# REAL TIME E-LEARNING PLATFORM

19-079

Software Requirements Specification

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# DECLARATION

I declare that this is my own work and this system requirement specification does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of Supervisor Date

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# 1 INTRODUCTION

## 1.1 Purpose

The main purpose of this document is to give a clear understanding about the scope, functional and non-functional requirements, dependencies along with the other relevant specifications of the proposed real time e-Learning platform. In addition, this document will illustrate the issues related with the current systems and actions to be performed by the development team are described in order to come up with a better solution. From this document developer will get a better understanding about the functionalities of the system and can be used to verify the user requirements. Here user can get an idea whether the system will meet the user's requirements or not and requirement of the hardware, software and other dependencies.

This document is intended primarily for reference of the supervisor, Dr. Malitha Wijesundara, co-supervisor Mr. Pramadhi Atapattu, research group members and any other personal interested in this field.

## 1.2 Scope

Primarily, purpose Real-time e-learning platform is to provide its users a real-life lecture hall experience through a web service that broadcast lectures and facilitate other features that are related to a physical lecture hall scenario. This document covers the requirements of the Real-time e-Learning Platform. Intention of this document is to provide a guide to the developers who design and build the solution. Scope of the SRS is also to describe the tools and techniques that are going to be used in developing this component. The technologies referred in the implementation of this component is also discuss in this document.

The system is developed as four separate components which will integrated together to perform the intended tasks. The components are Lecturer Tracking component, Video transcoding component, Video Player component and Student Questioning Handling and Whiteboard (SQHW) component.

Lecturer tracking is a part of the real-time e-learning platform solution. It will behave like a real cameraman by identifying lecturer and start sending video stream to a streaming server over a local network. Same video stream is processed using a specialized tracking algorithm. Output of the algorithm is a set of commands to a PTZ camera which moves according to those commands. Algorithm use lecture movements in the video frames to see his position relative the frame and map it to a set of PELCO commands which assist PTZ camera to move in the same direction and speed. Here it is applied to detect and track a single person in a lecture hall. But this can be further modified and improved to fulfill needs in surveillance industry to detect and track people based on given conditions like behavior anomalies.

Video transcoding module is in charge of converting an incoming RTMP stream into WebRTC format with multiple variants. These variants have different bitrates so that viewers with different levels of download bandwidth are able to consume live video streams at the best possible quality for their connection. Also this module will store live streamed video feeds to facilitate users with video playback for later.

SQHW component develop for the users to enhance the interaction between lecturer and the student connected via internet. If there are any questions has to asked from the lecturer in real time by the students connected via internet, he/she would be able to do so using the SQHW component.

This document describes the technologies, concepts, flow of the system using diagrams. Since this document will discuss the features and technologies to be used and will be guideline which will act as the reference to the developers to understand the final output with certain limitations.

## 1.3 Definitions, Acronyms, and Abbreviations

| Term | Definition |
|---|---|
| Latency | Delay over network |

*Table 1.3 1 Definitions for terms used in SRS*

| Acronym / Abbreviation | Definition |
|---|---|
| SRS | System Requirements Specifications |
| RTMP | Real-Time Messaging Protocol |
| PC | Personal Computer |

*Table 1.3 2 Glossary of Acronyms*

## 1.4 Overview

Real-time e-Learning platform is a live lecture streaming web application which will stream lecture modules in real-time. This application comprises with four major components.

### 1.4.1 Main Goal

Implementation of an e-Learning platform which facilitate real-time interactions between students and lecturers through a web application and also provide vital and useful statistics for the institute to improve their standards related to prevailing educational structure.

### 1.4.2 Specific Goals

- Lecturer face detection and tracking by using a single PTZ camera.
- Streaming both projector screen and lecturer tracking video feed to server.
- Transcoding video streams from RTMP/RTSP to WebRTC maintaining minimum delay and high quality.
- Providing the facility to access the lecture feeds even after they are being streamed in case if the student needed to revise the lecture again for any clarifications
- Streaming multiple lectures simultaneously.
- Developing a management console for maintaining separate session per each lecture, user connection handling and load balancing and resource handling as per the requirement.
- Provide online students with the facility to watch the lecturer, projector screen, whiteboard, and the live chat real-time and simultaneously using only a web browser. They may decide which feed to give priority.
- Provide an in-depth analysis on the students' interactions with the lecture feeds, their technical background, contents of the lecture materials, etc. as a feedback to improve the future performance.
- Converting audio stream of the lecture into text stream to provide the students to search videos using video contents as keywords
- Students can raise hand, if there any questions that has to asked from the lecturer.
- Provide access to the whiteboard facility for students when asking questions.
- Developing a chat box to ask questions by typing and upload files whenever needed using chat box.
- Whiteboard will be a vector based drawing window.
- Lecturer will able to see the online student list who connected to the lecture.
- Developing a web application containing all the features required by both lecturer and student to interact with the platform.

### 1.4.3 Users

This system is used by the students of the university to access lecture recordings and live streams. Lecturers of the university interacts with the system during live lecture streaming. They also capable of modifying recorded videos later. Administration panel use this system to monitor activities and behaviors related to students and lectures within the application.

# 2 OVERALL DESCRIPTIONS

The most common teaching and learning practice adopted by many enterprises has always been a classroom with one or more instructors and learners meeting physically and in real-time. But in this teaching model, there are several drawbacks which will be addressed as problems within this research.

A classroom based learning experience means the class schedule is predetermined and not subject to change. Students must shape their personal schedules around school instead of the other way around. If plans unexpectedly change or an emergency comes up, the student cannot adjust the class schedule to turn in the work at a different time. This is one of the main problems that this research will find solutions for.

Content non-reusability is another problem that can be found in classroom learning. Memorizing or writing all the necessary content while listening to a lecture is difficult. Therefore, students might miss many important points that the lecturer is pointing out during a lecture.

**Solution**

The proposed solution for the identified problems would be an e-Learning system to overcome lecture missing problems as well as content non-reusability problems. The

overall expectation of the system is to provide better experience as a real class room scenario with many useful functionalities.

