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# ONEKUBE: A Virtual Classroom Experience

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***Abstract*—Online Classrooms are a very promising and motivating platform for both teachers and students. It has proved to be very helpful, especially during the pandemic time. Even though various applications are available, there are some limitations associated with it. The proposed work is intended to improve the concept of online teaching and provide the integration of features essential for the proper functioning of a virtual classroom system, which are scattered throughout the web. Proper attendance assessment is also a major issue in online education. This paper address a solution to it using face recognition technology which is the key highlight.**

***Index Terms*—Virtual Classroom, Online Education, WebRTC, Jitsi, Face Recognition, E-Attendance, E-Learning, Collaborative Whiteboard.**

## I. Introduction

Educational institutions, especially in India, follow the traditional way of teaching which can also be termed as 'face to face lectures' or 'contact classes'. One thing which almost all sectors, including the educational sector did not foresee is the outbreak of Corona Virus(COVID-19). The impact of this deadly virus was such it forced the whole world to adopt new approaches for doing their everyday tasks. In educational institutions, due to the sudden halt in academic activities, a confusion was developed as on how to move forward with academics as well as the parallel tackling of the pandemic situation. So in order to move ahead, schools/colleges were forced to switch from the standard offline mode to a completely online mode of teaching. With the help of rising video calling applications like Zoom, Google Meet and Microsoft Teams etc. classes were able to resume. But the effectiveness of these online classes were much more abysmal compared to those of the former offline classes.

Both the students and teachers faced many issues associated with online classes. Some of these problems include the unavailability of a proper attendance management system, a proper online teacher-student communication system for educational task like assignment, quiz, notes etc. and the unavailability of a custom educational video calling interface which allows teachers to conduct classes effectively. All these problems, which prevailed, motivated us to develop OneKube - a unified web application that delivers almost all the features which are essential for the proper functioning of an online classroom, or in simple terms an integrated model comprising of all the essential features of a day-to-day classroom. Major highlights of our application include a website hosted service to enable a platform independent application, a custom designed video/audio conference for making online class effective, a real-time collaborative whiteboard with essential tools, a highly efficient and reliable attendance tracking system based on real time student participation in class and face recognition. Finally, an easy to use hassle free User Interface loaded with major education task like assignments,notes,quiz etc.

The Organisation of the paper is as follows: Section 2 discusses the state of the art and related works that have been published or that currently exists, similar to that of the proposed idea. Section 3 deals with the basic technologies whose knowledge is required to deploy the work. Section 4 discusses the architecture of OneKube which includes Huddle, Face Attendance and Whiteboard. Section 5 shows the result of our proposed idea and discussions based on the results. Finally, section 6 includes the conclusion and future scope.

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## II. Related Works

There have been lots of works that are related to digital learning, but the number of research papers that focuses on online classroom are still limited, though. One of the work by Ketut Sudarsana et al.[1] goes through the various features of google classroom specifying its importance in online education. Major findings listed by authors includes time-saving and organizational features of google which made things simple. The benefits stated that, using google classroom as educational platform would improve the teachers and students quality to use technology wisely, mainly in learning process, time saving, overcoming distance of residence, more collaboration among students and more convenient timeline.

The current major online platform for e-learning are Zoom, Google classroom and Microsoft teams. From various works conducted by A.Agarwal et al.[2], it showed that students enjoyed the ease of access of material via e-learning tools and majority of students are eager to adopt the e-learning platform features in their regular classroom teaching. Also the work by M.Rohman et al.[3] specifies that most students receive online learning using the Google Classroom application due to several considerations such as ease of access, user-friendly interface and time saving. Education has been forced to run 100% online after the pandemic. Hence E-learning system must be redefined with loaded features and strategies are needed for keeping educational activity as effective as contact classes and building the creativity in the study process so that learning remains interesting and meaningful (AMIT Asfar et al.[4]).

The most crucial part of online education is the active participation of students and proper evaluation methods for teachers. Additional effort from the teacher is needed nowadays to make sure attendance are marked correctly, which at the same time wastes a considerable amount of time. It can get much more complicated when there are more number of participants. According to the work by R.Navas-Gonzalez et al.[5], It cannot be stated that class attendance is fundamental to success in the subject but it does seem clear that success in the subject is accompanied by regular class attendance. So for better academic performance and to ensure students proper full-time participation more appropriate online attendance system is needed.

The effectiveness of online learning varies amongst age groups. The general consensus on children, especially younger ones, is that structured environment is required, because kids are more easily distracted. To make online education more useful, there needs to be a concerted effort to provide a structure that can replicate a physical class through various technologies, instead, of simply using a range of collaboration tools and engagement methods. Online mode education has a huge impact on upcoming era of technology. Multiple existing platforms could ensure connectivity and virtual mode of communication, but massively lacked the valid and hassle-free attendance management and management of online education activity in a coordinated way. OneKube ensures the involvement of students in real time classes along with all educational features. There are two type of attendance tracking for OneKube: face recognition based and real-time analysis of student participation in the entire class by calculating the presence time. Both would help teacher identify and improve students involvement. Thus, the main objective of OneKube is to show its effectiveness and its importance in the world of virtual education.

## III. Background

Major four components of OneKube consist of website interface, a video conference unit, face evaluation unit and whiteboard unit. Implementation of video conference unit uses WebRTC (Web Real-Time Communication) technology which is a collection of protocols, standards and JavaScript APIs that enables audio, video and data sharing communication between browsers. It can be used to deploy peer to peer communication , but can be extended to multiple user communication using various network topologies. For more information refer works of Schahin Rajab et al.[6] and D.Ammar et al.[7]. Video conference unit of onekube was developed by extending an open source project called Jitsi Meet which is a collection of free and open-source multi-platform voice, video conferencing and instant messaging applications for the web platform. It is a WebRTC JavaScript application that uses Video-bridge to provide high quality, secure and scalable video conferences. In the field of WeRTC for making video conference reliable and to ensure all time connectivity of remote users including users behind NAT network, servers named as STUN and TURN plays an important role. Also various concepts of video bit rate management along with various network topologies can be used to scale the number of participant in a conference, Detailed information can be found in Z.Zheng et al.[8] and S.Petrangeli et al.[9]. Considering any video conference unit media server is an important component, based on the use case there are different models for media servers. Jitsi Video Bridge (JVB) which is a Selective Forwarding Unit (SFU), which is the media server component and the core of Jitsi Meet. Work by W.Elleuch et al.[10] gives a clear view of various models of multimedia servers.

