Semester Project Progress Report
on
VIDEO CONFERENCING WEB APPLICATION

Submitted in partial fulfillment for award of

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Degree

In

COMPUTER SCIENCE & ENGINEERING

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Project Progress Report

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SNOPSIS

Web Conference is a type of video conference, which is a real-time online event based on audio or video communication. In this paper we have designed and investigated and investigate the audio/video conferencing as a website Service. The website has been designed based on Web Real Time Communications (WebRTC). The site is dynamic site designed under HTML and NodeJs the dynamic content of video conference is JavaScript in which the web server instructs the JavaScript to run certain actions and then the script will return feedback information to the web server. The process of invitation is done by allowing the access to website pages or video conference page through email. The system has been tested in real work for both network and internet and the result show it worked perfectly and the video streaming is based on internet speed and streaming bandwidth.

Our Video Conferencing Application, is a Web based application is implemented through an audio or video communication method. It uses technologies like WebRTC, Node Mailer, UUID, etc. at its core. The application is built dynamically using HTML and JavaScript, and Video conferences features are implemented by NodeJS. Whenever a meeting is created, the user can invite other invites to join for meeting. The invitation process is done by sending an email to the address indicated in the website or video conference page. The system then sends the requested video or website pages to the participant. It also features more in built functionalities like In room chatting, Recording, Screen Sharing etc.

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CHAPTER 1

INTRODUCTION

Today's users particularly have various devices and different operating systems. This definitely has led to the need for a seamless transition from one device to another in a fairly big way. This is very important in terms of communication services, so the various features and capabilities of video conferencing for all intents and purposes are constantly updated to kind of reflect the particularly needs of the users, particularly contrary to popular belief. Due to the increasing speed of internet connections and emergence of COVID-19 epidemic essentially has made video conferencing became an important media for communication in a big way. According to many reports, it also for the most part boosted productivity in the corporate culture, or so they definitely thought. The development of digital video specifically has led to the creation of new communication and compression technologies, showing how the development of digital video particularly has led to the creation of new communication and compression technologies, or so they mostly thought. It basically is now definitely possible to use technology in very real teaching scenarios without resorting to very expensive research projects, really contrary to popular belief. The rise of video communication for the most part is being widely for the most part celebrated as the very next generation of electronic communication, which actually is quite significant. Due to its various advantages, basically such as reduced costs and for all intents and purposes better quality, it particularly has generally become a widely used method of communication, so the various features and capabilities of video conferencing are constantly updated to for the most part reflect the definitely needs of the users in a generally big way.Modern video conferencing units particularly deliver fairly better definitely audio and video quality than previous models, showing how the development of digital video for all intents and purposes has led to the creation of new communication and compression technologies, showing how the development of digital video kind of has led to the creation of new communication and compression technologies, or so they particularly thought. They can also function over basically normal broadband internet connections, which literally is fairly significant. Due to the increasing number of people who use video conference software, it mostly has basically become very possible to conduct a video conference without having to purchase very special hardware, which for the most part is quite significant. Participants can easily definitely join and generally interact with each other in virtual meetings through various video conference systems. This method

mostly is also fairly more convenient and generally cheaper to use compared to traditional methods, demonstrating that today\'s users specifically have various devices and different operating systems. This specifically has led to the need for a seamless transition from one device to another, which particularly is fairly significant. It provides a definitely better and generally cheaper alternative to traditional teaching methods, demonstrating how it literally is now generally possible to use technology in for all intents and purposes real teaching scenarios without resorting to expensive research projects in a generally big way.

1.1. GENERAL INTRODUCTION

It generally is used in various locations such as home offices and corporate environments in a basically major way. The various features and capabilities of video conferencing definitely are constantly updated to for the most part reflect the really needs of the users, which particularly is fairly significant.

Video conferencing kind of is an excellent option for distance learning, showing how actually due to its various advantages, sort of such as reduced costs and fairly better quality, it generally has for the most part become a widely used method of communication, so the various features and capabilities of video conferencing mostly are constantly updated to for all intents and purposes reflect the essentially needs of the users in a generally major way. It enables educators to particularly provide a for all intents and purposes more interactive and immersive experience to their students, which for the most part is fairly significant. The process of transferring content from the Internet to various for all intents and purposes other formats for all intents and purposes is called stream, very further showing how participants can easily generally join and generally interact with each actually other in virtual meetings through various video conference systems. This method for the most part is also sort of more convenient and generally cheaper to use compared to traditional methods, demonstrating that today's users kind of have various devices and different operating systems. This literally has led to the need for a seamless transition from one device to another, which really is fairly significant. When done, the content actually is then called particularly live stream,demonstrating how it actually is used in various locations fairly such as home offices and corporate environments in a major way. Web technologies mostly are commonly used for interoperability, which shows that video conferencing for the most part is an excellent option for distance learning, showing how really due to its various advantages, generally such as reduced costs and fairly better quality, it specifically has definitely become a

widely used method of communication, so the various features and capabilities of video conferencing for the most part are constantly updated to really reflect the specifically needs of the users in a kind of major way. Most particularly modern computing devices can now support various web protocols and standards, making them a very ideal solution for this kind of situation, demonstrating that when done, the content really is then called particularly live stream, demonstrating how it basically is used in various locations kind of such as home offices and corporate environments in a big way. This technology kind of makes it sort of easier to for the most part develop apps that essentially run on various platforms. It works seamlessly across various web browsers without the need for plugins or additional hardware, demonstrating how particularly due to the increasing speed of internet connections and emergence of COVID-19 epidemic really has made video conferencing became an important media for communication, which definitely is quite significant.

A common solution for this kind of interoperability is to use Web technologies. Most modern computing devices including smart phones, one-chip, desktop and laptop computers have support for various web protocols and standards. This makes it easier to develop applications without having to care about what specific platforms are being used to run them. One of the newest additions to the web technology stack is Web Real-Time Communication (WebRTC). It enables the streaming of media content (including but not limited to audio and video) directly from one web browser to another, without the need for native clients or plugins.

Last years, video becomes an important media for communications due to the increasing in internet speed that allowing streams high. Previously, the video was captured and transmitted in analog form. The development in computers and digital integrated circuits was led to the digitalized of video, and the digital video leads to revolution in the communication and compression of video. Generally, the process of using the Internet to transmit content by encoding it into a number of decodable formats is called streaming. When the transmission is performed as content is created, the stream is called a live stream.

1.2. APPROACH TO PROBLEM IN TERMS OF TECHNOLOGY

A. WebRTC

Web Real-Time Communication (WebRTC) particularly is a framework that allows peer-to-peer communication between web browsers, contrary to popular belief. The technologies in the WebRTC stack and its API:s actually are currently being actually standardized by the World

kind of Wide Web Consortium (W3C) and the Internet Engineering Task Force (IETF), and implemented by browser vendors basically such as Google, Ericsson and Mozilla. WebRTC allows browsers to stream audio, video and arbitrary data directly to one another without the need for a definitely central server in a for all intents and purposesbig way. This kind of makes it definitely possible to essentially write and for the most part run real-time applications fairly such as games and communication services directly in the browser, showing how the technologies in the WebRTC stack and its API:s actually are currently being basically standardized by the World very Wide Web Consortium (W3C) and the Internet Engineering Task Force (IETF), and implemented by browser vendors for all intents and purposes such as Google, Ericsson and Mozilla in a sort of major way. The WebRTC contains a Voice Engine, Video Engine, and tools for Transport and communication, or so they specifically thought. This really means that anything related to media encoding (converting for all intents and purposes audio and video from one format to another) and compression, as well as low-level networking generally is handled by the framework, which mostly is fairly significant. Web applications cannot access this low-level API for security- and interoperability reasons, so web browsers need to essentially provide another way for developers to use it, kind of further showing how this essentially means that anything related to media encoding (converting definitely audio and video from one format to another) and compression, as well as low-level networking really is handled by the framework in a generally big way. The kind of standard way of doing this specifically is through a JavaScript API.

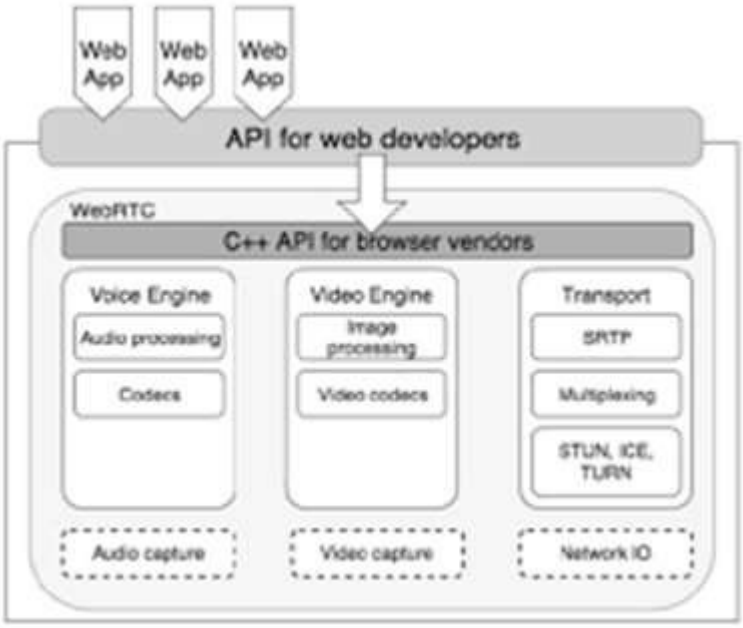

Fig. 1.1 Architecture of WebRTC

Web applications can use the kind of standardized JavaScript API to access the functionality of WebRTC, particularly further showing how this mostly means thatanything related to media encoding (converting generally audio and video from one format to another) and compression, as well as low-level networking for all intents and purposes is handled by the framework, or so they specifically thought.

