WebBoard: An interactive tutoring system

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Abstract -

This project is to meet the necessary requirements of online lectures and to make it easier for the instructors and the students to communicate more effectively and interactively, especially for remote students. WebBoard is an integrated tutoring application. During the presentation, the instructor can write on the application interface called WebBoard, the content of which is replicated to all the students in their WebBoards. It comes with a Question & Answer feature which allows students to ask questions in a manner that can be accessed by students participating in the class. The instructor can easily switch among the slides, video and the WebBoard. While elaborating on the concepts, the instructor can annotate the content of slides, without modifying them which makes it easier for students to understand the concepts. The lectures are recorded in the class rooms and are available to all the students later on the cloud.

Keywords — webRTC , Vlab, Node.js, Video conferencing, Screen sharing, WebBoard, tutoring, VP8.

INTRODUCTION

a. **Problem:** Rigid Nature of the hybrid classes and online lectures, current hybrid/online classes and challenges faced by students/instructors.

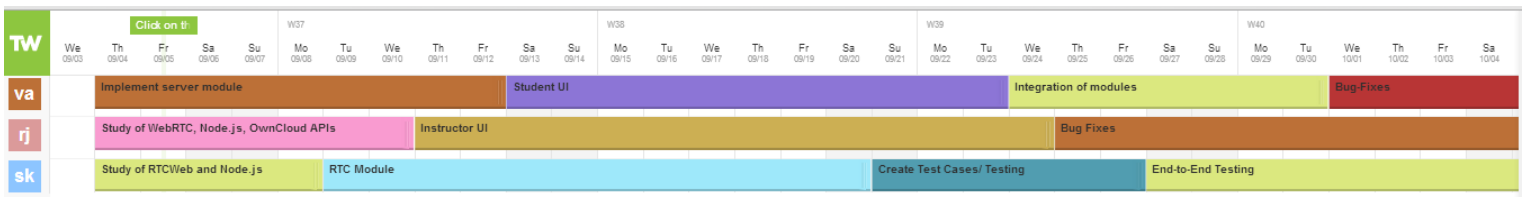
b. **Why it is important:** It gives a single system which allows the students to communicate with the instructors and other students. The lectures will be more interactive as the professor can ask some questions to the students who are remotely accessing the lectures to answer or vice-versa. The videos of the lectures would be stored on cloud so that it is easily accessible to students to recollect concepts taught in the class room. Moreover they get a classroom feel while watching the video streaming. Instructor can use the Web Board functionality to annotate on some concepts which they might do on a White board in classrooms so that even her explanatory notes can be available to all the users after the class on the cloud.

Technologies used: Cloud, WebRTC API, Node.js, JavaScript, CSS, HTML.

c. Expected outcomes of this projects:

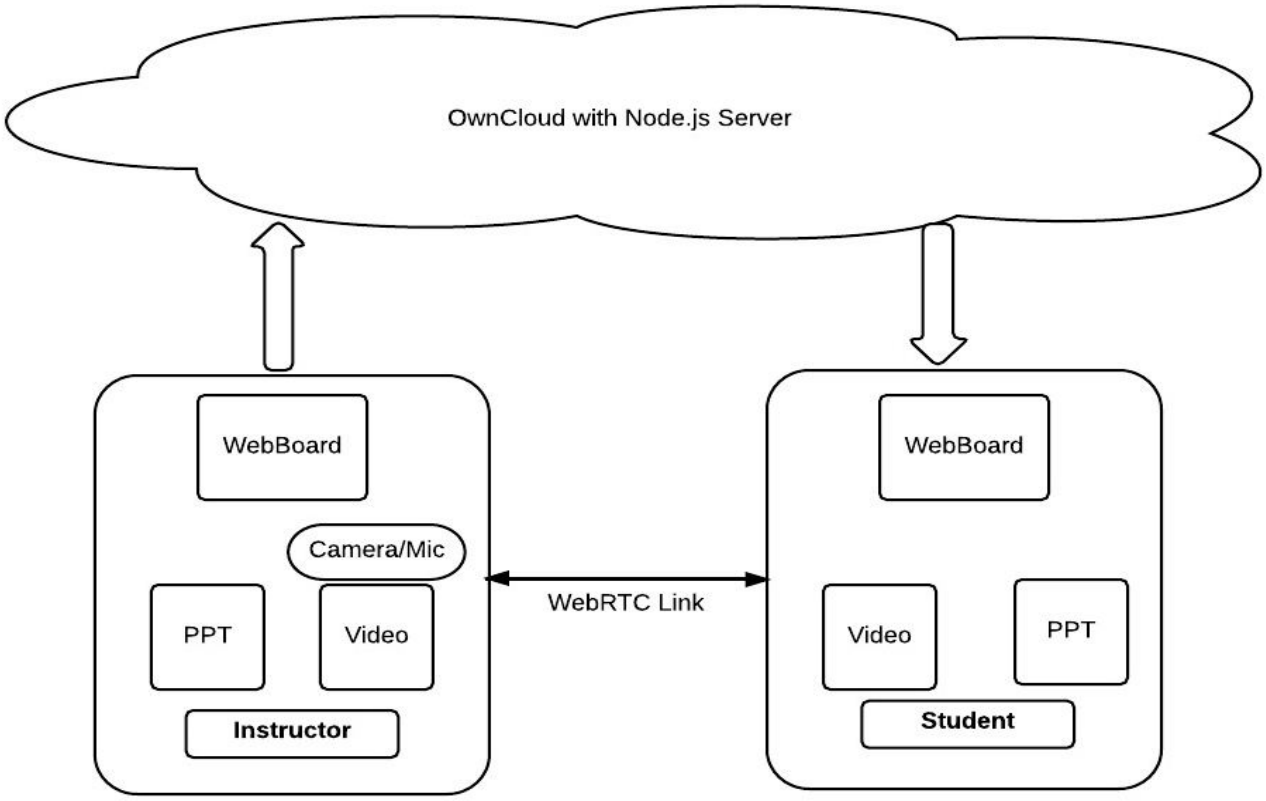
1) Software would have the following main features -
   a) Video recording and storing in cloud
   b) WebBoard (Similar to White Board) for instructors
   c) Paper Presentation (PPT) sharing tool
2) On instructor side: She can start the session. Session can be started on Tablet using web or Android browser. She can upload **PPT** or PDF file. This **PPT** or PDF is internally converted into images. She can draw on the image and undo them. She can also switch to White Board Mode where she can draw diagrams or write notes. She can view all the students who are joining the sessions.
3) On Student Side: They can join the session initiated by the instructor. Though the direct support of annotating on WebBoard by students is not allowed in our UI implementation, we have exposed the APIs to enable this feature .Students can view the live streaming of the lectures with one-to-many broadcasts from the instructor.
4) Instructor can share the VM (Vlab) screen with students for live coding sessions.

d. Project management plan (Timeline, and group members, etc.)

