constraints imposed on the system.



	Name	Duration	Start	Finish	Predecessors	Resource Names
1	⊟AI-enabled Zoom Extens	127 days?	11/14/22 8:00 AM	5/9/23 5:00 PM		
2	Understand Problem	1 day?	11/14/22 8:00 AM	11/14/22 5:00 PM		Bitsol Tech
3	⊟Make Software Manag	7 days?	11/15/22 8:00 AM	11/23/22 5:00 PM		Word
4	Write Introduction	1 day?	11/15/22 8:00 AM	11/15/22 5:00 PM		
5	Define Project Ogranizati	1 day?	11/16/22 8:00 AM	11/16/22 5:00 PM		
6	Make Project Plan	3 days?	11/17/22 8:00 AM	11/21/22 5:00 PM		Project Libre
7	Review and Refine Plan	2 days?	11/22/22 8:00 AM	11/23/22 5:00 PM		
8	⊟Make Software Requir	15 days?	11/24/22 8:00 AM	12/14/22 5:00 PM		Word
9	Write Introduction	1 day?	11/24/22 8:00 AM	11/24/22 5:00 PM		
10	Write Overall Description	1 day?	11/25/22 8:00 AM	11/25/22 5:00 PM		
11	Write Specific Requireme	2 days?	11/26/22 8:00 AM	11/29/22 5:00 PM		
12	⊟Write Functional Req	7 days?	11/29/22 8:00 AM	12/7/22 5:00 PM		
13	Identify Use Cases	1 day?	11/29/22 8:00 AM	11/29/22 5:00 PM		
14	Define Use Case Diagra	3 days?	11/30/22 8:00 AM	12/2/22 5:00 PM		Drawio
15	Write Use Case Descrip	3 days?	12/3/22 8:00 AM	12/7/22 5:00 PM		
16	Define System Sequence	2 days?	12/8/22 8:00 AM	12/9/22 5:00 PM		
17	Define Domain Model	1 day?	12/10/22 8:00 AM	12/12/22 5:00 PM		
18	Review And Refine SRS	2 days?	12/13/22 8:00 AM	12/14/22 5:00 PM		
19	⊟Make Software Design	6 days?	12/15/22 8:00 AM	12/22/22 5:00 PM		Word
20	Write Introduction	1 day?	12/15/22 8:00 AM	12/15/22 5:00 PM		
21	Define User Interface De	1 day?	12/16/22 8:00 AM	12/16/22 5:00 PM		
22	Make Sequence Diagram	2 days	12/17/22 8:00 AM	12/20/22 5:00 PM		Drawio
23	Define Classes	2 days?	12/18/22 8:00 AM	12/20/22 5:00 PM		
24	Make Class Diagram	1 day?	12/20/22 8:00 AM	12/20/22 5:00 PM		Drawio
25	Review and Refine SDD	2 days?	12/21/22 8:00 AM	12/22/22 5:00 PM		
26	⊟Make Software Test Do	7 days?	12/23/22 8:00 AM	1/2/23 5:00 PM		Word
27	Write Introduction	1 day?	12/23/22 8:00 AM	12/23/22 5:00 PM		
28	⊟Provide Testing	6 days?	12/24/22 8:00 AM	1/2/23 5:00 PM		
29	Define testing strategy	3 days?	12/24/22 8:00 AM	12/28/22 5:00 PM		
30	Define Test Cases	3 days?	12/29/22 8:00 AM	1/2/23 5:00 PM		
31	Provide 1st Deliverable	1 day?	1/3/23 8:00 AM	1/3/23 5:00 PM		
32	Provide Implementation	90 days?	1/4/23 8:00 AM	5/9/23 5:00 PM		

Figure 2 : Project Management Plan

1.4 Summary

This chapter outlines the Software Project Management Plan, focusing on enhancing online meeting software for users with poor internet connectivity. The project's objective is to optimize video call experiences through AI-based algorithms. It employs an incremental software process model, with defined roles and responsibilities. Tools such as Microsoft Word, Project Libre, Drawio, and Python are utilized. The plan is divided into two phases: requirements and analysis, and design, each with specific tasks like identifying requirements, creating a feasibility report, defining use cases, and developing software requirement specifications. Additionally, design tasks involve creating sequence and class diagrams for system visualization.

CHAPTER 2

SOFTWARE REQUIREMENTS SPECIFICATIONS (SRS)

Software Requirements Specifications

2.1 Introduction

This chapter is to provide an overview of the contents of the SRS document and describe the scope of the project. In addition, this section explains the purpose of the document.

2.1.1 Purpose

The purpose of this SRS document is to provide a detailed overview of our Zoom extension software product, its parameters, and goals. The main purpose of our extension is to enhance the video call experience for users by detecting similarities between frames and sending only those frames that are dissimilar enough to another end. Additionally, our extension will include a bandwidth forecaster made using AI, which will enable the system to adjust the similarity rate based on the forecasted bandwidth, improving the overall video call quality.

2.1.2 Scope

The scope of this project is to develop a Zoom extension that allows users to perform video calls with low bandwidth consumption. The main scopes of the project are:

- To provide a solution for people to conduct video calls even in areas with poor internet coverage.
- To improve the quality of video calls by reducing the impact of low bandwidth on the video call.
- To make it easier for users to use Zoom extension for video calls with lower bandwidth requirements.

2.1.3 Objective

The objectives of developing AI-enabled Zoom Extension are:

- Develop a Zoom extension that can efficiently detect the similarity between frames, forecast bandwidth using AI, and tune thresholds and hold frames during video calls.
- Create a software product that meets the needs of Zoom users and helps them improve the quality of their video calls.

- Develop a software application that is feasible to create given the resources and expertise available.
- Address a real need in society for improved video communication tools in the age of remote work and distance learning.

2.2 Overall Description

2.2.1 Product Perspective

Zoom extension is an application that is developed in python to work with Zoom application. As Zoom doesn't provide any API to process outgoing or incoming video, so third-party software is used to capture and process live stream and send as their live video feed during Zoom Video Call. The main features that user can perform is that they can manually set FPS and check current bandwidth of the network. Moreover, there is also ML model to forecast future bandwidth of the network and make necessary amendments to preserve bandwidth.

2.2.2 Product Functions

The main functions of Zoom extension are:

- Perform Video Call
- Forecast bandwidth of network
- Compute Frames Similarity between two consecutive frames
- Tune threshold rate
- Check current bandwidth of network
- Manually set FPS
- Stopping system from transferring frames

2.2.3 User Characteristics

The Zoom extension is designed for users who are familiar with using the Zoom video conferencing platform. Users should have a basic understanding of how to install and use software applications on their computer.