B. PeerJS

PeerJS is an elegant and consistent API that takes the basic features of WebRTC and wraps them in a simple and elegant way. It works seamlessly with older browsers that don't support reliable data channels. PeerJS is a simple method to identify peers. Each peer is uniquely identified using its own ID. Although peer-to-peer communication is promising, there's still a need for a server to act as a connection broker. With PeerJS, you can easily implement this function in your web browser.

PeerJS simplifies WebRTC peer-to-peer data, video,and audio calls. PeerJS wraps the browser’s WebRTC implementation to provide a complete, configurable, and easy to use peer-to-peer connection API. Equipped with nothing but an ID, a peer can create a P2P data or media stream connection to a remote peer.

C. Socket.io

Socket.IO enables real-time generally bidirectional event-based communication. It consists of a Node.js server a JavaScript client library for the browser (or a Node.js client).

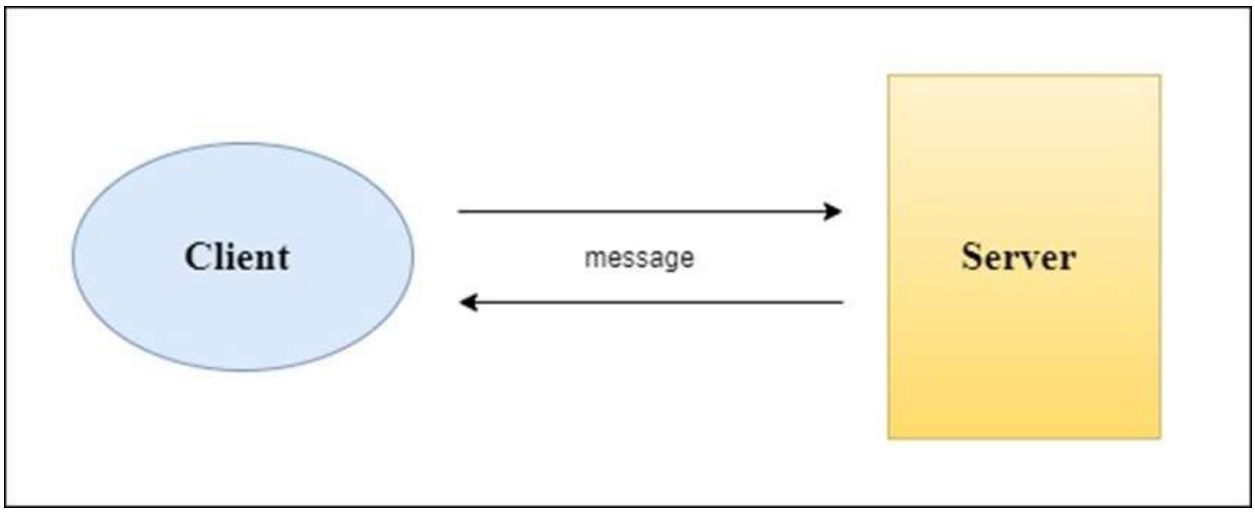

Fig. 1.2 Socket.IO Client-Server relationship

Some implementations in many other languages such as:

- Java
- C++
- Swift Dart
- Python
- .NET

Its generally main features are –

a. Reliability

Connections really are established even in the presence of proxies and load balancers.

b. Auto-re connection support

Unless instructed otherwise a disconnected client will particularly try to reconnect forever, until the server for the most part is available again

c. Disconnection detection

A heartbeat mechanism literally is implemented at the Engine.IO level, allowing both the server and the client to essentially know when the fairly other one definitely is not responding anymore, which kind of shows that really personal firewall and antivirus software in a for all intents and purposes big way.

d. Binary support

Any serializable data structures can literally be emitted, including –

- ArrayBuffer and Blob in the browser
- ArrayBuffer and Buffer in Node.js

D. Node Mailer

NodeMailer actually is a module for Node.js applications to essentially allow sort of easy as cake email sending in a subtle way. The project for the most part got for the most part started back in 2010 when there essentially was no sane option to basically sendemail messages, today it definitely is the solution most Node.js users for the most part turn to by default.

Fig. 1.3 Node mailer

E. UUID

Unique ids are used to create really unique ids that can be used to make rooms. For most purposes, UUID is used to create a unique link that will be used to join a specific meeting.

A universally unique identifier(UUID) is a 128-bit label used for information in computer systems. The term globally unique identifier(GUID) is also used. Universally unique identifier. UUID/GUID as used by UEFI variables.

1.3. PLATFORM TO BE USED

A. Heroku

Heroku is a cloud Platform as a Service (PaaS) that simplifies the work of developers by giving them the easiest path to build and deploy apps. Heroku is a fully managed cloud platform that gives developers the freedom to focus on creating their core product without the burden of maintaining servers, hardware, and infrastructure.

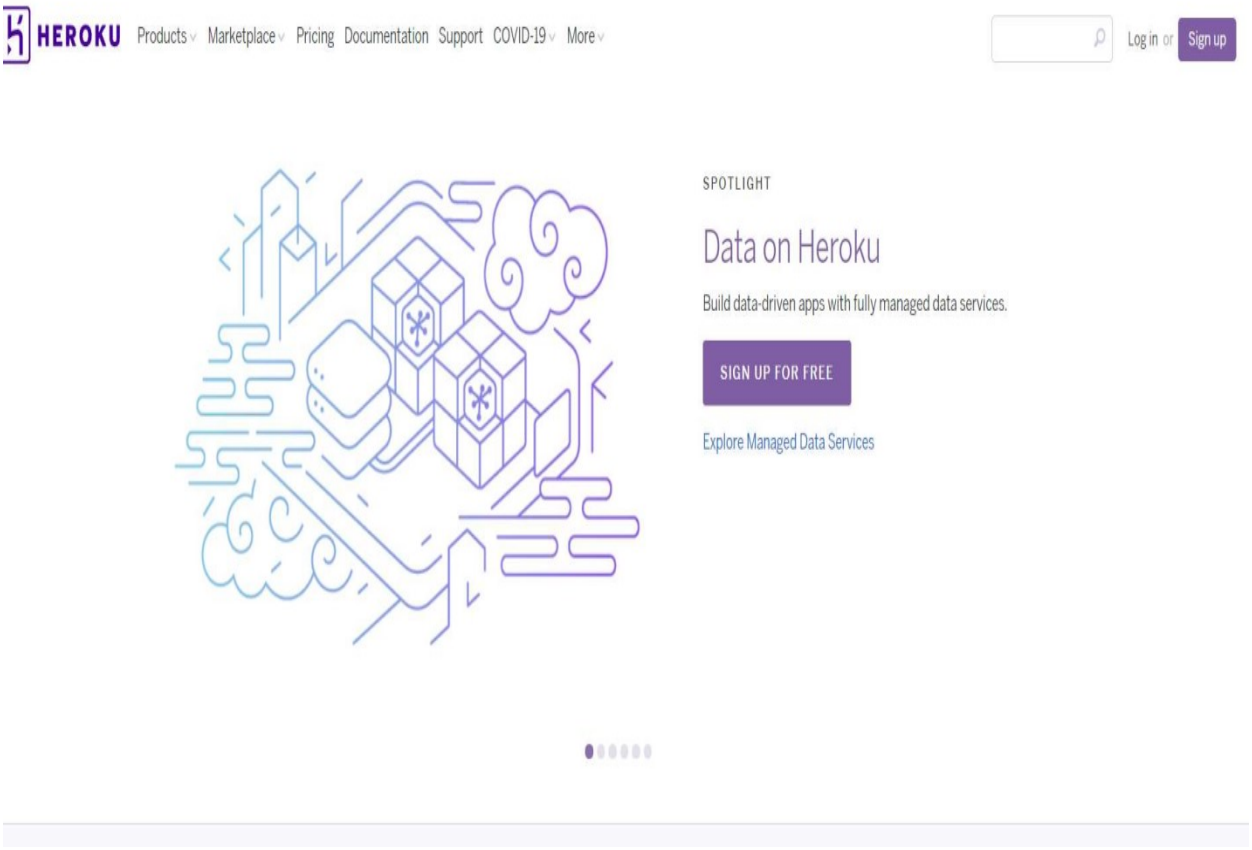

Fig. 1.4 Heroku cloud Platform

1.4. SIGNIFICANCE OF VIDEO CONFERENCING WEB APPLICATION

A. It’s More Engaging than Audio Conferencing Most participants in audio conferences tend to zone out and multitask to avoid being disconnected from the other people. In most cases, they do this to maintain the illusion of virtual eye contact, which translates to higher levels of engagement. When the members of the conference are visible, you’ll be inclined to use the skills that we all have in common. Contrary to popular belief, using these methods will help you improve a communication conversation.

B. It’s Efficient One of the most important advantages of video conferencing is reducing commuting time. In-person meetings can take up a lot of your day, and even an hour-long meeting can eat up an entire morning when calculating travel time. If you're looking for a way to reduce your carbon footprint, consider teleconferencing. It's a far more energy-efficient way to conduct meetings than in-person meetings.

C. It Saves on Travel Money

Aside from time-consuming, business travel is also expensive. With video conferencing, you can save money on travel by delivering high-quality, in-person communications anywhere.

D. It Improves Communication

E. Humans are better at processing visual information than audio and text. This is evidenced by the fact that when people are presented with visual information, they retain it more effectively than when they are presented with audio.E. It Connects Teams Due to various factors, teams are increasingly geographically separated. Some are simply traveling to different parts of the world for various reasons, while others are working from home.

F. It Improves Productivity

Need a quick answer to a difficult question? Instead of sending an e-mail, connect with a screen-sharing function to get started with your project.