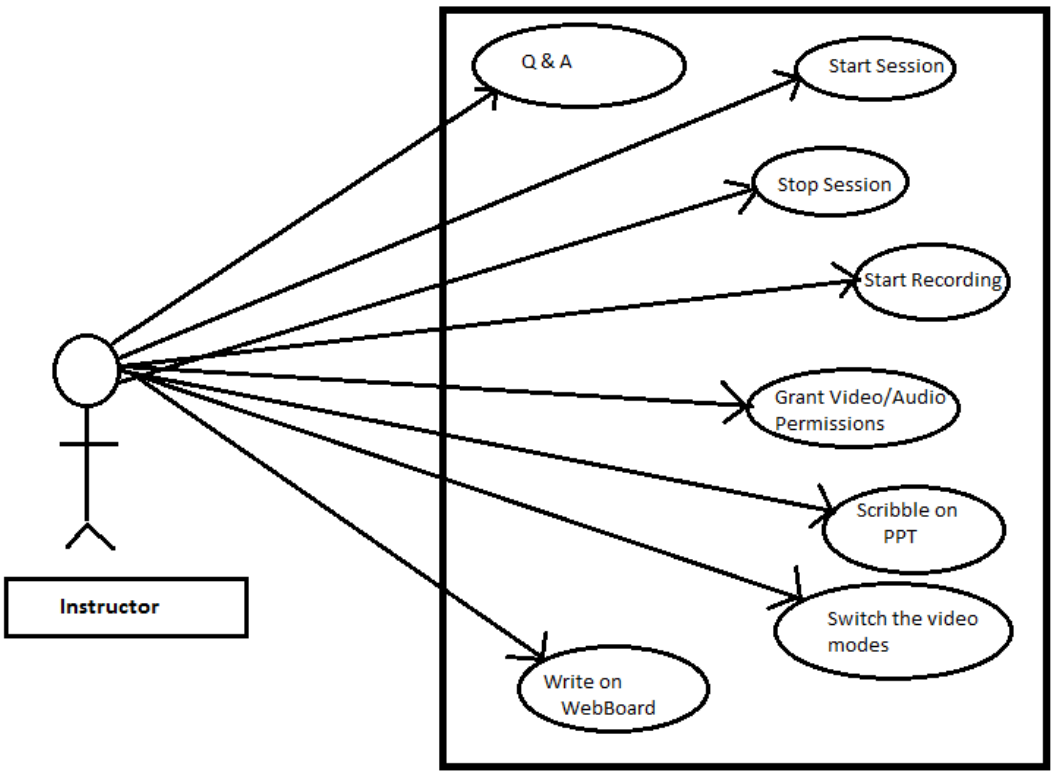


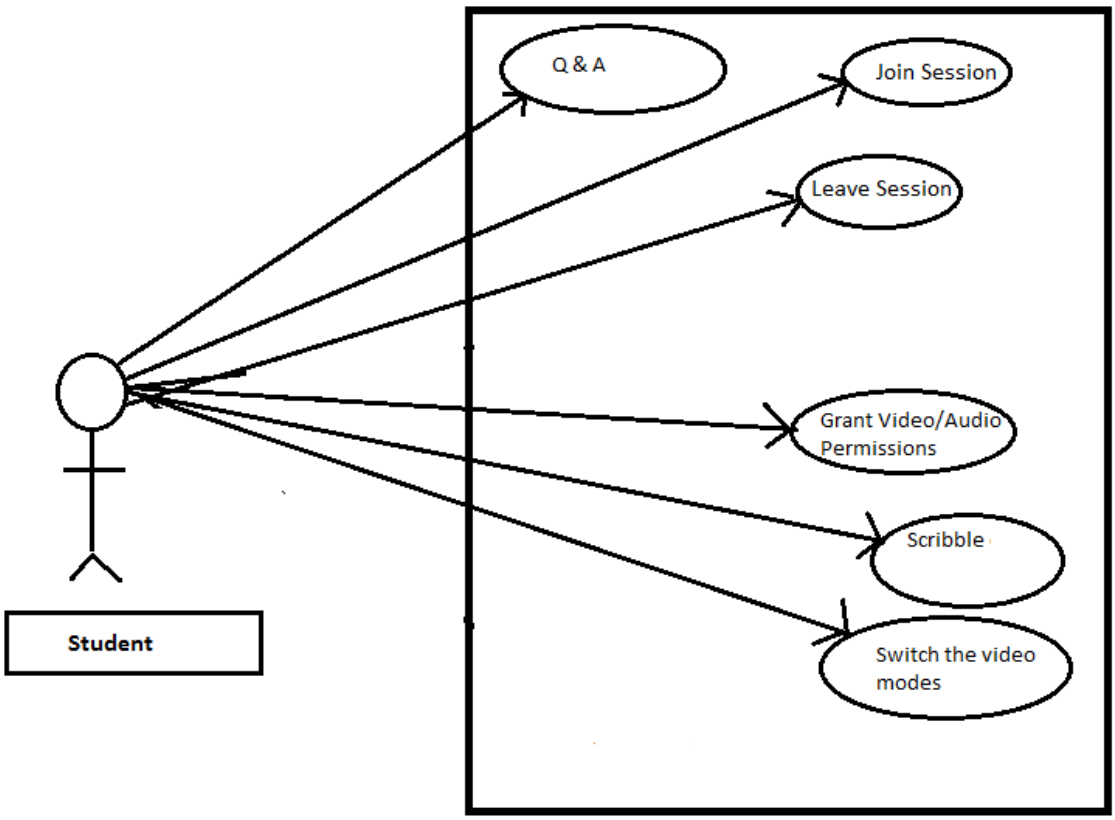
SYSTEM MODELS

a) System Model



WebBoard: Block Diagram


Q & A
Start Session
Stop Session
Start Recording
Grant Video/Audio Permissions
Scribble on PPT
Switch the video modes
Write on WebBoard
Instructor


Q & A
Join Session
Leave Session
Grant Video/Audio Permissions
Scribble
Switch the video modes
Student

b) Software

Tools: Sublime Text, Emacs, Git

APIs: WebRTC API, Node.js, Vlab, Heroku

Language: JavaScript, HTML & CSS.