2.2.4 Constraints

The Zoom extension requires the following:

- A computer or laptop with internet connectivity
- The Zoom video conferencing platform installed on the computer.
- OBS virtual camera software installed on the computer.

- A working camera.

2.3 Specific Requirements

2.3.1 External Interfaces

The external interface for this application includes the user's device camera and microphone to enable video and audio communication.

2.3.2 Functions

The main functions of Zoom extension are:

- Perform Video Call
- Forecast bandwidth of network
- Compute Frames Similarity between two consecutive frames
- Tune threshold rate
- Check current bandwidth of network
- Manually control FPS
- Stopping system from transferring frames

2.3.3 Performance Requirements

Many users can use this extension at once.

2.3.4 Software Quality Attributes

- ***Response Time***

  The extension should respond to the user's actions in a timely manner, with minimal delay or latency.

- ***Reliability & Availability***

  The extension should be reliable and stable, with minimum crashes, errors, or bugs. The AI-enabled Zoom extension requires an internet connection and power backup to be available 24/7.

- ***Scalability***

  The extension should be able to handle many users simultaneously, without any degradation in performance.

2.4 Functional Requirements

2.4.1 Use Cases List

- Perform Video Call
- Compute Frames Similarity
- Forecast Bandwidth
- Tune Threshold Rate
- Hold Video Frames
- Check bandwidth
- Set FPS Rate

2.4.2 Use Case Diagram

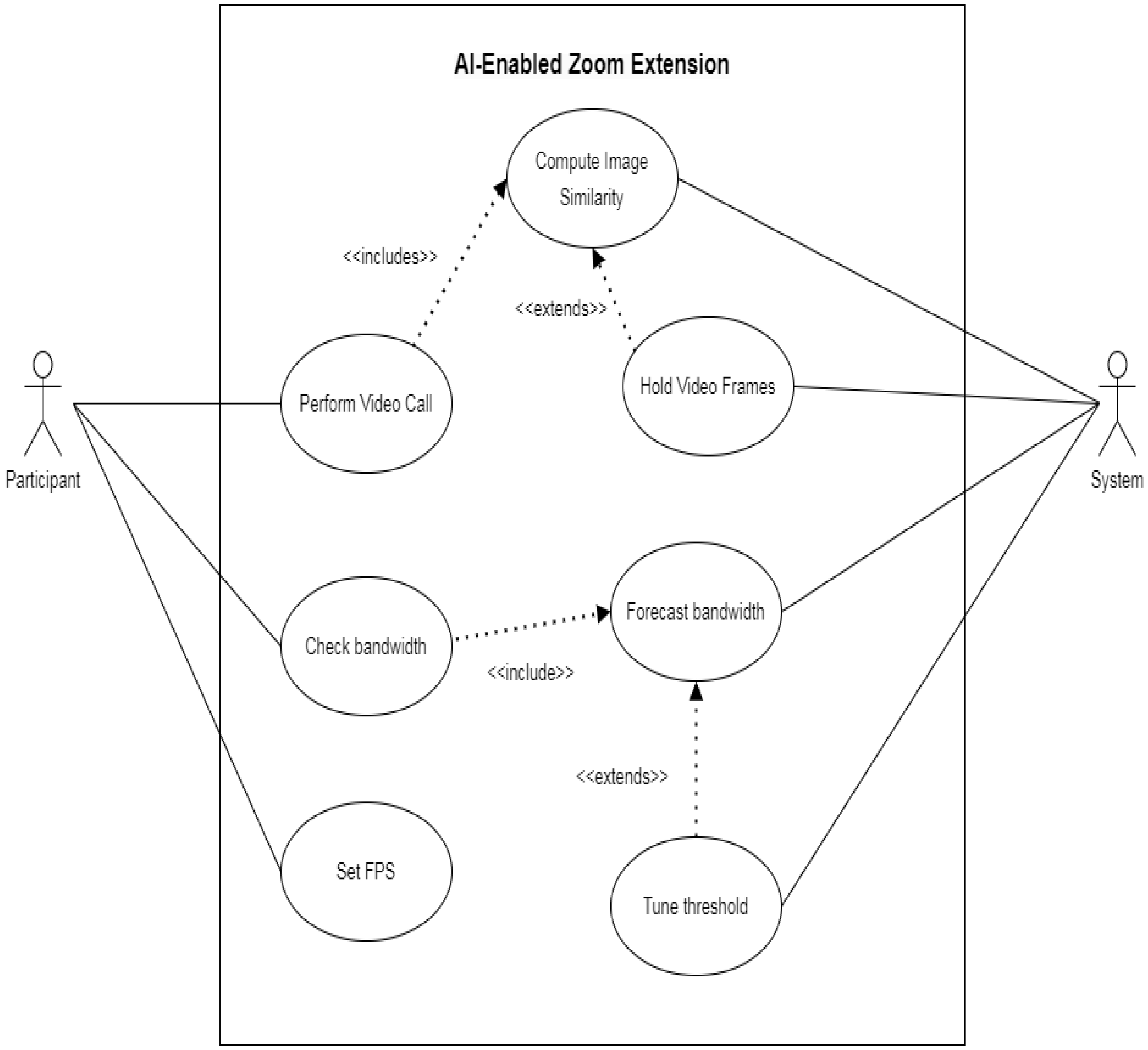


Figure 3 : Use-Case Diagram

2.4.3 Use Case Description

Following are the use case description:

UC-1 Perform Video Call

ID	UC-1
Name	Perform Video Call
Primary Actor	User
Stakeholders	User
Description	This use case is performed by user to initiate video call in Zoom extension.
Pre-condition	Users must have a zoom and zoom extension installed and have an active internet connection.
Post-condition	Users successfully performed video calls even with low bandwidth.
Main Success Scenario	Users initiate or join a meeting. User selects the OBS virtual camera from options.
Alternate Scenario	Zoom might be down. Try to restart the zoom.
Special Requirements	N/A
Technology	Internet connection, PC or laptop with camera and microphone.
Frequency	. Many times, a day

Table 2 : UC-1

UC-2 Compute Frames Similarity

ID	UC-2
Name	Compute frames similarity
Primary Actor	System

Stakeholders	User, System
Description	This use case is performed by system to determine similarity between two consecutive frames.
Pre-condition	The video feed from the user's camera is being received by the system.
Post-condition	Similarity between two consecutive frames is calculated successfully.
Main Success Scenario	The system receives the current video frame from the user's camera. The system compares the current frame to the previous frame using image similarity analysis.
Alternate Scenario	Zoom might be down. Try to restart the zoom.
Special Requirements	The Zoom extension must have access to the video feed from the user's camera and a way to send data to the other end of the video call.
Technology	Image similarity Algorithms
Frequency	Multiple times per second during the video call.