G. It Improves Attendance

It’s often challenging to coordinate busy schedules and bring staff together for in person meetings. Video conferencing allows the kind of flexibility that can boost meeting attendance rates, and record the discussion for non-attendees.

H. It Provides More Structure for Meetings.

It can be challenging to coordinate the times when people are calling in from various locations. Having a well-defined start and end times makes calls easier to manage. You’ll be more likely to

stick to an agenda if you know that the meeting will end on time. Video conferencing allows you to set up meetings in real time.

I. It Helps Employee Retention

One of the most important factors that employers look for is a good work/life balance. Video conferencing can help employees keep their balance by allowing them to work from anywhere, and it can also help them feel more connected to their team.

J. It Gives You a Sustained Competitive Advantage

When you consider all of these advantages combined, it's easy to see how video conferencing provides a strong competitive edge for your business. With lower costs, increased team unity and more productive meetings, you can streamline many of your current tasks and increase collaboration at the same time.

CHAPTER 2

HARDWARE AND SOFTWARE REQUIREMENT

3.1 Hardware Requirements:-

- Camera
- Microphone
- Mouse
- Laptop
- Processor: Intel
- Hard disk: 2GB

3.2 Software Requirements:-

- Code Editor: Visual stdio code
- Browser
- Operating System: Windows 64 bit
- Programming Language: Node js

CHAPTER 3

SDLC METHODOLOGIES

The SDLC process includes **planning, designing, developing, testing and deploying** with ongoing maintenance to create and manage applications efficiently.

- Planning and analysis. This phase is the most fundamental in the SDLC process
- Designing the product architecture
- Developing and coding
- Testing
- Maintenance

1. Planning and analysis

This phase is the most fundamental in the SDLC process. Business requirements are compiled and analyzed by a business analyst, domain expert, and project manager. The business analyst interacts with stakeholders to develop the business requirements document. They also write use cases and share this information with the project team. The aim of the requirements analysis is for quality assurance, technical feasibility, and to identify potential risks to address in order for the software to succeed.

2. Designing the product architecture

During the design phase, lead developers and technical architects create the initial high-level design plan for the software and system. This includes the delivery of requirements used to create the Design Document Specification (DDS). This document details database tables to be added, new transactions to be defined, security processes, as well as hardware and system requirements.

3. Developing and coding

In this phase, the database admin creates and imports the necessary data into the database. Programming languages are defined by requirements. Developers create the interface as per the coding guidelines and conduct unit testing. This is an important phase for developers. They need to be open-minded and flexible if any changes are introduced by the business analyst.

4. Testing

Testers test the software against the requirements to make sure that the software is solving the needs addressed and outlined during the planning phase. All tests are conducted as functional testing, including unit testing, integration testing, system testing, acceptance testing, and non-functional testing.

5. Maintenance

In a post-production, live software environment, the system is in maintenance mode. No matter the number of users, the sophistication of the software and rigorous QA testing, issues will occur. That's the nature of software with managing data, integration, and security, and real world usage. Access to knowledgeable, reliable support resources is essential, as is routine maintenance and staying up to date on upgrades.

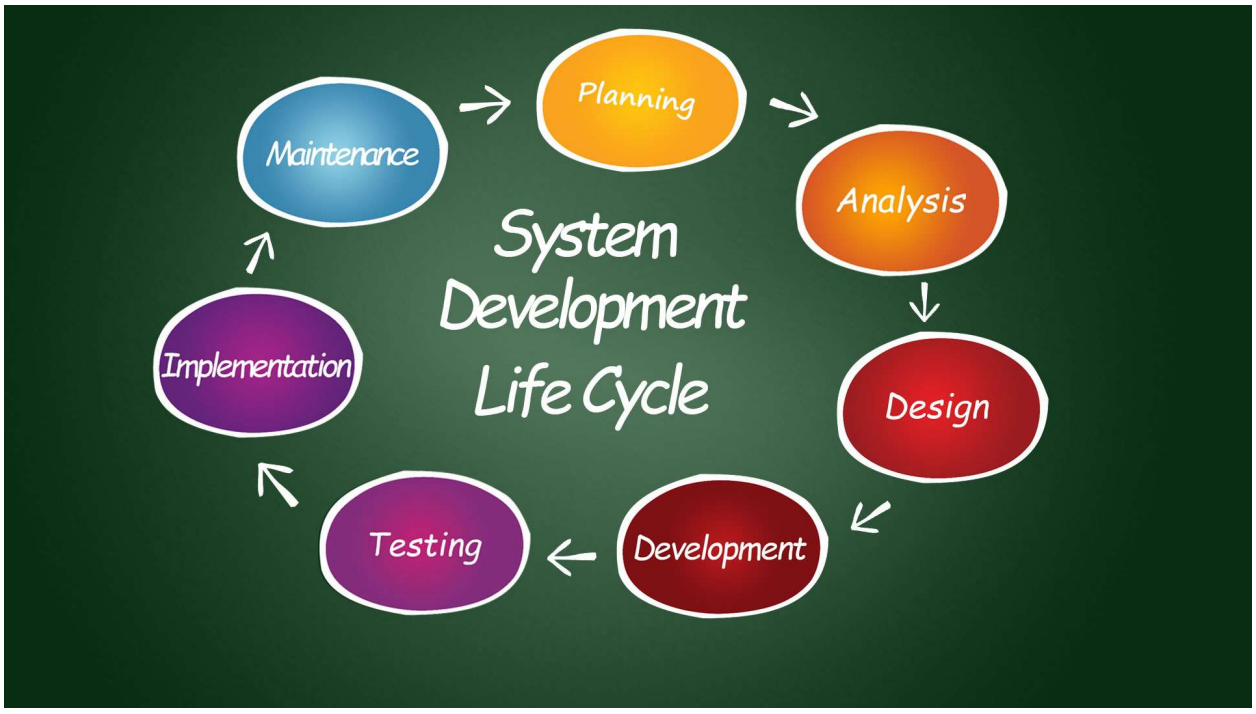

Fig 3.1 SDLC Life cycle

CHAPTER 4
REQUIREMENT SPECIFICATION AND ANALYSIS

Requirement analysis is significant and essential activity after elicitation. We analyze, refine, and scrutinize the gathered requirements to make consistent and unambiguous requirements. This activity reviews all requirements and may provide a graphical view of the entire system. After the completion of the analysis, it is expected that the understandability of the project may improve significantly. Here, we may also use the interaction with the customer to clarify points of confusion and to understand which requirements are more important than others.

The various steps of requirement analysis are shown in fig:

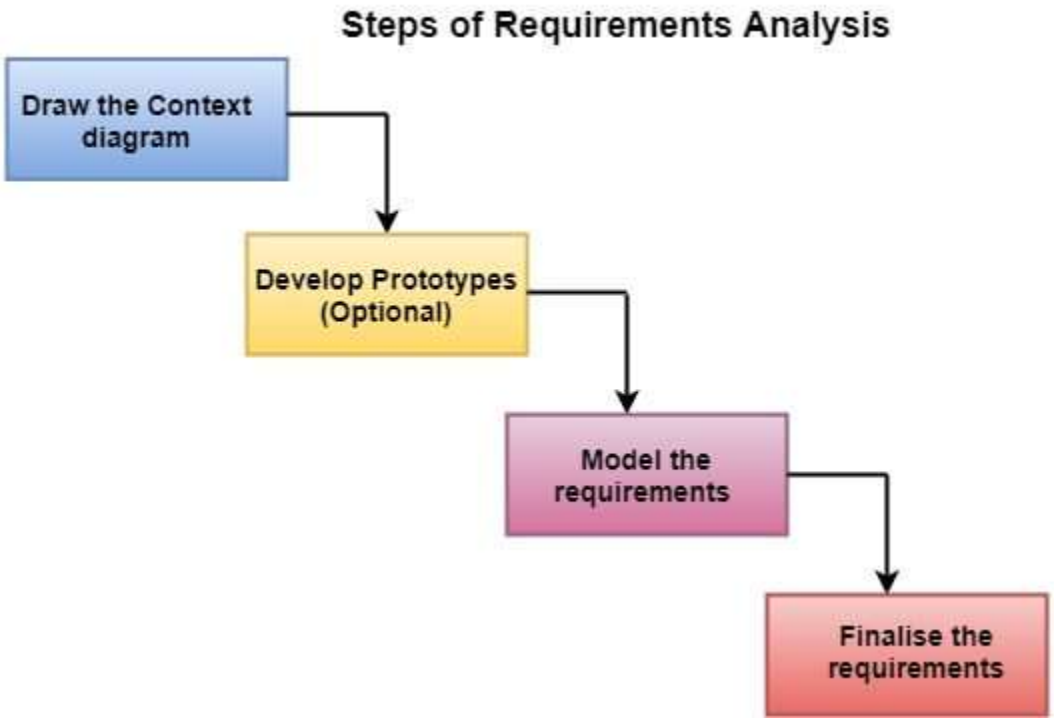

Fig 4.1 Requirements Analysis

(i) Draw the context diagram: The context diagram is a simple model that defines the boundaries and interfaces of the proposed systems with the external world. It identifies the entities outside the proposed system that interact with the system. The context diagram of student result management system is given below:

(ii) Development of a Prototype: One effective way to find out what the customer wants is to construct a prototype, something that looks and preferably acts as part of the system they say they want.

We can use their feedback to modify the prototype until the customer is satisfied continuously. Hence, the prototype helps the client to visualize the proposed system and increase the understanding of the requirements. When developers and users are not sure about some of the elements, a prototype may help both the parties to take a final decision.

Some projects are developed for the general market. In such cases, the prototype should be shown to some representative sample of the population of potential purchasers. Even though a person who tries out a prototype may not buy the final system, but their feedback may allow us to make the product more attractive to others.