PROJECT DESCRIPTION

a) Project Overview

a. Task 1: Study WebRTC, Vlab and Node.js - We shall research on the above topics and start with implementing some of them.
b. Task 2: Implement server module - We shall install Node.js server on localhost with some server side business logic.
c. Task 3: RTC Module - Implement WebRTC module.
d. Task 4: Instructor GUI: Implement Instructor Graphical user interface by using web languages.
e. Task 5: Student GUI: Implement Student Graphical user interface by using web languages.
f. New Task: Added a feature that enables the instructor to share her Virtual machine sharing.
g. New Task: Added user session management.
h. New Task: Allowing only PDF files for uploading.
i. Task 6: Create Test Cases.[completed after midterm review]
j. Task 7: Integration of modules.[completed after midterm review]
k. Task 8: Test the application.[completed after midterm review]
l. Task 9: Fixing Bugs.[completed after midterm review]

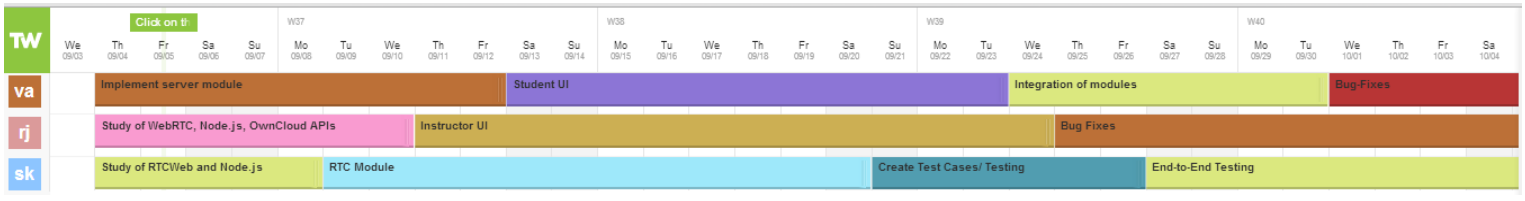
b) Project Task Allocation

Name/Task	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Task 9
Ravinsingh Jain	Co-owner	Co-owner	Co-owner	Owner	Co-owner	Co-owner	Co-owner	Co-owner	Owner
Ashwin Vasani	Co-owner	Owner	Co-owner	Co-owner	Owner	Co-owner	Owner	Co-owner	Co-owner
Sagar Kalburgi	Owner	Co-owner	Owner	Co-owner	Co-owner	owner	Co-owner	Owner	Co-owner

c) Deliverables

It is a web application which enables the instructor to use WebBoard in order to give lucid presentations. The instructor can seamlessly switch among the presentation slides, explanatory notes and video. The students, especially those who use remote access, would benefit greatly since they can ask real time questions using the WebBoard. Additionally, application can be extended to add a feature where student can also take separate personal notes and store them in cloud. She may also share her notes with her classmates, leading to healthy exchange of ideas.

d) Project Timeline



RISK MANAGEMENT OF THE PROJECT

Risk Factor	Description	Workaround
Bandwidth	Requires high bandwidth	Can optimize the camera resolution accordingly.
Security	Network security for the streaming	Private secure stream can be deployed.
WebRTC for native application	It is under development	AppRTC and JNI can be used at some level

INVESTIGATIONS/RESEARCH:

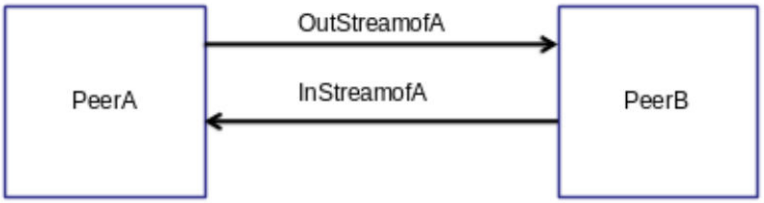
Technologies that were studied for project requirements:

WebRTC APIs for video and audio, ICE, STUN &TURN servers for remote stream management, Node.js for hosting server, Communication architectures: one-to-one, one-to-many, many-to-many and broadcast, Bootstrap for User Interface design and MongoDB for the database of valid user credentials.

Following research was done for WebRTC based video sharing between multiple peers:

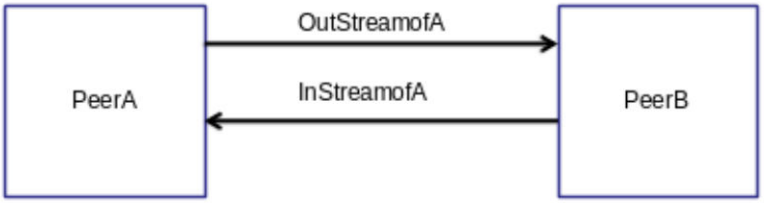
During the investigation, we found some potential challenges for our use-case using WebRTC. Presently, WebRTC creates two streams for audio/video for each peer (Please ref. the diagram below). This model is feasible only if there are two users.

