



Bharatiya Vidya Bhavan's
SARDAR PATEL INSTITUTE OF TECHNOLOGY
Munshi Nagar, Andheri (W), Mumbai – 400 058.
(Autonomous Institute Affiliated to University of Mumbai)

2.3.1: Student centric methods, such as experiential learning, participative learning and problem solving methodologies are used for enhancing learning experience and teachers use ICT- enabled tools including online resources for effective teaching and learning process

Contents

Sr. No.	Documents of Evidence	Page No.
1	Details of Experiential learning	3
	A. Industrial Visits	5
	B. Workshop on Cutting Edge Technologies	14
	C. Peer Teaching	15
	D. Virtual Labs and Simulations	24
	E. Volunteering/Seva/Satva/Activity Based Learning	32
	F. Internship by Students	49
	G. Undergraduate Research	56
	H. MOOC	62
2	Details of Participative Learning	67
	A. Mini Project	68
	B. Project competition	97
	C. Paper Presentation	98
	D. Extra-Curricular Activities	104

Sr. No.	Documents of Evidence	Page No.
3	Problem Solving Methodology	114
	A. Research Paper as outcome of problem solving	115
	B. Major Projects	125
	C. Research Internship	188
	D. Hackathon	201
4	ICT enabled tools	203
	A. Content Creation by faculties	204
	B. Learning Management System	216

1. Details of Experiential learning

A. Industrial Visits

Industrial visits provide students with the opportunity to witness the practical implementation of the theoretical concepts they study in the classroom. Students gain insights into the actual practices and processes employed by industries. This exposure is invaluable as it helps them understand the standards, methodologies, and technologies used in their respective engineering fields. It allows students to ask questions, seek guidance, and gain insights into the practical challenges faced by professionals in the field.

B. Workshop on Cutting Edge Technologies

Conducting a workshop on cutting-edge technologies is an excellent way to provide students with hands-on experience and insights into the latest advancements in the field. It facilitates interactions and collaboration among participants, encouraging the exchange of ideas and experiences. It emphasizes the industrial applications and relevance of these technologies, connecting theoretical knowledge to real-world scenarios.

C. Peer Teaching

When students take on the role of teachers, they become actively engaged in the learning process. Teaching requires a deeper level of understanding, encouraging students to thoroughly grasp concepts before explaining them to their peers. Through peer teaching, students can gain multiple viewpoints, fostering a more comprehensive understanding of the material. Peers can provide immediate feedback and clarification to each other. This real-time interaction allows for the identification and correction of misconceptions, fostering a more accurate understanding of the material.

D. Virtual Labs and Simulations

Virtual labs allow students to access and conduct experiments remotely, overcoming physical barriers. Students can repeat virtual experiments multiple times to reinforce their understanding or explore different variables without the limitations imposed by physical constraints. This flexibility enhances the learning experience. Virtual labs are accessible at any time, allowing students to work at their own pace and convenience. This asynchronous access is beneficial for students with diverse schedules or those in different time zones.

E. Volunteering/Seva/Satva /Activity Based Learning

Students are actively engaged in the learning process, promoting better retention and understanding of concepts. Problem-solving activities encourage critical thinking skills and the application of theoretical knowledge to real-world situations. Many activities are designed to reflect real-world situations, making the learning experience more relevant and applicable. Seva Satva activities involve students actively participating in community service projects, addressing local needs or contributing to social causes. Engaging in Seva Satva activities contributes to the personal growth of students by expanding their worldview, increasing cultural awareness, and enhancing their understanding of societal challenges.

F. Internship by Students

Internships provide an opportunity for students to apply the theoretical knowledge gained in the classroom to real-world situations. Internships allow students to develop a wide range of skills, including technical, communication, teamwork, problem-solving, and time management skills. Internships contribute to the overall professional development of students, helping them develop a sense of responsibility, adaptability, and a strong work ethic.

G. Undergraduate Research

Research projects require students to analyze information, synthesize findings, and draw conclusions. This process enhances critical thinking skills, encouraging students to evaluate and interpret data independently. Research projects often involve addressing complex problems. Working on such challenges helps students develop effective problem-solving skills and the ability to devise innovative solutions. Undergraduate research is a valuable and enriching experience that prepares students for future academic and professional endeavors while promoting personal and intellectual growth.

H. MOOC

MOOCs provide a flexible learning environment, allowing individuals to access courses from anywhere in the world at their own pace. MOOCs often allow learners to progress through the material at their own pace. This self-paced structure accommodates different learning styles and allows individuals to dedicate more time to challenging concepts.



Industrial Visits

NISP Council S.P.I.T. - Annual Report 2022-2023

NISP Council S.P.I.T. intends to guide HEIs for promoting students' driven innovations & start-ups and to engage the students and faculty in innovation and start-up activities on campus. It aims at enabling HEIs to build, streamline and strengthen the innovation and entrepreneurial ecosystem in campus and will be instrumental in leveraging the potential of student's creative problem solving and entrepreneurial mind-set.

The National Innovation & Startup Policy (NISP) is being implemented by MoE's Innovation Cell and in coordination AICTE, UGC, state/ UT governments and universities in promoting a strong intra and interinstitutional partnerships with ecosystem enablers and different stakeholders at regional, national and international level. Implementation of policy has been undertaken for quick adoption by HEIs.

Panel Discussion

NISP Council S.P.I.T initiated its activities for the year 2022-23 with a Panel discussion on 1st December, 2022. It was a highly esteemed event wherein the Panel speakers included Mr. Bharadwaj Bhat, CEO of KRED Robotics and also Outreach and Program Manager at SP-TBI (Sardar Patel Technology Business Incubator) and Mr. Shubham Hule, a final year student of S.P.I.T and also a Startup Founder. The event was a wonderful opportunity for all the students to gain in depth knowledge and insights about how an idea is generated and born as a startup which ultimately leads to benefit innumerable people in the world.





Industrial Visits

Industrial Visit

NISP Council S.P.I.T organized an Industrial visit to the fifth largest company in market capitalisation in India; LTIMindtree, Pune on 4th February 2023. This interactive and informative visit provided the students of S.P.I.T. with an insight into the working of not only the IT companies but also Indian and foreign market mindsets. The employees, having an experience of more than 10 years, provided guidance and quick-tips for varied fields of research and development, testing and support teams and human resources.

Students then visited the SSIG Manufacturing Advancements (SIGMA), Pune where they learnt through live sessions the mechanisms of robotics and automation through the implementation of the concept of Industry 4.0. Amongst various projects was a scaled down version of a factory, pneumatic driven machines, sensor based models and a robotic arm with 6 degrees of freedom.

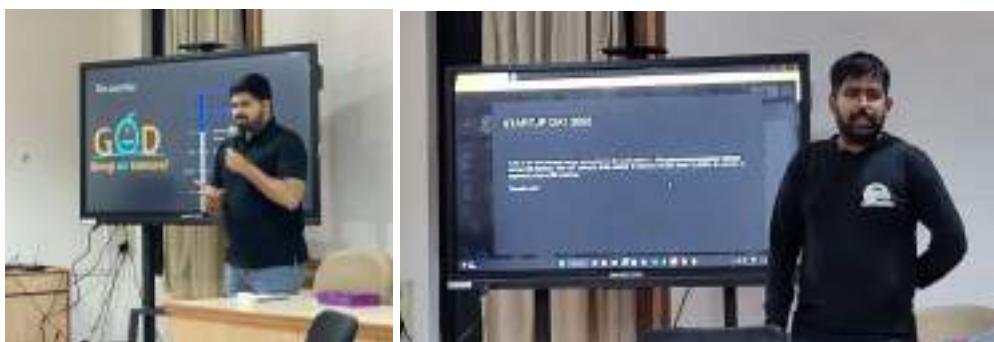




Industrial Visits

National Startup Day Celebration

On 3rd February, NISP Council held an event to celebrate the National Startup Day, with experts talking about their start-ups journey to stir up the feeling of entrepreneurship in the students. Our first speaker, Mr. Saurabh Soni, the Asst. Manager at Artiligent Solutions India Pvt. in his talk, informed us about the potential of Artificial Intelligence in the future by sharing his experience about the same. He discussed the prototypes that he had created. This aroused interest of the students in the field of artificial intelligence and machine learning. Then we were enlightened by the presence of Mr. Pranav Chaware, the Founder at VMOSA Technologies Pvt Ltd i.e. Guruji On Demand (G.O.D), who shared his inspirational journey about his start-up venture from facing initial failure to rising and establishing a stable business.



