Digital Board Marker (Storage Efficient System for Class Lectures)

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Submitted by:

Muhammad Haris Khan 2016-CS-105

Hamza Farooq 2016-CS-122

Ayesha Atif 2016-CS-152

Komal Shehzadi 2016-CS-178

Supervised by:

Samyan Qayyum Wahla

Department of Computer Science and Engineering

University of Engineering and Technology

Lahore Pakistan

Declaration

We declare that the work contained in this thesis is our own, except where explicitly stated otherwise. In addition this work has not been submitted to obtain another degree or professional qualification.

Signed: _____

Date: _____

Acknowledgments

First of all, we wish to thank Almighty Allah for giving us strength in fulfilling this work. It gives us great pleasure to express our deep sense of gratitude and respect to our supervisor, Sir Samyan Qayyum Wahla, for boasting our confidence and a sense of excitement and inspiring us in our work through his guidance. Our sincere thanks to him for his valuable suggestions and efforts. It is with great pride and pleasure that we submit this dissertation as his students. Lastly we would like to thank our parents for their unconditional, love, affection, kind cooperation and encouragement.

To out parents and respected members

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Abbreviations

LAH **L**ist **A**bbreviations **H**ere

Abstract

The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too...

Chapter 1

Introduction

1.1 Overview of the Project

Digital board marker is a size efficient, bandwidth saving lecture recording system. It can record lecture, providing automated google search of handwritten words. Provides on the spot wiki. Lecture text notes can be generated automatically. Lecture can be named and divided into topics and subtopics automatically. According to a survey, 94% students go for online help of recently attended lectures because they can't fully grab the concepts. Recorded lectures as video format require so much internet bandwidth to play. In most cases, large sized videos are difficult to handle or download. Because students mostly don't have huge amount of extra space available especially for the CSE students, as they already use bulky software and also students don't have large amount of bandwidth of internet available.

1.2 Background

The main aim of digital board marker is to provide ease to the students of all the educational institutes. Mostly lecture systems that already exist, of different universities, provide lectures online on youtube but the problem is they need great internet bandwidth and lot of memory to download and watch the lectures which is difficult for students especially in Pakistan. So that we provide bandwidth and storage efficient lecture system.

Universities are places of knowledge production, and the economy and society are the users of this knowledge. So universities can provide ease to student with this system.

1.3 Motivation

The motivation and purpose to do this project is to minimize the use of resources that are used in lecture systems now a days working in all over the world i.e. video lecture recording and streaming through internet.

- The first motivation is to deal with the large amount of storage that normally video lectures take. This system is not based on video recording but on recording the writing on the board with marker. It will record the position of the marker as the coordinates of board where marker touches and store it in the text file (which will later be converted and played like a video). This will take minimum amount of database storage to store this kind of data on a website.
- The second motivation to do this project is to use less internet resources for accessing the lectures. Normally the video lectures of different institutes worldwide are very large and to download those on the system through internet requires large amount of resources which are normally difficult for students to get and to download it in high quality even more resources are required. The lectures for recording are very low in memory as compared to normal video recording and will require very minimum resources to download on the system.
- The third motivation is for example a power failure occurred during the lecture and you cannot clearly see the board but teacher is still writing and erases the board after some time, this may result in not getting proper notes or missing the important point of lecture. Moreover students can get benefit by seeing the lecture again and again if they missed any concept or if they were absent minded or not attending lecture. These few are the reasons which motivated us to do this project.

1.4 Objectives of the Project

1.4.1 Industry Objectives

In industry most of the time it is hard to choose areas for work which have low bandwidth internet and let's suppose you are playing a lagging call of duty run-through and your stream is buffering and stopping because of low bandwidth it's like you are losing because of this or you are presenting something which is

improved work of someone else and It requires high quality fast internet to present it but it's not guaranteed.

In some places people try to reduce the cost of these things as much as possible but not having proper interface is the main reason of failure so we can cop up with this issue by this new system we are introducing.

- System will reduce internet bandwidth usage which will lead to progress in industry.
- It must minimize the storage issue which can increase working efficiency of industry.
- It will reduce the cost of internet and cost of storage and will help the industry in fast growing world of today.
- Main aim of the project is to provide ease and best performance than most previous ones and will eventually lead to progress in industrial field.

1.4.2 Research Objectives

In the development of digital board marker, computer vision is used and computer vision is most vital in the field of research. Computer vision plays a great role in research work. So by improving the uses of computer vision in future work its vast area for research work. Research objective of the system is to go through all the recent research work done in system's development fields and then on its basis, developing a system which is storage and bandwidth efficient.

- Project research is related to find position and orientation of marker precisely and accurately.
- The high level research part is finding the position and then syncing it with the audio data to play like a video.
- Research must be deep so that researchers must be able to discover new and improved techniques to reduce storage issues.
- Research should be able to help future work in detection of ball in any sort environment without assumptions and with more accuracy.

1.4.3 Academic Objectives

Digital board marker mainly cover academic area the main purpose is to provide each and every student all the lectures with better quality and less bandwidth because in Pakistan we students face this issue the most, as we know it cannot be resolved in near future we have to work something out for this issue and that's where this system will work it will provide an interface to all the students which have all the lectures of their respective subjects from their respective teachers which can be streamed online and downloaded for offline to play later on at very low bandwidth. It will provide all the assignment related material and lectures at same platform to students. It is the new revolution in the academic field.

- The main academic objective of the developers is to learn major computer science field i.e. computer vision.
- On basis of computer fields used in project developers must be able to use this knowledge to improve in this field.
- Developers must complete all the work before respective deadlines. so by working in a professional way project will be at its best.
- Developers must be able to risk the change management in their projects, as while doing the projects, developers might face different kinds of situation and their decision making plays and important role in leading them to success.

1.5 Problem Statement

To make a storage and bandwidth efficient system with a lecture player and learning management system for the students and the educational institutes.

1.6 Scope of the Project

Digital board marker mainly cover academic area the main purpose is to provide each and every student all the lectures with better quality and less bandwidth because in Pakistan we students face this issue the most, as we know it cannot be resolved in near future we have to work something out for this issue and that's where this system will work it will provide an interface to all the students which have all the lectures of their respective subjects from their respective teachers which can be streamed online and downloaded for offline to play later on at very

low bandwidth. It will provide all the assignment related material and lectures at same platform to students. It is the new revolution in the academic field. Although it covers industry and researches as well.

1.7 Challenges

1.7.1 Technology Selection

The technology used is:

- Angular 8 and C# for web application
- C# windows application for desktop application
- Embedded C for marker hardware

The selection of technology was one of the first major issue at the start of project. The first technology we thought of using was **django** (a python related framework) but we could not get comfortable with that so we switched to C# and angular 8. These were quiet familiar to us and also angular 8 was newly stable released latest technology so we opted these.

1.7.2 Camera Selection

To record the position and orientation of the camera the main issue was to use good quality cameras with low cost. High FPS cameras with low cost were very difficult to find. So this was also one of major challenges of hardware.

1.7.3 Stereo Vision Camera Input

Recording a stereo vision using two cameras and taking correct input, setting them at correct angle came up as a challenge.

1.7.4 Marker Hardware

Marker hardware was also a challenge. To make a marker which is almost same as light weight as the normal marker and make it easy to pick. Also to make it in less cost with all the hardware parts and wires attached.

1.7.5 Ball detection

The ball attached on the top of marker is used to detect the position of marker but sometimes the color of ball can match with dress of user and cameras can confuse with the color, which came up as a challenge.

1.7.6 Marker Orientation Calibration

There should be precise and accurate orientation data of marker so that proper position data can be recorded and later used which became a big challenge.

1.7.7 Pressure Sensor handling

There was a lot of noise in the data that is recording which was handled using pressure sensor, it was also one of the major challenges.

1.7.8 Transmission Speed

The transmission speed lag between **NRF24L01** came up as a challenge with and without antenna.