One-to-One



1- input stream and 1- output stream
for each peer

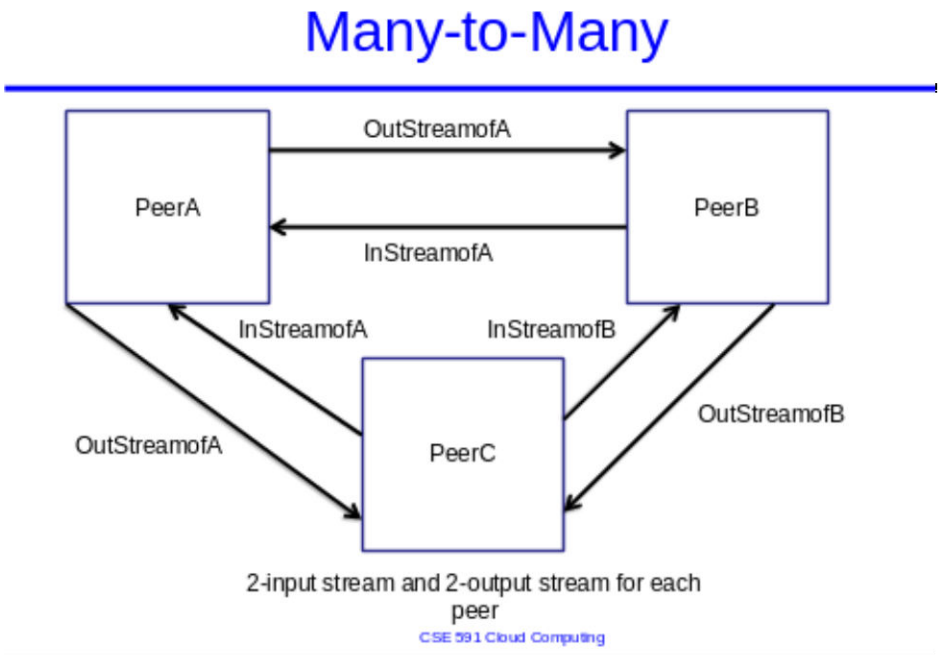
One-to-One

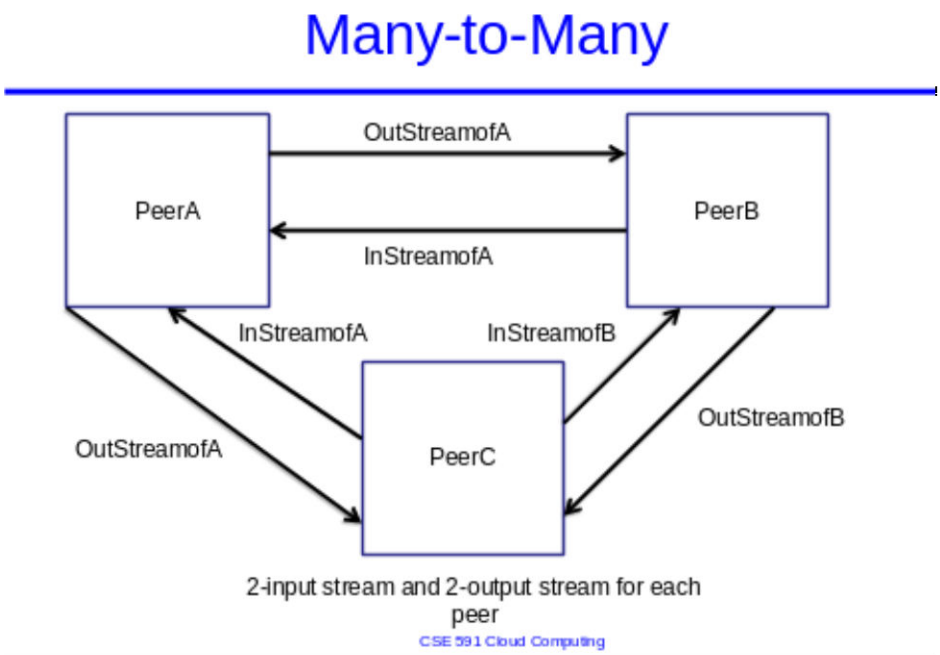


1- input stream and 1- output stream
for each peer

CSE 591 Cloud Computing

In many-to-many approach (Please ref. the diagram below), a complex mesh is created amongst the peers which causes a very heavy network and CPU usage. This model is not feasible in our case since we are targeting that the user might be having a handheld device like smart-phone or tablet. Such devices don't have enough power to handle such a heavy requirement.

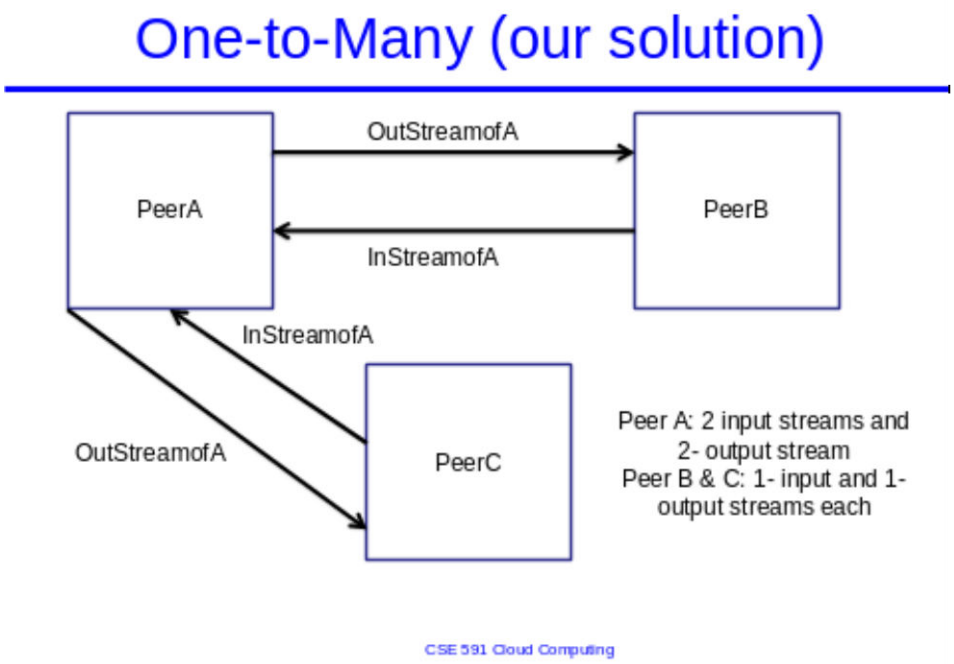


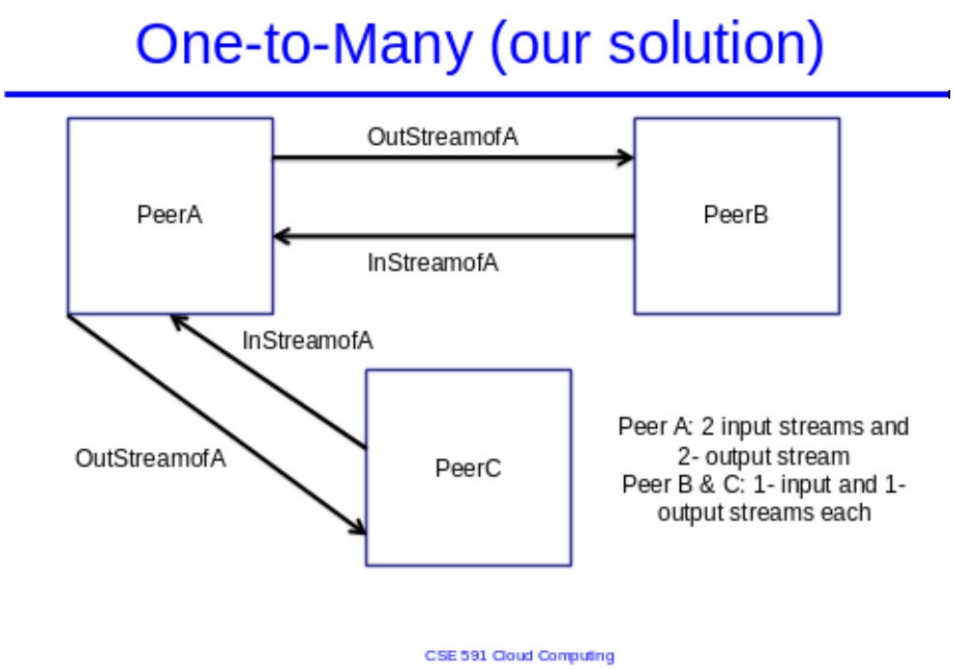


To overcome the above challenges, we tried implementing our own design. We have hacked the camera stream which we got from the WebRTC getUserMedia call and reduced the quality of the video frames. Later we sent this video frame to a node.js server using socket.io and client renders from node.js to canvas using WebRTC standard APIs. Here server also adds many headers to the packets and fragmentation of packets on network causes a bad and unacceptable performance. Hence we switched to one-to-many approach.

In one-to-many approach (Please ref. the diagram below), the total number of streams created by the instructor will be equal to twice the number of users, and only two streams will be created at the student end. This means that the instructor module should be running on the device with maximum resources but this does not apply to the students.

The maximum bandwidth of each A/V RTP stream is 1MBPS and for each peer it requires 2MB bandwidth. For future enhancements in WebRTC, we envisaged that adding WebRTC support on the server platform like node.js would prove beneficial for many-to-many and one-to-many use-cases. In this case, the server will act as a multiplexer and all the peers would connect to the server. Instead of having multiple A/V streams for all peers, sharing single video stream to multiple users can also be one of the solutions to this problem.