Session on Ideation

IdeaLab along with NISP Council of S.P.I.T conducted a session on ideation. with Mr. Dinesh Israni, Founder at Naman Angels India Foundation on 17th & 23rd February 2023. The session was briefly about guiding students about how to get an idea for a startup and encourage them to innovate something new for the future.





Industrial Visits

Session on SP-TBI Policy

On March 3rd, the NISP Council of S.P.I.T hosted a session on SP-TBI Policy with Prof Kiran Talele, Dean of Student Affairs, S.P.I.T as our esteemed speaker. The session aimed to inform students about the SP-TBI policies and the facilities and encouragement it provides for entrepreneurial endeavors through various forms of incubation, mentoring sessions and funding schemes.



THE INDUSTRY INSIDER - A Series of Podcasts

NISP Council S.P.I.T in collaboration with IIC S.P.I.T. conducted a series of Podcasts “The Industry Insider” with speakers who are experts from industry, startup world and business. The series aimed to invite renowned podcast speakers to share their expertise, engage in meaningful discussions, and provide valuable insights on diverse topics to foster a culture of learning, critical thinking, and engagement among students. The podcasts were streamed live on Instagram and a recorded video uploaded to YouTube on the IIC SPIT channel.

The Industry Insider #1

The first session was conducted along with **Mr. Yash Gawde**, who is an NFT artist and founder of Elite NFT with great knowledge in the field of Web3 on 15th April 2023. Throughout the Podcast, he talked about his experiences on building a startup from scratch, his life learnings, what an NFT is? How unique digital artworks are created and uploaded on blockchain to sell them as non-fungible tokens (NFTs) which in turn completely revolutionized the art market and enabled collectors to own rare, authenticated digital assets.





Industrial Visits



The Industry Insider #2

Mr. Surya Pasricha was invited as a guest for our second podcast on 22nd April, 2023. Mr. Surya is a social media strategist, organic growth expert and founder of BaatCheet media. The podcast commenced by exploring the early life and background of Mr. Surya. The guest provided insights into their upbringing, family background, education, initial entrepreneurial journey, etc. The podcast further explored the expertise of Mr. Surya in Content-Writing, Marketing & Advertising, etc. He guided students regarding Inbound and Outbound Marketing and how to use LinkedIn to acquire clients. He shared about his learnings through the podcasts he conducts and how it helped him to improve his communication and networking skills. At the end, he addressed some key skills that students need to develop before joining the corporate world.



Industrial Visits



BHARATIYA VIDYA BHAVANS
SARDAR PATEL INSTITUTE OF TECHNOLOGY
MUNSHI NAGAR, ANDHERI (WEST), MUMBAI - 400 058
AUTONOMOUS INSTITUTE AFFILIATED TO MUMBAI UNIVERSITY



The Industry Insider #3

For the third episode of "The Industry Insider", we had the distinguished speaker Ms. **Namrata Mehta** from "Strokes by Namrata Mehta" which is a designer brand for tableware, handbags and more started in 2020. The podcast was conducted on 28th April 2023 and provided an insight into the journey of her business. She emphasized on the aspect of "personal branding" as one of the key features in the development of her company. She shared valuable lessons about managing the company through her enormous experience. Her encouraging story of her designer handbags and cups venture, inspired the viewers on entrepreneurship.



Rishabhraaj

Industrial Visits



BHARATIYA VIDYA BHAVANS
SARDAR PATEL INSTITUTE OF TECHNOLOGY
MUNSHI NAGAR, ANDHERI (WEST), MUMBAI - 400 058
AUTONOMOUS INSTITUTE AFFILIATED TO MUMBAI UNIVERSITY



The Industry Insider #4

The last session of the Podcast series was conducted on 28th May 2023 with **Mr. Biren Parekh**, Director CRISIL Limited, Fintech Thought Leader, Angel Investor - 13x Startup and a distinguished person in the field of Management and Fintech. Dr. Biren spoke on Banking, Financial Services and Insurance (BFSI), the skills required to be a project manager, the interesting space of Digital Payments and integrating the same with the banking sector. Mr. Biren talked about Angel Investing and of the few different startups that he sees as upcoming and revolutionary. Mr. Biren additionally gave his input about building and making startups as well as the problems faced by today's startups and the impact of angel investment in the startup field as well as an insight into the corporate field of startups and banking. The Business Tip of the Day given by Mr. Biren Parekh was that of going the extra mile as a student and a professional.



S. Braudhai

Industrial Visits



BHARATIYA VIDYA BHAVANS
SARDAR PATEL INSTITUTE OF TECHNOLOGY
MUNSHI NAGAR, ANDHERI (WEST), MUMBAI - 400 058
AUTONOMOUS INSTITUTE AFFILIATED TO MUMBAI UNIVERSITY



Entre-View:

The NISP Council at S.P.I.T. organized Entre-view with a pre-event on 27th May 2023 and the main event on 3rd June 2023.

The pre-event provided participants invaluable insights into resume building and effective preparation for various corporate contexts.

The main event comprised two engaging parts. The first part entailed a Pitching round, designed to inspire young individuals with an entrepreneurial mindset. The second part focused on the Interview round, aimed at preparing participants for high-demand roles in industries such as technology, finance, and financial technology.

By integrating these elements, Entre-view provided a comprehensive platform to foster entrepreneurship and equip young individuals with the skills and knowledge necessary for prosperous careers in the industries.



Industrial Visits



BHARATIYA VIDYA BHAVANS
SARDAR PATEL INSTITUTE OF TECHNOLOGY
MUNSHI NAGAR, ANDHERI (WEST), MUMBAI - 400 058
AUTONOMOUS INSTITUTE AFFILIATED TO MUMBAI UNIVERSITY



Committee Members:

Darshini Kadme - Chairperson
Kshiteej Kakirde - Vice-Chairperson
Uthkrisht Narayan - Vice-Chairperson
Awani Khodwe - Head of Events
Aarya Patil - Head of Operations
Amey Agarwal - Technical Head
Mahesh Patil - Technical Head
Saanya Kadam - Head of Finance
Aditya Agrawal - Head of PR
Ronak Matolia - Head of PR
Neha Adhikari - Head of Creatives
Devam Gosalia - Head of Subcom
Kris D'costa - Head of Subcom



Workshop on Cutting edge technologies



SARDAR PATEL INSTITUTE
OF TECHNOLOGY

DEPT.CSE MCA

"A SEMINAR ON CUTTING-EDGE RESEARCH
AND CURIOUS DISCOVERIES."

6TH OCT , 2023



Rananjay Kulkarni





Bharatiya Vidya Bhavan's
SARDAR PATEL INSTITUTE OF TECHNOLOGY
Munshi Nagar, Andheri (W), Mumbai – 400 058.
(Autonomous Institute Affiliated to University of Mumbai)

PEER TEACHING METHODOLOGY FROM SENIOR STUDENTS

Subject Name: Object Oriented Programming

Class: 3rd Sem Information Technology

Academic Year: 2018-19

Taken By: Prof. Swapnali Kurhade

Mini projects serve as crucial milestones in engineering curricula, allowing students to apply theoretical knowledge to practical scenarios. However, students may face challenges in project implementation due to the complexity of technical concepts. Peer teaching offers a solution by enabling experienced students to share their knowledge and skills with peers, thereby enhancing overall learning outcomes. Students from Final year helped second year students by demonstrating various JAVA projects.

Mini Projects: Mini projects given to students where they got exposure of topic beyond syllabus i.e using JDBC, SQL, Swings, Java FX etc. This helps in exploring the subject. Final Year Engineering students helped second year engineering students by demonstrating the various projects.