1.7.9 Audio Hardware

Audio hardware itself was bit of a challenge which is to be attached so that synchronized audio data can be recorded.

1.7.10 Noise Reduction

The noise from audio should be removed to get clear audio which was also one of the challenge.

1.7.11 Marker and duster thickness configuration

Selecting the dimensions, size and configuration of marker and duster so that it can sync with stereo vision of cameras and input to camera.

1.7.12 Erasing board

When erasing the board or a part of board there should be removal from the video that is played in the video player. So it was a difficult challenge to keep record of that.

1.7.13 Seek bar control

Controlling the seek bar in audio player for forward and rewind of video came up as a challenge.

1.7.14 Getting familiar with new framework

Angular 8 came up as a new framework for the developers so it was a bit challenge for getting familiar with this. Moreover we started using simple HTML and then converting to angular material was bit of a challenge.

1.7.15 Cross Platform Linking

Connecting front end to API came up as a challenge as developers have never worked with API before. Also there were many development related issue to work with .NET core framework since it is updated version of what developers were already using (.NET classic). So it was a bit of challenge to combine API and front end.

1.8 Assumptions and Constraints

Following are assumptions which were kept in mind during the implementation of the project:

- The position is detected via ball using the computer vision so ball color should not interfere with color of surroundings.
- Teacher should erase complete board and not some words or some parts and also there should be an indication of that so that screen can be removed accordingly.
- Teacher or writer should not block the vision of camera by coming in the way.
- Teacher should start recording using a button on the controller app and similarly stop in the same way.

1.9 Possible Applications of Work

Following are the possible applications where DBM can be used:

1.9.1 Educational Institutes

There can be different types of users in educational institutes so DBM will be helpful to all these users:

FIGURE 1.1: Digital Board Marker Application: Educational Institute

1.9.1.1 Admin

Admin can interact with system in form of following tasks.

- Admin can directly login into the system.
- Admin can create different groups/roles.
- Admin can assign different permissions to each group/role.
- Admin can approve or disapprove the login access requests of the users.
- Admin can add courses.
- Admin can assign courses to teachers.
- Admin can update and delete the courses.

1.9.1.2 Teacher

Teacher can interact with system in form of following tasks.

- Teacher can register himself in the system.
- Teacher can login into the system.
- Teacher can reset his password.

- Teacher can upload course assignments.
- Teacher can delete assignments.
- Teacher can **Add, Edit, View and delete** course content/notes.
- Teacher can approve or disapprove course enrollment requests of students.
- Teacher can download and view students submitted assignments.
- Teacher can start/end recording lectures.
- Teacher can delete course lectures.
- Teacher can add, delete and edit classes.
- Teacher can view students list.
- Teacher can add announcement.
- Teacher can view and edit course related announcements.
- Teacher can delete announcements.

1.9.1.3 Students

Student can interact with system in form of following tasks.

- Student can register himself in the system.
- Student can login into the system.
- Student can reset his password.
- Student can view courses.
- Student can enroll in any course.
- Student can view course content.
- Student can view course assignments.
- Student can download course assignments.
- Student can submit course assignments.
- Student can play course lectures.

- Student can download course lectures.
- Student can view and download course content.
- Student can view course announcements.

1.9.2 Online Tutors

Online tutors can use DBM. There can be different types of users in online tutors as well:

FIGURE 1.2: Digital Board Marker Application: Online Tutors

1.9.2.1 Tutors

Tutor can interact with system in form of following tasks.

- Tutor can login into our system.
- Tutor can start/end recording lectures.
- Tutor can delete, download and play lectures.

1.9.2.2 Users

Users can interact with system in form of following tasks.

- User can play tutorials.
- User can view lectures list.
- User can download lecture.

1.9.3 Sketch Artist

Sketch artists can use the system just like online education and showing their sketch skills and help others in improving theirs.

FIGURE 1.3: Digital Board Marker Application: Sketch Artists

1.9.3.1 Industrial Presentations

Digital board marker can be helpful in industrial presentation so that if any person cannot appear at the particular time, that person can watch the recorded (storage efficient) presentation later.

FIGURE 1.4: Digital Board Marker Application: Industrial Presentations

Chapter 2

Literature Review

2.1 Literature Review

This paper presents a technique that aimed to accomplish an efficient balance between video compression using H.265 protocol and retention of 8K resolution. The study implements multi-level of optimization in the encoding process using H.265 where JPEG2000 standards play a crucial role. The study also applies a novel concept of orthogonal projection that manages pixels metadata required in every frame transition followed by motion compensation. By using multiple file formats of 30 video datasets, the outcome of the study is found to be accomplishing approximately 49% of enhancement in data quality and around 59% of improvement in video compression in comparison to the existing techniques of HEVC-based video compression.[2]

Web-based lecture technologies are being used increasingly in higher education. One widely-used method is the recording of lectures delivered during face-to-face teaching of on-campus courses. The recordings are subsequently made available to students on-line and have been variously referred to as lecture capture, video podcasts, and Lectopia. We examined the literature on lecture recordings for on-campus courses from the perspective of students, lecturers, and the institution. Literature was drawn from major international electronic databases of Elsevier ScienceDirect, PsycInfo, SAGE Journals, SpringerLink, ERIC and Google Scholar. Searches were conducted using key terms of lecture capture, podcasts, vodcasts, video podcasts, video streaming, screencast, webcasts, and online video. The reference sections of each article were also searched and a citation search was conducted. Institutions receive pressure from a range of sources to implement web-based technologies, including from students and financial imperatives, but the selection of

appropriate technologies must reflect the vision the institution holds. Students are positive about the availability of lecture recordings. They make significant use of the recordings, and the recordings have some demonstrated benefits to student learning outcomes. Lecturers recognise the benefits of lecture recordings for students and themselves, but also perceive several potential disadvantages, such as its negative effect on attendance and engagement, and restricting the style and structure of lectures. It is concluded that the positives of lecture recordings outweigh the negatives and its continued use in higher education is recommended. However, further research is needed to evaluate lecture recordings in different contexts and to develop approaches that enhance its effectiveness.[3]

The flipped classroom has become more widely used in engineering education. However, a systematic and quantitative assessment of its achievement outcomes has not been conducted to date. Purpose: To address this gap, we examined the findings from comparative articles published between 2008 and 2017 through a meta-analysis to summarize the overall effects of the flipped classroom on student achievement in engineering education. Scope/Method: We searched and analyzed journal and conference publications on flipped classroom studies in engineering education in K-12 and higher education contexts. Twenty-nine comparative interventions were included in a meta-analysis involving 2,590 students exposed to flipped classroom and 2,739 students exposed to traditional lectures. A content analysis was also conducted to determine how the flipped engineering classroom benefits student learning. Conclusions: The meta-analysis comparing these 29 traditional—flipped interventions in relation to student achievement showed an overall significant effect in favor of the flipped classroom over traditional lecturing (Hedges' g = 0.289, 95% CI [0.165, 0.414], p ¡.001). A moderator analysis showed that the effect of the flipped classroom was further enhanced when instructors offered a brief review at the start of face-to-face classes. Our qualitative findings suggest that self-paced learning and more problem-solving activities were the two most frequently reported benefits that promoted student learning. Based on quantitative and qualitative support, several implications are identified for future practice, such as offering a brief in-class review of preclass materials. Some recommendations for future research are also provided.[1]

Chapter 3

Proposed Methodology

3.1 Proposed Solution

The proposed system focuses on size efficiency of the output video. System acts well in the environment where there is storage issue and bandwidth issue in terms of internet transfer rate. Ultra-durability makes the system more portable to use and more reliable to handle. Re-positionable cameras make the system able to work well in different canvas sizes i.e. size of writing board. System automates the process of video compression technique. Video of the lecture is not recorded as it as video format rather only the important data is extracted. By utilizing the stereo vision and high-speed cameras and low wireless latency, video animation and sound quality is maintained in noisy environment as well.