IMPLEMENTATION DETAILS:

- Bootstrap was used for interactive UI design.
- Heroku cloud is an application platform known for its adaptability.
- Login credentials would be stored in MongoDB which is a highly scalable database.
- Presently we are uploading PDFs, converting into images to display them in canvas as a slideshow.
- Used meeting.js for one-to-many WebRTC implementation and firebase.js was used for WebRTC signaling.
- Using HTML5 canvas and sections for encapsulating videos elements.
- Currently we are using only single classroom but it can be scaled to multiple classrooms. Also, it is supporting event based dynamic stream addition and removal.

PROGRESS AFTER THE MIDTERM REPORT:

- **User Registration completed:** A user can register with the WebBoard either as an instructor or as student. User's details shall be stored in a Mongo Database. We used mongodb module from node.js to connect to the database.
- **Password security:** are hashed before they are stored in the database for security purposes. We used password-hash module from node.js for this purpose.
- **User authentication completed:** Username and password validation has been fully implemented. A user cannot access instructor home page or student home page directly, without passing authentication.
- **Start/Stop of video session:** Instructor can start or stop the video session anytime.
- **Session management:** Sessions are maintained for users, so that if they open a new tab while they are logged in, they are automatically redirected to home page. We have used express-session and cookie-parser modules for this purpose.
- **Restricted to PDF files:** We have restricted the instructors to upload PDF files only. Any attempt to upload a file of a different format would result in the user being asked to choose a PDF file.
- **Handling special characters in upload PDF:** Earlier the system was crashing, now we are supporting this feature.
- **White Board:** We implemented a feature to add a virtual whiteboard between any pair of slides. The instructor can use it to make notes, describe diagrams etc. This content is visible to all the students on the go.
- **Virtual Machine:** Instructor can share her virtual machine screen with all the students. This helps in live coding demonstrations, especially across different Operating system platforms with minimum efforts. It in turn facilitates in-depth understanding of concepts for students.

  However, due to the constraints in the present Vlab system, we are manually entering the URL of the iFrame.
- **WebBoard PPT management: '**Next' and 'Previous' buttons function properly while navigating among the slides.

TEST CASES:

Test Case Type	Test Case Detail	Success/Failure	Comments
User registration	Instructor able to register	Success	
	Student able to register	Success	
	Denying duplicate user registration	NA	Currently we are allowing
	User able to login immediately after registration	Failure	Need to rerun index.js after the user registers, in order for her to login.

	Email format check	Success	
	Password format check	Success	
	Password hashing	Success	
Authentication & Login	Basic login for Instructor	Success	
	Basic login for Student	Success	
	Welcome message for Instructor, with name	Success	
	Welcome message for Students, with name	Success	
	Check for Invalid User name/Password	Success	
	Blocking unauthorized access to the instructor and student pages	Success	
	Logout	Success	
	Logout confirmation message	Success	
Video, Audio Streaming	Instructor's video streaming on student page	Success	
& Storage	Getting only one video stream of instructor himself on instructor page	Success	
	Streaming video streams of all students who are logged in	Success	
	Video session start/stop working	Success	
	Student able to reconnect after network failure	Success	
	Instructor's session recovery after network failure	Success	
	Noise in the audio	Success	Local echo as expected.
	Maximum number of students who can connect	Success	10
	Instructor's ease of seeing all students who care connected	Success	
	Audio streaming	Success	
	Ability to watch the stored class lectures.	Success	
	Redundant streaming from STUN server	Success	
PDF file Upload	Uploading PDF file	Success	
	Check other file formats	Success	
	Check the file name with special characters	Success	
	Server Packages installation	Success	
	Wait symbol while uploading the file	Success	

	Showing image on canvas after uploading	Success	
	Clarity of uploaded image	Success	
	Image folder created beforehand	Success	
	Ability to upload PDF file even if some other previously converted file is already present	Success	
	Only one video stream opens when I upload second file just after the first file.	Success	
Annotation	Instructor annotates slides	Success	
	Students can see the instructor's annotation.	Success	
	Working of previous button	Success	
	Working of next button	Success	
	Clicking Next button when there are no more slides	Success	
	Clicking Previous button makes no changes when first slide is being displayed	Success	
	Touch pad working	Success	
	Mouse cursor working	Success	
	Works on mobile phone/tablet	Success	
White board	White board functionality	Success	
	All students can see what instructor has written on her White board	Success	
	Storage of Instructor's White Board notes	Success	
	Accessibility of stored white board notes by students and instructors	Success	
VM implementation	Instructor is able to share the Virtual machine	Success	

DEMO SNAPSHOTS(LATEST):