As we switch to this online mode of teaching, we need ways to ensure that the students are effectively present throughout the course of the class. For this reason, development of a system to calculate attendance based on facial recognition was used. A huge part of the code depends on the Open CV library which is used to handle images, to compare them and to execute the face recognition part. Open CV-Python is a python library designed to solve computer vision problem, Emami et al.[11] developed an application that would allow user access to a particular machine based on an in-depth analysis of a persons facial features.

## IV. Proposed Model of OneKube

OneKube consists four major components, a web platform for all login and educational activity, video conference unit called ”huddle”, collaborative whiteboard and a powerful face recognition unit.

### A. Architecture

The website platform of OneKube provides interface for users. All the fundamental requirements including video conference, face recognition and whiteboard is integrated into it. There are mainly 3 user modes: Admin, teacher and student. The architecture of system is depicted in fig 1.

The entire system starts with admin login and adding subject, classes, students, teachers and departments. Once all details are added by admin, teachers and students may sign up and create their personal password for login. Once completed teachers and student are directed to their corresponding dashboard. The interface of teacher classroom dashboard is depicted in fig 2. Teacher can start teaching in a classroom via adding subjects to a specified class. The subjects and classes will be listed depending on admin inputs. Once teacher creates a new class, automatically all students in that class will be assigned to the same class. Teacher can navigate and select all the classes created. In main dashboard teacher can add announcements, assignments, quiz and materials for multiple classes in one go. Personal backpack storage, shared teacher folder, messaging features are also available. On selecting a class, teacher can individually access the corresponding class where they may view notification of students assignment submissions, material uploads etc. Both admin and teachers are given option to add events to calendar which can be seen by students. There is an option for hosting/joining live class for teacher and student. Teacher is given additional access over video call including class invitation link share and mute-all. Teacher is also provided with a capture button for capturing remote student image in real-time, which is processed by python code running for face recognition. Collaborative whiteboard too is integrated to the interface.

*1) Huddle:* Huddle is the video conference unit of onekube which use jitsi media server. The class is hosted by the teacher and the student can join the class. Jitsi media server services is integrated into website using jitsi iframe functions. Hence, huddle which is deployed in another VPS (virtual private server) is loaded as an iframe into OneKube website. Using jitsi iframe functions, all necessary information on jitsi server can be loaded into OneKube website thereby allowing real-time attendance analysis and other basic video call functions. A demonstration of huddle interface is depicted in fig 3.

A demonstration of jitsi iframe functions is depicted in fig 4. StartMeeting is a jitsi iframe javascript function for creating a video conference, roomName contains the required room name and displayName contains the name of user logged in. Using querySelector we can specify the tag for loading conference screen in website. ConfigOverwrite is an iframe function where all pre-configuration of media server can be specified like setting the camera and microphone turned off on entering the conference. Domain contains the domain name of hosted jitsi media server and options specify the configuration and details of conference call. Using JitsiMeetExternalAPI function, apiObj object is created which holds entire conference call setting loaded from media server.

Apart from the face recognition based attendance, provision for viewing the real time analysis of students participation in entire class which is done by computing the presence time of each student in the video conference. During the class, presence of each student is calculated in intervals of 30 seconds and updates the real time presence percentage. Teacher can view real time attendance of students in percentage after the class or even during an ongoing session were percentage is shown up-to the last updated percentage.

*2) Face Attendance:* The face recognition based attendance is done by capturing images of all students in the video conference by a single button click provided at teacher side. The capture button is depicted in fig 3: The camera icon in the left side panel of teacher interface. The captured images are then stored in the database for later evaluation. The goal here is to compare and check whether the student sitting in front of the screen is the same as that logged in and whether he/she is present throughout the duration of the class. First of all, during the initial sign up procedure student uploads a high-resolution picture of themselves as their avatar on the site which can be viewed by teacher. This will be the base image upon which comparison will be done. The captured test image of students by teacher throughout the duration of the class is stored in the database(Any number of photos can be captured during class. For the demonstration in session 5.1: five images of each student is captured). After the class gets over, captured images are processed using face recognition technology and the database is updated with the comparison results. The effective attendance based on face recognition result is calculated and presented to the teacher which is called as ”Face Attendance %”. Apart from the face recognition based attendance, a real-time analysis of each student participation in the entire class is calculated by comparing the presence time of each student in the meeting and the total duration of class, which is called as ”Huddle %”–Session 5.1 fig 7,fig 8,fig 10 depicts the same. All the captured images with results are shown in color coordinates to teacher. Different colours are used to specify different cases handled by the algorithm such as present, absent, another person and unrecognizable. The final verdict of whether to mark the student as present or absent will always remain at the hands of the teacher. Once the information of the students, their real-time presence results and face recognition results has been conveyed to the teacher, teacher can mark attendance and understand the effectiveness of the period. Also once the attendance is marked teacher can view the attendance and edit them in attendance management system. A detailed analysis with pictorial representation is given in section 5.1.