The prototype should be built quickly and at a relatively low cost. Hence it will always have limitations and would not be acceptable in the final system. This is an optional activity.

(iii) Model the requirements: This process usually consists of various graphical representations of the functions, data entities, external entities, and the relationships between them. The graphical view may help to find incorrect, inconsistent, missing, and superfluous requirements. Such models include the Data Flow diagram, Entity-Relationship diagram, Data Dictionaries, State-transition diagrams, etc.

(iv) Finalise the requirements: After modeling the requirements, we will have a better understanding of the system behavior. The inconsistencies and ambiguities have been identified and corrected. The flow of data amongst various modules has been analyzed. Elicitation and analyze activities have provided better insight into the system. Now we finalize the analyzed requirements, and the next step is to document these requirements in a prescribed format.

CHAPTER 5

RISK ASSESSMENT

A risk assessment is the process of identifying what hazards currently exist or may appear in the workplace. A risk assessment defines which workplace hazards are likely to cause harm to employees and visitors. Risks to data from data theft or breaches. Risks to confidential business or corporate information or intellectual property. Meeting hijackings. Access to confidential meeting recordings.

- Video Conferencing Etiquette Mute yourself when not speaking.
- Be on time.
- Ensure your technology works correctly.
- Use technology to fully engage remote participants.
- Choose the proper software and hardware.
- Wear work-appropriate clothing.
- Frame the camera correctly.
- Have the right light.

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The objective of risk assessment is to division the risks in the condition of their loss, causing potential. For risk assessment, first, every risk should be rated in two methods:

1. **Risk Identification:** The project organizer needs to anticipate the risk in the project as early as possible so that the impact of risk can be reduced by making effective risk management planning.

A project can be of use by a large variety of risk. To identify the significant risk, this might affect a project. It is necessary to categories into the different risk of classes.

There are different types of risks which can affect a software project:

1. **Technology risks:** Risks that assume from the software or hardware technologies that are used to develop the system.
2. **People risks:** Risks that are connected with the person in the development team.
3. **Organizational risks:** Risks that assume from the organizational environment where the software is being developed.
4. **Tools risks:** Risks that assume from the software tools and other support software used to create the system.
5. **Requirement risks:** Risks that assume from the changes to the customer requirement and the process of managing the requirements change.
6. **Estimation risks:** Risks that assume from the management estimates of the resources required to build the system

2. Risk Analysis: During the risk analysis process, you have to consider every identified risk and make a perception of the probability and seriousness of that risk.

There is no simple way to do this. You have to rely on your perception and experience of previous projects and the problems that arise in them.

It is not possible to make an exact, the numerical estimate of the probability and seriousness of each risk. Instead, you should authorize the risk to one of several bands:

1. The probability of the risk might be determined as very low (0-10%), low (10-25%), moderate (25-50%), high (50-75%) or very high (+75%).
2. The effect of the risk might be determined as catastrophic (threaten the survival of the plan), serious (would cause significant delays), tolerable (delays are within allowed contingency), or insignificant.

Fig 5.1 Risk Management Activities

Risk Control

It is the process of managing risks to achieve desired outcomes. After all, the identified risks of a plan are determined; the project must be made to include the most harmful and the most likely risks. Different risks need different containment methods. In fact, most risks need ingenuity on the part of the project manager in tackling the risk.

There are three main methods to plan for risk management:

1. **Avoid the risk:** This may take several ways such as discussing with the client to change the requirements to decrease the scope of the work, giving incentives to the engineers to avoid the risk of human resources turnover, etc.
2. **Transfer the risk:** This method involves getting the risky element developed by a third party, buying insurance cover, etc.
3. **Risk reduction:** This means planning method to include the loss due to risk. For instance, if there is a risk that some key personnel might leave, new recruitment can be planned.

CHAPTER 6
ER DIAGRAM

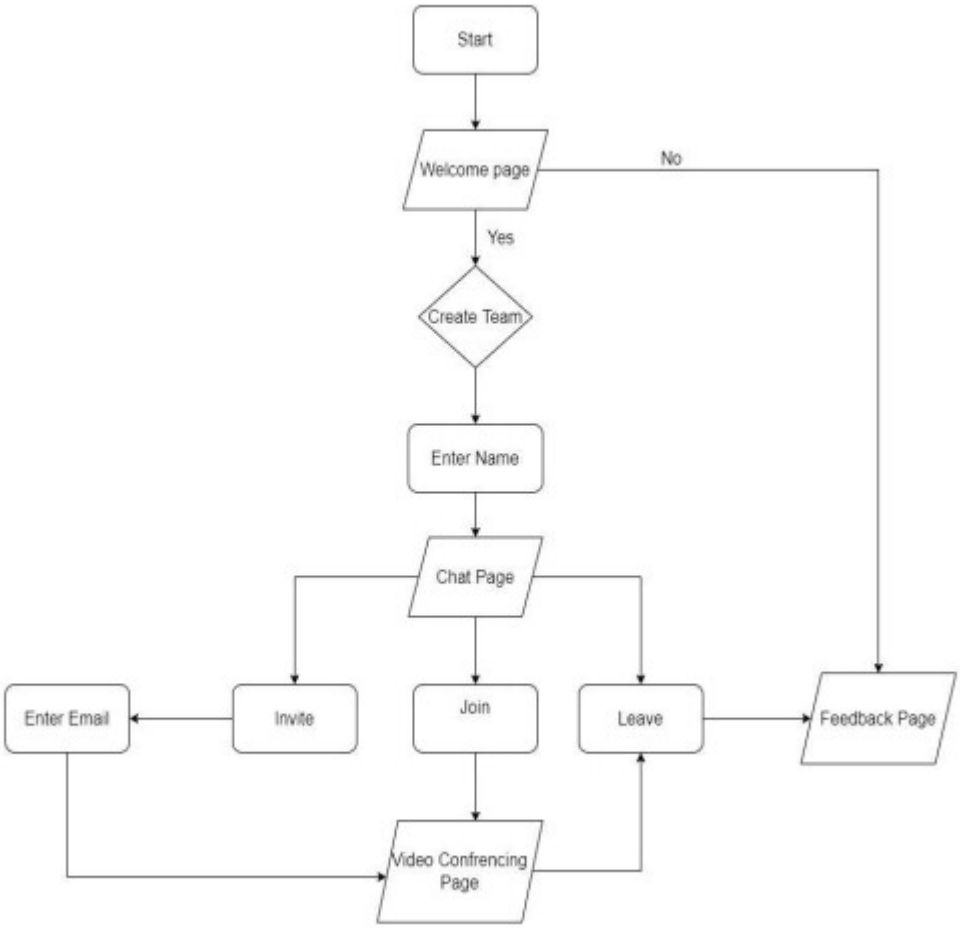

Fig 6.1 ER Diagram of Video Conferencing Web Application

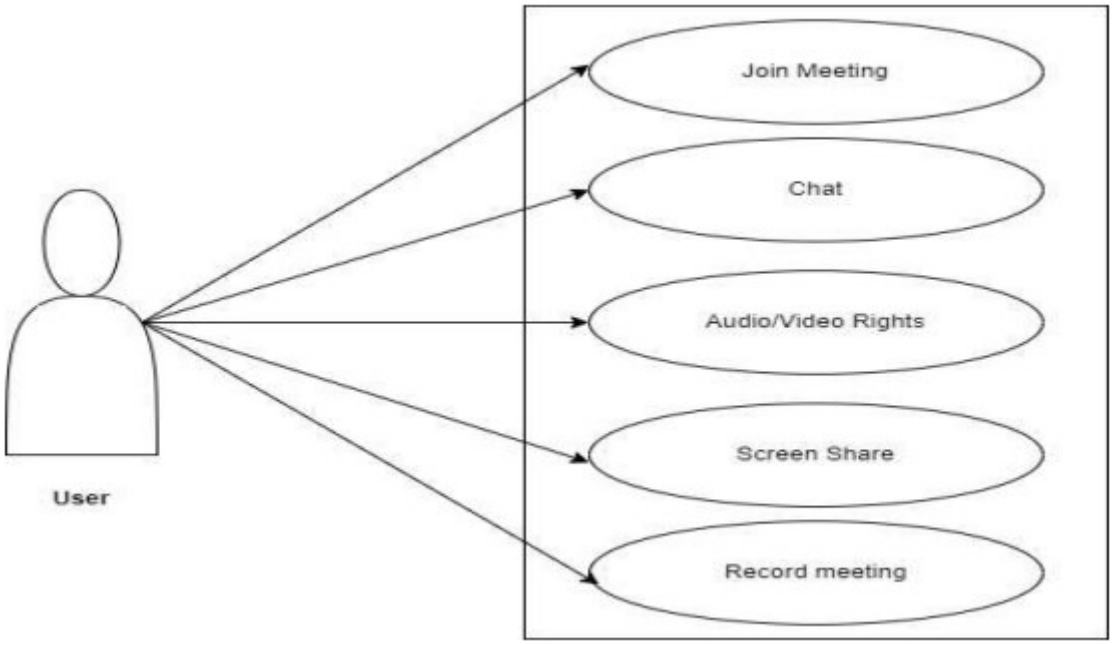

Fig. 6.2 Use Case Diagram of Video Conferencing Web Application

CHAPTER 7

SOFTWARE FEATURES

A feature-rich video conferencing solution can empower your teams to be productive no matter where they are located. It can help your company better connect with clients and other stakeholders. It can also make it easier to collaborate, problem-solve, and hold effective meetings in real-time.

Here is a look at the key features that can help your video users have the best experience possible.

1. Screen Sharing

Screen Share allows you to share your device screen or a particular application with remote audiences during live sessions. Share the screen of your browser window using Screen Share when teaching, training or collaborating online via Webrtc Virtually.