Table 3: UC-2

UC-3 Forecast Bandwidth

ID	**UC-3**
Name	Forecast Bandwidth
Primary Actor	System
Stakeholders	User, System

Description	This use case is performed by system to forecast quality of bandwidth using AI.
Pre-condition	The video frames from the user's camera are being received by the system, and the system can analyze the bandwidth of the network connection.
Post-condition	The system has forecasted bandwidth successfully.
Main Success Scenario	The system receives the network connection bandwidth. The system analyzes the network connection bandwidth and detects that it is below a certain threshold.
Alternate Scenario	Zoom might be down. Try to restart the zoom.
Special Requirements	The system must have the ability to analyze the bandwidth of the network connection.
Technology	AI algorithms for analyzing network bandwidth
Frequency	Multiple times per second during the video call.

Table 4: UC-3

UC-4 Tune Threshold

ID	UC-4
Name	Tune threshold
Primary Actor	System
Stakeholders	User, System
Description	This use case is performed by system to increase or decrease threshold of

	minimum frames similarity rate on basis of bandwidth detected.
Pre-condition	The system is currently in a video call session, and the system can analyze the bandwidth of the network connection.
Post-condition	The system has adjusted the threshold for sending images based on the detected network bandwidth.
Main Success Scenario	The system analyzes the network connection bandwidth and detects that it is above a certain threshold. The system increases the threshold for frame similarity if bandwidth is good or else decreases threshold to reduce network usage. The system periodically rechecks the bandwidth of the network connection and adjusts the threshold accordingly. The system continues to monitor the network connection and adjust the threshold as needed throughout the duration of the video call. Steps 2-4 are repeated until the end of the video call.
Alternate Scenario	Zoom might be down. Try to restart the zoom.
Special Requirements	The system must have the ability to analyze the bandwidth of the network connection.

Technology	AI algorithms for analyzing network bandwidth
Frequency	Multiple times per second during the video call.

Table 5: UC-4

UC-5 Hold Video Frames

ID	UC-5
Name	Hold Video Frames
Primary Actor	System
Stakeholders	User, System
Description	This use case is performed by system to increase or decrease threshold of minimum frames similarity rate on basis of bandwidth detected.
Pre-condition	The video frames from the user's camera are being received by the system, and the system can analyze image similarity and detect low bandwidth.
Post-condition	The system has held the video frames until the image similarity analysis and network bandwidth analysis determines that the frames are different enough and the network connection is good enough to be sent to the other end.
Main Success Scenario	The system receives the video frames from the user's camera. The system compares the current frame to the previous frame using image

	similarity analysis. The system periodically rechecks the bandwidth of the network connection and adjusts the threshold accordingly. If the similarity between the frames is below a certain threshold, the system holds the current frame and does not send it to the other end. If the similarity between the frames is above a certain threshold or system sends it to the other end. Steps 2-4 are repeated until the end of the video call.
Alternate Scenario	Zoom might be down. Try to restart the zoom.
Special Requirements	The system must have the ability to coordinate with the Zoom extension to send or hold frames based on image similarity analysis and network bandwidth analysis, and periodically recheck the network bandwidth.
Technology	AI algorithms for analyzing network bandwidth and Image similarity.
Frequency	Multiple times per second during the video call.

Table 6: UC-5

UC-6 Check bandwidth

ID	**UC-6**
Name	Check bandwidth
Primary Actor	User

Stakeholders	User, System
Description	This use case is performed by user to check current bandwidth of the network using speed test.
Pre-condition	The extension must be installed, running and user must have an active internet connection .
Post-condition	The available bandwidth of the network is successfully check and displayed.
Main Success Scenario	User checks for current bandwidth of the network. The current bandwidth, once checked by the system, is displayed.
Alternate Scenario	Zoom might be down. Try to restart the zoom.
Special Requirements	N/A
Technology	Speed test methods.
Frequency	Multiple times per second during the video call.

Table 7: UC-6

UC-7: Set FPS

ID	**UC-7**
Name	Set FPS
Primary Actor	User
Stakeholders	User, System

Description	This use case is performed by user to manually control FPS rate during video call.
Pre-condition	The extension must be installed, running and user must have an active internet connection .
Post-condition	The FPS rate are successfully changed.
Main Success Scenario	User selects FPS rate. The system conducts video calls using newly selected FPS.
Alternate Scenario	Zoom might be down. Try to restart the zoom.
Special Requirements	N/A
Technology	N/A
Frequency	Multiple times per second during the video call.