*3) Whiteboard:* Another major highlight included is whiteboard based on an open source project (cracker0dks-lightweight whiteboard). This whiteboard supports collaborative writing with all necessary tools. Various tools like pen, pencil, eraser and predefined shapes etc. are included for teaching. Whiteboard has shortcut keys for faster shifting of tools, it supports drag and drop of images, content download and restore option. Also both whiteboard and video conference allow teachers additional option of sharing URL if any other teacher want to join. Additional features like creating a whiteboard session by teacher, granting writing permission for students and revoking writing permission from students is also

(2).png

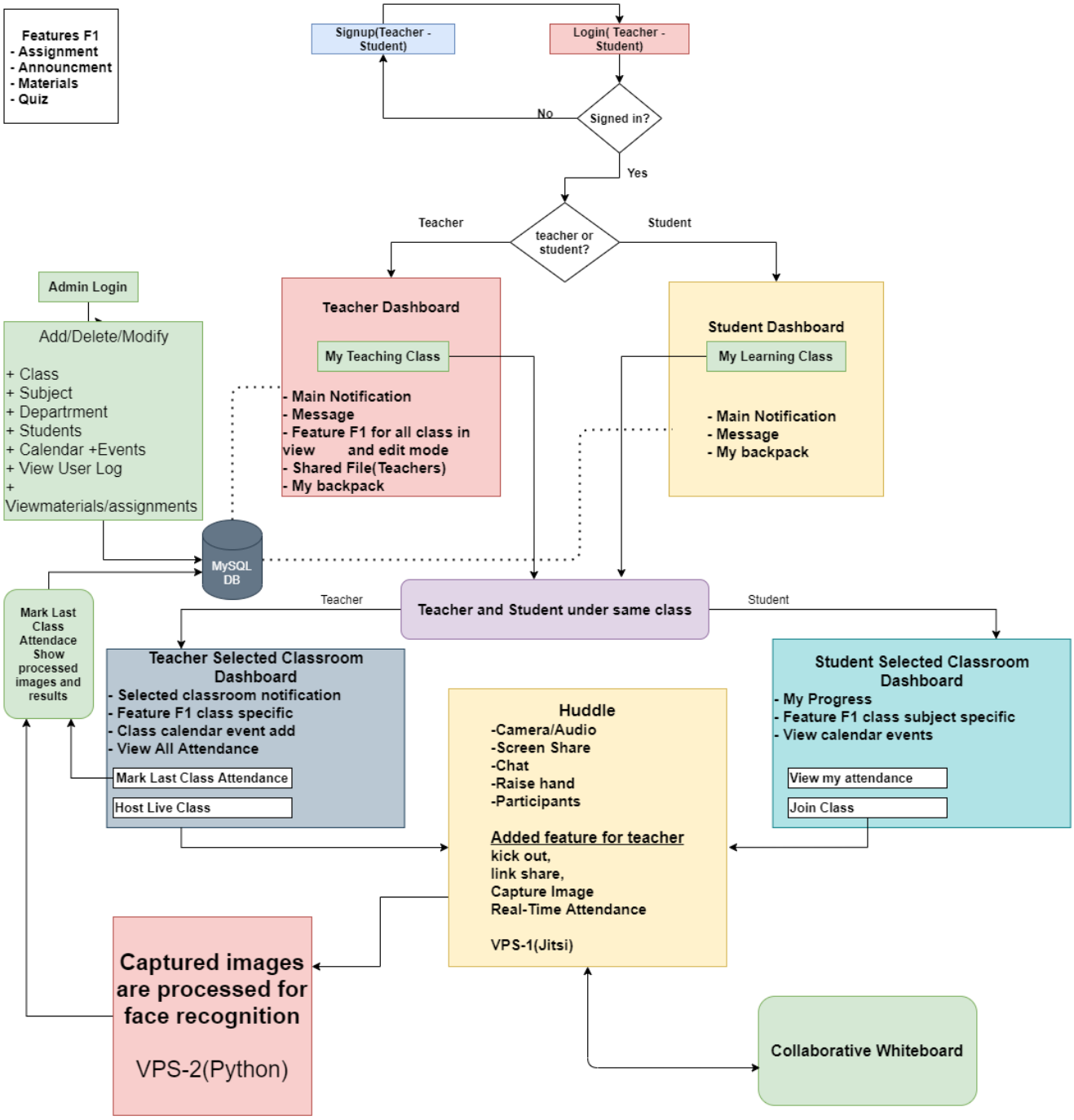


Fig. 1. Architecture of OneKube.