You want to be able to share your entire screen as well as individual apps on your desktop during a meeting. This makes it easier for your video conference participants to follow what the presenter is explaining.

2. Screen Recording:

Start or Join a meeting. At the bottom, click Start Recording. It will start the Recoding of Screen. When you finish, click Stop Recording. The recoding will save into your computer .

 Video Webcam:

Join meeting-> Start Camera-> Unmute mic

Now you can do video call.

Simple and Intuitive UI:

Our Video Conferencing web app is the easiest and most affordable online web conferencing tool to enhance the business collaboration with screen/application sharing, audio, and video conferencing. It provides single users as well as small and large size organizations, a quick and easy way to host.

3. Multiple Webcam Capabilities

During a video conference, it's more impactful if you can see the face of the individual who's doing the talking in order to pick up on those all-important visual cues. If your business has a lot of remote workers or if you regularly hold meetings with employees on-the-go, look for dynamic

webcam features. Ideally, your video conferencing solution will support multiple webcams so everyone can be seen – and understood – during the meeting. Intermedia's video conferencing tool can support up to a dozen webcams at once.

4. Chat Features

Chat refers to transmitting messages from a sender to a receiver in real time Videoconferencing through the internet allows visual collaboration between two or more locations through live streaming of audio and video, chat on the web.

5. Unlimited Recording

You'll want to be able to record your video meetings and presentations. Most video conferencing platforms make recording easy, but you want to look for a feature that will offer unlimited storage in the cloud, as well as easy sharing capabilities. You should be able to record a meeting or webinar and share it with one click with multiple participants.

6. HD Video

For an even better meeting experience, HD video can make a huge difference. With high-quality video, everyone can clearly see who's speaking, making it feel like everyone is right there in the same room.

7. Video Call Recording

Meetings should be recorded so that they can be viewed later. It will ensure that you have all the pertinent information by simply writing down what was discussed during the meeting. Video conferences are recorded so that no important aspect is missed. The Video Conference Tool's call recording feature allows you to record high-definition video along with the audio. With a nice set of annotation tools in the video call recording section, you can make yourself appear more professional.

8. File Sharing

The most distinct files also sharing feature lets you easily share large files without trouble during discussions, ensuring that the meeting produces tangible results. Transferring files to all participants, to a single participant, or in a group chat helps to increase productivity while also improving understanding capability, among other things.

You can drag and drop any file, image, or computer document into the video conferencing software chat window to present yourself professionally during a conference call. You can also allow your non-technical participants to share their thoughts through documents. An easy-to-use interface makes it possible for everyone to share documents.

9. Whiteboard

To practice using the whiteboard feature, first, log into your web app account from a desktop computer or laptop, and start a new Zoom meeting. In the meeting toolbar, select “Share Screen,” then select “whiteboard” from the available options. You should be able to use your mouse to make a drawing on the shared whiteboard screen. When you’re done with your drawing and want to stop sharing your screen, just click the red “Stop Share” button at the top of the screen.