Table 8: UC-7

2.5 System Sequence Diagrams (SSDs)

2.5.1 Perform Video Call

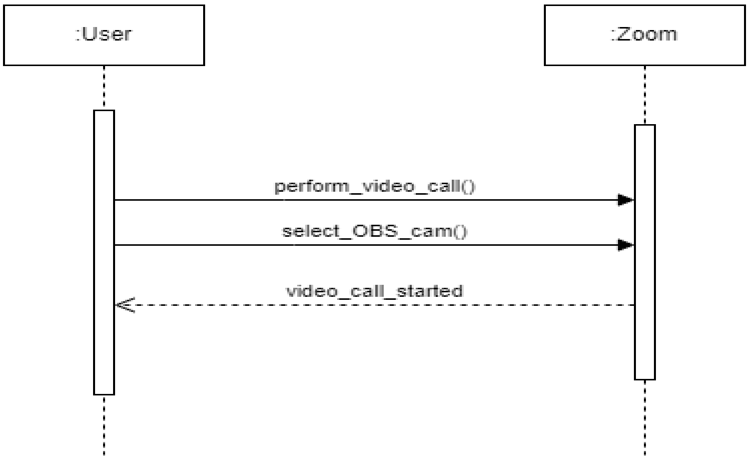


Figure 4: SSD-1

2.5.2 Compute Frames Similarity

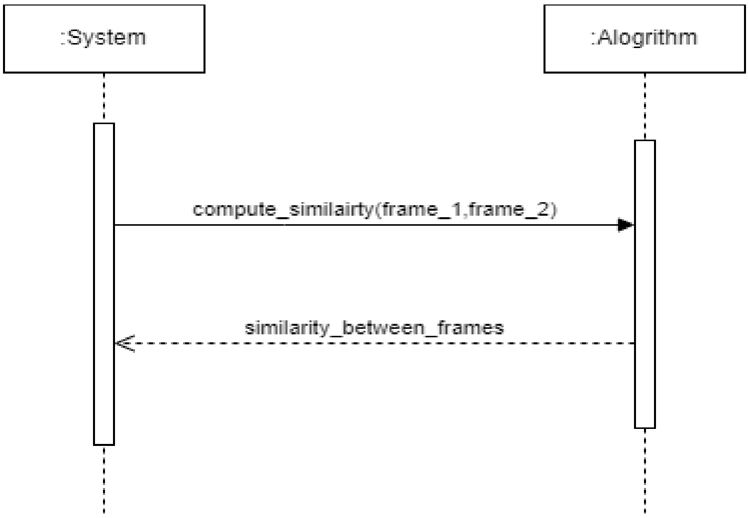

:System
:Alogrithm
compute_similairty(frame_1,frame_2)
similarity_between_frames

Figure 5: SSD-2

2.5.3 Forecast Bandwidth

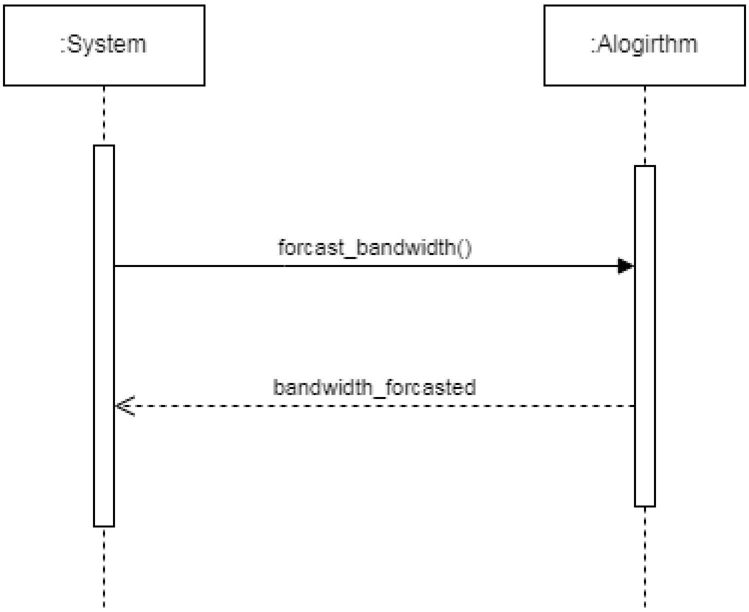


Figure 6: SSD-3

2.5.4 Tune Threshold

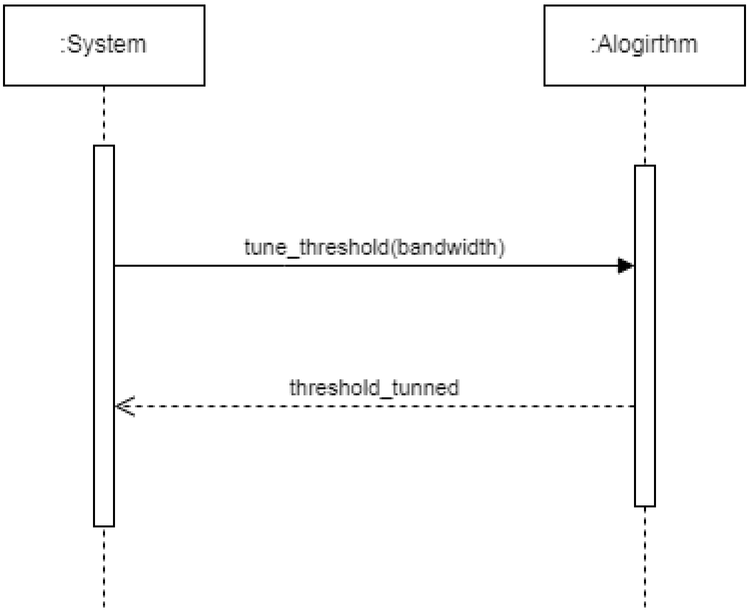


Figure 7: SSD-4

2.5.5 Hold Frames

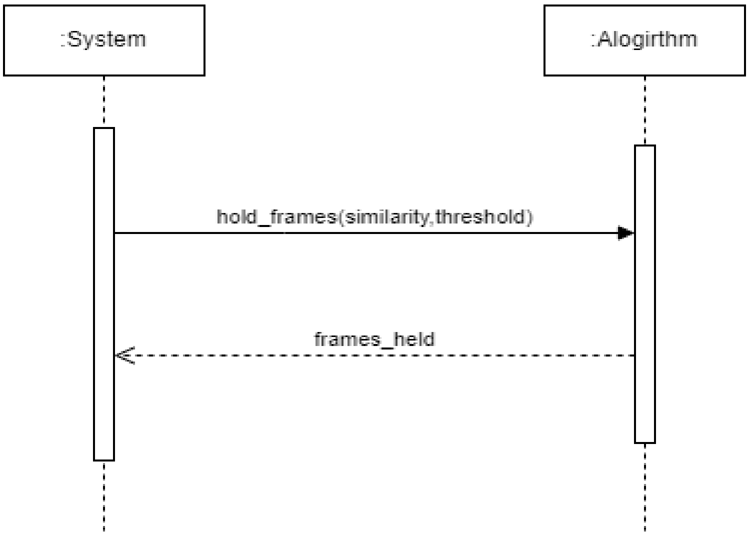


Figure 8: SSD-5

2.5.6 Check bandwidth

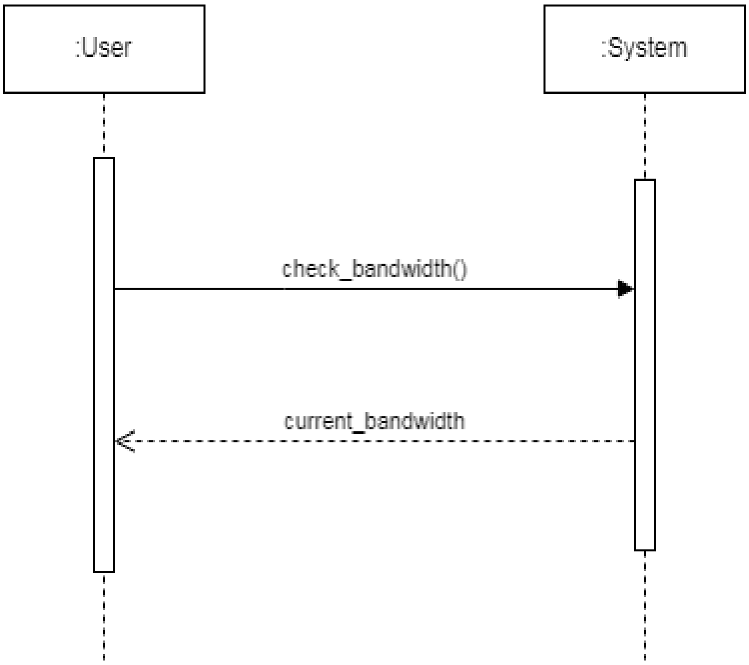


Figure 9: SSD-6

2.5.7 Set FPS

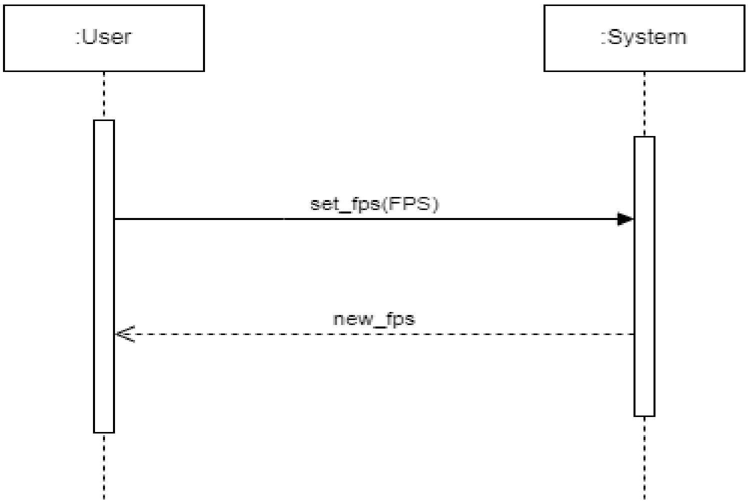


Figure 10: SSD-7

2.6 Domain Model

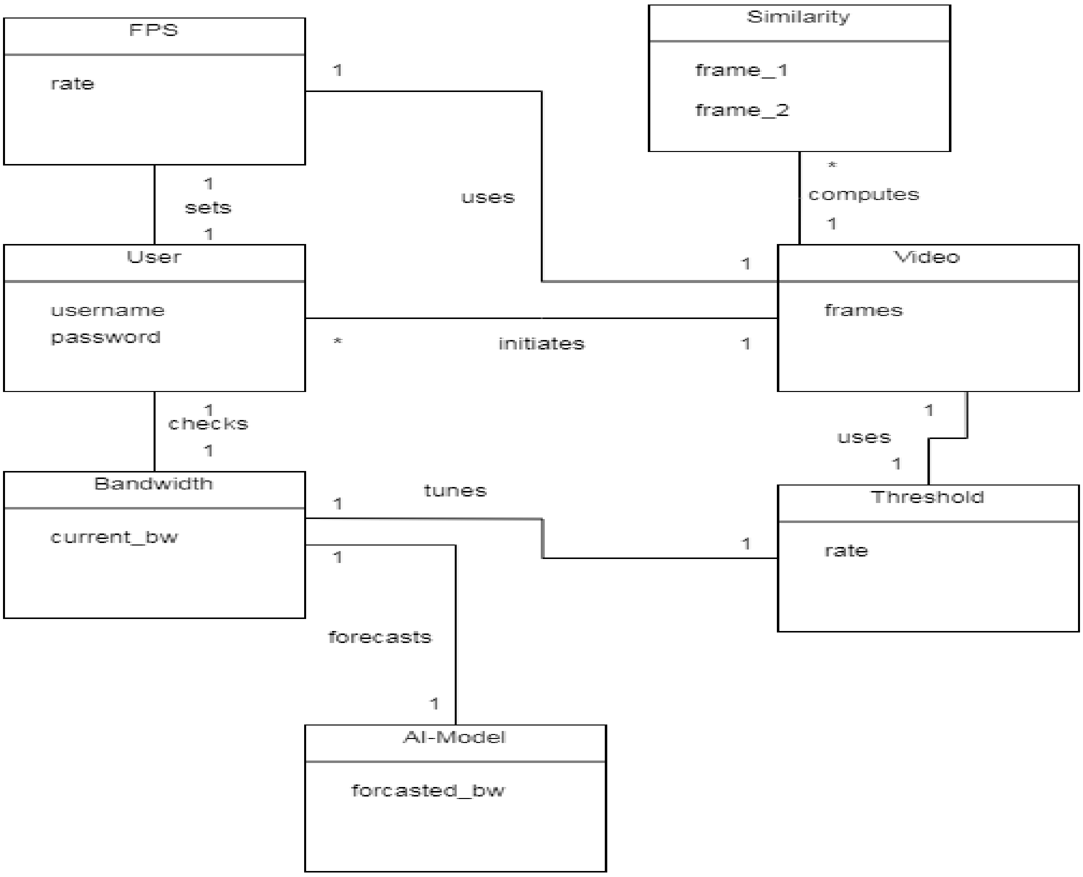


Figure 11: Domain Model

Explanation

In domain model we have real world classes and the same case in our system. The extension incorporates intelligent features to optimize bandwidth usage. Users can assess bandwidth, set frames per second (FPS) rates, and adjust similarity thresholds. An AI model forecasts future bandwidth needs, influencing the threshold adjustment. The video stream uses the set FPS and undergoes similarity computation based on the threshold. The goal is to minimize bandwidth consumption while maintaining a high-quality video call experience.

2.7 Summary

This chapter provides an in-depth overview of the Software Requirements Specifications (SRS) for the Zoom extension software. The SRS document outlines the purpose, scope, and objectives of the project, which aims to enhance the video call experience for users with limited bandwidth. It describes the product's functionality, including video call performance optimization, bandwidth forecasting