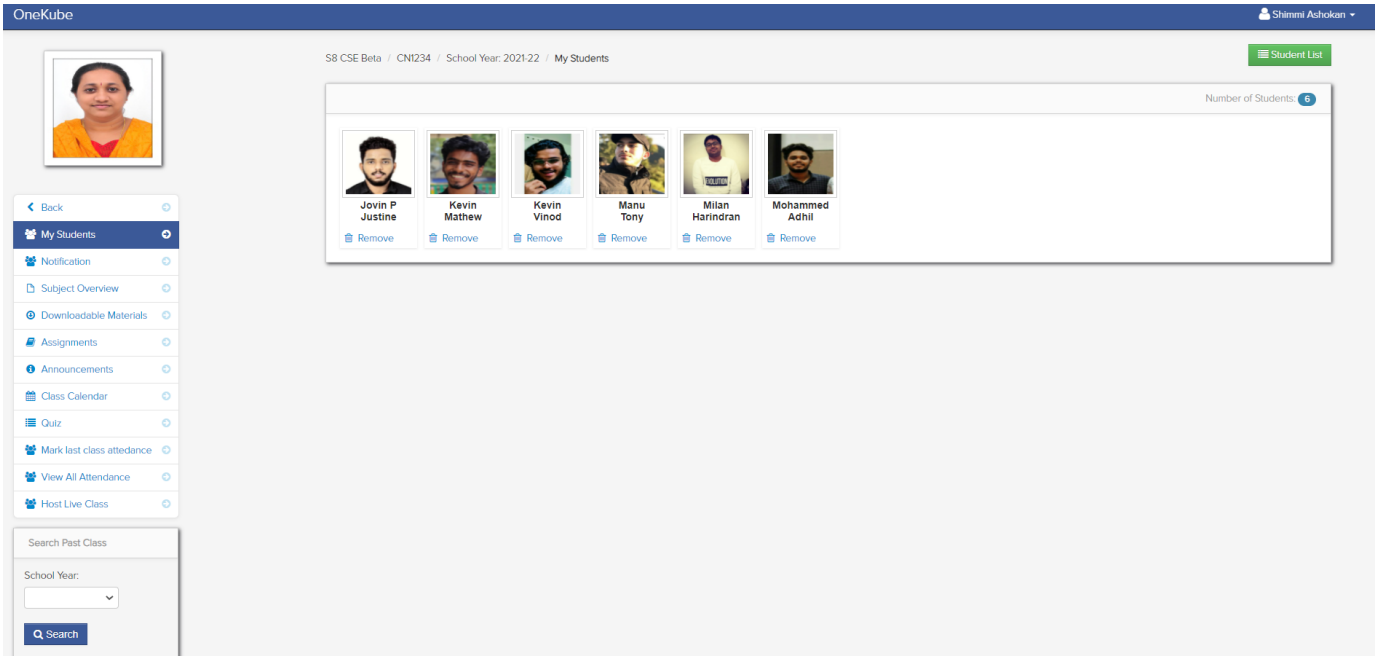


Fig. 2. Teacher Dashboard.

included by extending the open source project using HTML canvas, web sockets and javascript. A detailed information can be found in Gao et al.[12]. The teacher, initially opens the whiteboard and shares the access as read only so that the students can only view the contents of whiteboard. If the teacher wants to specifically give access to only a particular student, to use the whiteboard he/she can select the students name from the drop-down menu provided and select submit. In order to revoke the permission granted, revoke button is clicked. Various tools are provided and extra includes feature to export the whiteboard canvas as an image, save content as json file and restore anytime later for continue from where teacher stopped. A demonstration is depicted in fig 5.

Now to summarise the features that are being offered by OneKube, proper evaluation of participation of students in a class using face attendance algorithm and real time analysis of students presence. The UI used offers a fresh and friendly experience to its users. Provides quick and easy access to all features including assignments, quiz, study material, messages, attendance, personal storage, teacher-teacher shared folders, calendar events, showing student progress, announcements are clearly provided in adminteacher-student login. By integrating jitsi into onekube, the need to share the session URL or room codes to join sessions hold no more importance. OneKube handles each class hosting in separate rooms just through button clicks. In addition to video conferencing features, Jitsi Meet has the features of direct rendering of YouTube videos. Image capture button and whiteboard access button is embedded in video conference interface for faster and easy access. Apart from these, an one-on-one video session for clearing doubts, which is minimal compared to Huddle is included. OneKube maintains sorted and organized notifications for each classroom. An advanced quiz for students is also included that run strictly in full screen-mode and with limited timing. Quiz is coded for identifying tab switching and any attempt to exit full screen. Any violation of rules will result in forfeit of quiz with last updated mark. Also, there is a button for alerting the students logged in but not joined the class.

## V. RESULTS AND DISCUSSION

This work was build considering scalability and low budget. The back-end server configuration for huddle and whiteboard used while development and testing involves 1core CPU, 1 GB Ram, 20GB SSD, Geek bench score of 3513, 1TB bandwidth, Dedicated IP, 100 mbps network system running Ubuntu 18.04 OS. Face recognition algorithms were executed in PC with specification of 8GB Ram, intel i7 processor running on windows 10. Multiple PC with a load balancer or any one high configuration computer can be used to scale the recognition to a higher rates.

This work is easily scalable since the basic website and whiteboard doesnt require any higher configuration and anyone could deploy easily. However, the media server setup would require high specification and video bridges for managing multiple rooms and accommodating multiple students. But that would never be an issue since jitsi public server can be used for free and anyone can use their server to integrate their video conference (they currently specify a hard limit of 75 people per room - which is pretty decent). OneKube was developed loading jitsi to a private server for testing and integration purposes. Even though it was developed on private server all the documentation and working remains the same. In short, replacing the jitsi free public server URL as domain name in above start meeting function in Fig.3 would make the project scalable without any private server.

HTML, CSS and JavaScript is used to design and implement the web application. The database used is MySQL. PHP is used to manage database connections and server