The system covered with four components as

- Real time audio/video transcoding component
- Face tracking component
- Student Question Handling & Whiteboard (SQHW) component
- Video player with data analytics component

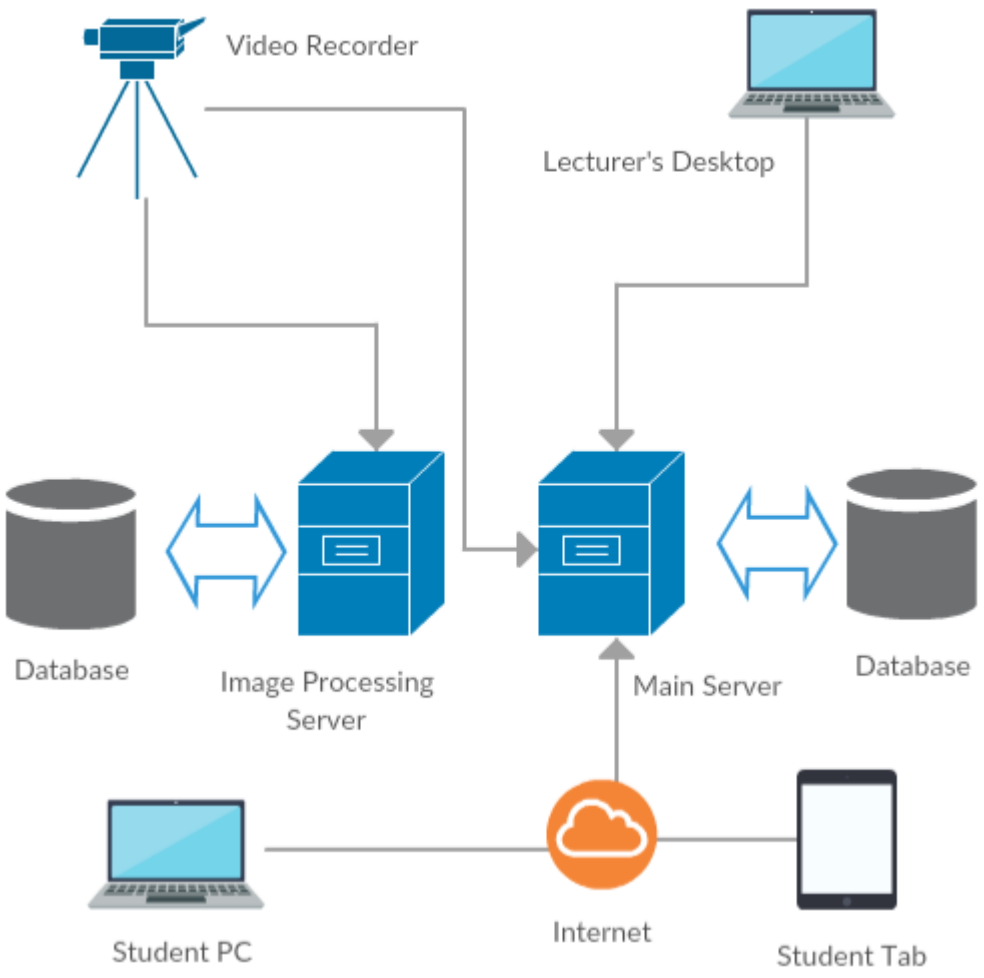


*Figure 3.1.1: Architecture Design*

The system we are proposing will be developed as a web application in order to make the solution platform independent and to provide mobile support with less development effort.

Figure 3.1.1 shows the architecture design for the proposing real-time e-learning platform.

A database will be created using face-ids of the existing lecturers. Using a PTZ camera, already registered lecturers will be automatically identified. Then the live feed will be sent to a dedicated server where it will be processed and it will determine the camera movements so it will keep the lecturer in the view. PTZ camera will be operated in response to the PELCO commands from the server based on the video feed.

If there are multiple registered lecturers in the camera view, one lecturer can be selected for tracking and only that lecturer will be tracked. If the lecturer is not registered in the database, he/she can get registered before the lecture so that he/she will be tracked throughout the lecture.

Also as shown in Figure 3.1.1, the same feed from the tracking camera will be sent to the Main Server using Real-Time Messaging Protocol (RTMP) / Real-Time Streaming Protocol (RTSP) for live streaming purposes along with the projector video feed. A transcoding server is used to convert above RTMP/RTSP feeds into WebRTC with multiple variants like 1080p, 720p, etc.

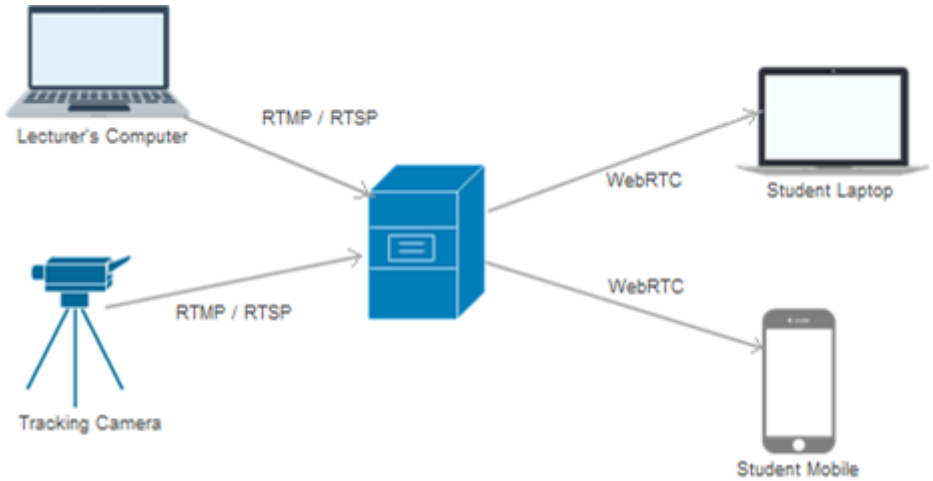


*Figure 3.1.2: Transcoding Protocols*


*Figure 3.1.3: Transcoding Protocols*

A text stream will be generated from the audio stream of the lecture using a voice to text conversion module which is running parallel to other modules of the server.

Also all the video feeds received at the main server will be stored for the use of video playback feature.

Server will be able to stream multiple lectures simultaneously. Each lecture will be assigned to a session where multiple users can join. Load balancing and resource allocation will be handled per session considering the demand for the session. These details will be monitored and controlled by a management console.

In the student's interface of the proposed web application, there will be media player with multiple views for camera feed, projector screen feed, whiteboard, chat window and student question video feed (only when available). The layout of the player will be a dynamic one allowing the student to maximize any view as he/she likes.

This player will be used for both real-time and playbacks. In real-time, students can participate in the chat, ask questions and use the whiteboard after permission is given by the lecturer. But in playbacks, these whiteboard and chat will replicate the original experience by automatically animating the whiteboard and scrolling the chat on seeking the playback timeline. At any time, all the feeds will be in sync.

Additionally, the video contents can be searched using the keywords that are already been translated in the main server using the voice to text conversion module.

In the background, player will collect various data like which parts of the video played and skipped, which video feed was maximized at any given time, which device was

used to play and which time of the day it was played, etc. These data will be analyzed and statistics will be displayed in the management console.

## 2.1 Product Perspective

The proposed e-Learning platform consists of more newly introduced features which resolves various problems existing with students relating the studies than existing applications.