Peer Teaching in terms of fast and slow learner

Animation and Graphics Lab
Fast Learner Activity

Learner: Nitin Thopate

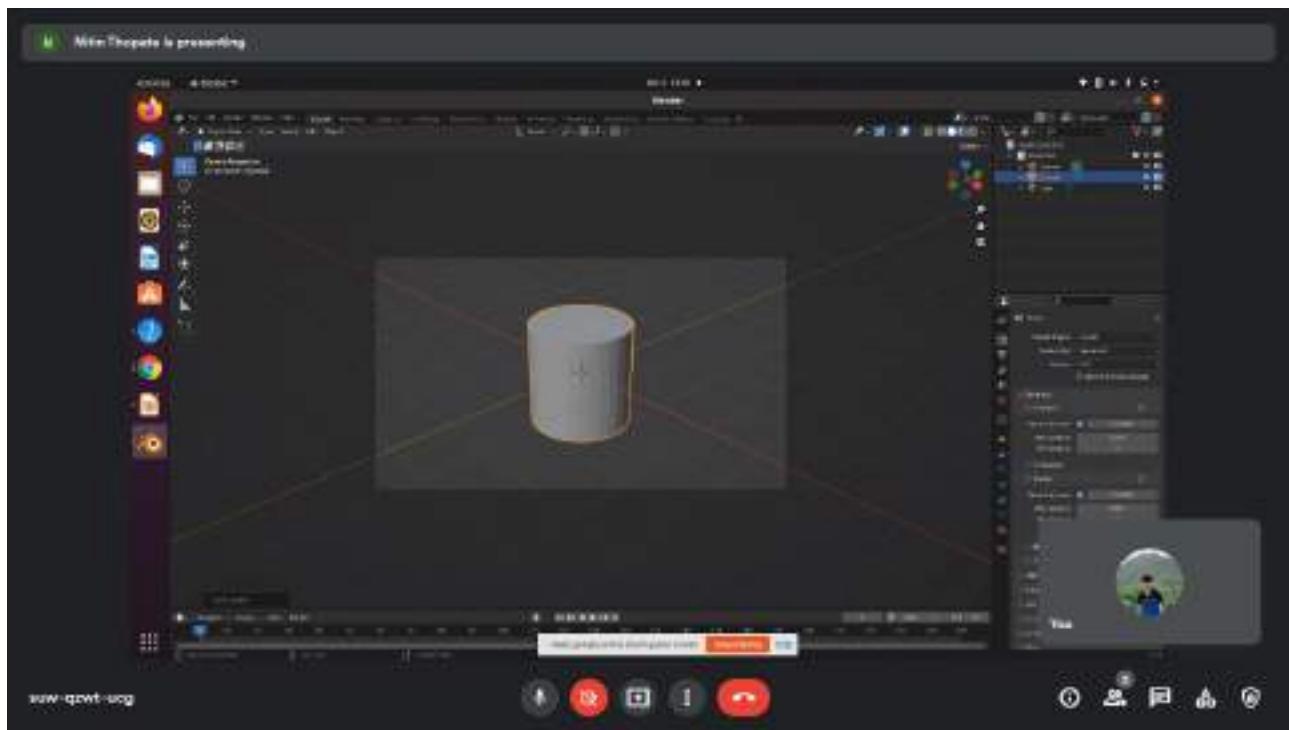
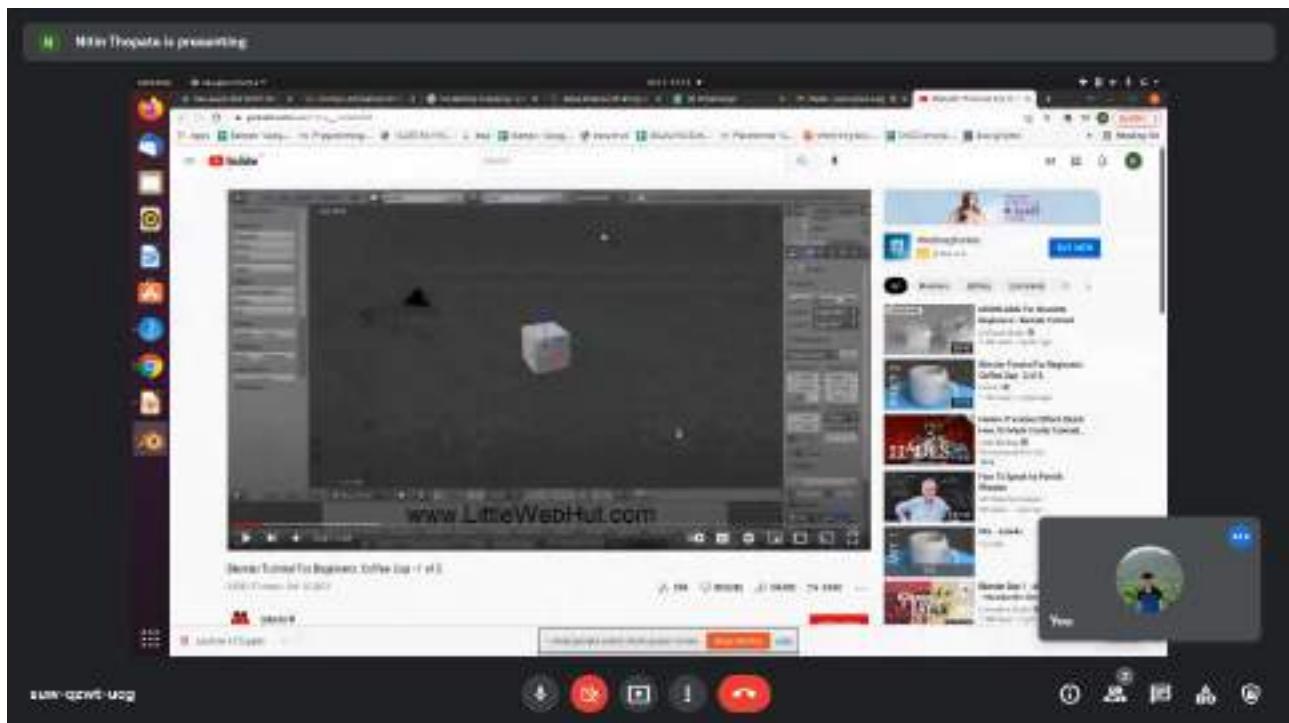
Facilitator: Nikhil Suwalka

Meet Link: <https://meet.google.com/suw-qzwt-ucg>

Video Link:

<https://drive.google.com/file/d/1f9CZJ0-r2OnUL-7GdANrmUGMyuBNFGdI/view?usp=sharing>

Screenshots:

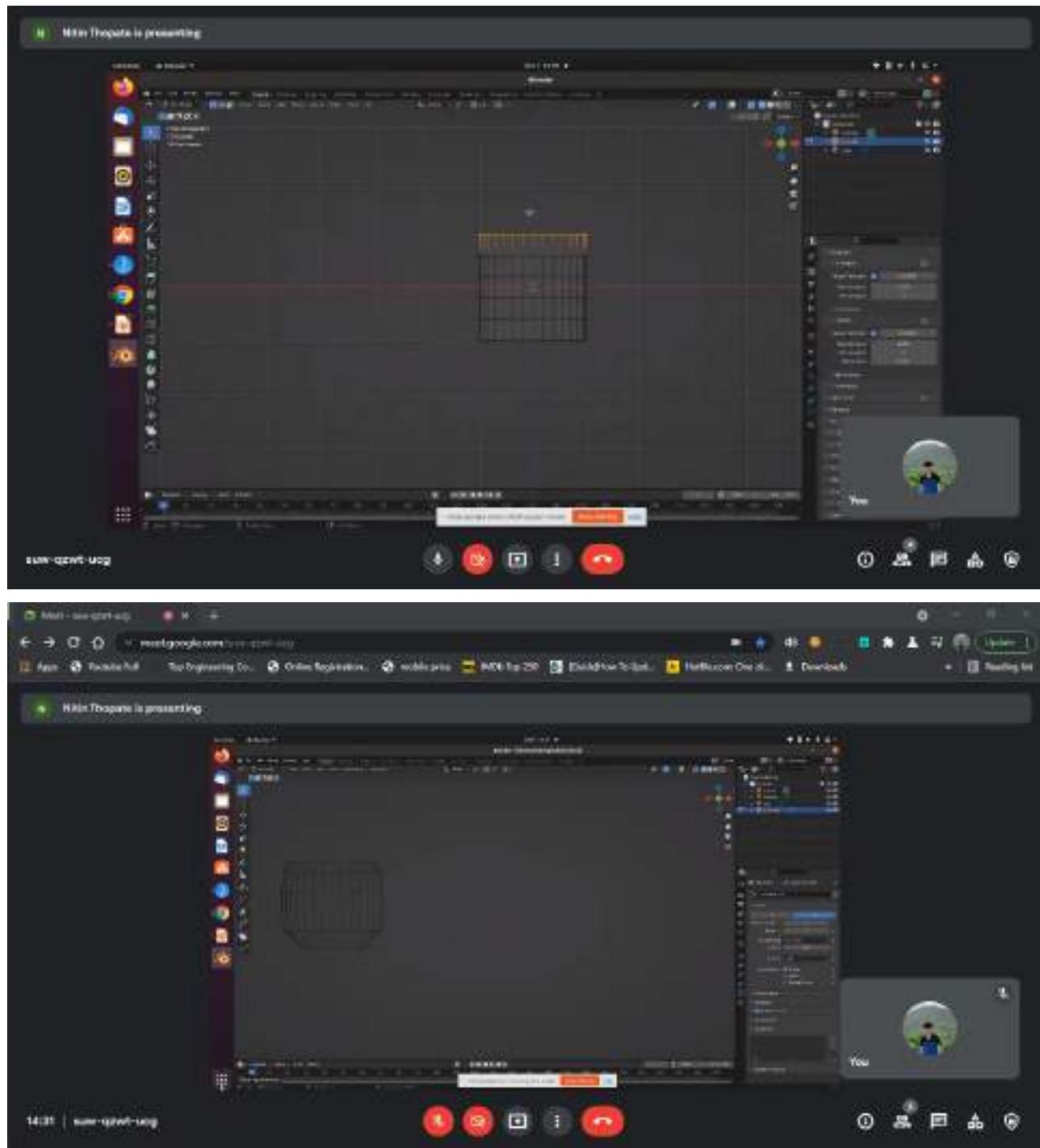


S. Bhraudhaji



Peer Teaching in terms of fast and slow learner

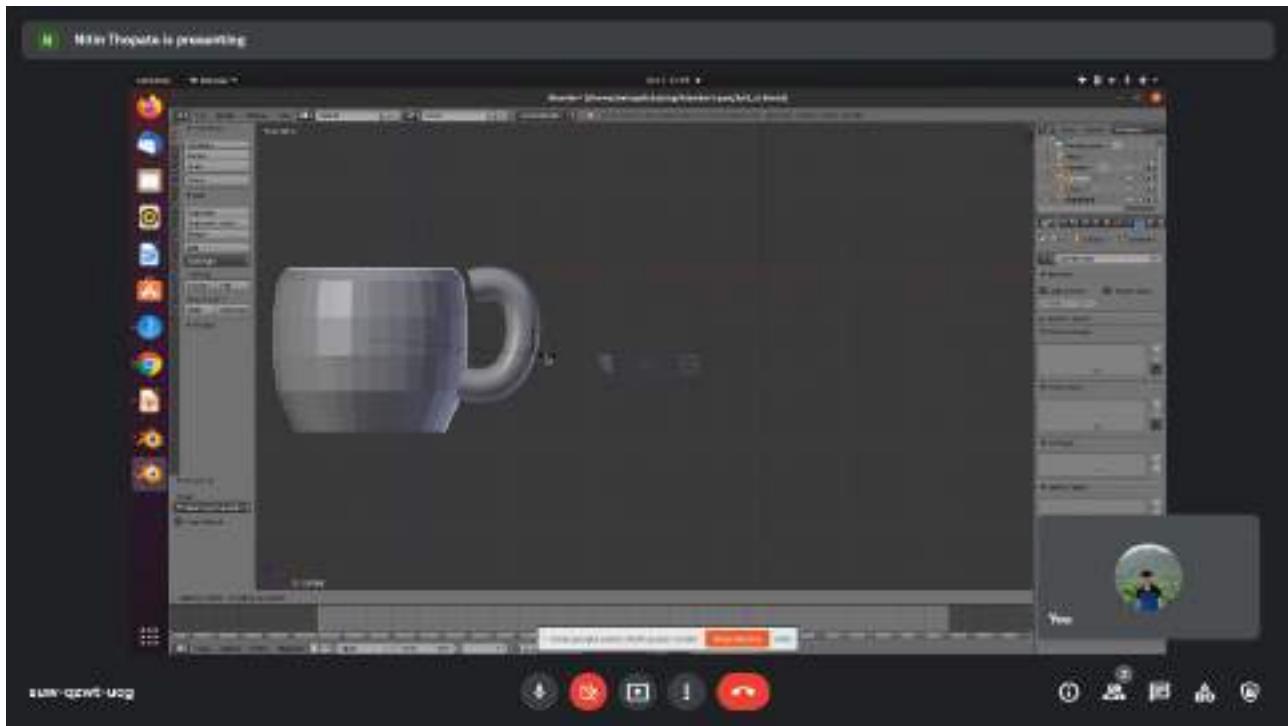
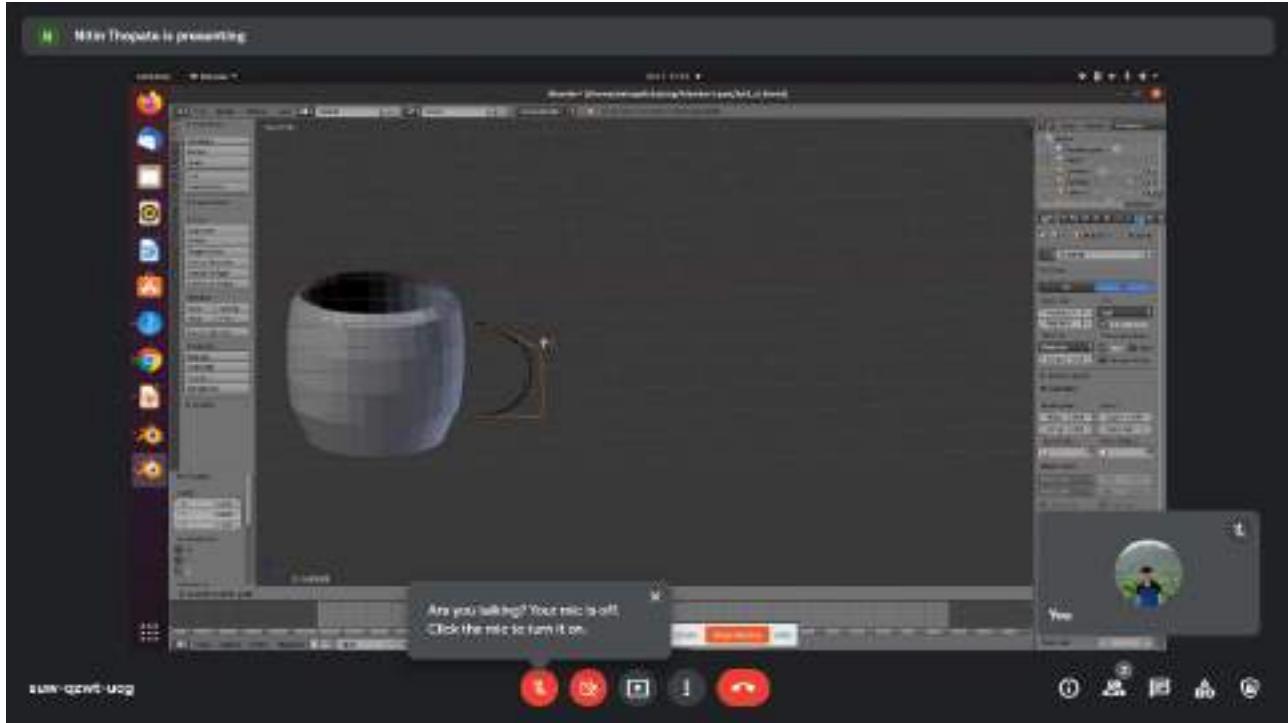
Animation and Graphics Lab
Fast Learner Activity