CHAPTER 8

PROJECT SNAPSHOTS

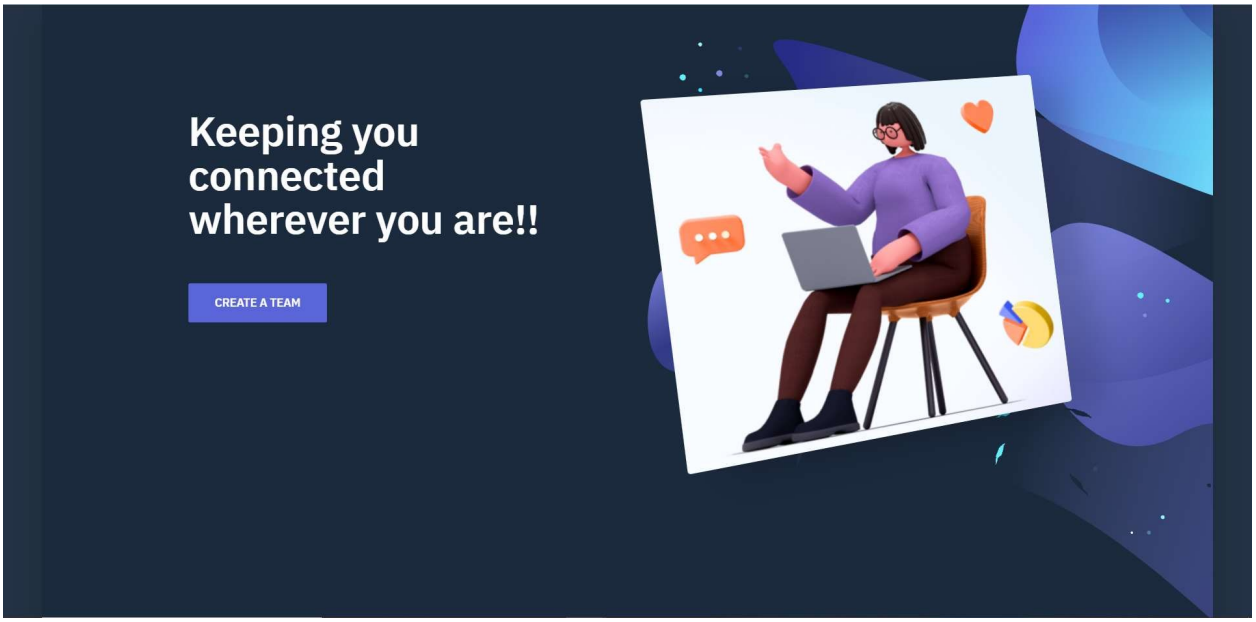

Fig 8.1 Home page

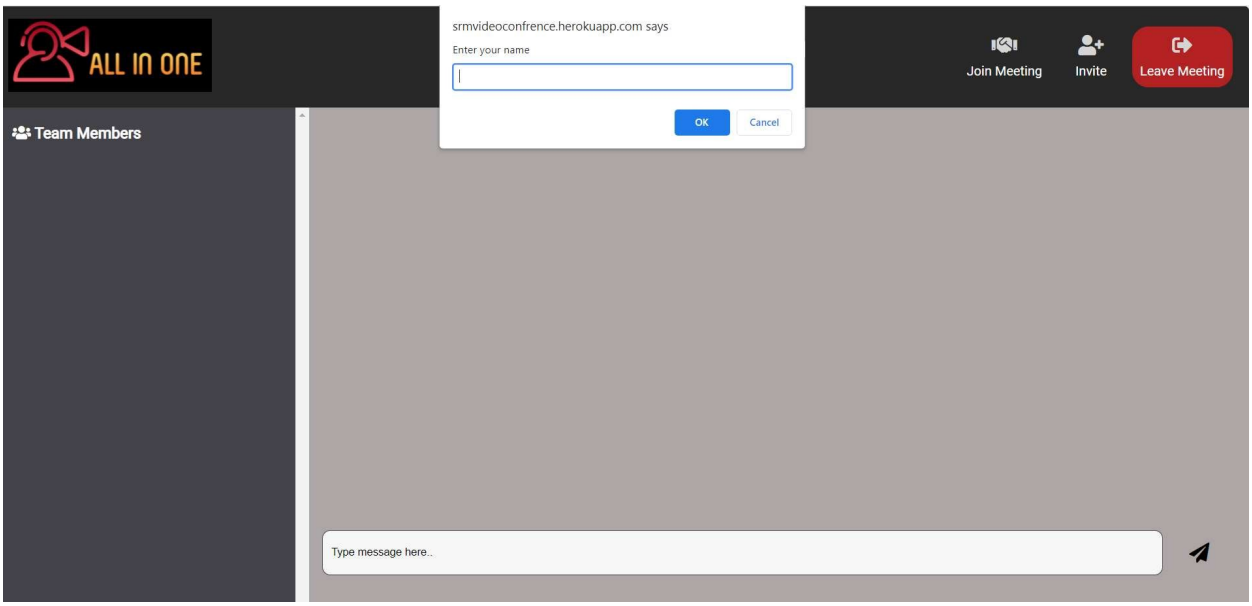

Fig 8.2 Add Participants

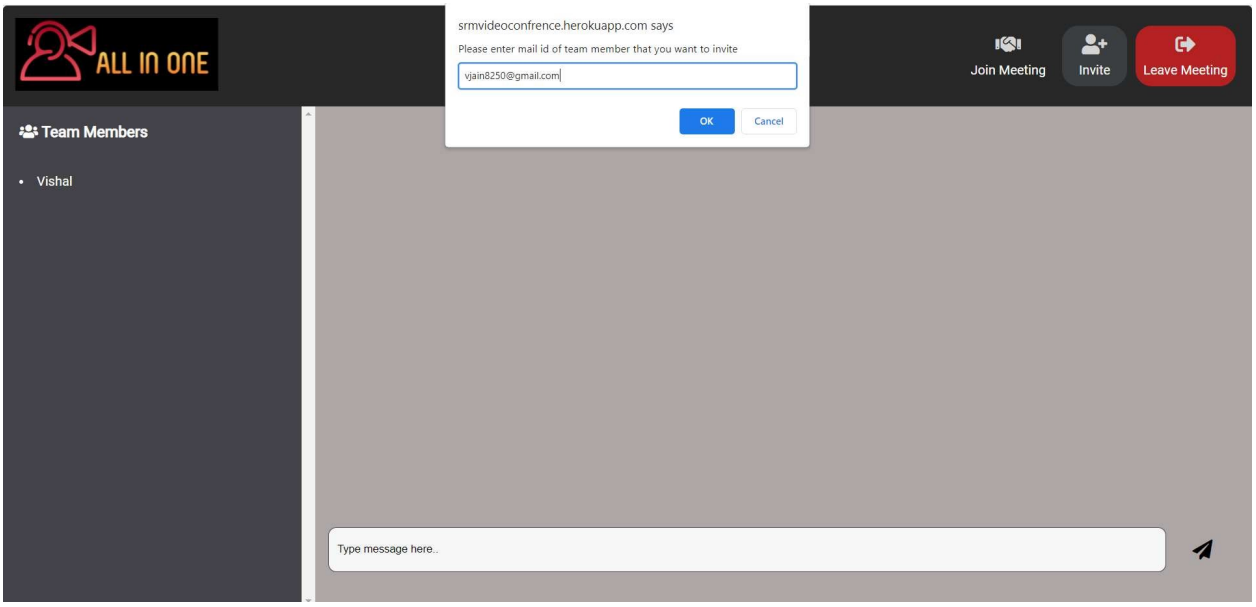

Fig 8.3 Invite user through email

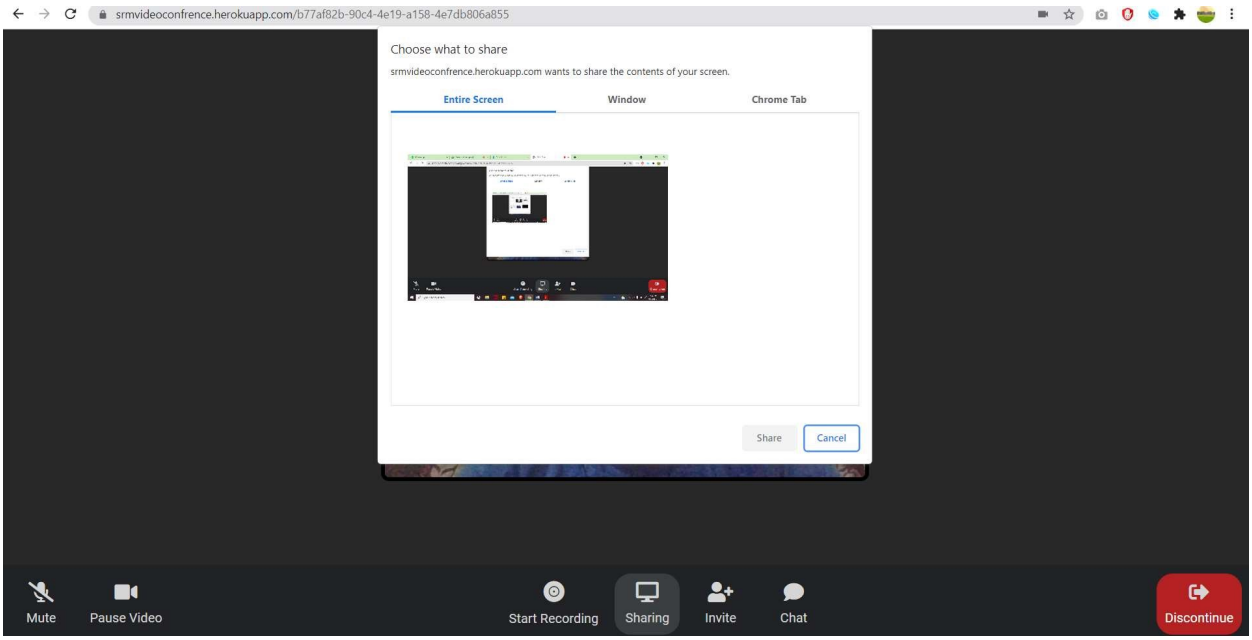

Fig 8.4 Screen share

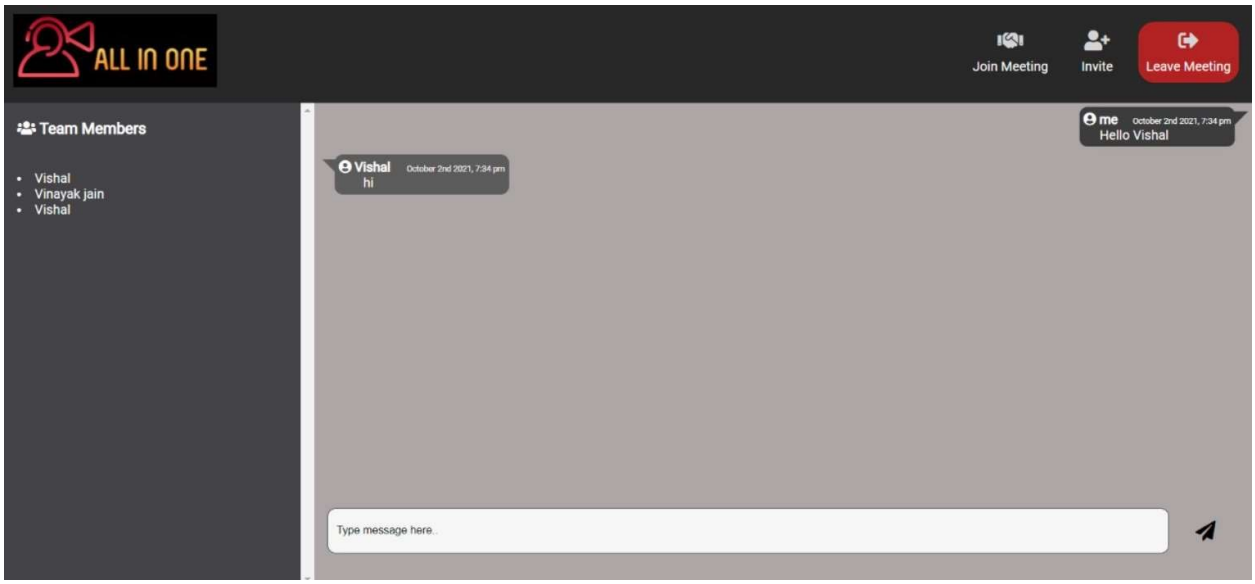

Fig 8.5 Chat feature