Lecturer Tracking Algorithm

| **Features** | **Eduscope** | **Proposed System** |
|---|---|---|
| Smooth Real-Time Tracking | No | Yes |
| Real-Time Face Detection | Yes | Yes |
| Real-Time Face Recognition | No | Yes |
| Using CNN For Improved Face Recognition | No | Yes |

*Table 2.1.1 Lecturer Tracking Algorithm Comparison*

Student Questioning Handling and Whiteboard

| **Features** | **Eduscope** | **Proposed System** |
|---|---|---|
| Vector based Whiteboard | No | Yes |
| Text-based lecturer student interactions | Yes | Yes |
| Video-based lecturer student interactions | No | Yes |

*Table 2.1.2 Student Questioning Handling and Whiteboard Comparison*

Video Transcoding

| **Features** | **Eduscope** | **Proposed System** |
|---|---|---|
| Real-Time Transcoding | Yes with considerable latency | Yes |
| Adaptive Bitrate Capability | No | Yes |
| Webcam support student questioning facility | No | Yes |
| Video playback | Yes | Yes |

*Table 2.1.3 Video Transcoding Comparison*

Video Player and Data Analytics

| **Feature** | **BigBlueButton** | **Proposed System** |
|---|---|---|
| Real time streaming (WebRTC) | Yes | Yes |
| Multiple simultaneous streams | No | No |
| Polling | Yes | No |
| Dynamic Layout | No | Yes |
| Usage Report | No | Yes |
| Real time transcribing | No | Yes |
| Closed caption (CC) | No | Yes |

*Table 2.1.4 Video Player and Data Analytics Comparison*

### 2.1.1 System Interfaces

Real-time e-Learning platform does not interact with any other external systems and hence there are no system interfaces.