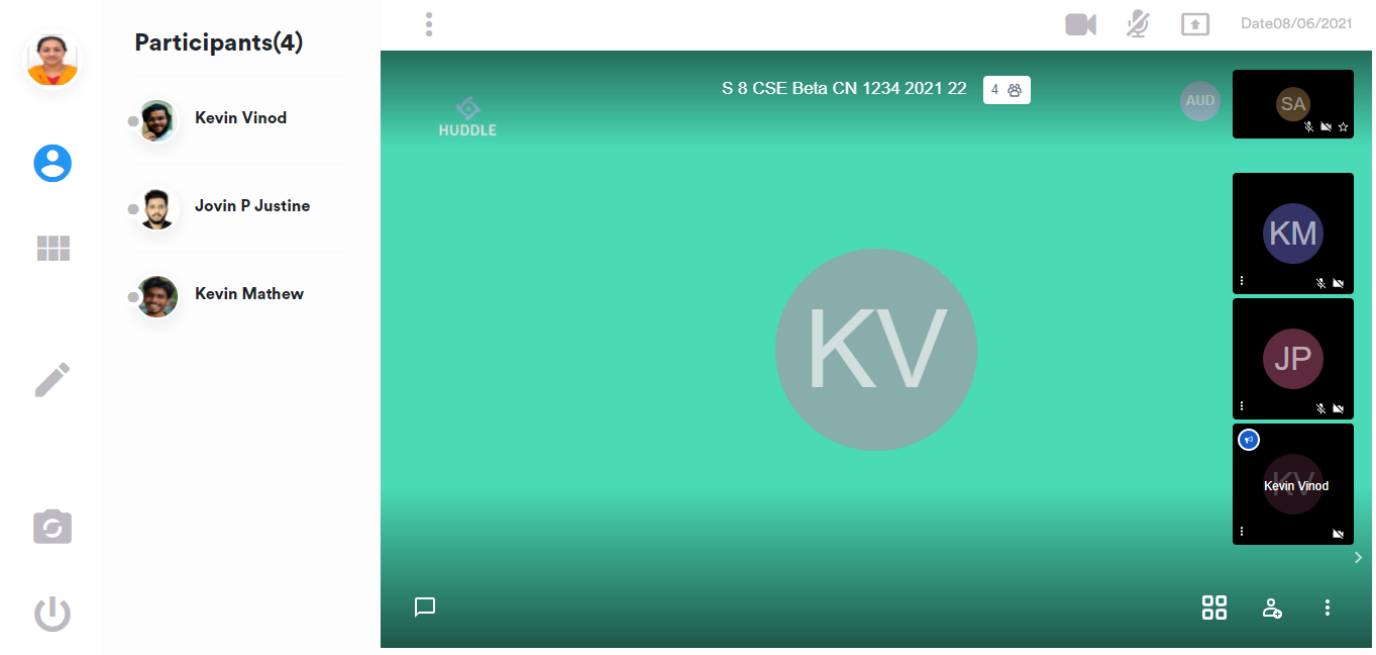


Fig. 3. Huddle Interface.

```
var apiObj = null;
function StartMeeting()
{
    const domain = 'onekubehuddle.tech';
    const options = {
        roomName: roomName,
        width: '100%',
        height: '100%',
        parentNode: document.querySelector('#content'),
        userInfo: {
            displayName: displayName
        },
        configOverwrite:{startWithAudioMuted: true , startWithVideoMuted: true },
        interfaceConfigOverwrite: {TOOLBAR_BUTTONS: [
       'microphone', 'camera', 'fullscreen',
        'fodeviceselection','hangup', 'profile','chat', 'recording',
        'livestreaming','sharedvideo', 'settings', 'raisehand',
        'videoquality', 'filmstrip', 'invite','stats','shortcuts',
        'tileview', 'videobackgroundblur', 'download', 'help', 'mute-everyone'
    ]}
    };
    apiObj = new JitsiMeetExternalAPI(domain, options);
}
```

Fig. 4. Video Call Integration Javascript Iframe Code

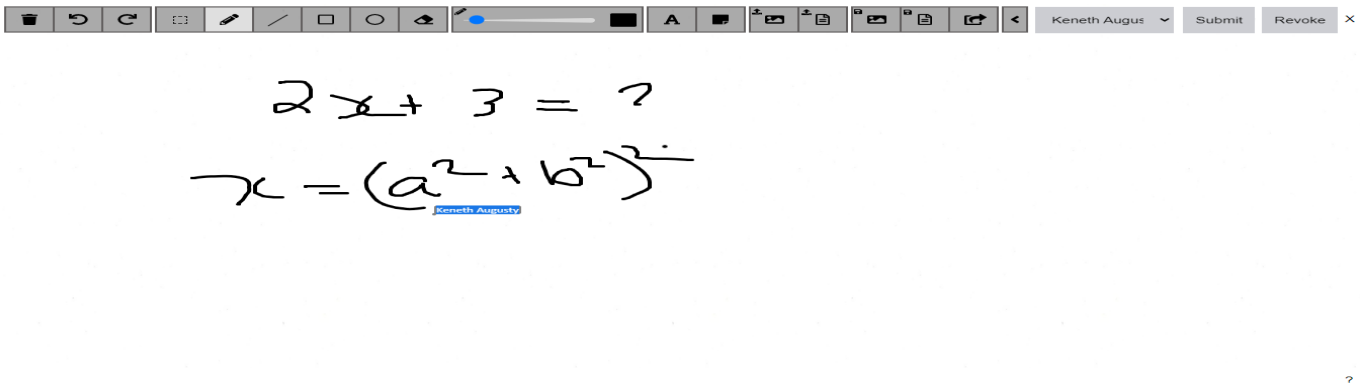


Fig. 5. Collaborative Whiteboard

side processing. For Huddle, java script libraries(modules) are also used which include webcamjs for student image capturing. For the whiteboard HTML5 Canvas plays the important role. WebSocket is used for making whiteboard collaborative. Whiteboard was coded mainly in javascript and use nodejs for backend JavaScript running. Face attendance is purely coded in Python along with few libraries including Open CV, Dlib, NumPy Library.

The major highlighted results of Onekube application is depicted in fig 6.

### A. Results Of Face Evaluation

For evaluation of face recognition system we have considered 5 cases. Each image of students captured by teacher undergoes face recognition, result are presented in various colour: Green (True: Student is present), Red (False: Some other person is attending the class), Yellow (Unable to detect face or Image being blurred or Student is logged in but not present in front of the screen), Blue (Might be true), Absent icon (Student is absent). Different scenario where included in order to identify reliability and efficiency of algorithm.

Case 1: All students are from valid login with average and usual lighting conditions. All the images except one has be recognised correctly. A demonstration is depicted in fig 7.

Case 2: All students are present with valid login and all student avatar images is set to medium quality where student 1 is in back-light source. Majority images of student 2 and 3 has been recognised properly except student 1 where only 2 out 5 was recognised due to back-light source. A demonstration is depicted in fig 8.

Case 3: All students are present throughout the session, except student 3 who joined late. All are from valid login and student 1 avatar image/learning image set to lowest quality. Student 4 is made in a back-light source with the highest quality avatar image. As depicted in fig 9 student 1 image is hardly recognised since the learning image is of the lowest quality. All images of student 2 who joined late and majority of images of student 3 is correctly recognised. All images of student 4 who is behind a back-light source but has a high definition learning image is recognised correctly except one might be true case (blue). Also student 1 was not present in the class during one image capturing and algorithm could identify it correctly.

Case 4: Here all learning images (avatar image) were of highest quality. Student 1 was made to sit in low light condition, student 2 in good lighting condition and student 3 absent. This scenario was tested in order to analyse the efficiency of algorithm in determining and computing the facial encoding of a student in low light condition. As depicted in fig 10 all the images where recognised correctly.