3.2 General Proposed Model

General working model of the system can be seen below

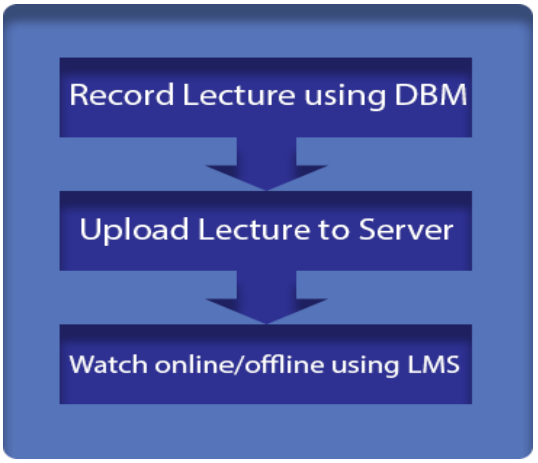

FIGURE 3.1: General Methodology View of the System

3.3 General Flow

The system consists on several modules and deliverables one of which is controller application. This application is quite important because it include major functionalities and complex image processing algorithms. Furthermore, the instructor in mainly connected to the controller application so that he/she is controlling the recording of lecture i.e. he can start, pause or stop the recording. After the lecture is recorded, he can replay the lecture for any further changes. When the lecture is finally uploaded to central computer, students can play lecture online or save the lecture file in .dbm(file extension) extension to watch later.
Offline player is also one of the major modules of the project. It plays the downloaded lecture file just like video player. Learning management system is the online platform where all uploaded online lecture hierarchy is accessible. It is a comprehensive management system designed by placing the convenience of instructor and student in focus. Reliability, security and quality are the top priorities. A simple visual of the working of system can be seen below

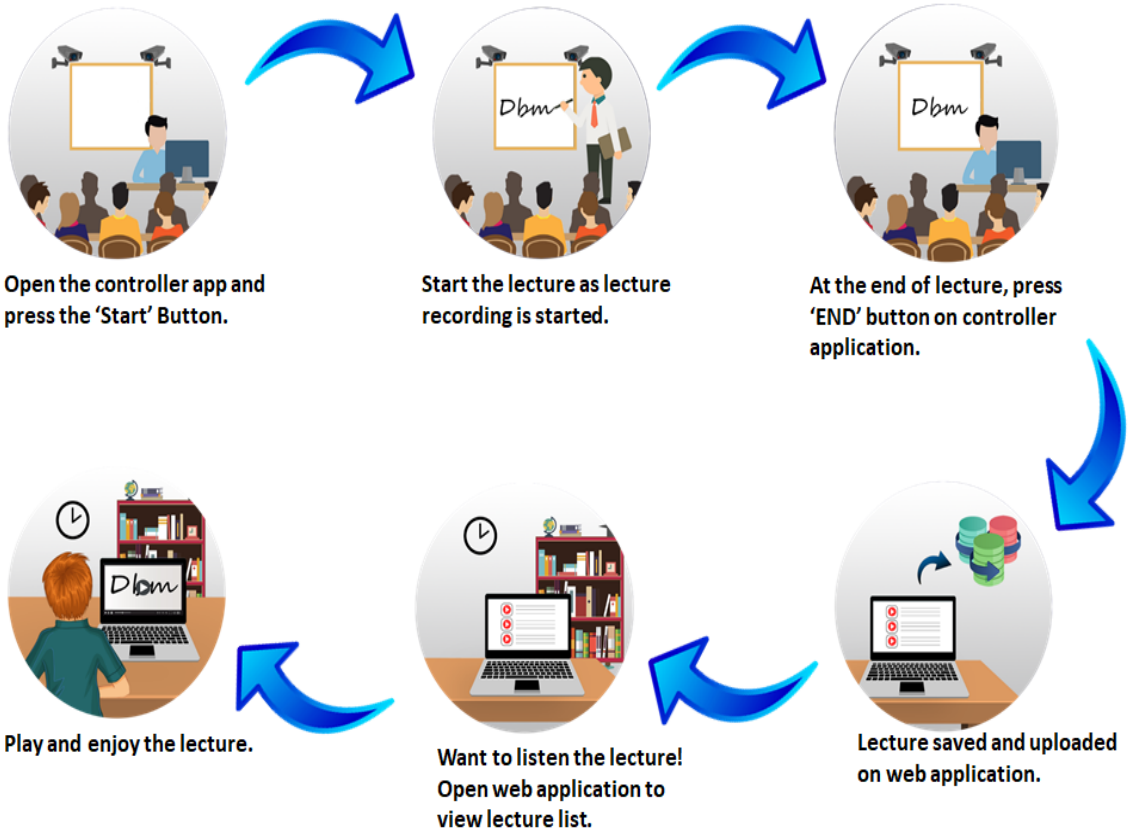

FIGURE 3.2: General Flow of the Project

3.4 Formulas Used

Descriptor	**Explanation**	**Formula**
Euler Angles Rotation Matrices	Transpose of the fixed-axis matrix. Used in orientation extraction of Board Marker	$R_x(\theta) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix}$ $R_y(\theta) = \begin{bmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{bmatrix}$ $R_z(\theta) = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$
Quaternion to Euler conversion	Used in Marker calibration when an offset is given in particular dimension.	$q_{IB} = \begin{bmatrix} \cos(\psi/2) \\ 0 \\ 0 \\ \sin(\psi/2) \end{bmatrix} \begin{bmatrix} \cos(\theta/2) \\ 0 \\ \sin(\theta/2) \\ 0 \end{bmatrix} \begin{bmatrix} \cos(\phi/2) \\ \sin(\phi/2) \\ 0 \\ 0 \end{bmatrix}$
Euclidean distance formula	Used to compute the distance in one-dimension.	$d(x,y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$
Equation of line in slope-intercept form	Used to draw lines and get relative position of Marker with respect to cameras.	$y = mx + c$

Table 3.1: Formulae and Equations used

3.5 Use-Case Diagrams

To describe the system requirements, use-case diagrams in form of simple user interaction are detailed below

3.5.1 Controller Application

The main end user of controller application is the class instructor or teacher. Teacher use the controller application in

- Calibrating hardware
- Record the Lecture
- Live Stream Lecture
- Generate Lecture File and annotate it
- Send Lecture file to Central Server

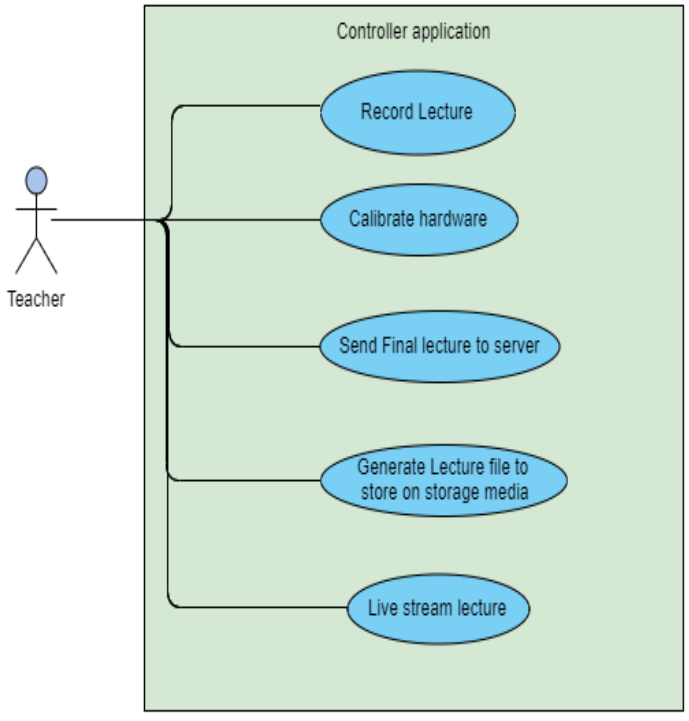

FIGURE 3.3: Use-case Diagram of Controller Application

3.5.2 Player Application

Just like media player, the player application plays the lecture. Common end user of Player Application is student. Teacher and Student are end users of controller application. Typical actions of Player application are:

- View Playlist
- Play Lecture
- Live Stream Lecture

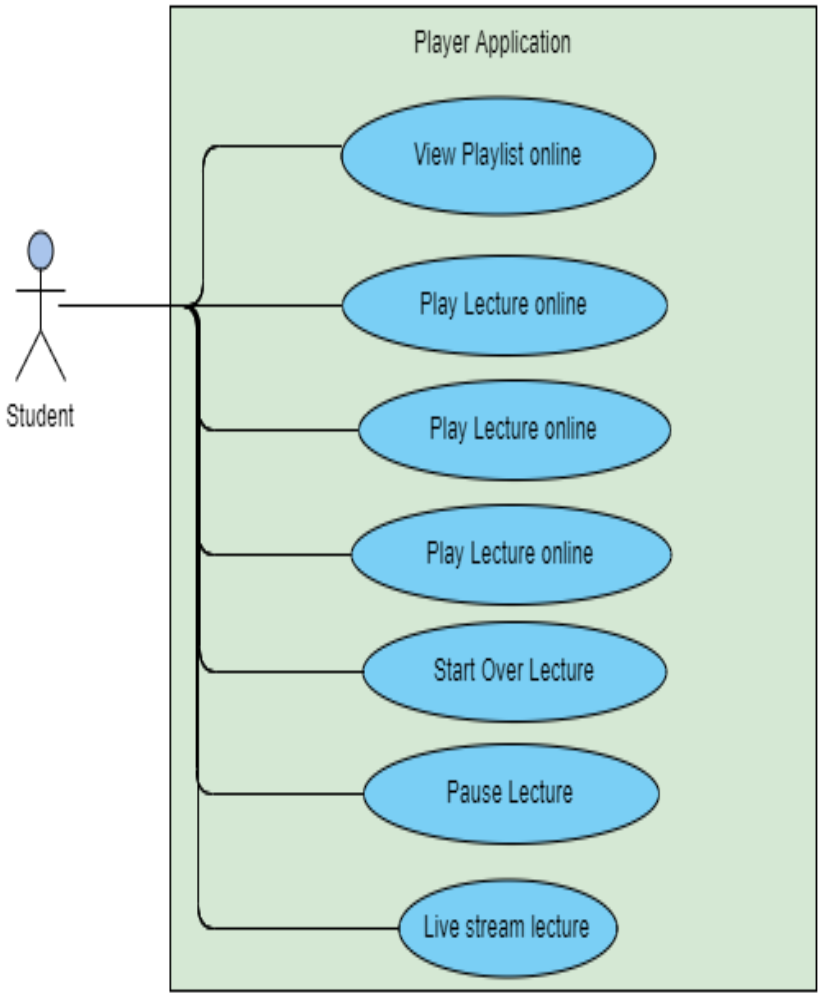

FIGURE 3.4: Use-case Diagram of Player Application

3.5.3 LMS Web Application

LMS application is major module in terms of accessibility. Students, Teachers and administration can have access to this module simultaneously. LMS functionality is sub-divided into following different users:

- Admin, who manages the institute.
- Teacher, who manages students
- Users, who are students