### 2.1.2 User Interfaces

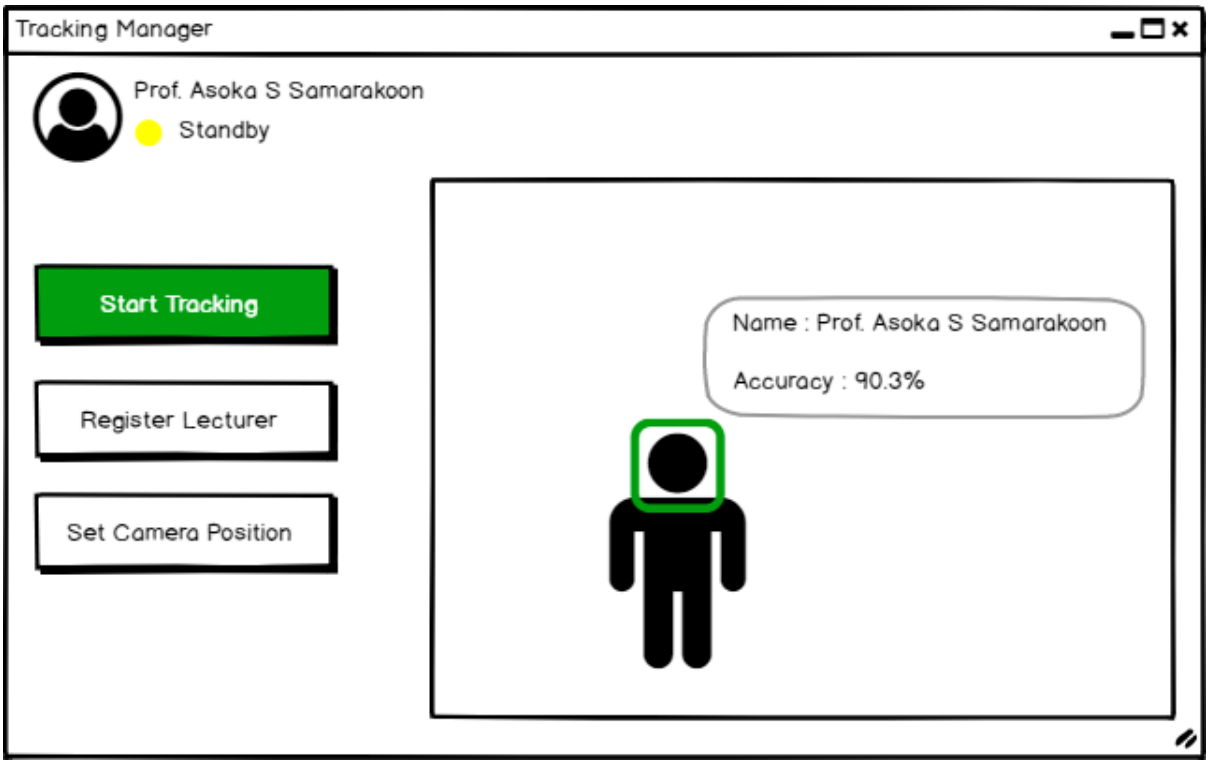


*Figure 2.1.2 1 Start tracking*

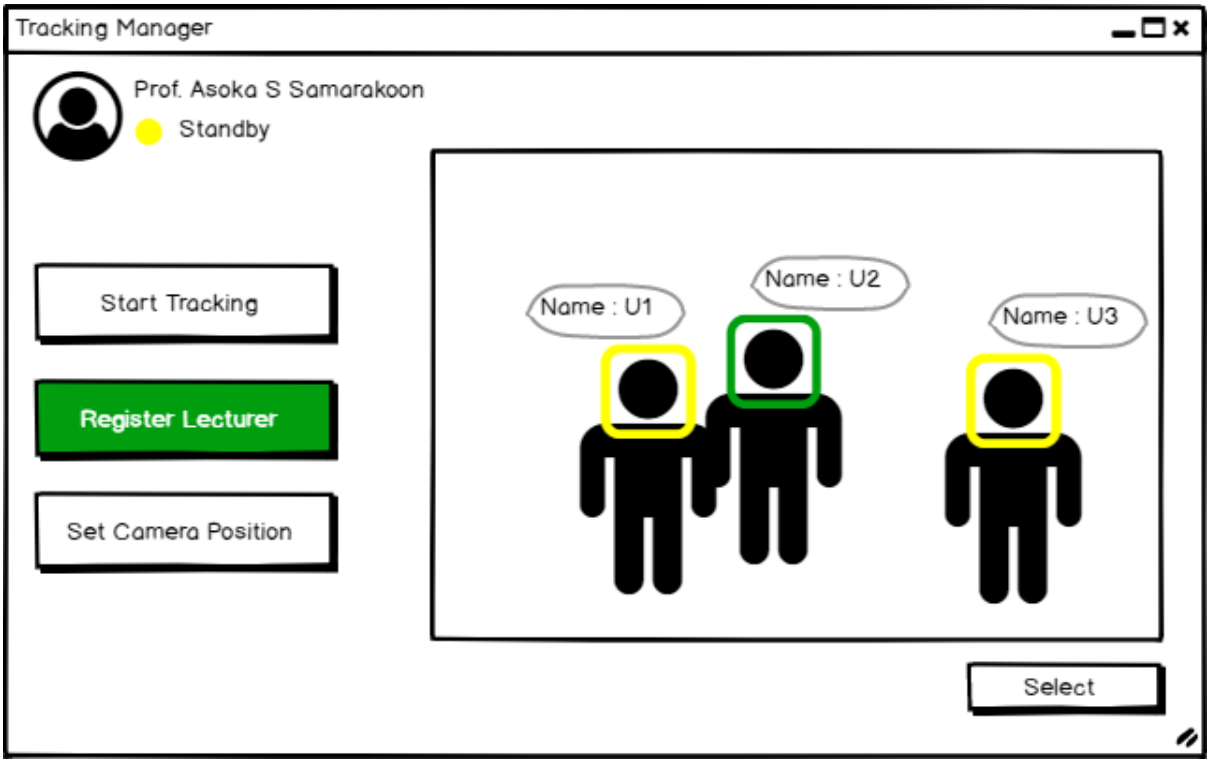


*Figure 2.1.2 2 Register Lecturer*

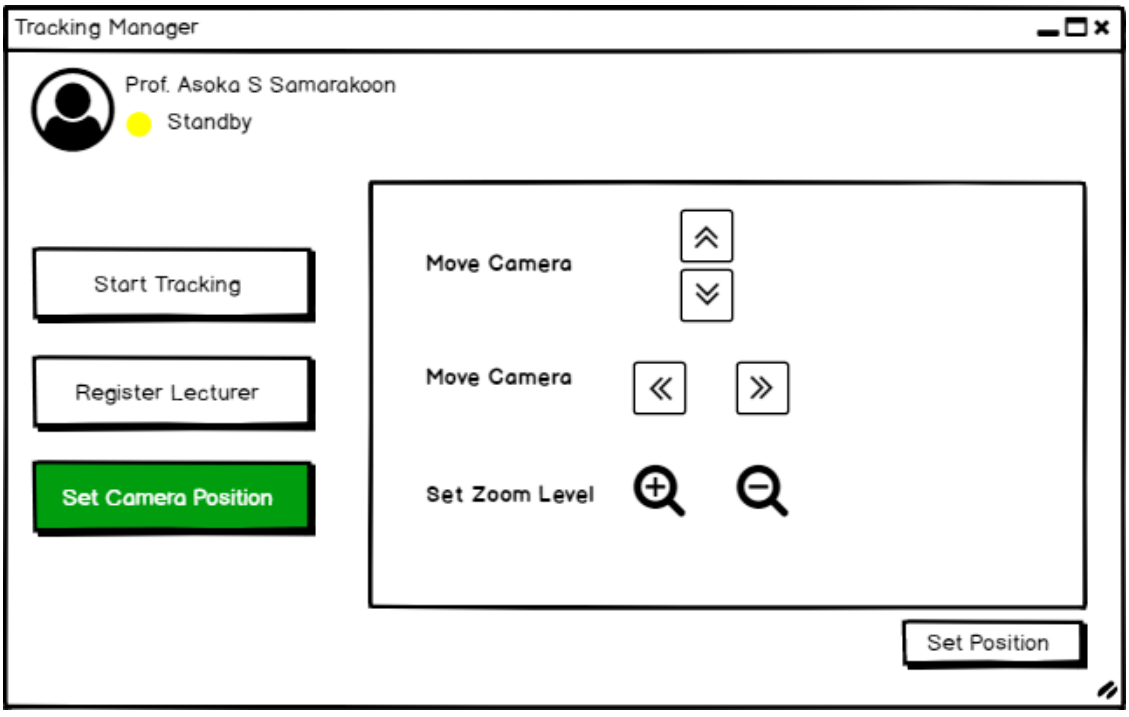


*Figure 2.1.2 3 Set Camera Position*

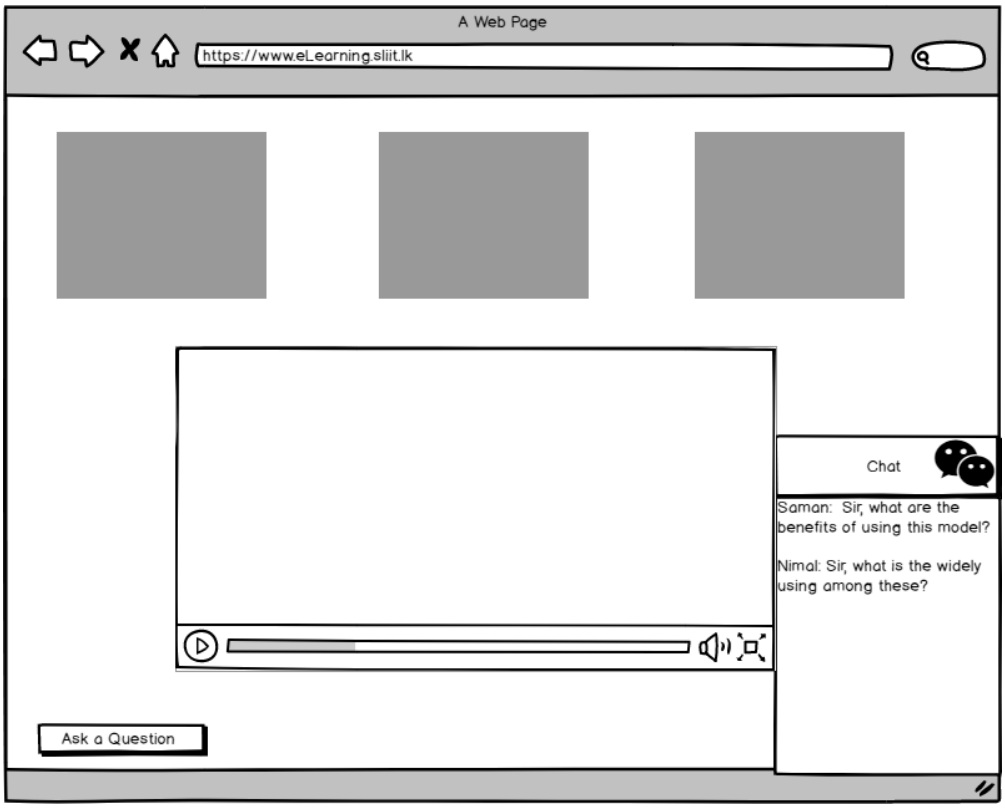


*Figure 2.1.2 4 Student Questioning Facility*

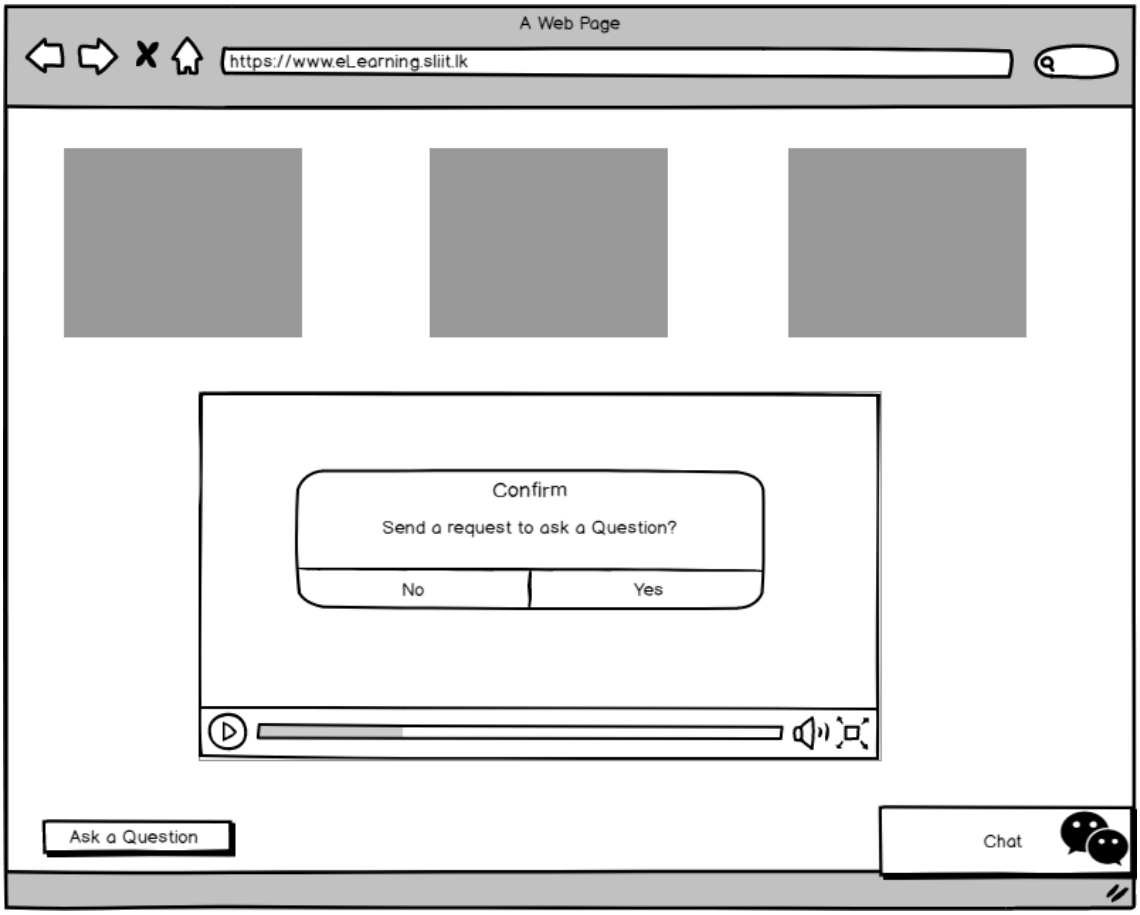


*Figure 2.1.2 5 Student Questioning facility c*

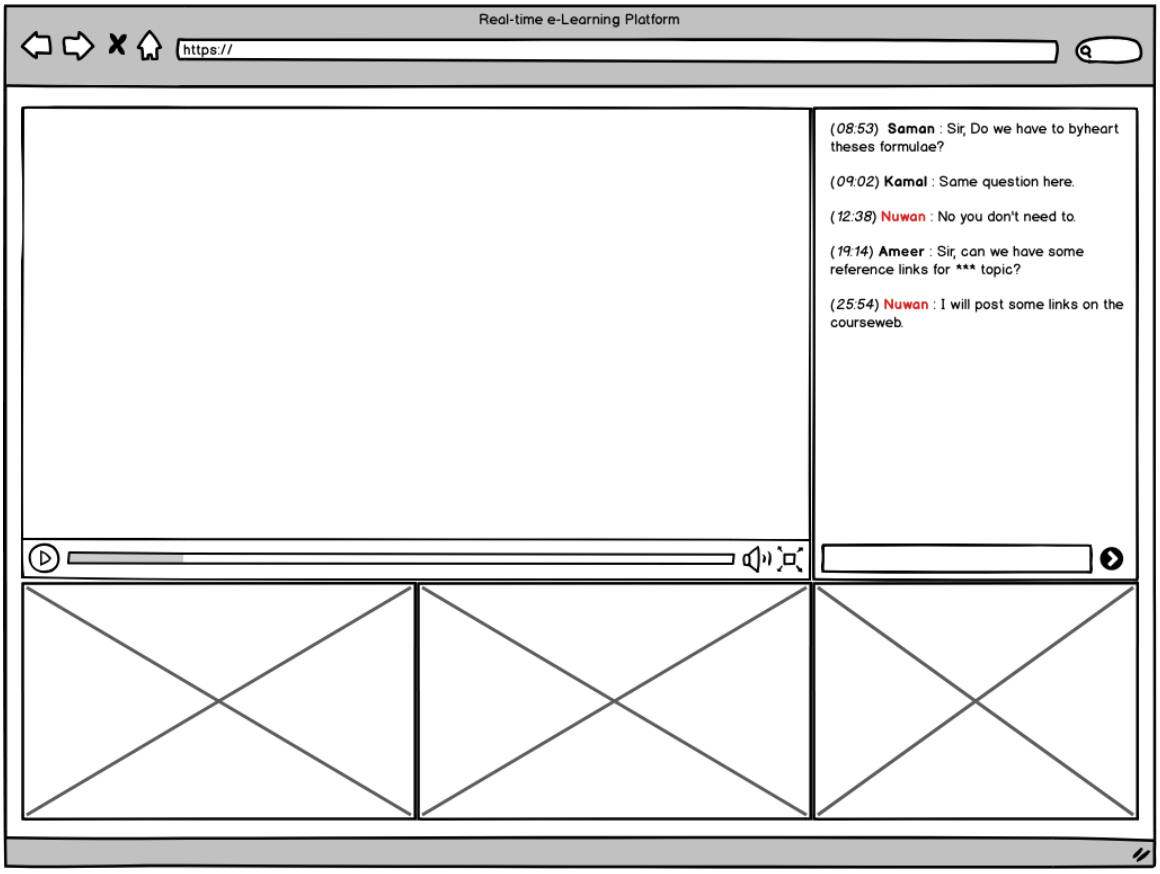


*Figure 2.1.2 6 Player*

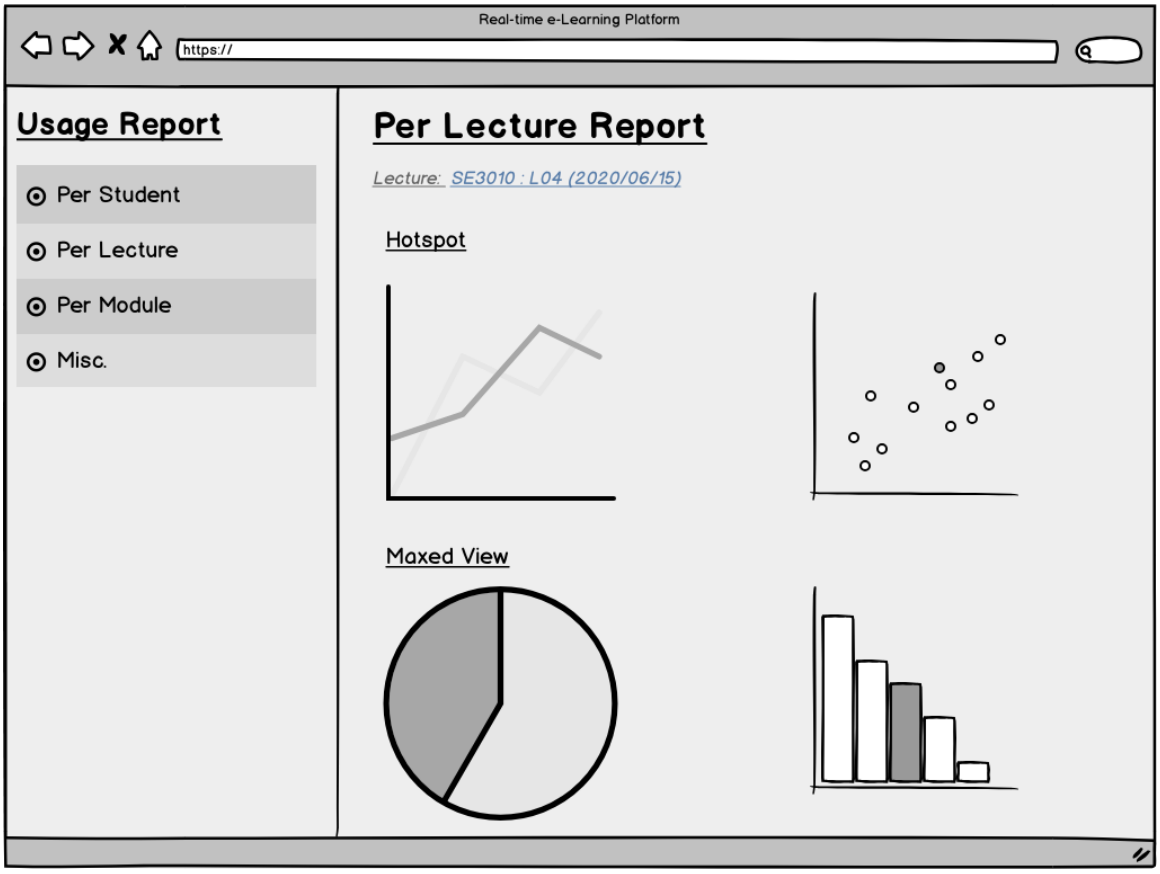


*Figure 2.1.2 7 usage Reports*

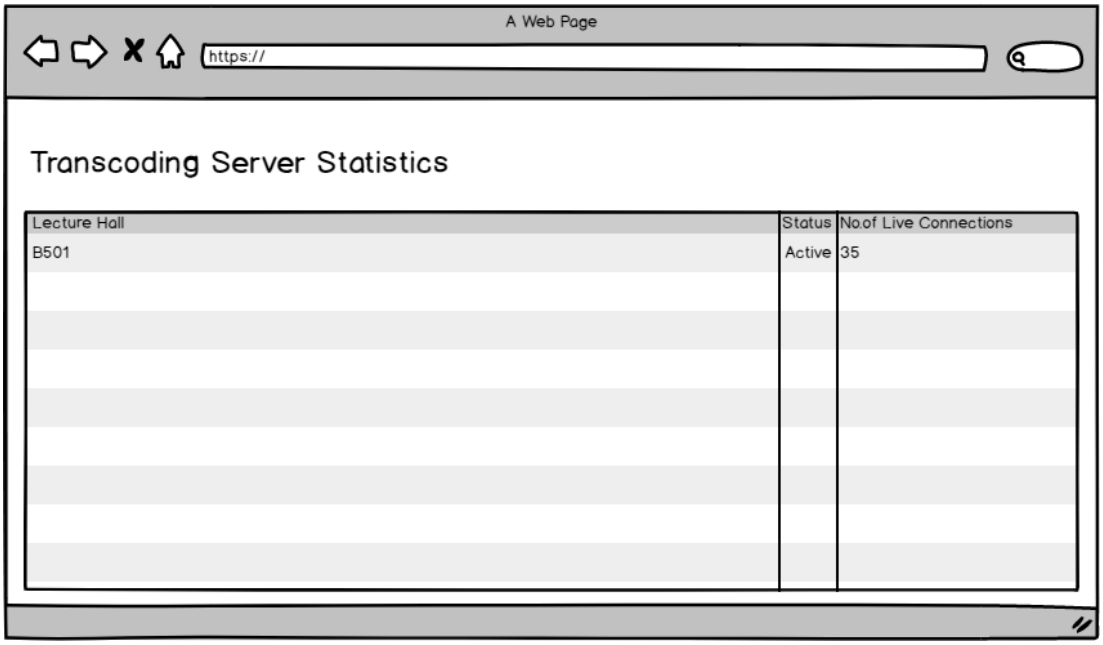


*Figure 2.1.2 8 Transcoding Server Statistics*

### 2.1.3 Hardware Interfaces

PTZ Camera is used to track the lecturer movements. Camera movements will be controlled according to the PELCO commands send through LAN by the tracking algorithm. Camera will be connected to the image processing server.