Case 5: Here students 2 and 4 is absent. Student 1 is from valid login, student 3 and 5 are from cross login (Kevin Mathew is logged in as Kevin Vinod and Manu Tony is logged in as Milan Harindran ). Since students 3 and 5 are from different login their face recognition must fail. From the above result it is concluded that the algorithm successfully identifies the different faces and marks them accordingly. A demonstration is depicted in fig 11. True Positive (student 1-valid login): 100%, True Negative(students 3 and 5 - invalid login): 80%, Average True case: 90%

From the evaluation results depicted in fig 12, we can observe that students who have better learning image (Avatar image) will have higher true cases even in medium low light condition (Student 1 in fig 10) and even in a back light source they have a higher chance of recognition(Student 4 in fig 9). In fig 9 student 1, we can see that there is no valid case(Green) since student avatar image was set to the lowest quality. This signifies the importance of high quality learning images. Also it can be seen that student 1 (fig 9) is not present before camera in image no: 4 which is perfectly identified by algorithm and marked absent(red). Overall, considering all the cases the algorithm generated a success rate of 79.588%. Uploading a high-quality image for recognition can improve the recognition to 80%-85% success rate. Avoiding back light can improve the algorithm to 80%-85%. We can conclude that considering both cases of high-quality learning image and avoiding back-light that is sitting in good lighting condition can increase algorithm success rate above 85%. Fig 13 depicts the results of all the 5 cases in color coded bar graph.

| | |
|---|---|
| **Interface** | Calendar of Events, Messaging, One-to-One Call, Join Alert |
| **Huddle** | Direct White Board Access, Attendance Access, Photo Capture, other Teacher Specific Tools |
| **Attendance Management** | Real-Time Attendance, Face Attendance |
| **White Board** | Basic Tools, Wide Canvas |