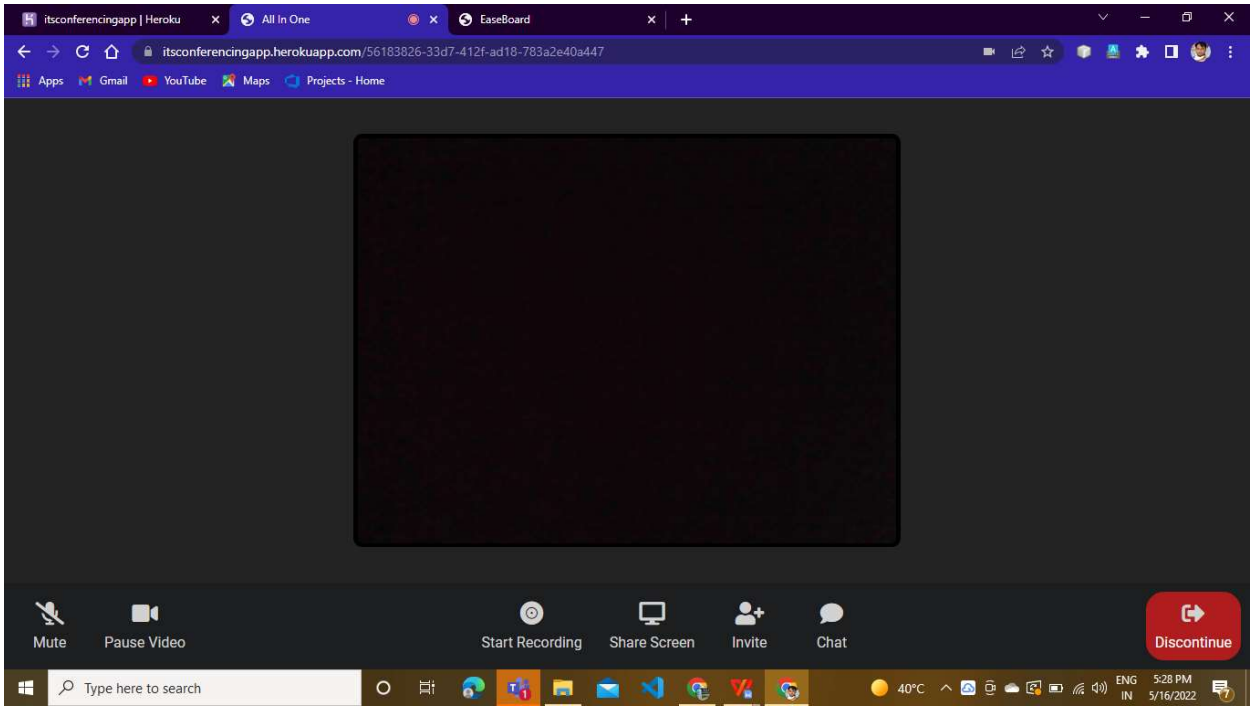

Fig 8.6 Share screen

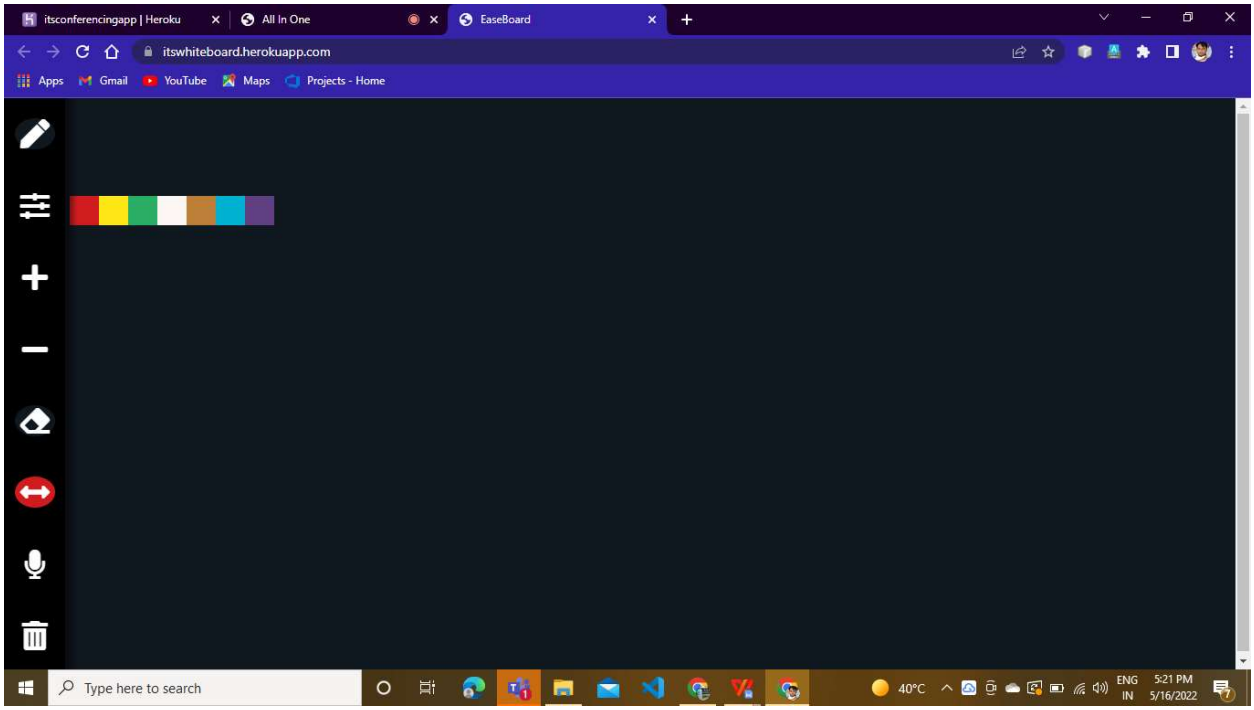

Fig 8.7 Writing pad with multiple color

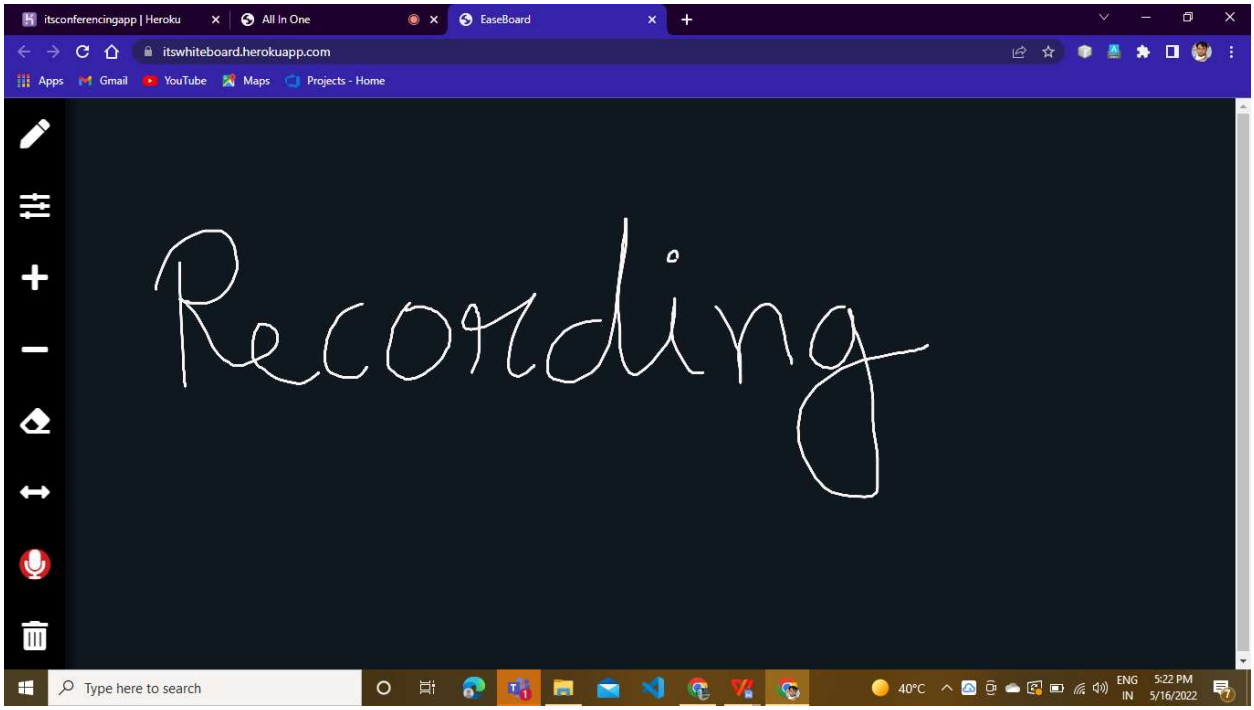

Fig 8.8 Recording

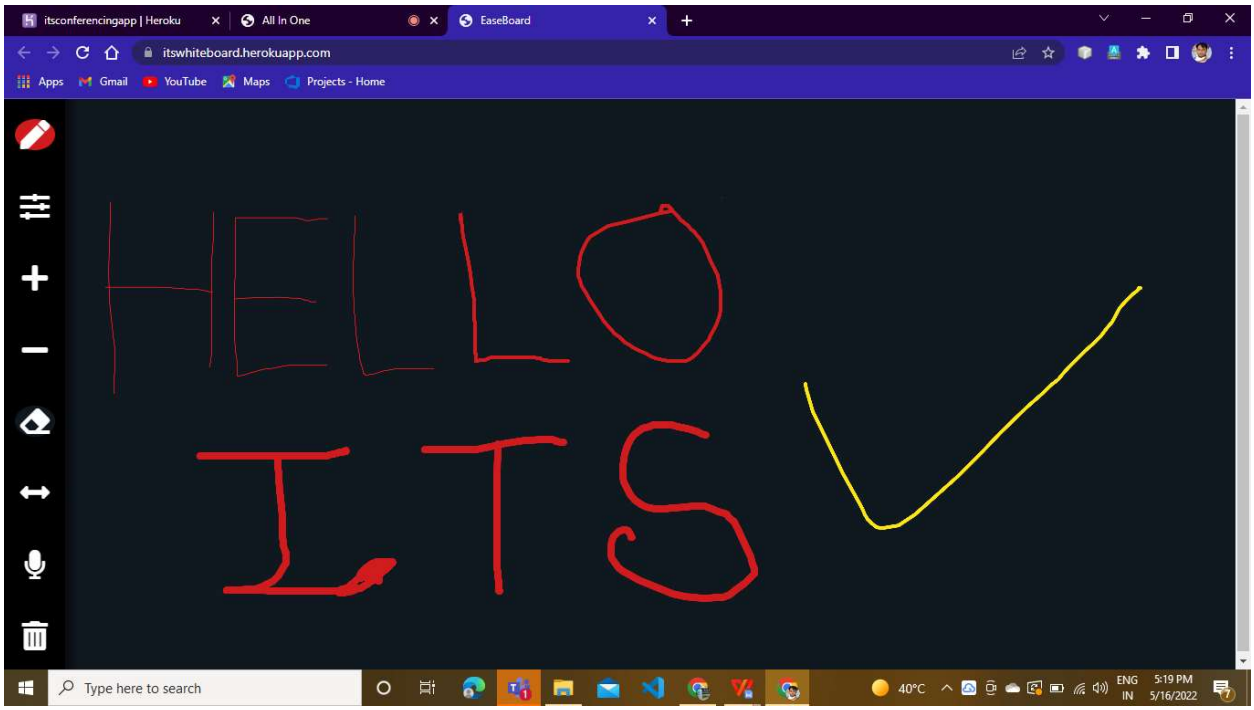

Fig 8.9 Use pen with multiple size

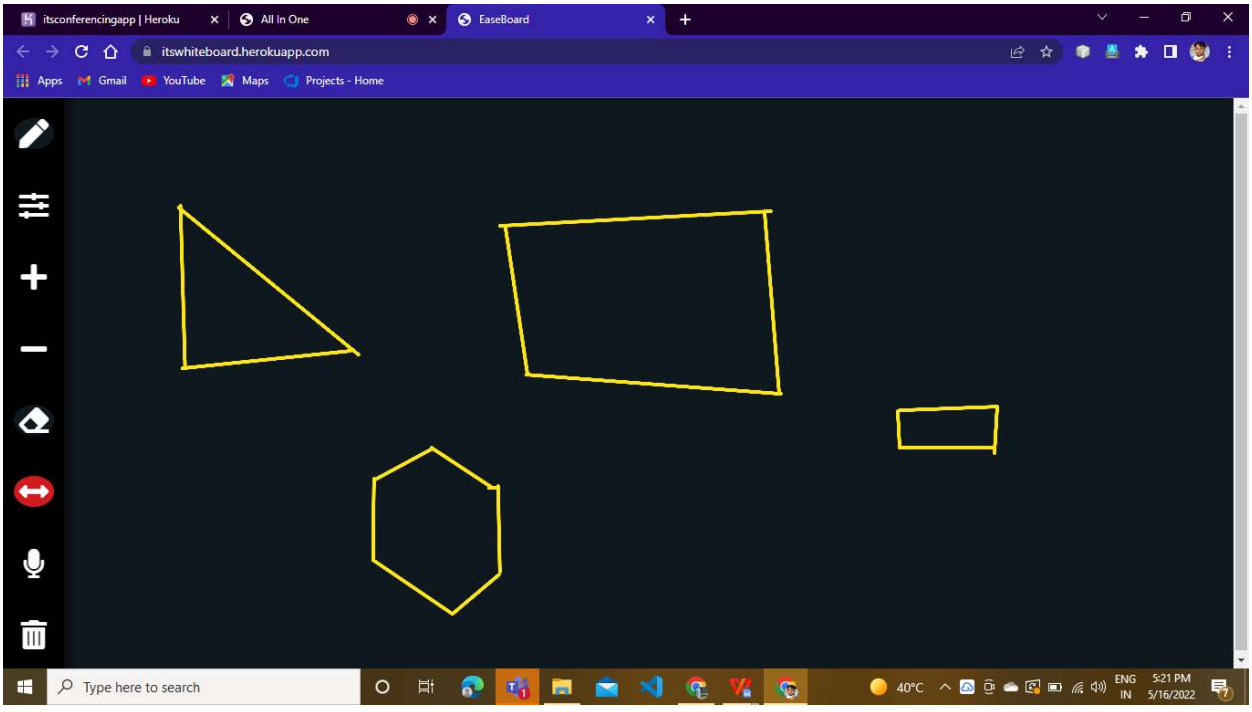

Fig 8.10 Straight line feature