Transcoding module also acquires video feeds from the same PTZ camera and a desktop feed of a PC. Amplified audio from the lecture hall will also be received via an amplifier.

Web camera and a microphone is use to acquire students video feed during live questioning facility.

### 2.1.4 Software Interfaces

Web browser is required to access the application.

The Transcoding module will use kurento media server 6.9.0 for transcoding purposes.

MySQL 5.7 is use as the database for the application.

### 2.1.5 Communication Interfaces

Communications between the lecture hall and the transcoding server requires an internet connection or a local network connection and for the communication between server and the student's PC requires internet connection.

### 2.1.6 Memory Constraints

Server:

- Processor speed of 3.0GHz, 32GB RAM
- Minimum 10TB storage capacity

Client

- 2GB Memory for PC users
- 1GB Memory for Mobile users

### 2.1.7 Operations

- Student should be a registered student of the university.
- Student should allow access to the webcam and the microphone of the device.

### 2.1.8 Site Adaptation Requirements

Student does not require to perform any special operations or knowledge to use this application. Granting the permission for the webcam and microphone access should be done by the student to use all the facilities given by the system. Lecturers will be given a brief introduction to the system before using it.

## 2.2 Product Functions

This section will discuss the major functions of the proposed system. When the lecturer arrives, with the use of auto login function lecturer will be identified and tracked by the system. PTZ camera will starts tracking and focusing on the lecturer movements and will produce a quality video to send media server for streaming. Server will transcode the stream in to webRTC and will broadcast the streams. Users can view the streams via web application using the web browsers.