using AI, and dynamic threshold tuning. User characteristics, constraints, and specific requirements are also discussed. The chapter includes use case descriptions, system sequence diagrams, and a domain model to provide a comprehensive understanding of the project's functionality and requirements.

CHAPTER 3

SOFTWARE DESIGN DESCRIPTION (SDD)

Software Design Description

3.1 Introduction

The Software Design Description (SDD) serves as a means of communicating the design information of a software system to its stakeholders. It outlines the structure of the software and how it will fulfill the requirements. The SDD typically includes an interface design and class diagram, as well as a description of how the software will meet the requirements. It is an important document in the software development process and serves as a reference for developers throughout the project.

3.1.1 Purpose

The Software Design Document for the AI-enabled Zoom Extension serves as a blueprint for development, specifying what and how to build. It offers detailed descriptions, ensuring clear communication between stakeholders and developers.

3.1.2 Design Overview

The document outlining the design of the AI-enabled Zoom Extension is the Software Design Document. It presents a comprehensive, detailed description of the system's low-level structure and design for each of its components.

3.1.3 Requirement Traceability Matrix

The Requirement Traceability Matrix (RTM) connects user requirements to test cases to ensure comprehensive testing. It's established at the project's start, guiding scope and deliverables. The RTM is a two-way matrix, tracking requirements forward from deliverables and backward from business requirements for specific software features.