S. Shaudhayi

Peer Teaching in terms of fast and slow learner

Animation and Graphics Lab
Fast Learner Activity

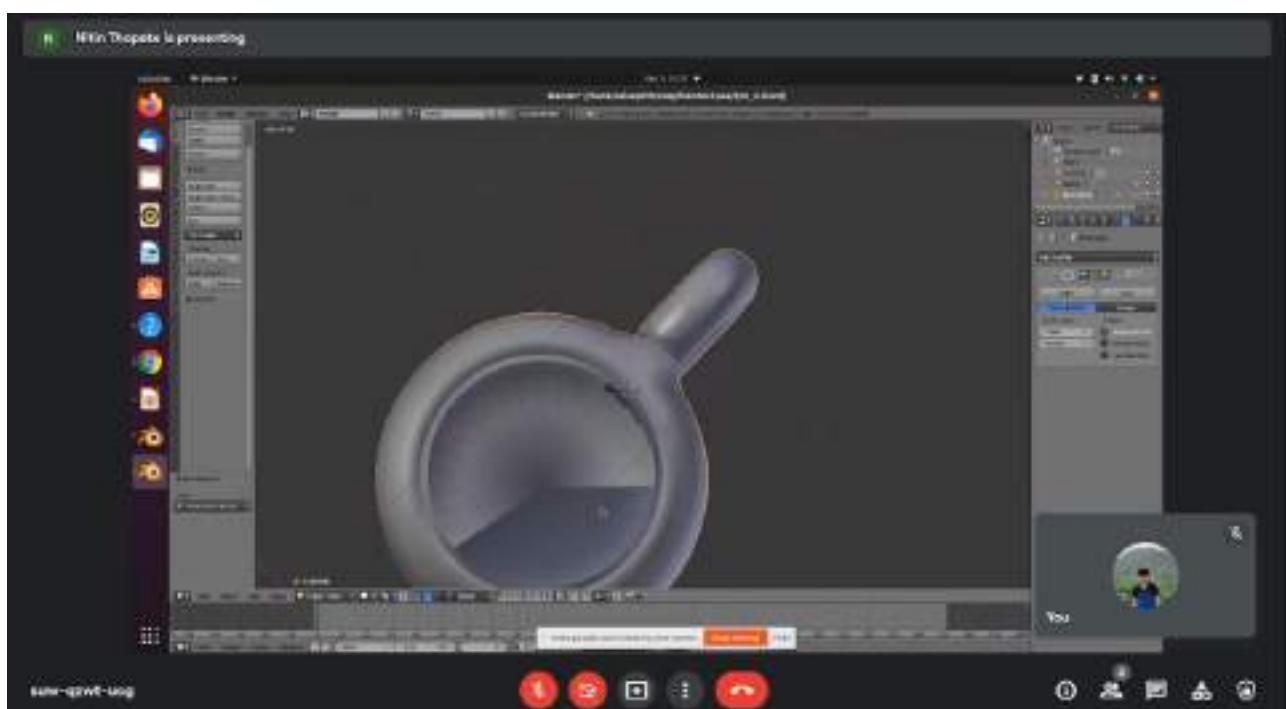
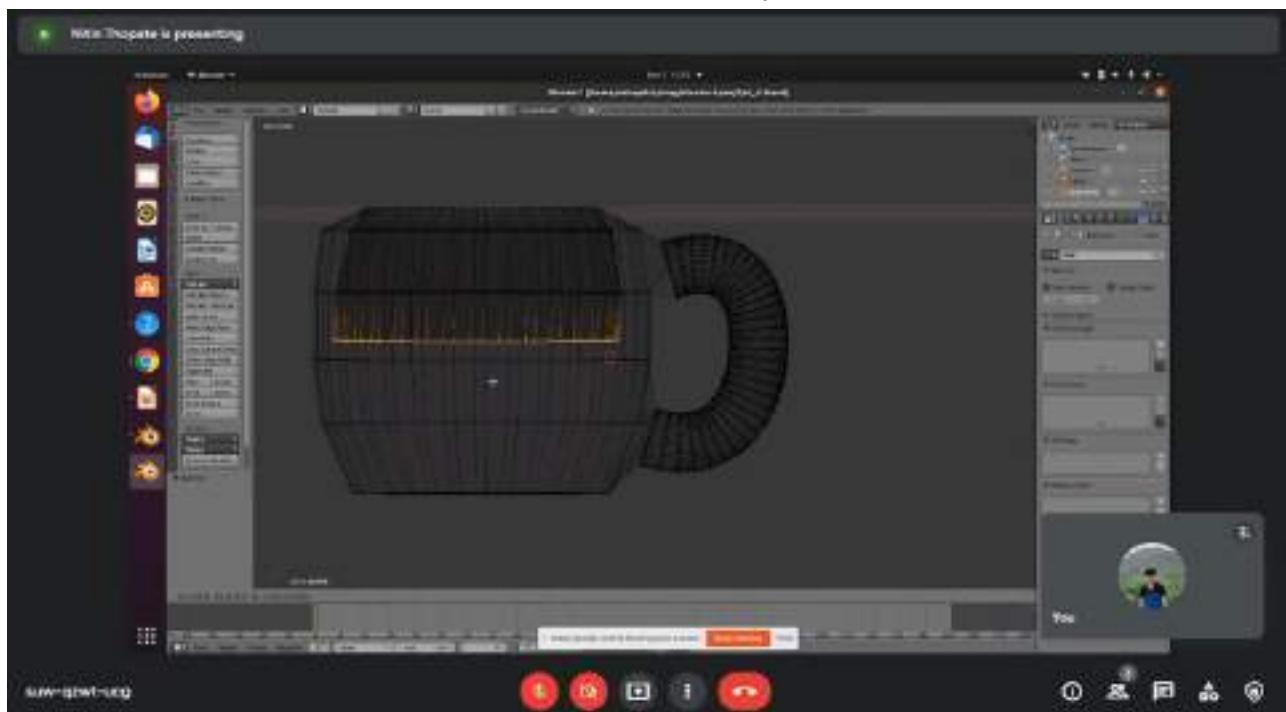


S. Bhaudhari

Peer Teaching in terms of fast and slow learner

Animation and Graphics Lab

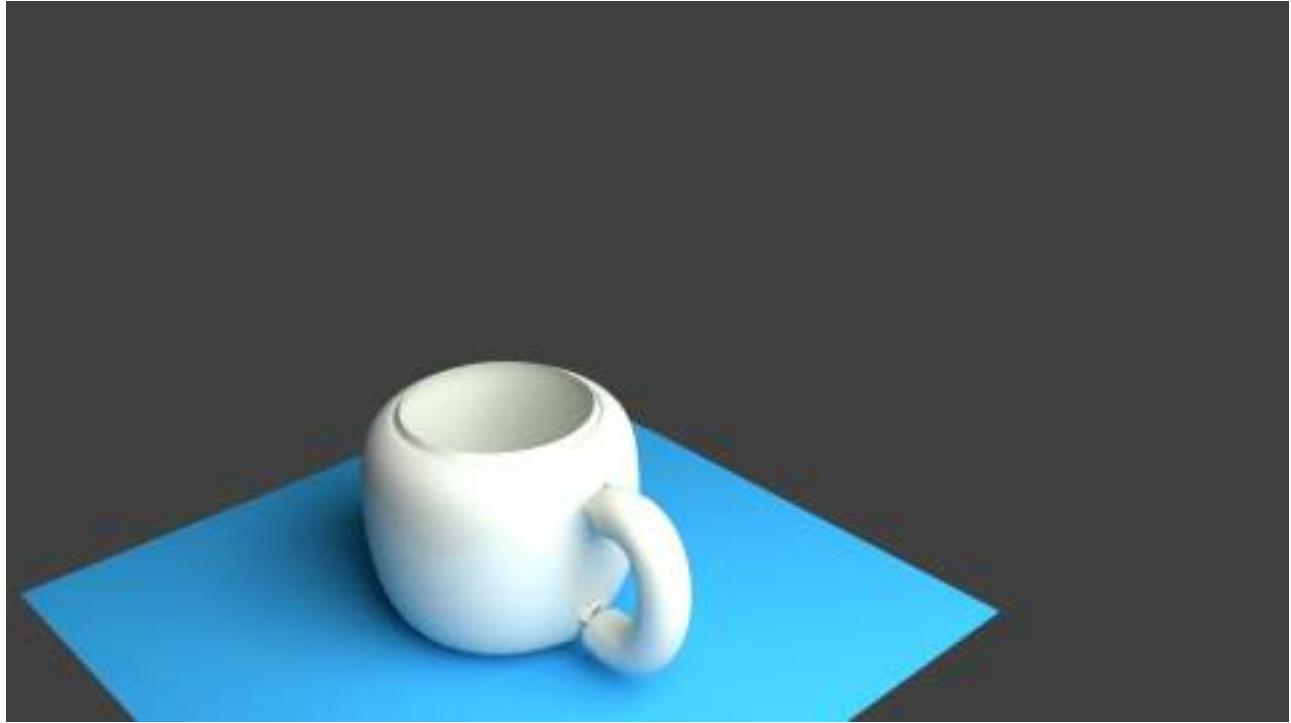
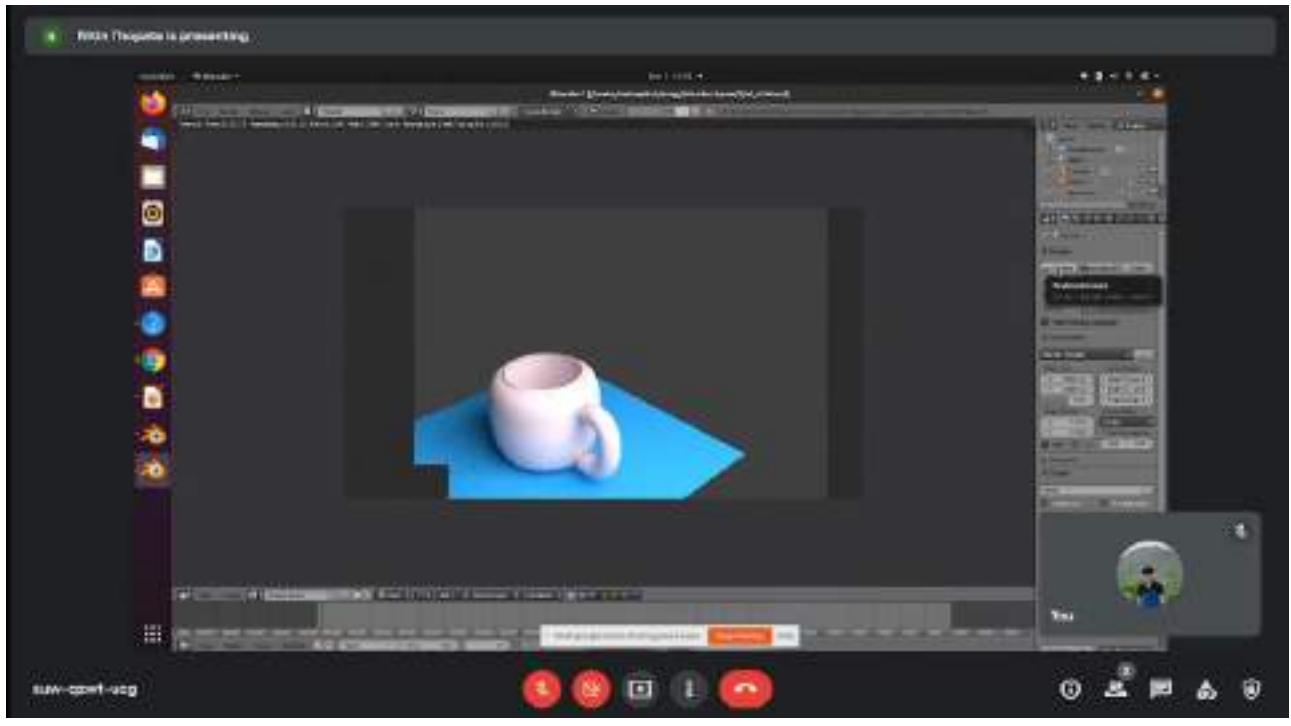
Fast Learner Activity