### 2.2.1 Use Case Diagram


*Figure 2.2.1 1 System Use Case Diagram*

### 2.2.2 Use Case Scenarios

| | | |
|---|---|---|
| **Use case ID** | UC_1 | |
| **Use case name** | Start Tracking | |
| **Goal in context** | Tracking a known lecturer throughout the lecture | |
| **Pre-condition** | Lecturer should be logged in to Tracking System | |
| **Post-condition** | None | |
| **Primary actor** | Lecturer | |
| **Secondary actor** | None | |
| **Main flow** | **Step** | **Action** |
| | 1 | The use case begins when lecturer click on start tracking button in the application. |
| | 2 | Lecturer face will be surrounded by a green square and lecturer details will be displayed in a box just above lecturer head. |
| | 3 | Video status will be changed from standby to streaming |
| | 4 | Camera will be moved according to the lecturer movements |
| | 5 | Streaming server will receive a continuous video feed until lecturer stops tracking |

*Table 2.2.2 1 Use Case Scenario 1*

| | |
|---|---|
| **Use case ID** | UC_2 |
| **Use case name** | Tracking a unknown lecturer throughout the lecture |
| **Goal in context** | Streaming lecture |
| **Pre-condition** | Lecturer should be logged in |
| **Post-condition** | None |
| **Primary actor** | Lecturer |
| **Secondary actor** | None |

| | | |
|---|---|---|
| **Main flow** | **Step** | **Action** |
| | 1 | The use case begins when lecturer click on register lecturer button in the application. |
| | 2 | All the faces in the camera view is recognized and surrounded by yellow squares |
| | 3 | Lecturer can select the person's face who is doing the lecture on that particular day and press select button in the application |
| | 4 | Then lecturer can start tracking by clicking on start tracking button |
| | 5 | Streaming server will receive a continuous video feed until lecturer stops tracking |

*Table 2.2.2 2 Use Case Scenario 2*

| | | |
|---|---|---|
| **Use case ID** | UC_3 | |
| **Use case name** | See the online students | |
| **Goal in context** | See the online students who connected to the lecture | |
| **Primary Actors** | Lecturer | |
| **Pre-conditions** | i.Lecturer should login to the system | |
| **Main flow** | **Step** | **Action** |
| | 1 | Lecturer click the online student button |
| | 2 | App will pop-ups the current online student list |

*Table 2.2.2 3 Use Case Scenario 3*

| | |
|---|---|
| **Use case ID** | UC_4 |
| **Use case name** | Send a request to ask questions |
| **Goal in context** | To ask the questions request has to be send to the lecturer |
| **Primary Actors** | Student |

| | | |
|---|---|---|
| **Pre-conditions** | i.Student should login to the system<br>i.Student should connected with the live lecture | |
| **Main flow** | **Step** | **Action** |
| | 1 | Student clicks ask question button |
| | 2 | Student click ‘yes’ on the confirmation box |
| **Post-conditions** | A request will be send to the lecturer for confirmation | |

*Table 2.2.2 4 Use Case Scenario 4*

| | | |
|---|---|---|
| **Use case ID** | UC_5 | |
| **Use case name** | Ask questions | |
| **Goal in context** | Ask the questions using student webcam and microphone | |
| **Primary Actors** | Student | |
| **Pre-conditions** | i.The request should be accepted by the lecturer | |
| **Main flow** | **Step** | **Action** |
| | 1 | Student allows to use microphone and webcam |
| | 2 | Ask the question |
| | 3 | Draw using whiteboard |
| | 4 | End the session |
| **Post-conditions** | Video, Audio & Whiteboard streams to all connected students | |

*Table 2.2.2 5 Use Case Scenario 5*

| | | |
|---|---|---|
| **Use case ID** | UC_6 | |
| **Use case name** | Approve the student request | |
| **Goal in context** | Decide whether to approve or decline the request sent by student for questioning | |
| **Primary Actors** | Lecturer | |
| **Pre-conditions** | i.The request for questioning should be sent by the student | |
| **Main flow** | **Step** | **Action** |

| | | |
|---|---|---|
| | 1 | When a request comes from a student there will be a notification |
| | 2 | Lecturer decide whether to approve or decline the request by clicking the button |
| **Extensions** | 2a | If the lecturer didn't approve the request student will not be able to ask the questions |
| **Post-conditions** | Student will able to ask the question | |

*Table 2.2.2 6 Use Case Scenario 6*

| | | |
|---|---|---|
| **Use case ID** | UC_7 | |
| **Use case name** | Type questions in chat box | |
| **Goal in context** | Ask the questions using chat box | |
| **Primary Actors** | Student | |
| **Pre-conditions** | Student should connected to an ongoing lecture | |
| **Main flow** | **Step** | **Action** |
| | 1 | Student clicks chat box at the bottom of the UI |
| | 2 | Chat box will be maximized |
| | 3 | Type the question and click send button |
| | 4 | Close the chat box |
| **Post-conditions** | Question will be streamed to all the connected students | |

*Table 2.2.2 7 Use Case Scenario 7*

| | |
|---|---|
| **Use case ID** | UC_8 |
| **Use case name** | Play Video |
| **Goal in context** | Play the requested video (Live or Playback) |
| **Primary Actors** | Student |
| **Pre-conditions** | Student should login and arrive through a valid link |

| Main flow | Step | Action |
|---|---|---|
| | 1 | Student clicks chat box at the bottom of the UI |
| | 2 | Chat box will be maximized |
| | 3 | Type the question and click send button |
| | 4 | Close the chat box |
| **Post-conditions** | Question will be streamed to all the connected students | |

*Table 2.2.2 8 Use Case Scenario 8*

## 2.3 User Characteristics

Users of this application are the students and the lecturers as well as the system administrators of the university. All the users should have some basic knowledge related to computers and English language.

## 2.4 Constraints

- Application will not cover each and every device, it will support majority of the modern mobiles and web browsers currently available.
- A high speed network connection is required to avoid latency.
- A high performance computer is required to deploy the application.
- Large storage is required to store recorded videos for playback purposes.
- A device with a webcam and a microphone is required for a user to use live questioning facility.

## 2.5 Assumptions and Dependencies

- Users have the authorization to access the web application.
- Users have a high speed internet connection.
- User devices have the capability of a webcam and a microphone.
- Devices should have minimum requirements mentioned in chapter 2.4

## 2.6 Apportioning of Requirements

Main requirements mentioned in above chapters of this document will not be changed during the development phase. However, the technologies and some approaches will be changed in order to make the application better.

# 3 SPECIFIC REQUIREMENTS

## 3.1 External Interface Requirements

### 3.1.1 User Interfaces

Figure 2.1.2.1 shows the main UI after user logged in to the tracking manager. Mainly there are three options to operate with. If the lecture details are correct and he or she is recognized by the system, they can proceed by clicking on start tracking button

As shown in figure 2.1.2.2, If the lecturer is not recognized or not registered in the lecturer database, then they will be provided with an option to select a person to be tracked at lecture time itself. After selecting a face user can click select to proceed with tracking.

If the lecturer does not need real-time tracking, he can set camera position manually to a preferred view and continue the lecture using the interface shown in figure 2.1.2.3

As shown in Figure 2.1.2.4, when student wants to ask a question using chat box, he/she should expand the bottom right corner chat box first. Then the student can type the question that he/she wants to ask and send it.

As shown in Figure 2.1.2.5, there is an ‘Ask a Question’ button placed on left bottom of the page. This will use to send a request when the student wants to ask a question using voice based questioning facility and whiteboard facility. After confirming the confirmation box, the request will be send to the lecturer.