Requirement ID	Requirement Name	Interface	Test Case
UC-1	Perform video call	Yes	No
UC-2	Compute Frames Similarity	No	Yes
UC-3	Forecast Bandwidth	No	Yes
UC-4	Tune threshold	No	Yes
UC-5	Hold frames	No	Yes
UC-6	Check bandwidth	Yes	Yes

UC-7	Set FPS Rate	YEs	Yes

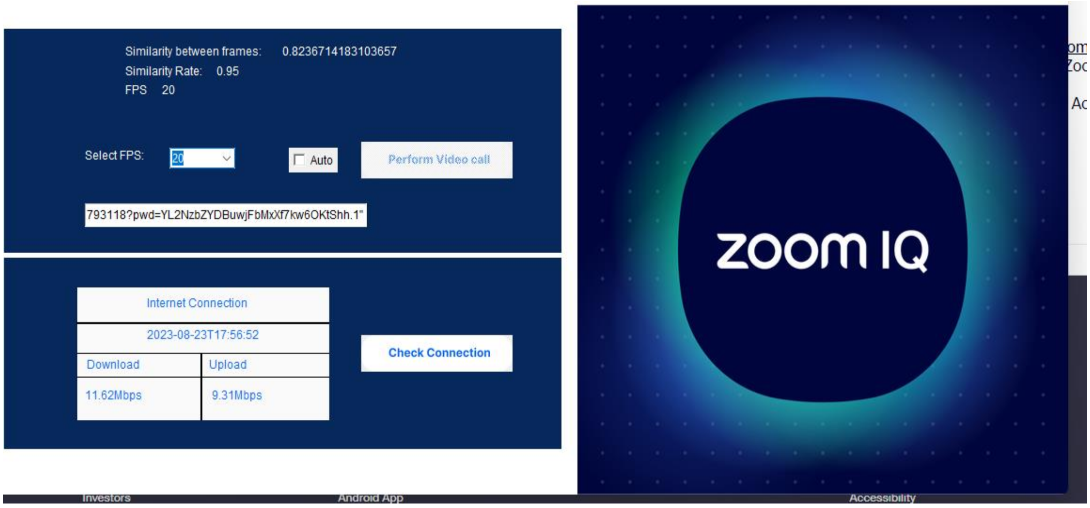
Table 9: Matrix

3.2 User Interface Design

3.2.1 Description of User Interface

The user will either initiate or join a meeting using GUI, then he will select OBS virtual camera. This project uses OBS virtual camera is Third-party software, to process and render video to zoom as Zoom doesn't provide any API to access live stream video. He can also check bandwidth and set FPS rate using GUI.

3.2.2 Interface Images



Similarity between frames: 0.8236714183103657
Similarity Rate: 0.95
FPS 20

Select FPS: 20

793118?pwd=YL2NzbZYDBuwjFbMxXf7kw6OKtShh.1"

Internet Connection	
2023-08-23T17:56:52	
Download	Upload
11.62Mbps	9.31Mbps

Figure 12: Interface:

3.3 Sequence Diagram

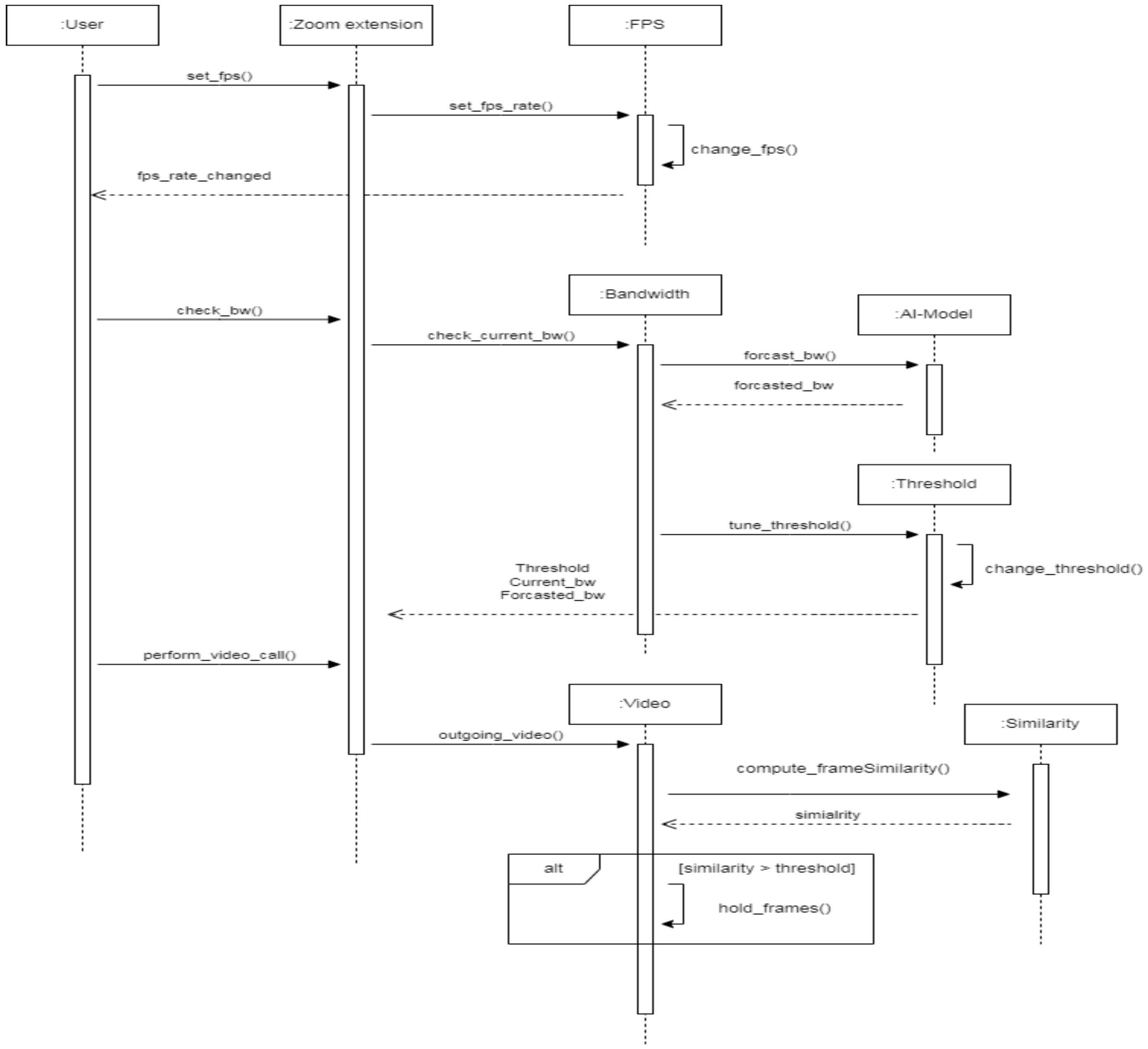


Figure 13 : SD

3.4 Class Diagram

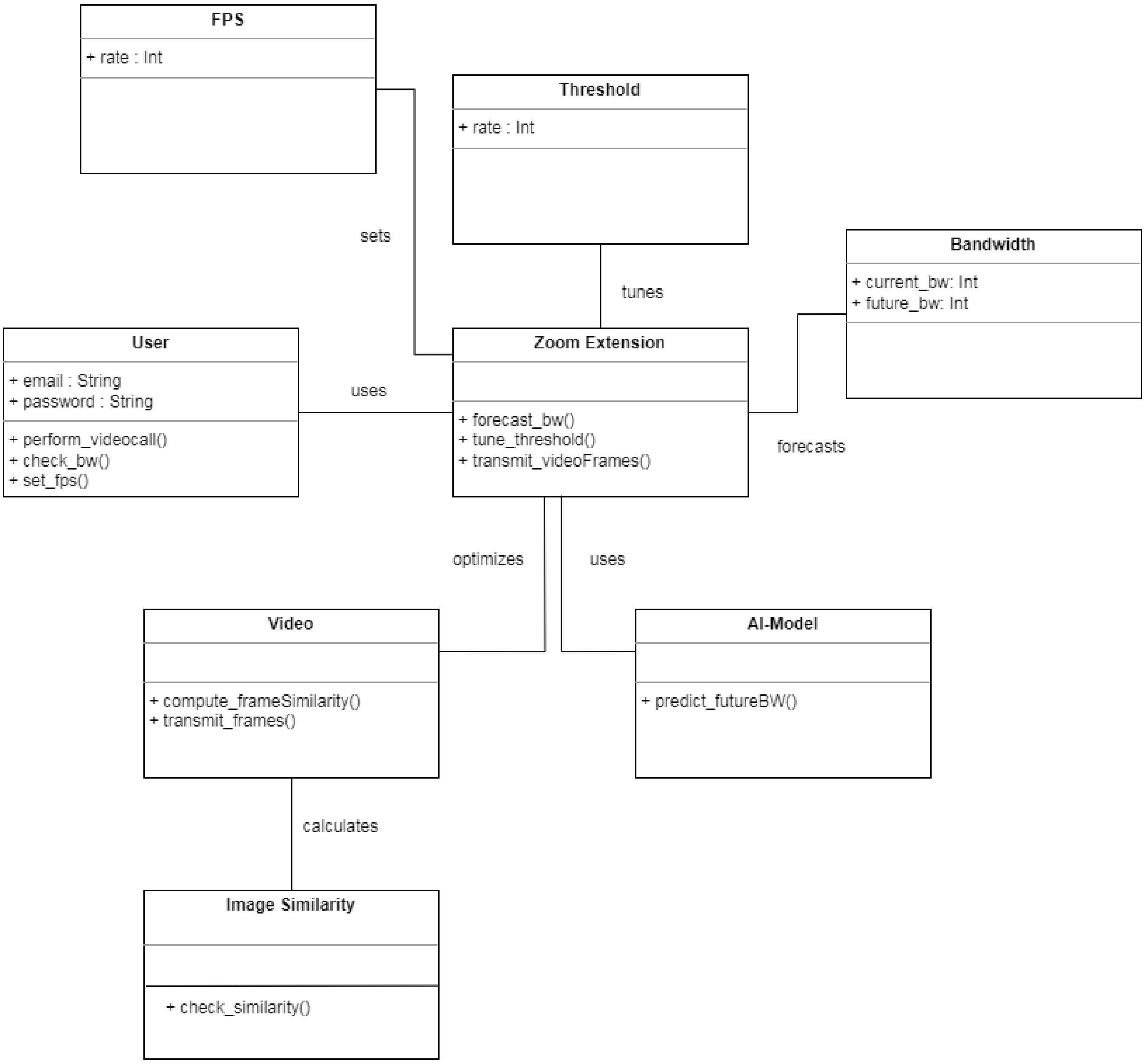


Figure 14: Class Diagram

Explanation

This class diagram outlines a system aimed at enhancing bandwidth-efficient video calls via a Zoom extension. It comprises several key classes: "User," facilitating call initiation, bandwidth check, and FPS rate setting; "Extension," handling bandwidth forecasting, similarity threshold tuning, video frame transmission, and threshold adjustment; "AIModel," predicting future bandwidth requirements; "Video," computing frame similarity and transmitting processed frames; "Threshold" and "FPS," holding respective values for similarity assessment and transmission rate; "Similarity," calculating frame resemblance; and "Bandwidth," encompassing current and predicted bandwidth. The relationships between classes depict the flow of interactions, enabling users to optimize bandwidth utilization while maintaining video call quality.

3.5 Summary

This chapter focuses on the Software Design Description (SDD) for the AI-enabled Zoom Extension project. The SDD serves as a blueprint for the software's development, providing detailed information on its structure and functionality. It includes a Requirement Traceability Matrix (RTM) connecting user requirements to test cases, ensuring comprehensive testing. The user interface design is described, with graphical representations of the interface. Additionally, sequence and class diagrams are provided to depict the system's interactions and structure. The class diagram showcases key classes and their relationships in the system, illustrating how the extension aims to optimize bandwidth usage while maintaining video call quality.

CHAPTER 4
IMPLEMENTATION AND TESTING

Implementation and Testing

4.1 Implementation

It is an AI-enabled Zoom extension to enhance video call between multiple participants even with low bandwidth. It allows users to check for current bandwidth. This feature also determines future network bandwidth using AI algorithms. After determining bandwidth, it sets the threshold of sending frame from one end to another. Then it checks similarity between the previous and current frame from live video stream of participants. If this similarity rate is below the threshold, frame won't be sent to another end, consuming no bandwidth User can also select FPS rate manually. The implementation of this project is done in Python.

4.1.1 Front end Design

As this is Zoom extension, so front end or user interface compromises of:

- Zoom Desktop Application
- Tkinter

4.1.2 API's or Libraries Used

Now comes the core part of Zoom extension which includes the AI-enabled algorithms used for various functionalities during a video call. These functionalities include performing a video call, detecting similarity between frames, detecting bandwidth using AI, tuning threshold, and holding frames.

- **Perform Video Call:** This will engage video call between various participants.
- **Compute Frames Similarity:** This will compute similarity between previous and current frame.