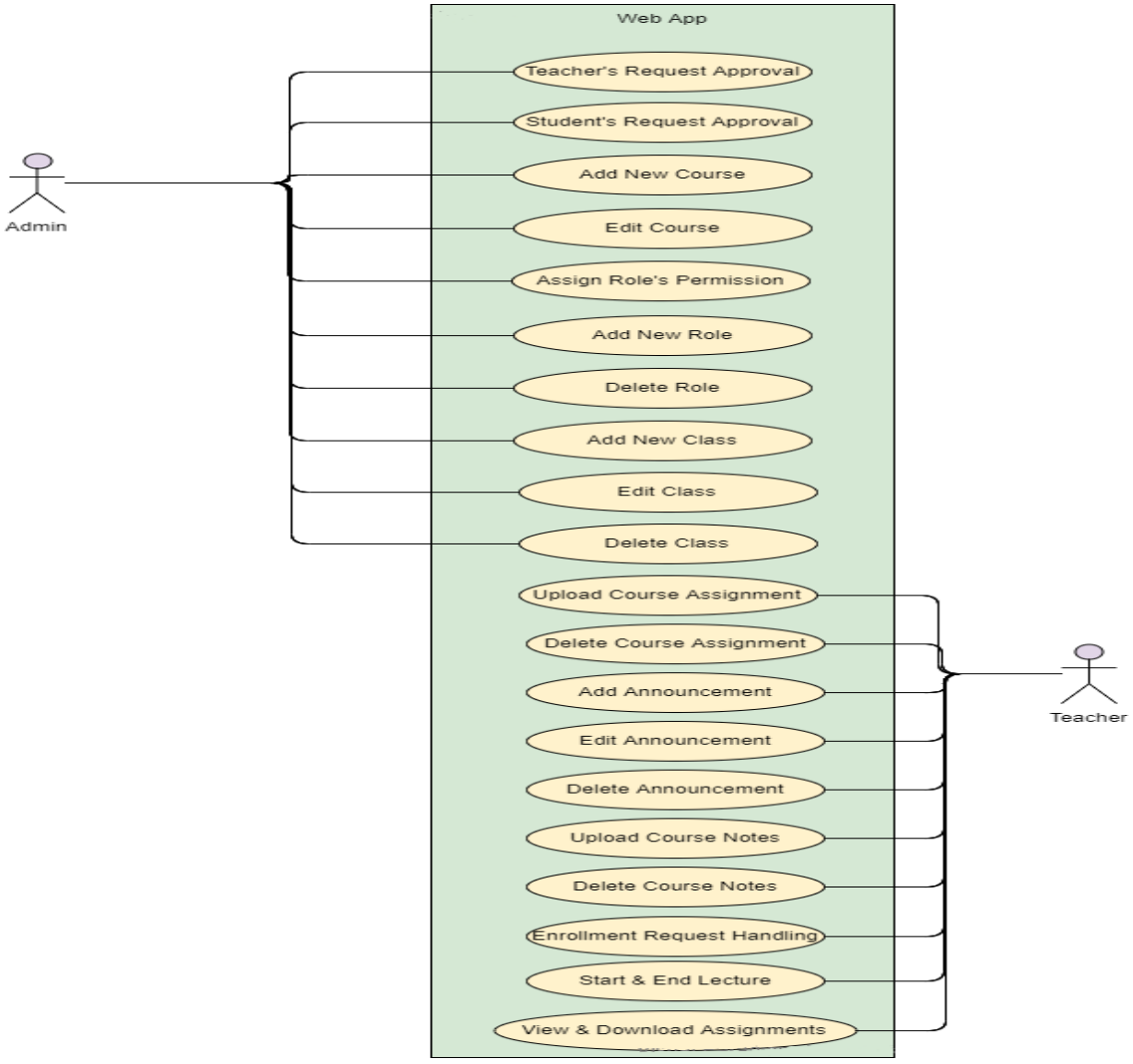

FIGURE 3.5: Use-case Diagram of LMS Web Application Part-I

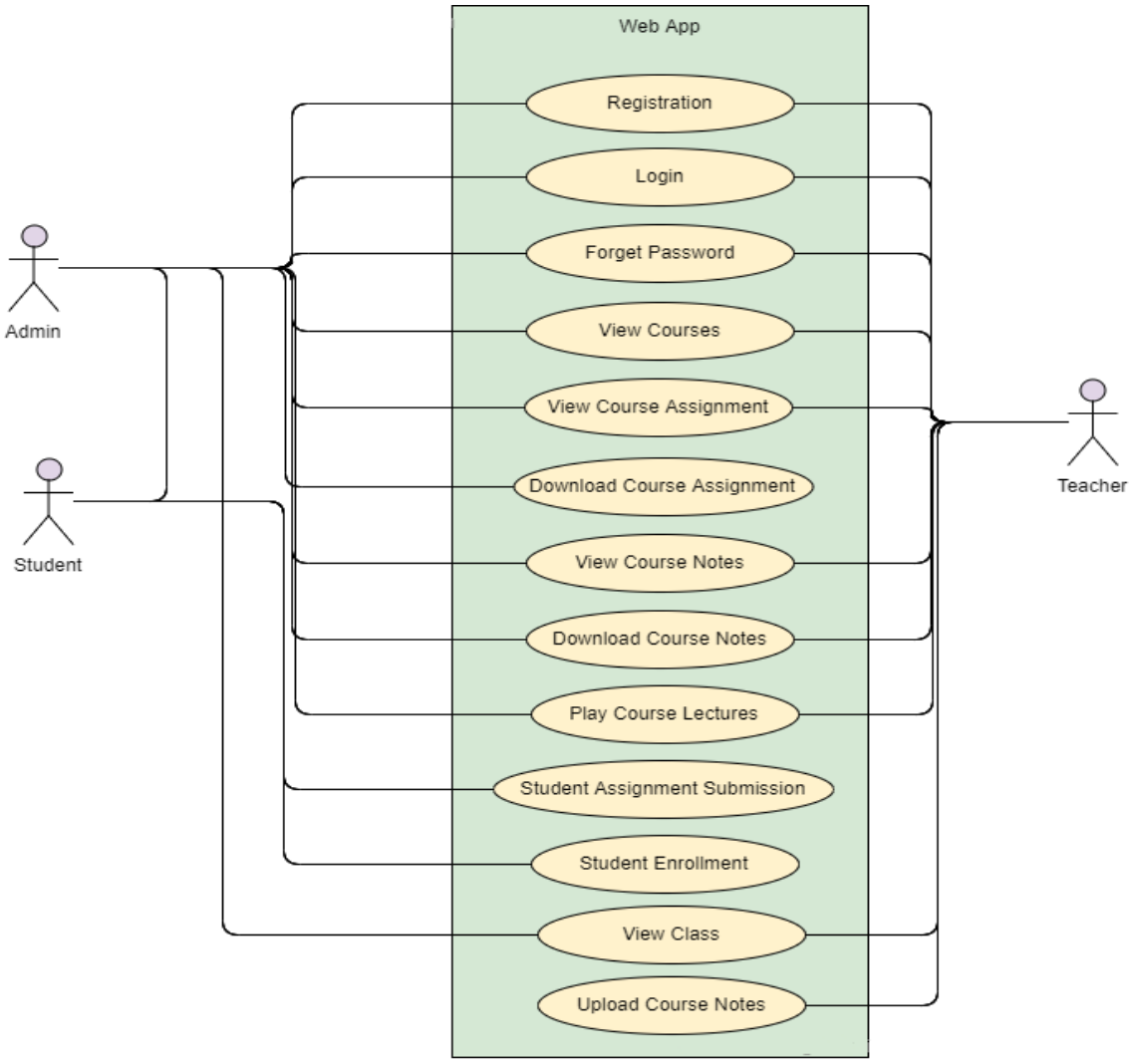

FIGURE 3.6: Use-case Diagram of LMS Web Application Part-II

3.6 Architecture Diagram

Interaction among different modules of the system is not simple but can be simplified and easy to understand. The set of rules and concepts concerned by the overall project are visually explained by the Architecture Diagram shown below. It consist of follow modules:

- Stereo Vision Cameras
- Marker Hardware
- Audio Hardware
- Controller Application
- Player Application

- Learning Management System

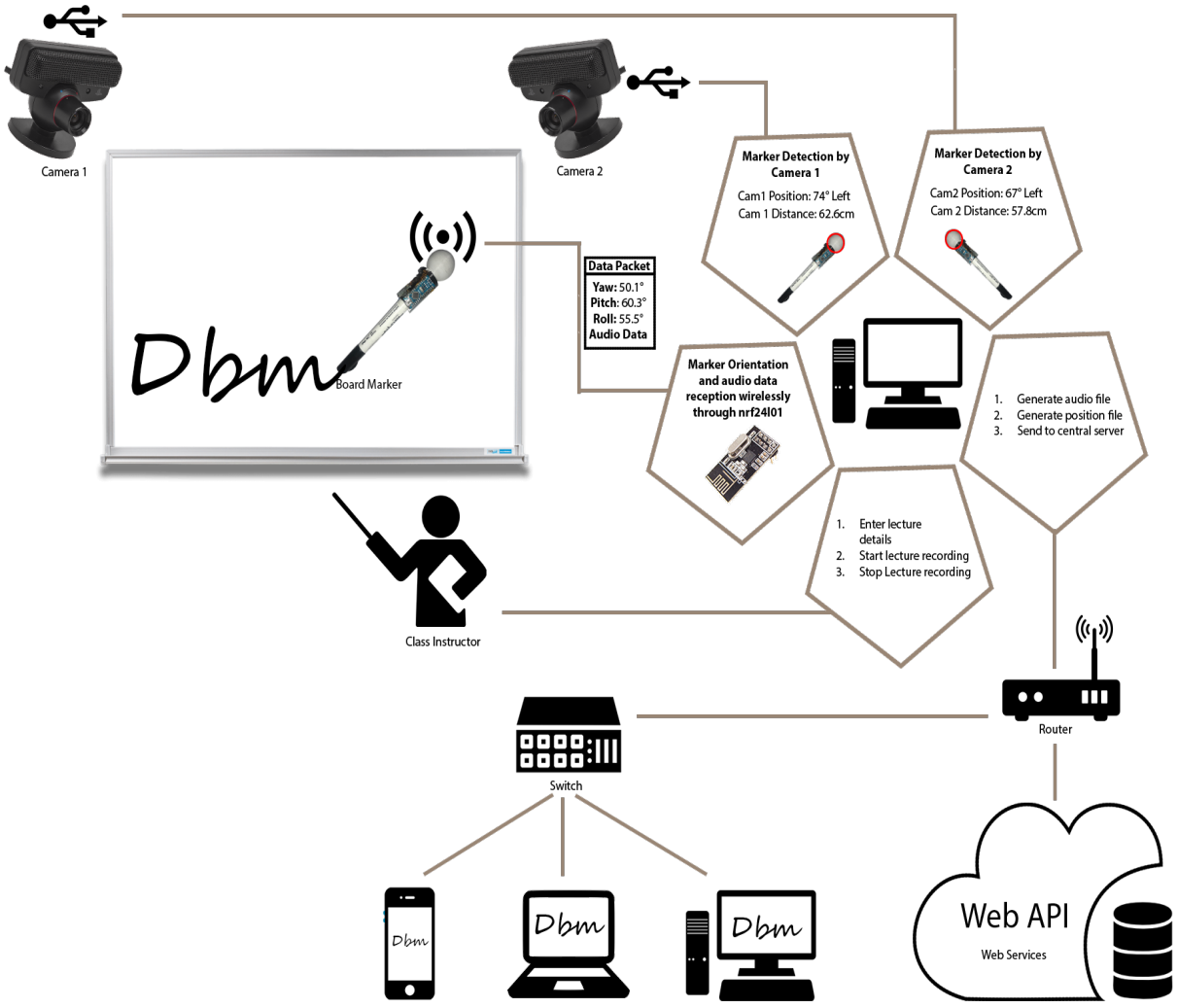

FIGURE 3.7: Architecture Diagram of Digital Board Marker

3.7 Modules Methodology Description

System consists of five major modules. General work flow of each module is detailed using visuals and diagrams.

3.7.1 Board Marker

Board marker transfer the position data of currently written word on the platform i.e. Whiteboard. It is subdivided in two sub-modules

3.7.1.1 Stereo Vision Cameras

At least two high framerate cameras get the video of back ball and send it to controller application. Stereo vision is important for accurately extracting marker position by placing these cameras at such position so that different angles make same alignment to the writing platform irrespective to size. Square and rectangular boards can be mapped to same parent algorithm with simple to calibrate camera placement guide.