Figure 2.1.4.6 shows the video player use to view live and playback videos. This has multiple views. A view of choice can be maximized.

Interface shown in Figure 2.1.4.7 is used to generate usage reports based on data collected by the video player. Reports can be customized based on various filters.

Figure 2.1.4.8 is the user interface for the transcoding server where server statics can be viewed by the system administrators for server troubleshootings.

### 3.1.2 Hardware Interfaces

- Tracking camera to acquire lecture tracking video feed.
- Laptop / Desktop / Tablet of the lecturer
- Microphone
- Web camera

### 3.1.3 Software Interfaces

- Web browser
- Kurento media server 6.9.0 for transcoding purposes
- MySQL 5.7 as the database to store necessary information related to the service.

### 3.1.4 Communication Interfaces

An internet connection will be needed as this is a web app. Due to heavy downloading of video streams and occasional video streaming requirements, a high bandwidth and low latency internet connection is required. This requirement will vary with the selected quality of the downstream video. However, a connection speed above 3 MBps is preferred.

## 3.2 Classes/Objects

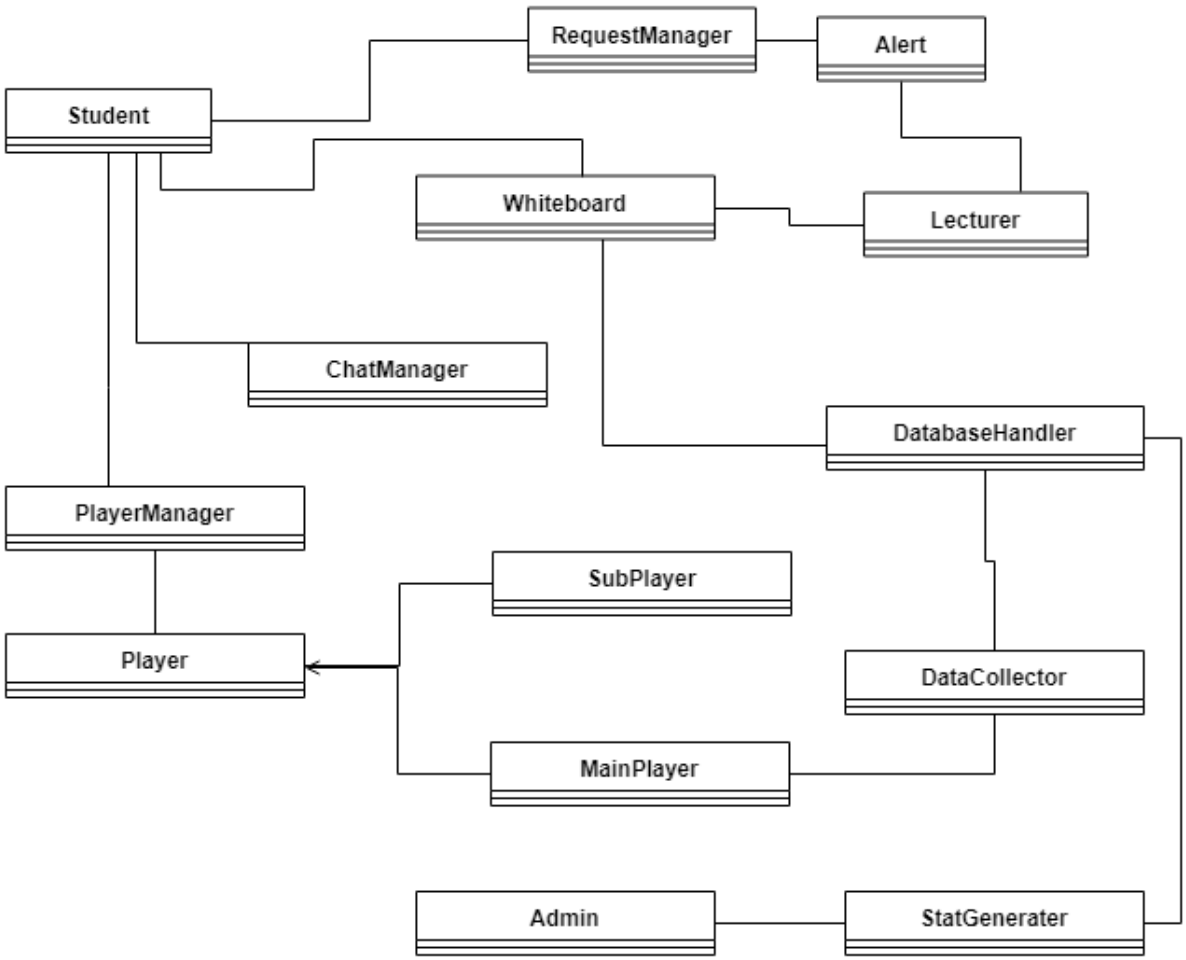


*Figure 3.2 1 Class Diagram*

## 3.3 Performance Requirements

- The system will track lecturer movements in real-time with minimum delay.
- Transcoding server should support 50 simultaneous lectures with two video feeds per each lecture. And these should be delivered to approximately 200 online viewers.

- Product should perform without any lag under any stress. The highest stress is expected when the student stream from his/her device while viewing the downstream at full video quality.
- All the streams should be in sync at least at a level that is unnoticed by a human.
- Generation of any report should not take more than 1000 ms.
- Whole system should load up and come to an idle state within 3000ms.

## 3.4 Design Constraints

- System has to be designed with minimalistic UI features in order to increase the amount of supporting devices.

## 3.5 Software System Attributes

### 3.5.1 Reliability

In real time tracking, algorithm must send accurate commands to PTZ Camera to move accurately and smoothly. So the algorithm will be designed in a manner where all the movements are accurate any smooth.

Video streams should be very close to real-time which means with very minimum latency. In order to achieve that, this application has to be deployed in a high performance server. And also we have introduced adaptive bitrate feature as well to the application. Also student questioning video stream should be deliver to the lecturer without any delay.

### 3.5.2 Availability

System will be available any time for the users except pre-scheduled and notified downtimes for maintenance purposes. System will be implemented on a cloud base server ensuring the high availability of the system.

### 3.5.3 Security

The system can only be accessed by the authorized personals related to the specific university that the system is deployed. Live streams will be restricted from downloading by using 3rd party software's reserving copyrights of the institute.

### 3.5.4 Maintainability

Components of the system is designed in a modularized way so that each component can be shut down for maintenance without affecting the availability of the other modules.

System will contain redundant storages for data backups. New features and performance improvement patches will be released with future versions of the system.

## 3.6 Other Requirements

# 4 SUPPORTING INFORMATION

## 4.1 References

[1] Yueshi Shen, "*Live Video Transmuxing/Transcoding:FFmpeg vs TwitchTranscoder Part I* " https://blog.twitch.tv/live-video-transmuxing-transcoding-ffmpeg-vs-twitchtranscoder-part-i-489c1c125f28. [Accessed: 2019-05-13]

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