Fig. 6. OneKube Results

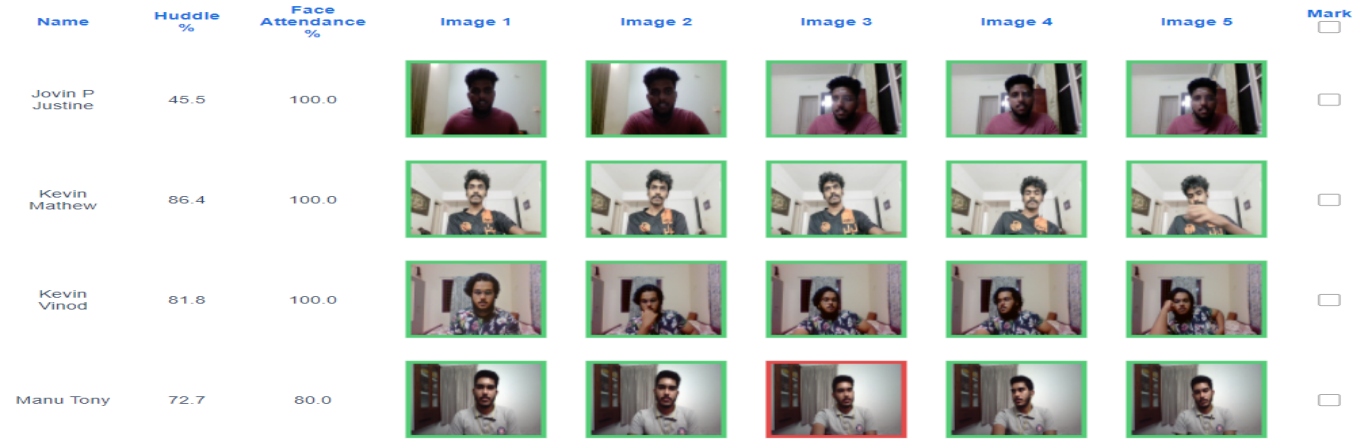


Fig. 7. Test Case 1

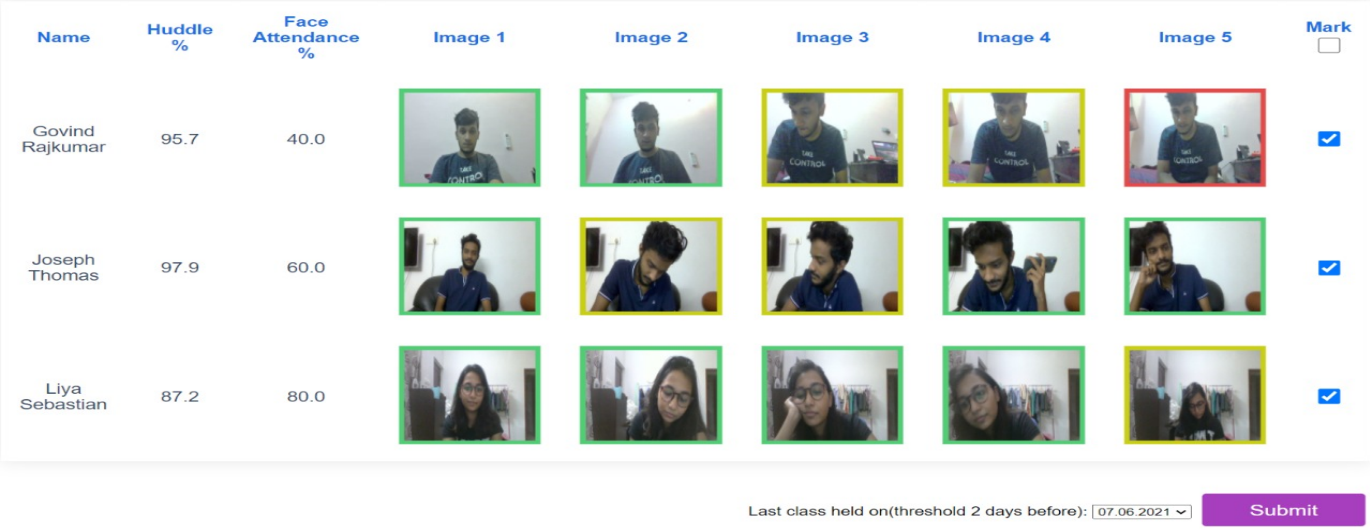


Fig. 8. Test Case 2

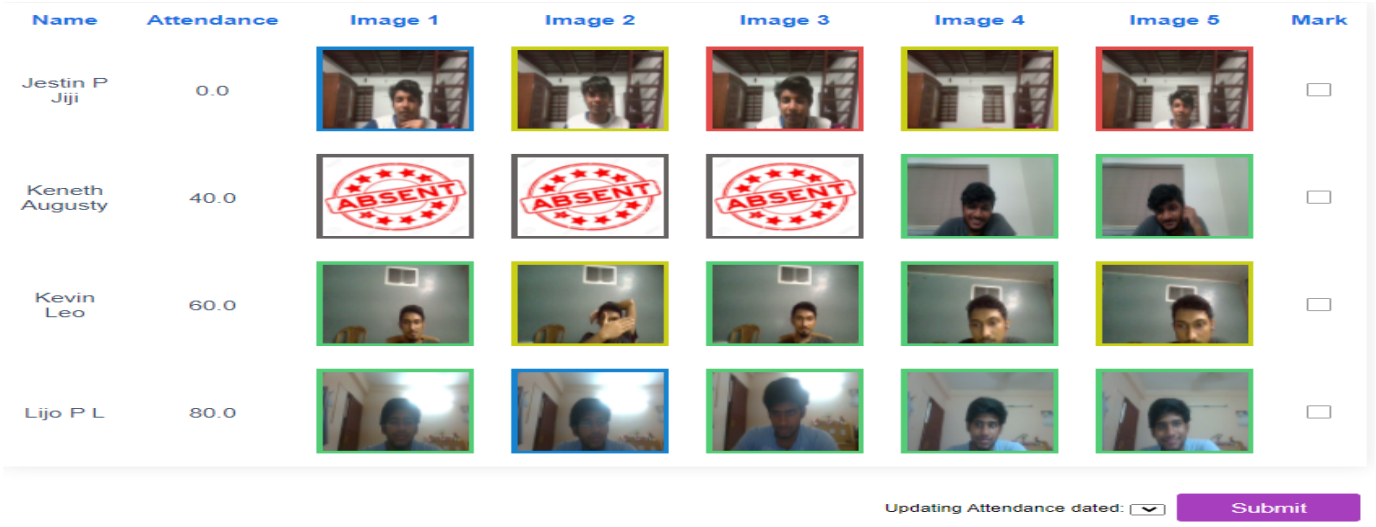


Fig. 9. Test Case 3

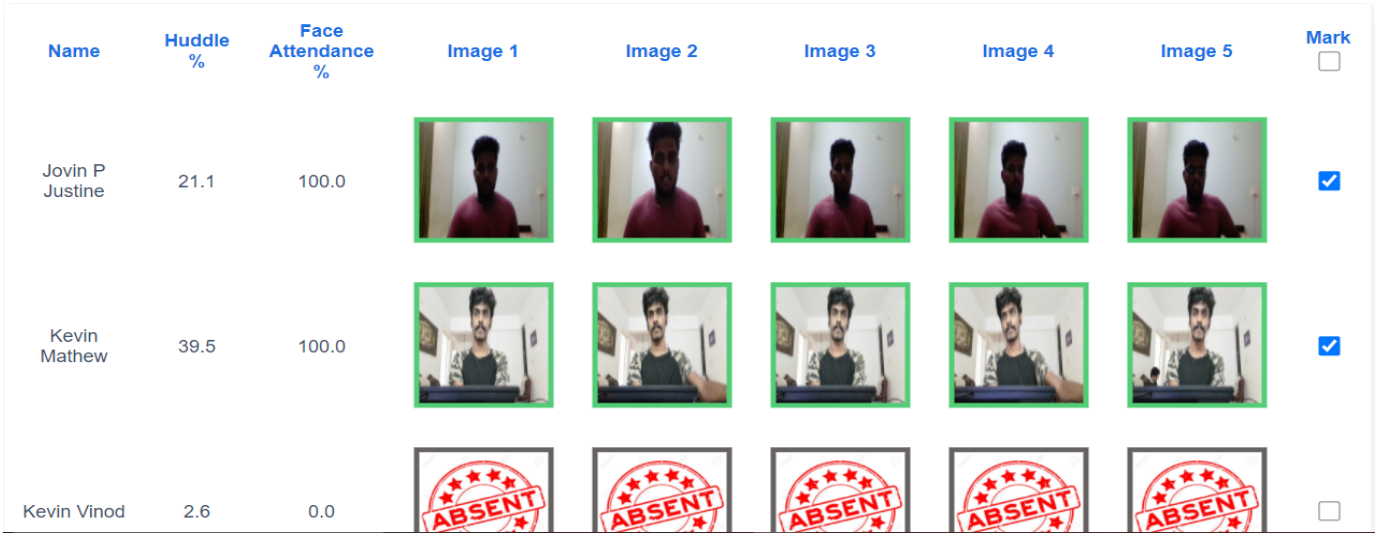


Fig. 10. Test Case 4


Fig. 11. Test Case 5

| | True | False | Unable To detect | Might Be True |
|---|---|---|---|---|
| Case 1 | 95 % | 5 % | 0 % | 0 % |
| Case 2 | 60 % | 6.66 % | 33.33 % | 0 % |
| Case 3 | 52.94 % | 11.76 % | 23.52 % | 11.76 % |
| Case 4 | 100 % | 0 % | 0 % | 0 % |
| Case 5 | 86.66 % | 0 % | 13.33 % | 0 % |