S. Shandhar

Peer Teaching in terms of fast and slow learner

Animation and Graphics Lab
Fast Learner Activity



Signature



Peer Teaching in terms of fast and slow learner

Fast Learner

Subject: GA

Sem: V

Class: T.Y.MCA

Subject In-charge: Prof. Sakina Shaikh

Name : Nisarg Patil

UCID : 20194500391

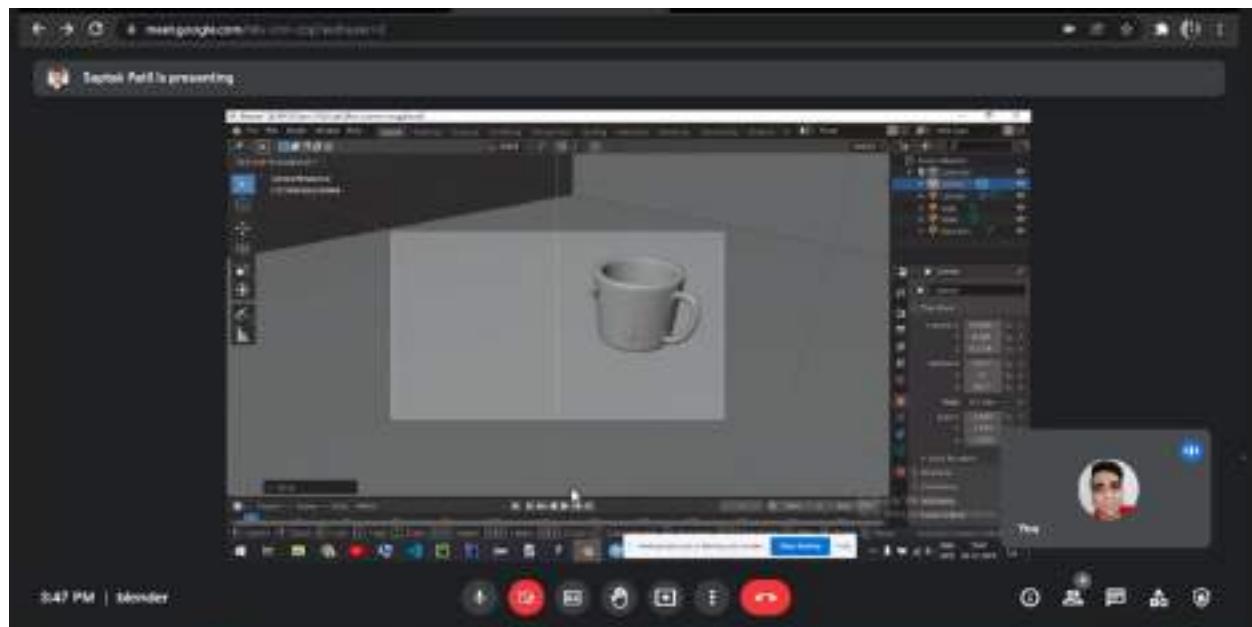
Group :

2019450040	Saptak	Patil	2019450037	Vishal	Parab
2019450019	Siddhesh	Gurav	2019450039	Nisarg	Patil

Meet Link : <https://meet.google.com/hkv-znir-zop>

Recorded Video Link: [Recorded session Link](#)

Screenshot of the Meet:



A handwritten signature in black ink that reads "Sakina Shaikh".

Winners of Sculpting Task are as follows:

1st Place: Akash Singh (16 Votes)

2nd Place: Vishal Parab (9 votes)

3rd Place: Jayesh Marathe (7 votes)

Peer Teaching in terms of fast and slow learner

Congratulations to all the Winners!!!!

Winner for Experiment 8 (Running race of Glossy and Transparent Glass Balls)

Winner List For Balls Racing Task

Winners of Balls Racing are as follows:

1st Place: Vishal Parab (17 Votes)

2nd Place: Manish Jha (14 votes)

3rd Place: Pranav Soneji (9 votes)

Congratulations to all the Winners!!!!

Task for Slow Learner and Fast Learner

Task:

Each Slow Learner (Learner) will be associated with Fast Learner (Facilitator). Fast Learner is suppose to teach slow Learner an activity given. The Activity has to be taken through google Meet and the session has to be recorded.

A Report has to be submitted by the Fast Learner which will have meet link, Recorded Video Link, Screenshot of the Meet.

Slow Learner has to upload the rendered image, Blend File and their experience of Learning (in short paragraph) it through the Fast Learner.

Following are the groups:

Learner	Facilitator
2019450002 Mangesh Bachhe	2019450020 Manish Jha
2019450005 Siddharth Bhalerao	2019450050 Nishit Shanbhag
	2019450015 Karan Gandhi
2019450040 Saptak Patil	2019450037 Vishal Parab
2019450019 Siddhesh Gurav	2019450039 Nisarg Patil



2019450041	Sucheta	Patil	2019450053	Ketaki	Shinde
2019450043	Onkar	Pawar	2019450055	Pranav	Soneji
			2019450059	Jay	Visave
2019450018	Amar	Gurav	2019450046	Ayush	Sah
	Nitin	Thapate	2019450056	Nikhil	Suwalka

Task:**Create a Mug with giving effects:**

-  Slow Learner Activity Submission
-  Fast Learner Activity Submission

Grade Report Submission

Kindly Upload your Grade Report

-  Grade Report Submission

 Moodle Docs for this page

You are logged in as sakina shaikh (Log out)

[Home](#)

[Get the mobile app](#)



Welcome to Artificial Intelligence & Deep Learning Lab @S.P.I.T.