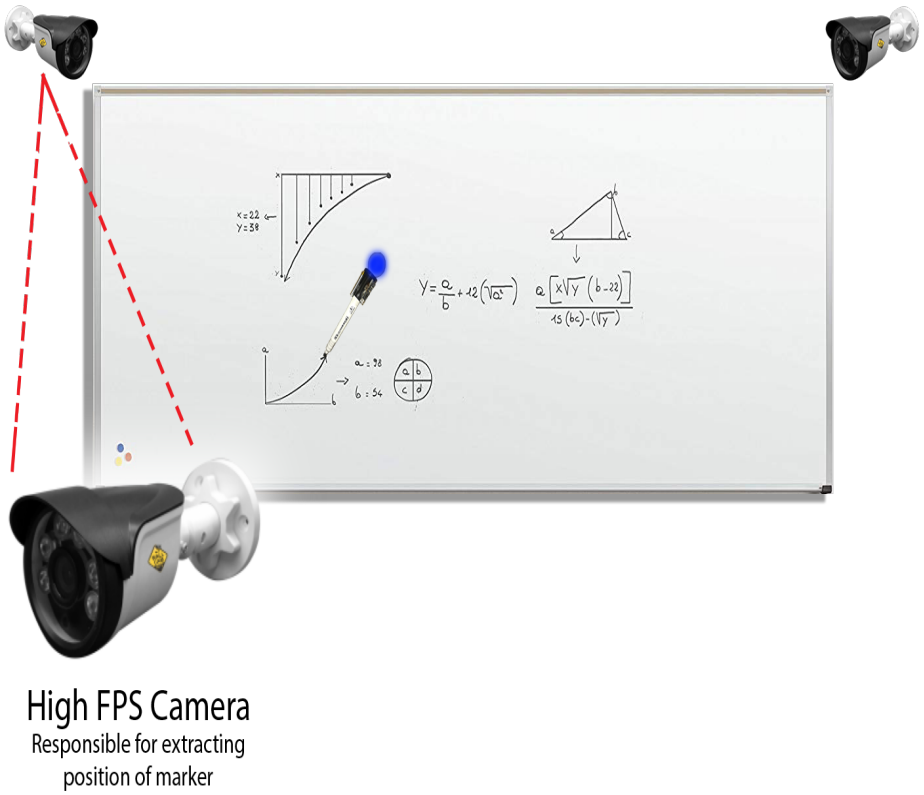

FIGURE 3.8: High frame rate camera placement

3.7.1.2 Marker Hardware

To extract marker orientation, Marker Hardware is connected to controller application.

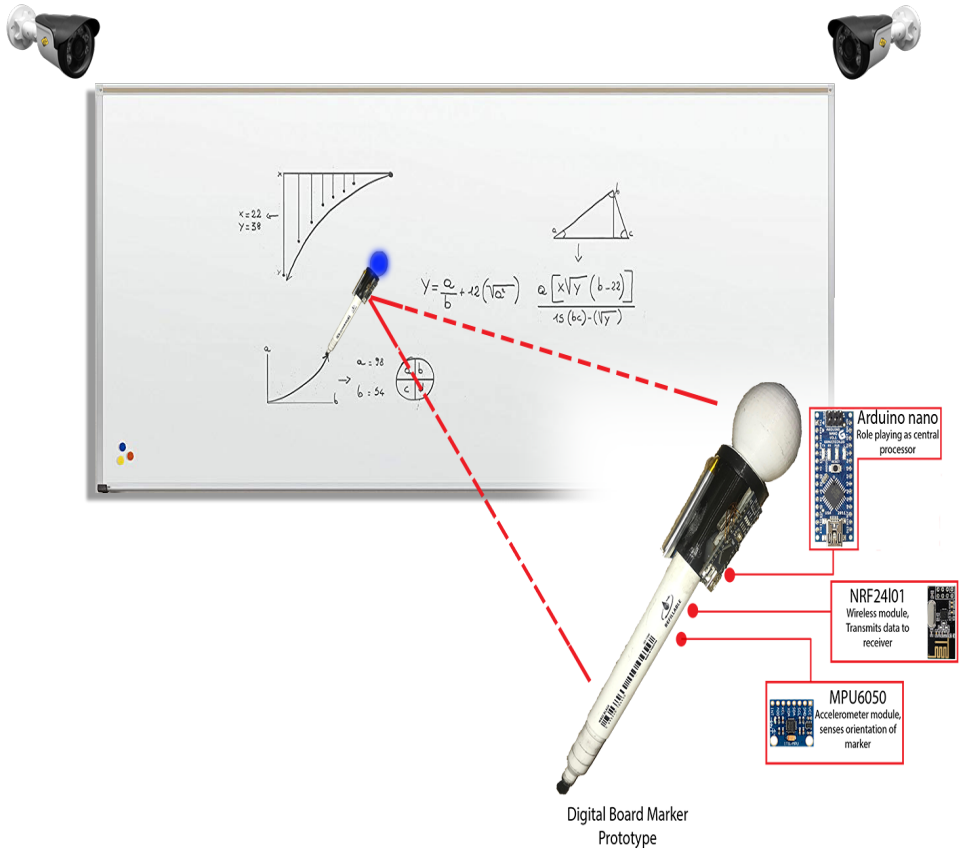

FIGURE 3.9: Marker Hardware working methodology

3.7.2 Audio Hardware

Wireless voice transmission is done by this module. Voice data is accepted at transmitter module. This data is converted into digital audio. Digital audio is then transmitted to receiver at another end. Receiver module decode the digital audio into analogue audio. Receiver module is attached to computer through Line-in[2] on which controller application is being executed. Controller application encode the analogue audio into lightweight ogg(file extension) file format. After the audio file generation is successful, audio file is then embedded into lecture file and uploaded to central server.

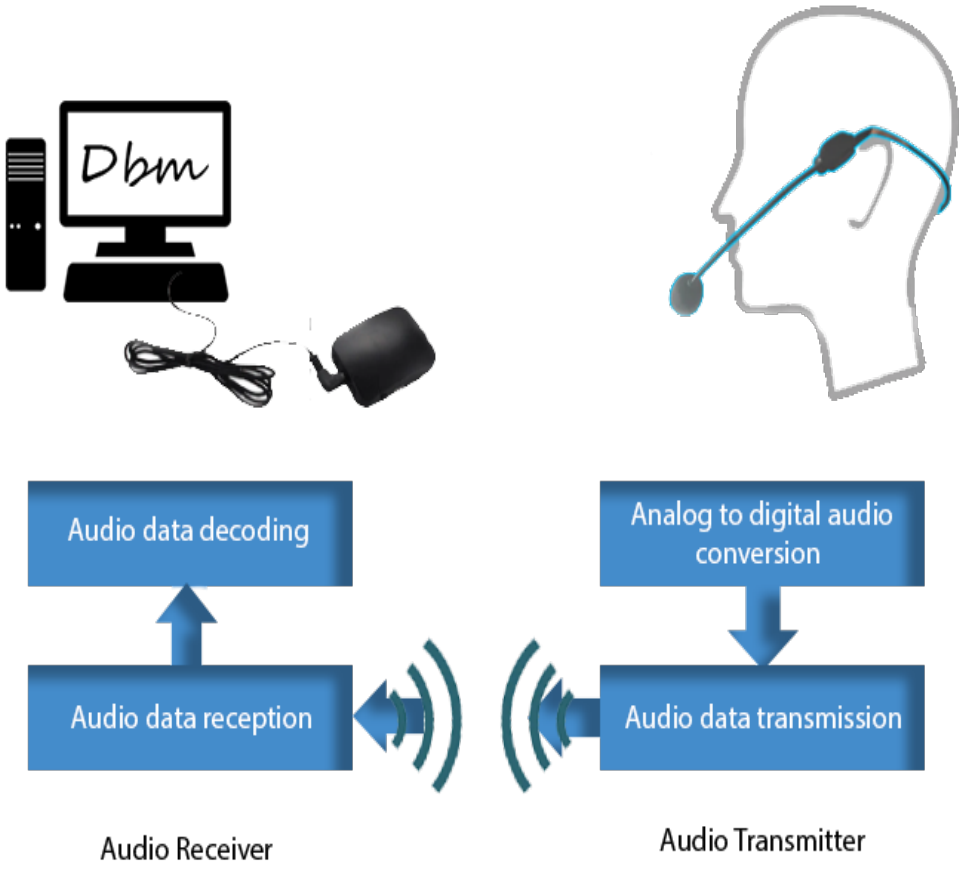

FIGURE 3.10: Audio Hardware General Methodology

3.7.3 Controller Application

Controller application plays several roles in the project. First of all, it is responsible for application of computer vision algorithms to detect marker and extract the position data. At least two camera perspectives are considered for position extraction. Manual calibration system aids in the setup and view port positioning of multiple cameras. Marker position data and audio data have to be synchronously written in the final output file.