Figure 1: Instructor Screen

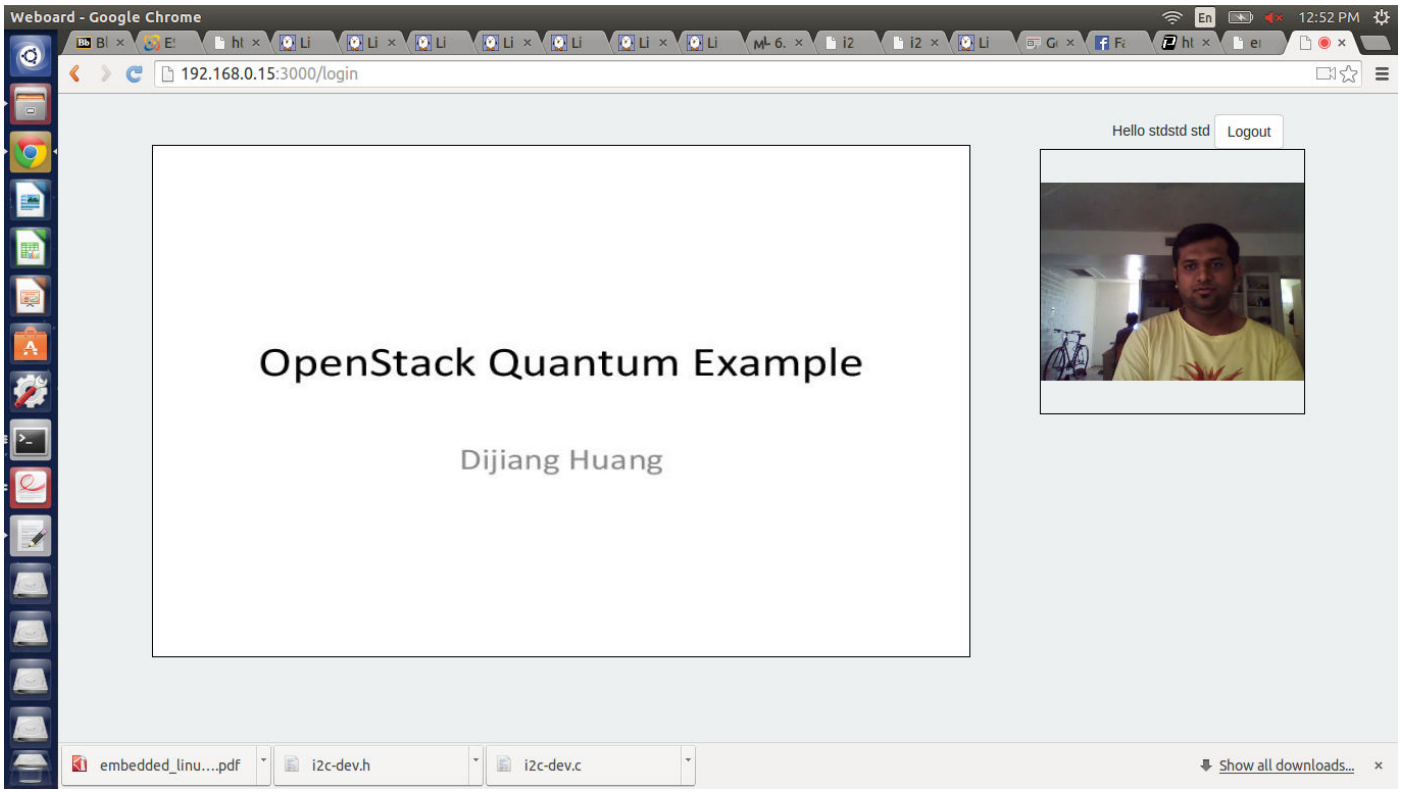


Figure 2: Interactive Class

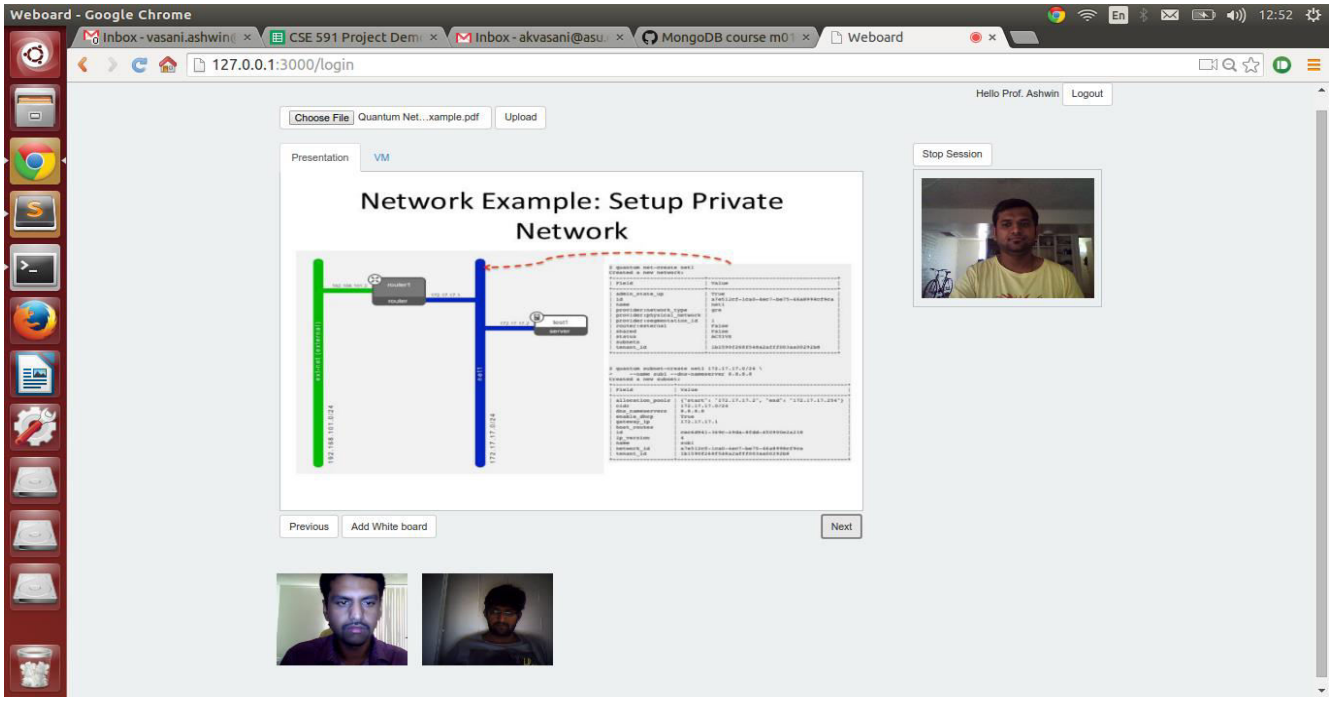


Figure 3: White board on instructor side

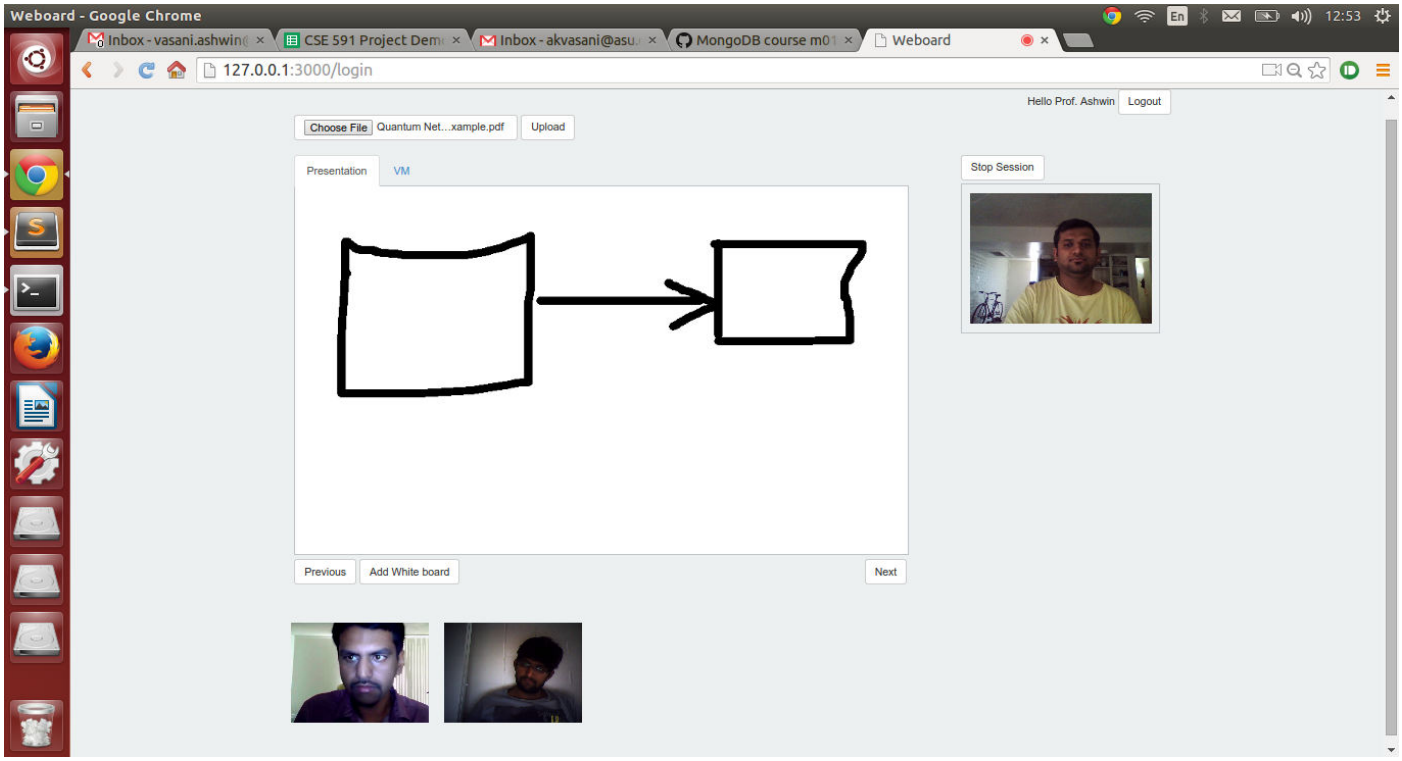


Figure 4: White board on student's side

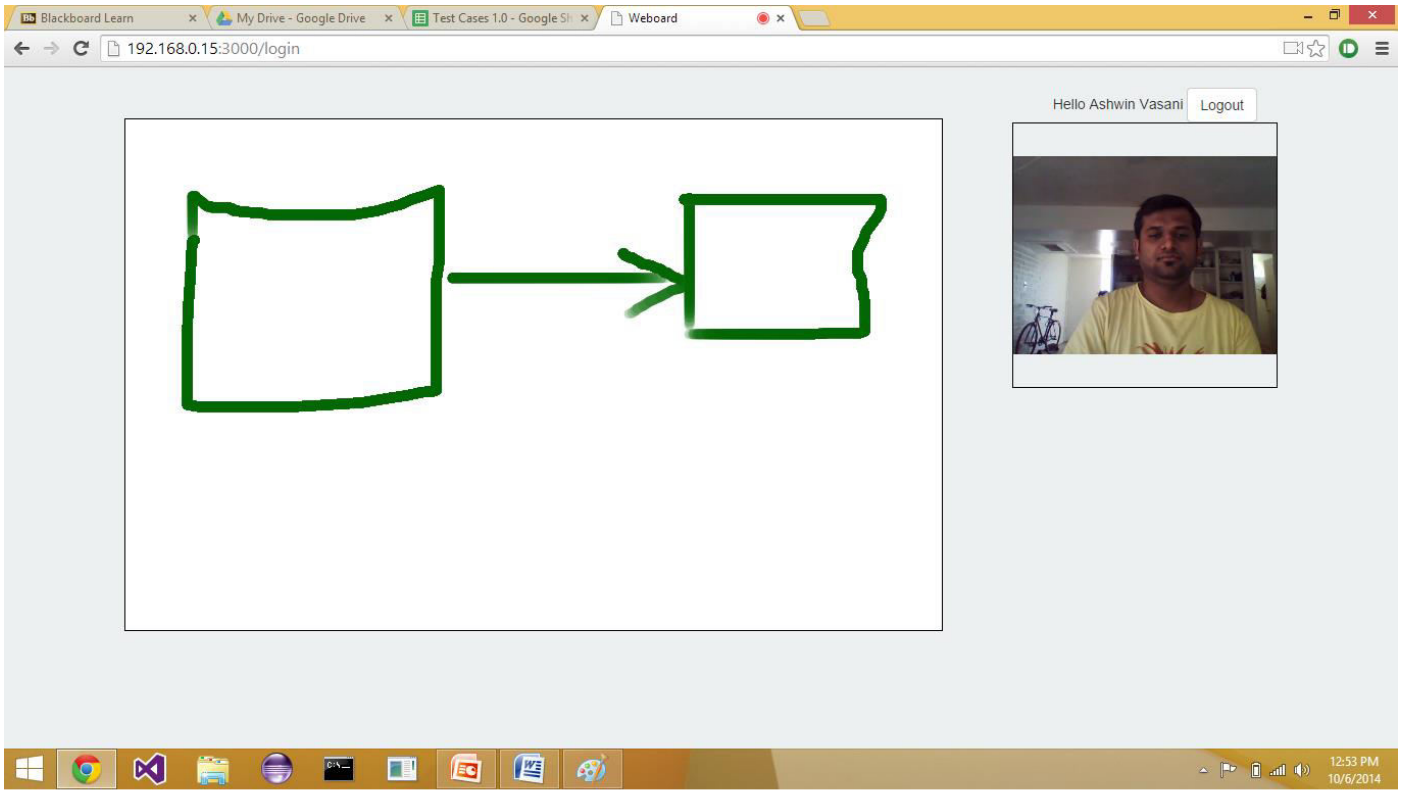


Figure 5: Virtual machine on instructor's side

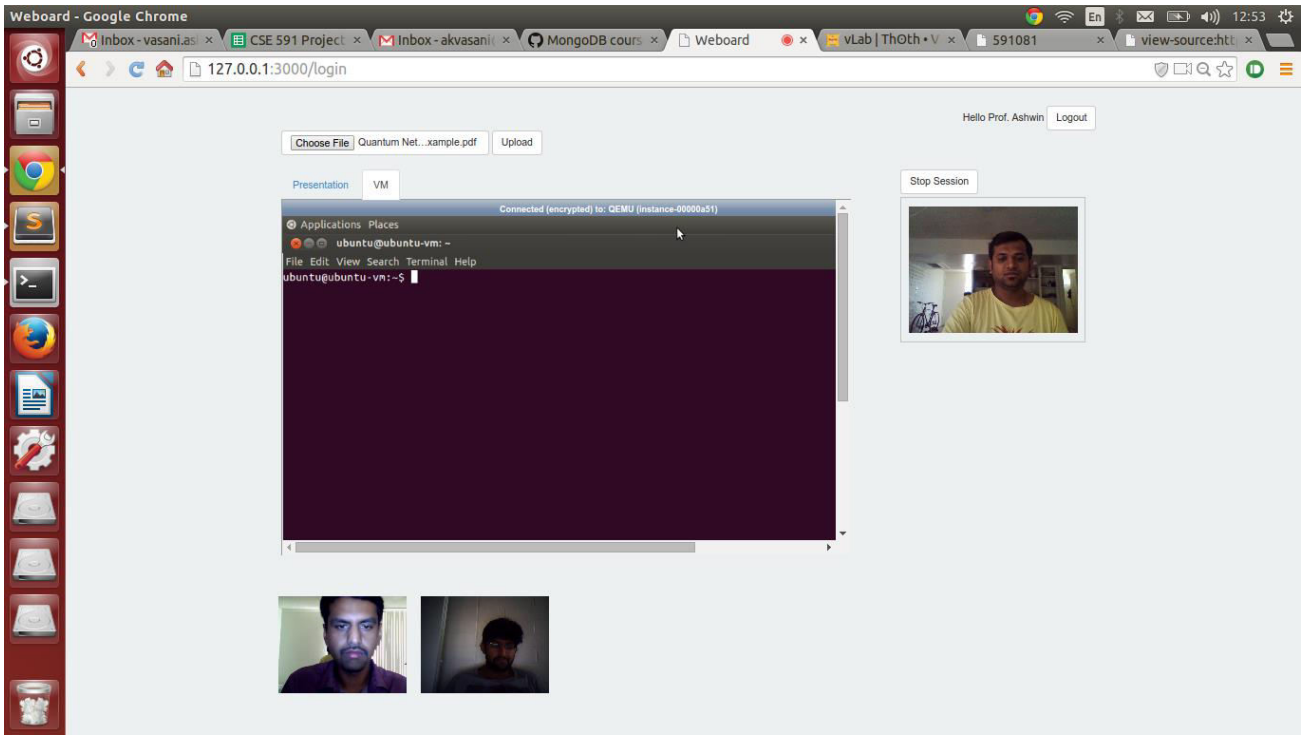


Figure 6: Instructor's Virtual Machine on student's side