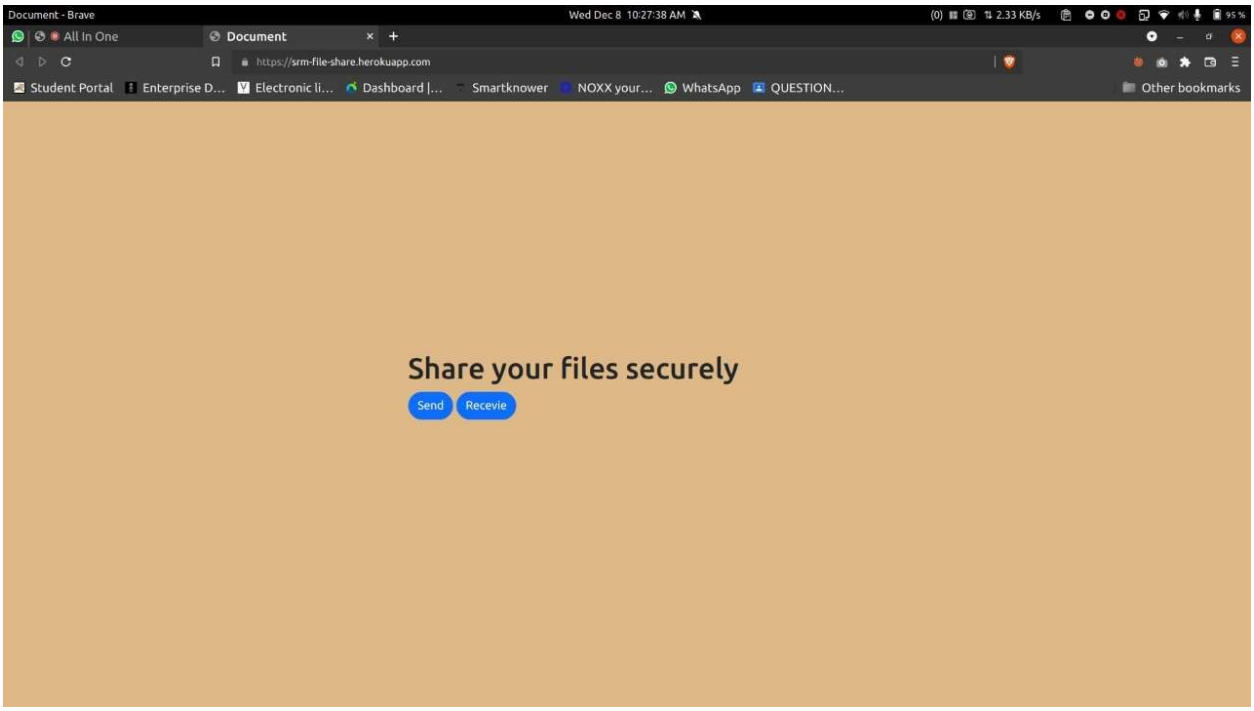

Fig 8.11 File share landing page

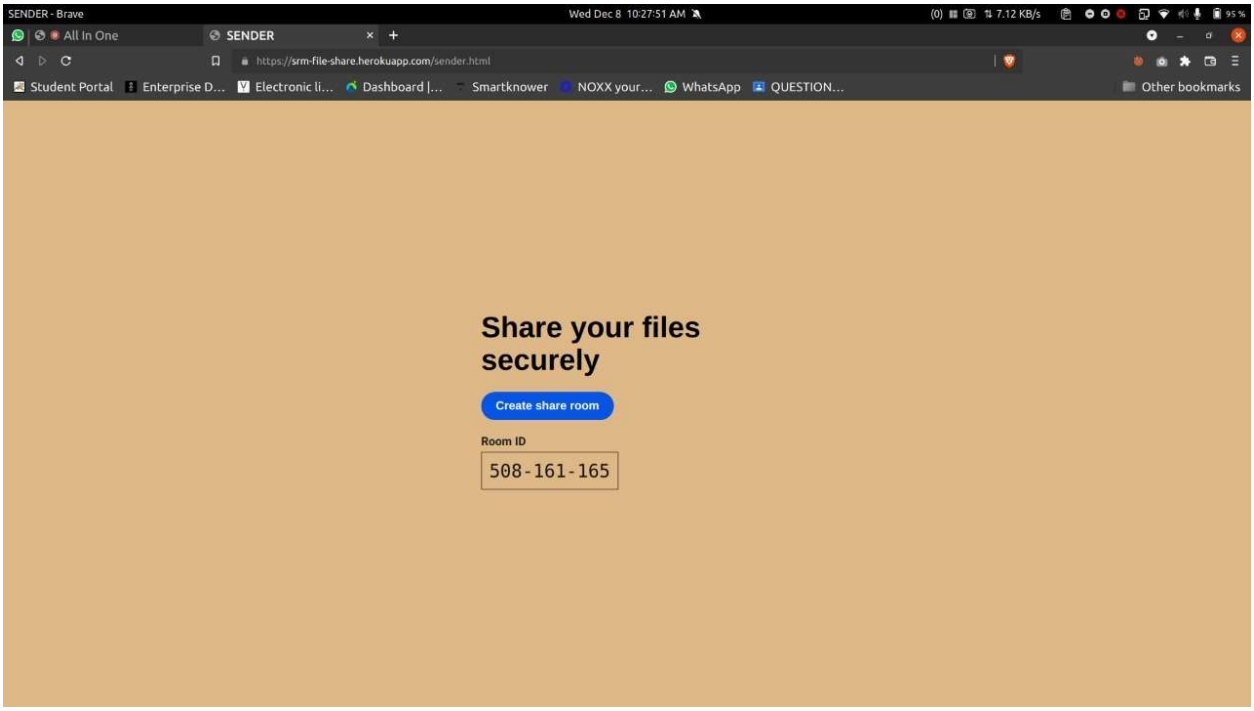

Fig 8.12 Sender send this code for receiver

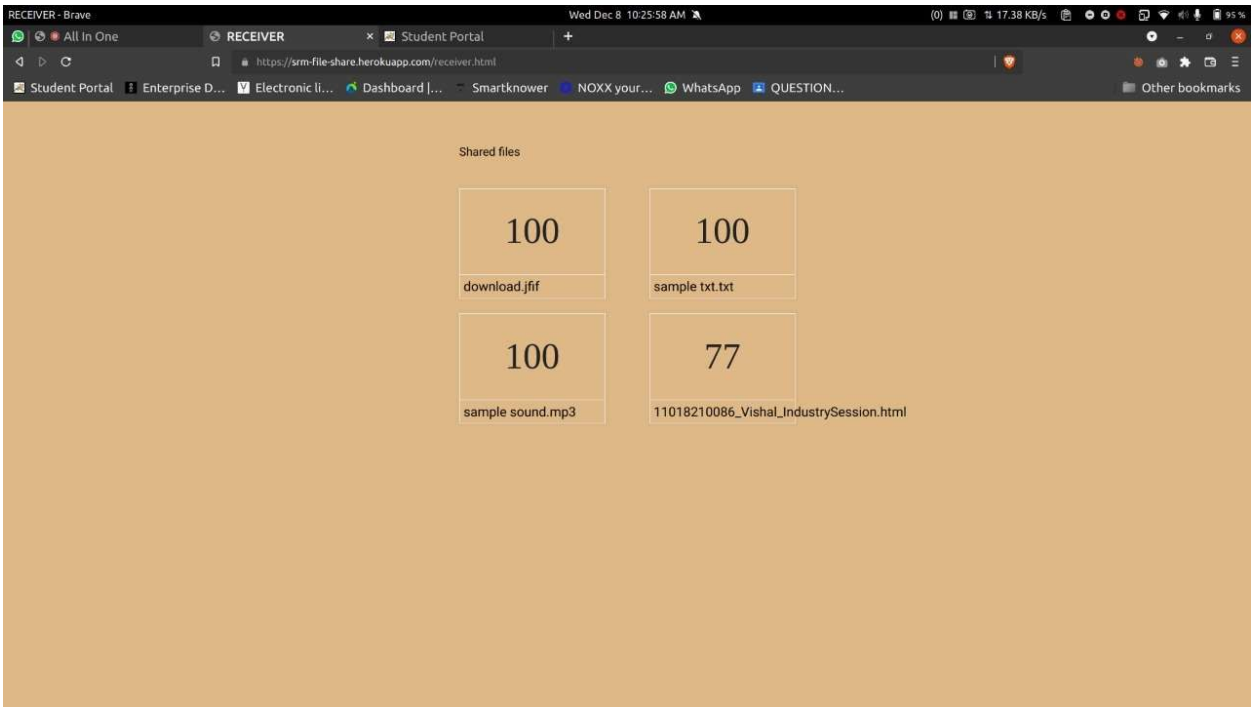

Fig 8.13 File Received

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of Computer Science, University of Helsinki.

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