Second, it is also responsible for decoding the orientation data. Orientation data is sent using encoded packet by Marker Hardware and received by the controller application. Orientation is extracted using quaternions. Euler angles then extracted using converted quaternion to avoid gimble lock. Position of the marker is extracted.

Third, it can play the lecture file before uploading the lecture. Lecture can be paused, resumed and replayed. also, the lecture can be annotated by the instructor i.e. topic and sub-topic markings. Audio and video quality can be controlled

over performance of lecture play media.

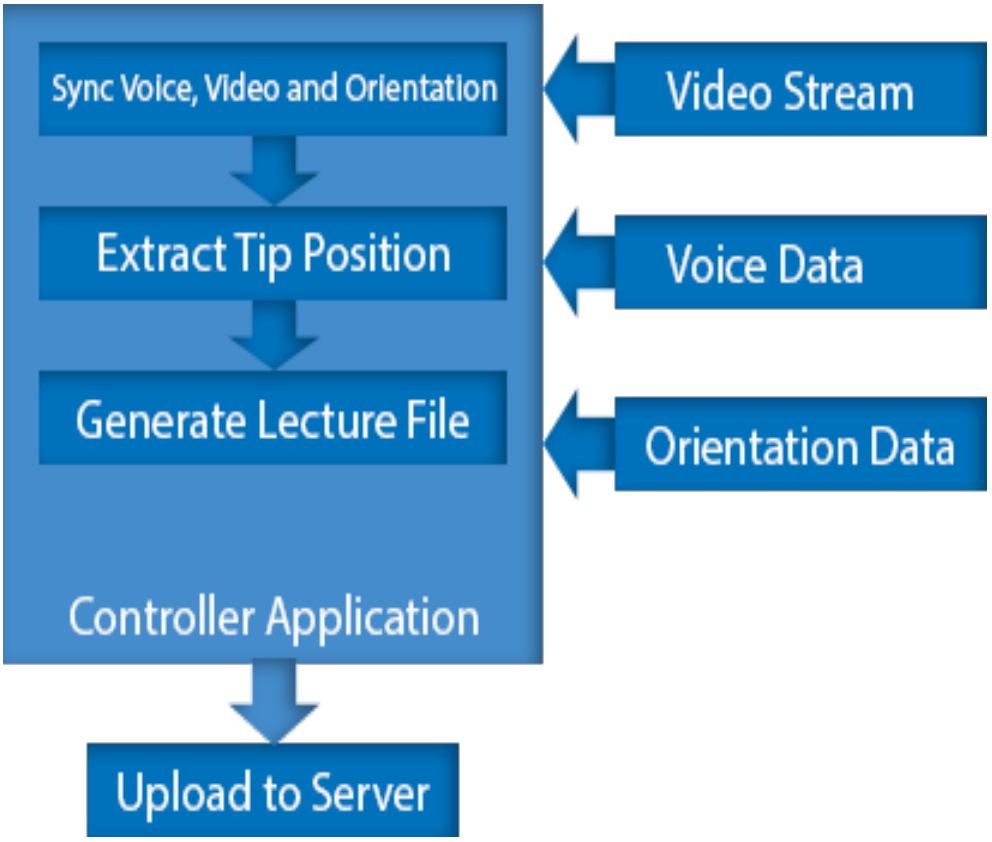

FIGURE 3.11: Controller Application General Methodology

3.7.4 Player Application

Just like media player, the player application plays the lecture. Common end user of Player Application is student. Player application has two version based on data availability.

3.7.5 Offline Player

Lecture file can be played on the computer via Offline Player with no interaction with internet at all. Typical end user is student. A student can rewind, play, pause, stop and resume while watching the lecture. As the lecture is being played by generated lecture file So, there is no compromise on quality.

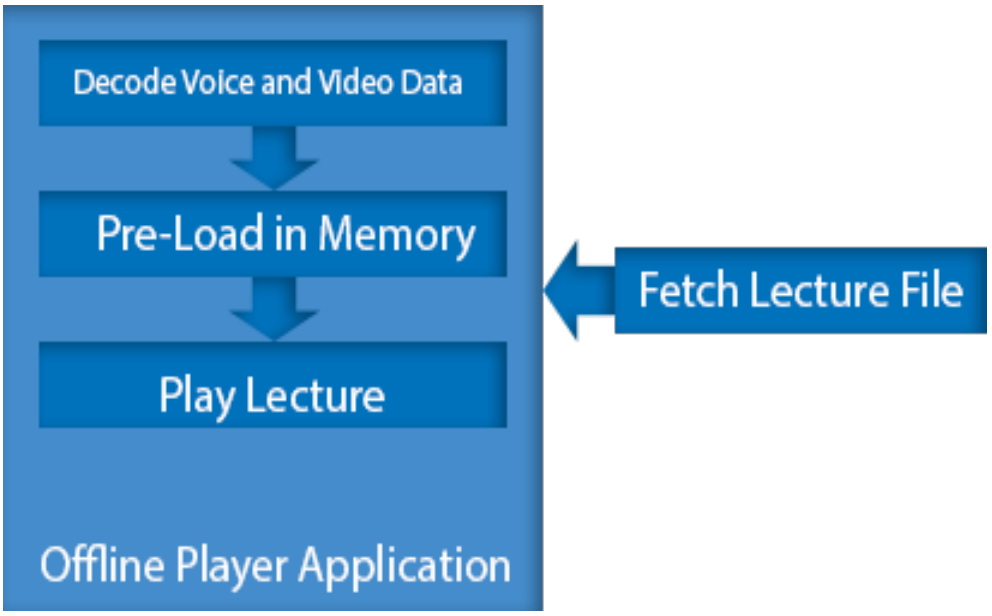

FIGURE 3.12: Offline Player Application General Methodology

3.7.6 WebGL Player

It is an online in-browser player that streams the lecture right in the webpage. Similar to video media player, flow of video can be controlled by user. This online player first loads its necessary packages and plugins before it could be fully functional. While browsing the lecture hierarchy, any lecture can be played by user and annotated by an instructor.