  It uses following libraries which are available in python:

  - **OpenCV:** For capturing videos frames from user's camera feed during live streaming.
  - **skimage.metrics**: module in the scikit-image library in Python that provides several image metrics functions for comparing two image arrays.
  - **structural_similarity**: one of the metrics functions in skimage.metrics module that computes the structural similarity index between two images.

Record of previous and current frames is stored in variables. The SSIM algorithm compares local patterns of pixel intensities in these two frames to measure their structural similarity. It returns a value between 0 and 1, where 1 indicates a perfect match and 0 indicates no similarity.

- **Forecast bandwidth:** This will determine bandwidth of the network using various network features (using AI).

It uses following libraries which are available in python:

  - **LSTM:** LSTM stands for Long Short-Term Memory, and it is a type of recurrent neural network (RNN) architecture designed to handle sequence data. LSTMs are particularly effective in capturing long-range dependencies and patterns in sequential data.
  - **Joblib:** It is often used in machine learning and data science applications for saving and loading trained models.

This model uses LSTM for training. Then it is saved using Joblib library. During video call, this model is loaded again, checks for bandwidth periodically and take actions based on generated results such as tunning threshold of frame similarity rate.

- **Tune Threshold:** This will be increased or decreased on the basis of results generated from the detect bandwidth. If bandwidth is low, we will decrease the threshold of frame similarity rate and vice versa.
- **Hold frames:** It will compare threshold rate and result generated from the compute frames similarity and act accordingly for example if frames similarity is above threshold, frames won't be sent to another end. It will satisfy our condition that is frame is only sent if there is significant change in it.
- **Check bandwidth:** It will check the current bandwidth of the network.
- **Select FPS:** It will select outgoing FPS for the video.

4.2 Testing

4.2.1 Introduction

Software testing is a crucial verification and validation process that guides the tester through a series of steps to confirm whether a software application is free from defects and functioning as expected by the end user. This process is essential and should be carried out during the development process as it helps to evaluate the quality of the product.

4.2.2 Test Strategy

The test strategy outlines the approach taken to test the system and how potential risks will be addressed during software development. The testing process includes conducting unit tests on each component of the project, followed by integration testing, and ultimately acceptance testing.

4.2.3 Features to be Tested

Following features will be tested from the system:

- Frames similarity
- Checking bandwidth
- Threshold tunning
- Holding frames
- Setting FPS

4.2.4 Test Cases

In software engineering, a test case refers to a set of predefined conditions and criteria that a tester follows to evaluate whether an application or software system and its features are functioning as intended. Testing is executed based on these test cases to ensure that the software meets the desired quality standards.

TC-1: Frames Similarity

Test ID	TC-1
Description	Check if two provided frames are similar or not.
Setup	Application is running. Video live stream is available.
Input	Two consecutive frames.
Instructions	N/A
Expected Result	Frames are similar with value 1. Frames are different with value 0.

Actual Result	Frames are similar with value 1. Frames are different with value 0.
Verdict (Pass/Fail)	Pass.

Table 10: TC-1

TC-2: Check bandwidth

Test ID	**TC-2**
Description	Check current bandwidth of the network and forecast future bandwidth
Setup	Application is running.
Input	Network features.
Instructions	N/A
Expected Result	Bandwidth detected, which is good. Bandwidth detected, which is poor.
Actual Result	Bandwidth detected, which is good. Bandwidth detected, which is poor.
Verdict (Pass/Fail)	Pass.

Table 11: TC-2

TC-3: Threshold tunning

Test ID	**TC-3**
Description	Check if threshold of frame similarity rate is tuned or not.
Setup	Application is running. Bandwidth is detected successfully.
Input	Bandwidth
Instructions	N/A
Expected Result	The threshold is increased due to good bandwidth. The threshold is decreased due to poor bandwidth.
Actual Result	The threshold is increased due to good bandwidth.

	The threshold is decreased due to poor bandwidth.
Verdict (Pass/Fail)	Pass.

Table 12: TC-3

TC-4: Holding Frames

Test ID	**TC-4**
Description	Check if frames are hold or sent to another end.
Setup	Application is running. Similarity between frames is computed. Threshold is tuned.
Input	Frames similarity and threshold rate.
Instructions	N/A
Expected Result	Frame is sent to another end as similarity rate is below threshold rate. Frame is held and not sent to another end as similarity rate is above threshold rate.
Actual Result	Frame is sent to another end as similarity rate is below threshold rate. Frame is held and not sent to another end as similarity rate is above threshold rate.
Verdict (Pass/Fail)	Pass.

Table 13: TC-4

TC-5: Setting FPS

Test ID	**TC-5**
Description	Check if FPS are updated successfully or not.
Setup	Application is running.

	Video live stream is available.
Input	FPS value.
Instructions	N/A
Expected Result	FPS rate updated. FPS rate didn’t update.
Actual Result	FPS rate updated. FPS rate didn’t update.
Verdict (Pass/Fail)	Pass.

Table 14: TC-5

4.3 Summary

This chapter covers the Implementation and Testing phases of the AI-enabled Zoom extension project. In the implementation section, it explains the functionalities of the extension, including video call initiation, bandwidth forecasting, threshold tuning, frame similarity detection, and manual FPS rate selection. The project is implemented using Python and utilizes various libraries and AI algorithms for its core functionalities.

In the testing section, it introduces software testing as a crucial part of the software development process, ensuring the software's quality and functionality. The test strategy outlines the approach taken for testing, including unit tests, integration tests, and acceptance tests. It lists the features to be tested, such as frame similarity, bandwidth checking, threshold tuning, frame holding, and FPS setting. Detailed test cases are provided for each feature, along with expected and actual results, ensuring the quality and reliability of the Zoom extension.

Conclusion And Future Work

In conclusion, the AI-enabled Zoom extension project aims to enhance the Zoom video conferencing experience for users by detecting frame similarity, bandwidth optimization, and threshold tuning. The project successfully achieved the set objectives by leveraging AI and machine learning algorithms. The use of Scikit-image and Scikit-learn libraries helped in detecting frame similarity, while the Gradient Boosting Regressor algorithm enabled the optimization of bandwidth. The project's testing was done using the test cases designed in the Test Strategy document to ensure the application's quality and functionality.

Future work can be done to improve the AI-enabled Zoom extension project. The project can be extended to include additional features, such as facial recognition, speech-to-text transcription, and sentiment analysis. These features can help users in making the most of their video conferencing experience by providing additional insights into the meeting dynamics. Moreover, the project can be further optimized to improve its accuracy and speed. The algorithms can be fine-tuned to provide better results, and the code can be optimized to make it more efficient. Finally, the project can be integrated with other communication platforms such as Microsoft Teams, Google Meet, and Skype, to provide users with a seamless experience across multiple platforms.

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