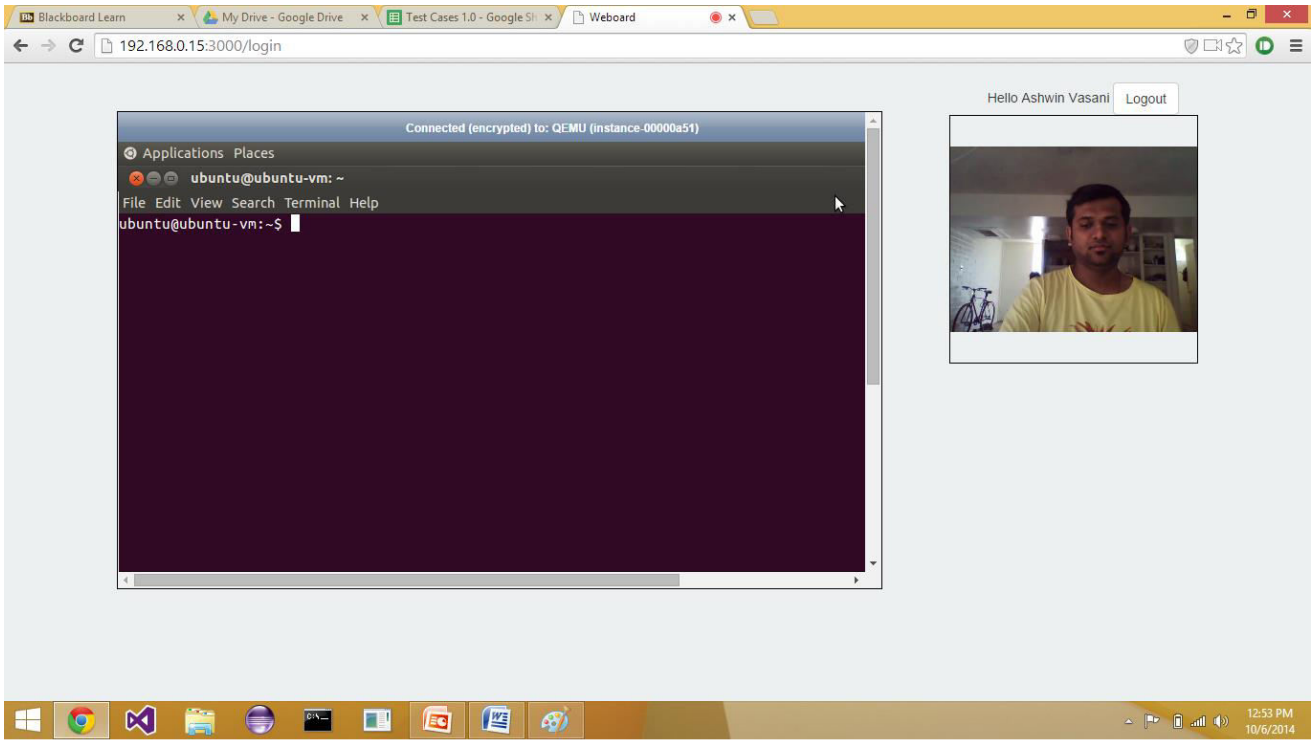
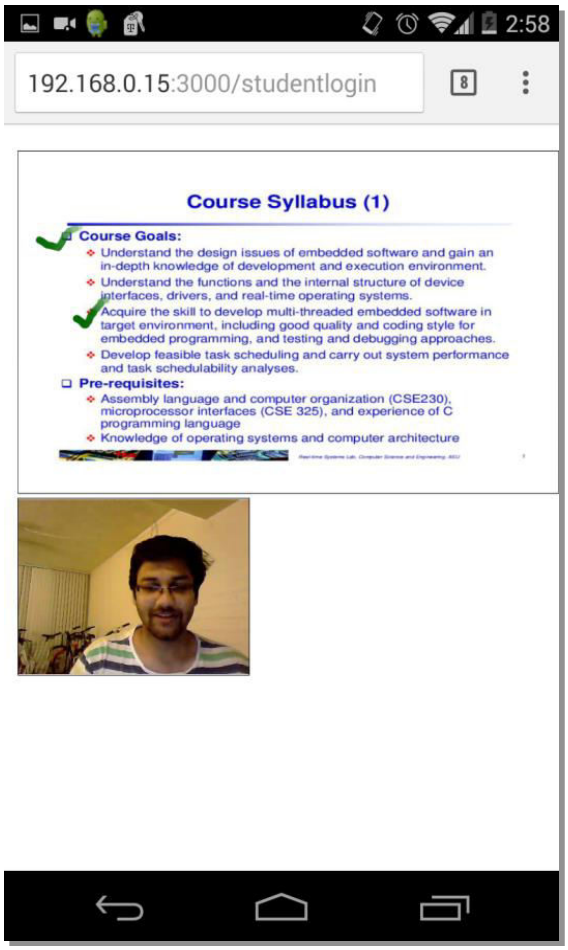


Figure 7:Application demo on Android Chrome Brower



CONCLUSION

Considering the limitations of the current online learning technologies, our WebBoard system aims to better the classroom experience, thus ensuring that the students and the instructors are on the same page, especially for remote students.

Future prospects:

- A Student may use a real time language translator in case she doesn't know the medium of instruction.
- Hearing impaired students can be provided with subtitles.
- The application can be integrated with native applications
- Many to many interaction can be provided.
- Desktop sharing on cloud using WebRTC .

ACKNOWLEDGMENT

We are grateful to Prof. Dijiang Huang, Huijun Wu and Bing Li who guided and motivated us to take up this project.

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