Get started with exciting experiments to enrich your knowledge

Objectives



Boost enthusiasm

Through this lab we aim to foster learning. To enthuse students to conduct experiments by the arousing their curiosity. This

Remote-access to Labs for everyone

To provide remote-access to Labs in various disciplines of Science and Engineering. These

Complete Learning Management System

To provide a complete Learning Management System around the Virtual Labs where

Virtual Lab at S.P.I.T.

would help them in learning basic and advanced concepts through remote experimentation. And help the student try and innovate things.

Virtual Labs would cater to students at the undergraduate level, post graduate level as well as to research scholars (everyone).

the students can avail the various tools for learning which will help in animated demonstrations and self evaluation.

AI-DL Virtual Labs

Learning algorithms effectively and virtually!

[Home](#)[About](#)[Team](#)[Experiments](#)[Contact Us](#)

Sardar Patel Institute of Technology

Product Development Center (PDC@SP-IT)

Simulation Centre at S.P.I.T.

Dear Students,

Sub: internship at PDC@SP-IT

Greetings from Sardar Patel Institute of Technology Product Development Center (PDC)!

We hope and pray that all is good with you and your family during this difficult time, as the global COVID-19 pandemic is still peaking around many countries.

Product Development Centre at SP-IT is a zone for innovation, where students under the guidance of senior faculty develop products that have world-changing potential using world-class equipment and software, with backing from the industry for research and development.

We provide mentorship from our senior faculty, consisting of Prof. Y. S. Rao, Prof Rajendra Sawant, and others who have tremendous experience in industry-backed research and a vast portfolio of published papers. Students can also opt to work with startups under SP-TBI or assist external industry experts in their research work. Students also gain access to connections within the electronics industry, a chance to network with like-minded seniors and alumni, and permanent access to the PDC premises along with a certificate to back the work, they have done with us.

Since the PDC undertakes projects which are multidisciplinary in nature, there is no restriction regarding the branch of students who wish to join.

We are happy to announce that once again we are offering the internship program at Sardar Patel Institute of Technology Product Development Center. Looking at the COVID-19 pandemic situation this time we are conducting an online one-month training program from 21st August 2021 onwards, with the "hands-on session" on live online products.

Summer Internship program covers in-depth session of:

1. online theory session taught by experts
2. online learning material
3. virtual lab - remotely write/test/debug code on our lab hardware!

Internship program hands-on session of:

Software & Hardware development and testing on industrial products being developed at the PDC.

We take the pleasure of inviting you to participate in this unique training program conducted by various industry experts.

Look forward to the pleasure of meeting and interacting with you in this training program



Sardar Patel Institute of Technology Product Development Center (PDC@SP-IT)

For Registration:

https://docs.google.com/forms/d/e/1FAIpQLSdMDoc0jm0y_axT9O-7Ofsv4_6bLrZNBYs2nDj6PDPGsbl_0A/viewform

Simulation Centre at S.P.I.T.

Training program is on the following Topics:

- I. Introduction to Software and hardware design, Real-time systems, Minimum system design, Embedded "C" Programming.
 - Virtual lab session on Embedded "C" Programming
- II. Soft computing techniques for real-time systems
- III. Digital signal processing in Real-time
- IV. Hardware system Design for Arduino Platform
 - Virtual lab sessions on Peripherals, Sensors and Closed loop control system
- V. IoT Protocols
 - Virtual lab sessions on IoT Protocols and Cloud based applications
- VI. dsPIC Microchip Architecture, Industrial applications and System Design
 - Virtual lab on Peripherals and Industrial Programming Examples
- VIII. Texas DSP TMS 320x28335/28069 Single chip Architecture, Industrial applications and System Design
 - Virtual lab on Peripherals and Industrial Programming Examples

Other Benefits:

1. Participants will be evaluated from time to time and get a Participation Certificate.
2. Industrial visits (In December)
3. Free Rs 10,000/- worth virtual lab hardware setup
4. Internship 2 to 6 months @ PDC
5. Network with like-minded people

Who should apply:

- ❖ The program is open to all the engineering college students, research scholars, and other working professionals.

Prerequisites: Anyone programming language

Participant Registration Fee:

- ❖ For S.P.I.T students Registration Fee is Rs. 10,000/- + 18% GST per Attendee
- ❖ For other students Registration Fee is Rs. 15,000/- + 18% GST per Attendee

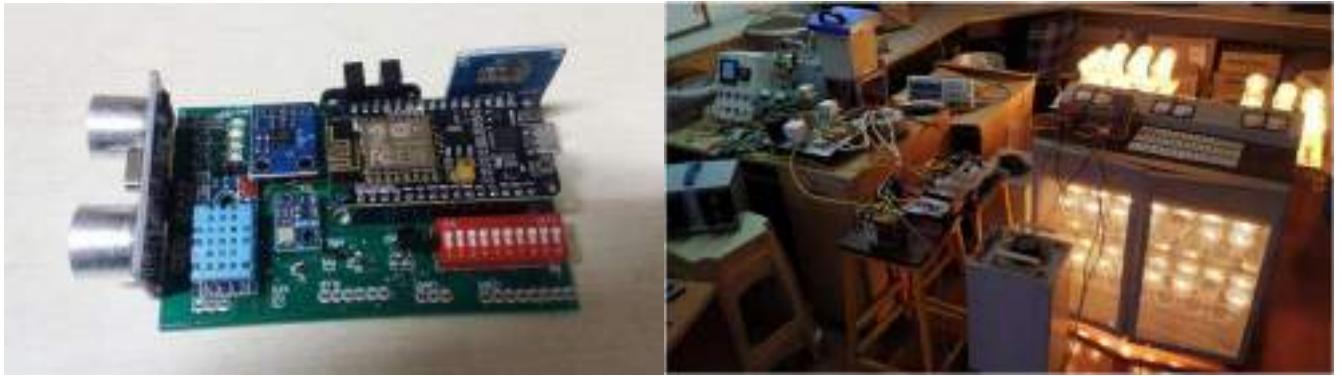


R. Shaudhay

Simulation Centre at S.P.I.T.

Sardar Patel Institute of Technology

Product Development Center (PDC@SP-IT)



Payment Account Details:

A/C No: 876819488
IFSC: IDIB000B092
SP-IT Allied Division,
Indian Bank, Bhavans Campus,
Andheri-W, Mumbai-58

Contact:

Dr Y S Rao
ysrao@spit.ac.in
9820962870 / 9137692917



Sardar Patel Institute of Technology
Product Development Center (PDC@SP-IT)
Simulation Centre at S.P.I.T.
PDC@SP-IT



A handwritten signature in black ink, which appears to read "Rehauddin".

Simulation Centre at S.P.I.T.

Sardar Patel Institute of Technology

Product Development Center (PDC@SP-IT)



A handwritten signature in black ink that reads "Ela Bhattcharya".

Simulation Centre at S.P.I.T.

Sardar Patel Institute of Technology

Product Development Center (PDC@SP-IT)

A handwritten signature in black ink, appearing to read "Anil Patel".

Seva Satva and Activity Based Learning curriculum



Bharatiya Vidya Bhavan's
Sardar Patel Institute of Technology

(Autonomous Institute Affiliated to University of Mumbai)
[Knowledge is Nectar]

Liberal, Pi-Model of Engineering Education @ SPIT (Department of Computer Science & Engineering[DS])

CURRICULUM SCHEME FOR UNDERGRADUATE ACADEMIC PROGRAM (COMPUTER SCIENCE & ENGG[DS]) AT SPIT

(For 2021-2025 Batch)

Salient Features

- 160-Credit **Liberal** Engineering Education Model.
- A strong **program core of 15 courses** and **6 baskets of program electives** to ensure the breadth and depth in a chosen domain of studies. Program electives are arranged either to grow in a specified vertical or have diversified exposure.
- **Full semester industry internship to interested students.**
- Aggressive model of “**Learning-by-doing**”. (Engagement in classroom and laboratory sessions is 50:50)
- Special tracks for “**Minor**” Certification for interested learners, ensuring significant awareness of additional discipline leading to multiple specializations
- **Unique, multi-track model of “Honors” Certification**, for well performers for enhanced depth in the domain of study.
- Special sequel of optional **industry floated “SCOPE”** courses (Skilled Certification for Outcome-based Professional Education) for interested learners, ensuring high technical skills, in the diversified cutting-edge technologies.
- **First-of-its-kind-in-education** blend to Engineering Curriculum. “**ABLL@LLC**”® (Activity Based Liberal Learning about **Life, Literature and Culture**) in **Six** semesters, ensuring **all dimensional holistic growth** of the learner. These eight activity based mini courses are offered as two sequels namely “**SEVA**”®(Social Empowerment through Various Activities”, and “**SATVA**”® (Self accomplishment through various Activities).