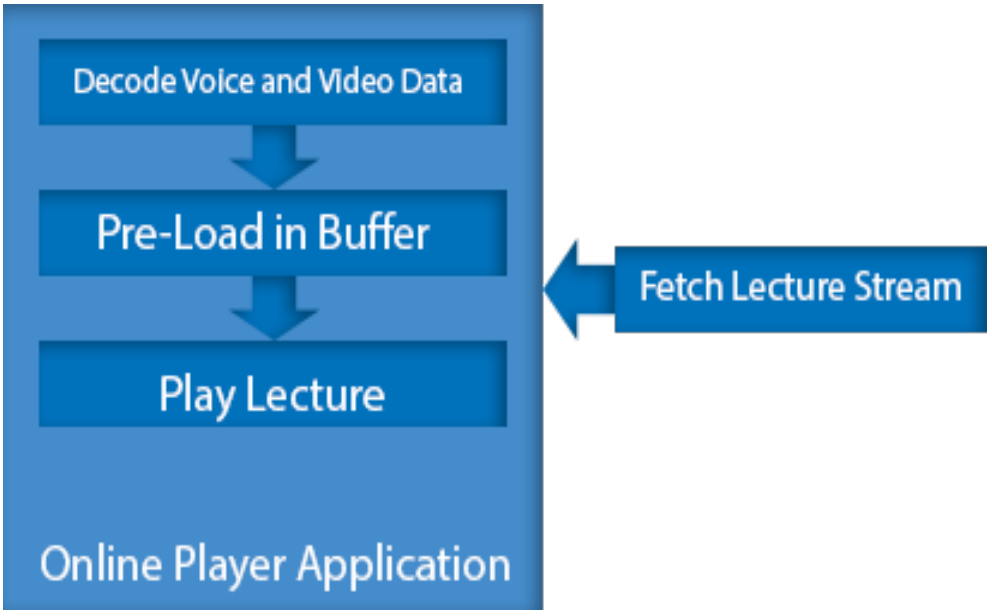

FIGURE 3.13: Online Player Application General Methodology

3.7.7 Learning Management System

LMS System that provides platform for playing online lectures, assignment submission and course content management. This module will act as a final deliverable when integrated with Online Lecture Player. This module consists of many submodules and functionalities. It also acts as an online portal for students and play important role in maintaining their profile. Below is further detailed discussion about this module. LMS developed for this project has other features including Administration, Access to high quality study material and learning data, email updates for students as well as teachers, fast delivery of learning material guided by the instructor and organized by existing institute, updates of emerging technologies to make students up-to-date and excel in their career in future. Report generation is another major advantage of the developed module. Using this functionality, instructor of the class can generate reports daily, weekly, monthly and so on. Also, reports are not only about the students. They can be about course material and Lecture data as well. Attendance of students and instructors as well can be maintained and reported easily. Concerned party can view the generated report at any time. Students can view timetable. Concerned instructor can suggest the adjustments to the timetable that administration can see and adjust accordingly. The application is web based so that accessibility of the system could be increased. Reliability and security are major concerns to the system. Administration can suspend the user by analysing the suspicious activity performed by the corresponding person.

3.7.7.1 Entity Relationship Diagram

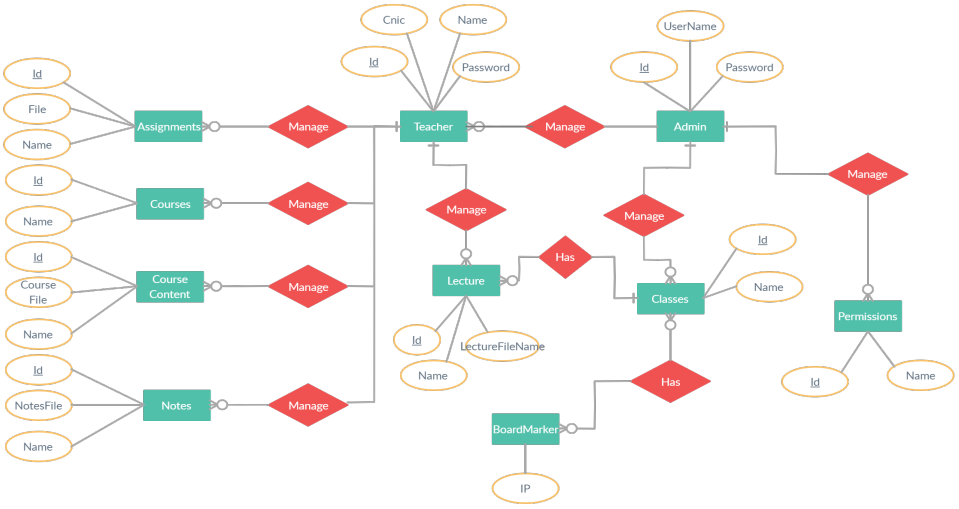

FIGURE 3.14: ER Diagram of LMS

3.7.7.2 Database Diagram

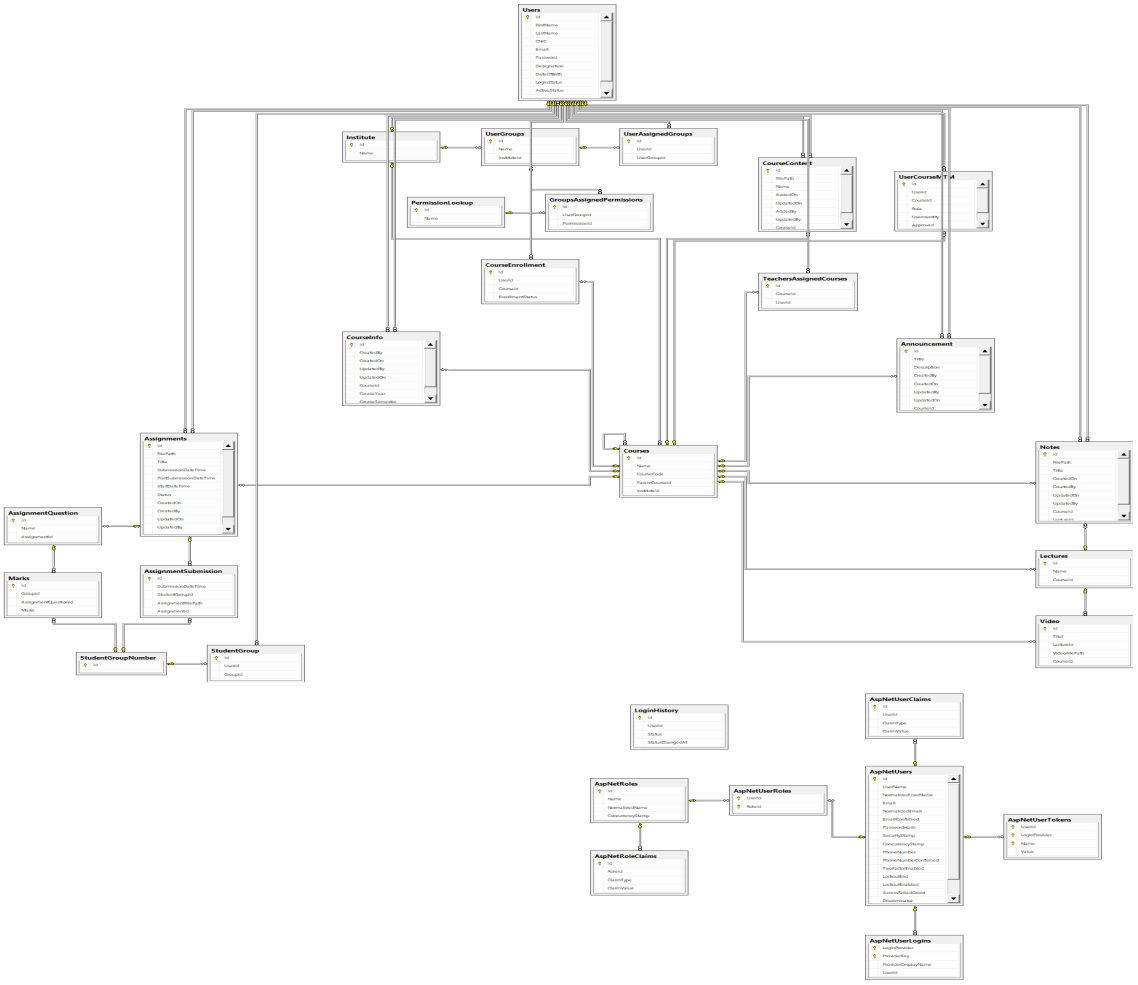

FIGURE 3.15: DB Diagram of LMS

Chapter 4

Implementation

Chapter 5

Evaluation Criteria

Chapter 6

Results

Chapter 7

Future Work

References

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