Fig. 12. Face Evaluation Result

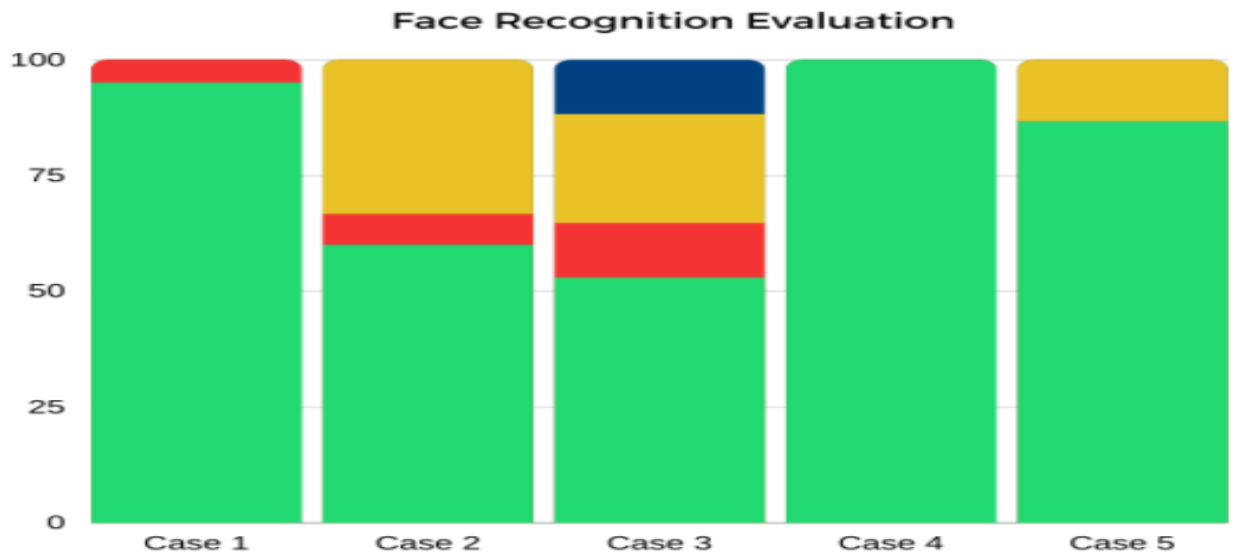


Fig. 13. Case Study Graph

## VI. Comparison with Similar Applications

Here the comparison is with google classroom, microsoft teams, zoom and cisco webex and Fig 13 depicts the same.

Considering video call, Huddle supports all the video conference requirements like all the other platforms with an additional integration with real time attendance and face attendance making it much more reliable in terms of attendance management. An option to render YouTube video directly without the use of screen share option is always an advantage. The teacher also has the option to send a notification to every student notifying them that the class has begun.

OneKube has a custom designed educational interface with user friendly and easy to understand commands on both teacher and student side. All the features like assignments, quiz, study materials, doubt session, view attendance and manage attendance, calendar, announcements, personal and shared storage, messaging and join/host class all these features are clearly classified based on individual subjects and is presented to teacher and student for easy and faster navigation. Cisco and zoom are a general conference platform and hence lacks many educational features.

The whiteboard provides the basic set of tools for drawing, erasing etc. It also provides an extra feature where you may save the contents that are currently on the whiteboard, and load it up at another time. Image insertion option is also available. Shortcut keys are also available for each tool. Whiteboard is directly connected to each subject/teachers class thereby making it easier for both teachers and student to access it. OneKube doesn't use any links both for video conference and whiteboard like google classroom. This make things much more easier.

| | Video Call | Interactive Interface | Whiteboard Feature | Real Time Attendance | Attendance Management | Anti - Cheat Quiz |
|---|---|---|---|---|---|---|
| OneKube | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Google Classroom | ✓ | ✓ | ✓ | ✗ | ✗ | ✗ |
| Microsoft Teams | ✓ | ✗ | ✓ | ✗ | ✗ | ✓ |
| Zoom | ✓ | ✗ | ✓ | ✗ | ✗ | ✗ |
| Cisco Webex | ✓ | ✗ | ✓ | ✗ | ✗ | ✗ |

Fig. 14. Comparison to other platforms

A numerical depiction of how much percentage of the period the student has been present in the video call and the results of the face attendance algorithm are given to the teacher with average attendance percentage. Images of each student are shown with proper color coded borders. Hence onekube ensures proper attendance evaluation of each classes held. Even after the evaluation the records are saved and OneKube provided an attendance management portal for viewing attendance and editing them.

A quiz(Anti-cheat) feature is embedded in the user interface which takes the student attending the quiz into full screen mode so that they may not browse between any other windows. A timer is also set for each question giving a limited time for students to think and answer each question. If one tries to exit the quiz before completion, the quiz immediately shuts off and the last result is updated till the last completed question.

## VII. Conclusion and Future Scope

As the situation of Corona Virus is getting worse day by day, it would take a very long period for the world to be restored back to normalcy. Instead of focusing on the negatives, people should adapt to the changes that are being introduced. This application is one step towards adapting to the change. The features that are offered with the application excellently caters to the needs of both teachers and students. And would help in introducing an interesting approach to the concept of online classrooms.

Huddle: Video calling and whiteboard was developed by extending and modifying two open source projects. These stand-alone open source project worked on a link-sharing basis, were integrated into onekube website and face recognition unit. On implementing this work as an open source project, the capabilities can be extended. This integrated works setup procedure and source-code will be available on GitHub soon. Anyone can download and run them on their servers.

The number of users that can access this software can be scaled based on the server's capability. The principle by which the system works is same for any number of users. Here media server(video calling server) requires the most computational power. However this project doesn't require massive server specifications for scaling if public media server provided by jitsi(free) is used apart from hosting the media server in private server. Regarding restriction of number of users and time duration, if jitsi public media server is used it has a hard limit of 75 users per room currently and there is no time duration limit. Whereas if jitsi media sever is hosted in private server, number of users can be increased by adding jitsi video bridge servers. The scalability of this project purely depends on server capabilities.

Future Scope includes but is not limited to: A minimal android app of the Web Application, with important features. An improved version of quiz: subjective exams (provision to write and upload answers). An improved face attendance algorithm that increases the efficiency of identifying faces in high exposure photos, by editing the photo using python and evaluating it. An automated attendance system for taking photos, evaluating it and marking attendance all by its own. Automated note creation by using speech to text synthesis.

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