This curriculum aims at development of an **all-rounded** personality. It follows **holistic** approach of education, ensures strong science, mathematics foundation and program core, develops expertise in domain vertical though sequel of electives, ensures significant exposure of additional discipline through “**Minor**” program, collaborates



Seva Satva and Activity Based Learning curriculum

outside world for the imparting relevant skills through “SCOPE” courses, challenges good learners through “Honors” evaluation, and systematically develops soft skills, and social, physical, mental, spiritual personality through carefully articulated **Liberal Learning** and **Humanities** sequels. Thus, offers a unique, liberal “**Pi-Model**” of Engineering Education.

Program Core

At SPIT, every undergraduate program consists of **Twelve Core Courses** referred to as Program **Core**. Several academic models from reputed institutions in the country and outside the country are studied in articulating this Program Core, to make curriculum Globally Competitive. All courses in this Core have laboratory components to augment the learning. Each program core course has an additional optional component of “Contents beyond the curriculum” which is carefully designed to ensure additional 15-20 hours engagement of the learners. The learner thus is nurtured towards the “Self-Learning” and “lifelong learning” which are essential attributes of 21st Century learner.

Program Electives

At SPIT, every program has **Six baskets** of Program Electives, each basket having a minimum 3 courses. This enables learners to grow in a **domain-specialization** or **domain-vertical**. For example, learners can graduate with B.Tech Electronics with a vertical in “Embedded Systems” or “VLSI” or “Signal Processing”. Or a learner can graduate with B.Tech Computer Science and Engineering with specialization in “Security” or “ML & AI” or “Computer Networking” or “Data Science”. At the same time, a learner can increase her bandwidth by opting for elective courses which are general in nature, not pointing out towards a specific vertical.

Open Electives

Every undergraduate program has three baskets of open electives. This is planned to give exposure to interdisciplinary and cross disciplinary domains. The courses in these baskets are planned both at department and institute level. Students can choose any combination of these courses (not floated by the parent department) to get familiar with other domains of learning. One of these open electives must be chosen from Basic science courses or Engineering Science courses. **This unique approach of offering additional basic science or engineering science elective at senior level aims at appreciating the importance of other domains of learning.**

Humanities and Social Science Electives

National Education policy 2019 has aptly spelled out the necessity of Humanities in Professional Education. It quotes, “A holistic and liberal education as described so beautifully in India’s past is indeed what is needed for the education of India in the future to truly lead the country into the 21st century and the fourth industrial revolution. Even engineering schools such as the IITs must move towards a more liberal education integrating arts and humanities”. Every program at SPIT has three baskets of humanities. Learners are encouraged to take diversified courses in the field of languages, law, history, economics, management, finance etc.



Seva Satva and Activity Based Learning curriculum

SCOPE Certification

This unique sequel is designed to systematically develop skills required for an industrial sector. SPIT is partnering with various industries to offer the high-end skills required for a specific industrial sector. Well performing students can stretch the envelope and add a new dimension to their Professional Personality by earning this certification. There are multiple tracks for SCOPE certification. Each track is offered with partnership with a reputed institution or industry. These tracks are jointly designed by SPIT and partnering industry. Each track has four courses (modules). Each module/course is of 2-3 credits including laboratory components for most of the tracks. These tracks are also open for outside learners, leading to Certificate Program in a chosen domain.

Minor Certification

This additional and optional certification provides an opportunity to learners to develop the learners in the additional domain of interests. It broadens the education and ensures the multi-disciplinary development which is an essential attribute of 21st century engineers. However, this is optional. Well performing students can stretch the envelope and add a new dimension to their Professional Personality. Each track for this minor certification is offered either by SPIT or with partnership with other reputed institutions. Each track has four courses (modules). Each course is of 3 credits and laboratory components if any. These tracks are also open for outside learners, leading to a Certificate Program of 12 credits in a chosen domain.

Honors Certification

While the Minor and SCOPE certifications aim at adding an additional professional dimension to the professional personality of the learners, the Honors certification gives opportunity to well performing learners to drive deep in the chosen field of study. Multiple plans/ways are planned to encourage learners to earn this certification which essentially excite the learners to push an envelope and go extra/deep in the chosen area of the study. Students earn additional stars (*) as shown in Table 1 during their program. If at the time of graduation a student earns total **TWELVE** stars, she is conferred with “Honors” certification.



Activity Based Liberal Learning about Life, Literature and Culture (ABLL@LLC)

“Education will fail ignominiously in its objective if it manufactures only a robot and called him an economic man stressing the adjective economic and forgetting the substantive man. A university cannot afford to ignore the cultural aspects of education whatever studies it specializes in. Science is a means, not an end. Whereas culture is an end in itself. Even though you may ultimately become a scientist, a doctor, or an engineer, you must, while in college, absorb fundamental values which will make you a man of culture...”

Kulpati Dr. K. M. Munshi

How aptly our visionary founder has given direction to the education. His wisdom towards education inspires, encourages us to experiment in the field of education, to make it as relevant and helpful to the society as possible. Mahatma Gandhi once quoted, *“By education I mean an all-round drawing out of the best in man; body, mind and spirit.”*

Recently announced National Policy on Education-2019, reconfirms this and profoundly stresses the need of liberalizing the higher education including professional education. It quotes, *“Higher education must develop good, well-rounded and creative individuals, with intellectual curiosity, spirit of service and a strong ethical compass”*. Moving towards a more liberal undergraduate education is one of the most important features of this policy. It narrates, *“The needs of the 21st century require that liberal broad-based multidisciplinary education become the basis for all higher education. This will help develop well-rounded individuals that possess critical 21st century capacities in fields across arts, humanities, sciences, social sciences, and professional, technical, and vocational crafts, an ethic of social engagement, and rigorous specialization in a chosen field or fields. Such a liberal education would be, in the long run, the approach across all undergraduate programs, including those in professional, technical, and vocational disciplines. Imaginative and flexible curricular structures will enable creative combinations of disciplines for students to study, thus demolishing currently prevalent rigid boundaries and creating new possibilities for lifelong learning. The notion of ‘knowledge of many arts’- i.e. what is called ‘liberal arts’ in modern times – must be brought back to Indian education, as it is exactly the kind of education that will be required for the 21st century.”*

We at Bhavan’s SPIT, make sincere attempt to blend engineering education appropriately with arts, humanities, crafts, ethic of personal and social engagement to ensure holistic development of the learner. We have carefully designed liberal learning courses covering Life, Literature, and Culture (LLC @ LLC) for all the semesters of the program. Learner concurrently studies these courses. These courses broadly fall under two groups, namely “SEVA (Social Empowerment through Various Activities)” and “SATVA (Self Accomplishment through Various Activities)”. Each of these groups, has four modules as indicated in Table 2 and Table 3. Further each module has multiple courses of 1 or 2 credits (An engagement of 35-40 hours is expected to earn one credit). Every learner at SPIT is expected to take 1 such course on LLC every semester. We strongly believe that these EIGHT liberal learning modules will help us to appropriately blend the professional education as envisaged by the National Policy Makers.

OEHXX	Management Principles
OEHXX	Research Methodology
OEHXX	IPR and Patents
OEHXX	Law for Engineers
OEHXX	Organizational Behavior
OEHXX	Leadership, Innovation and Entrepreneurship
OEHXX	Project Management
OEHXX	Finance for Engineers
OEHXX	Any course approved by Dean Academics and Principal

Humanities and Social Sciences Electives

Special Tracks

	HSSE-I		HSSE-II		HSSE-III
HSE11	Law for Engineers-I	HSE12	Law for Engineers-II	HSE13	Law for Engineers-III
HSE21	Finance for Engineers-I	HSE22	Finance for Engineers-II	HSE23	Finance for Engineers-III
HSE31	Psychology-I	HSE32	Psychology-II	HSE33	Psychology-III
HSE41	Economics-I	HSE42	Economics-II	HSE43	Economics-III
HSE51	Ancient India	HSE52	Medieval India	HSE53	Modern India
HSE6X1	Language X-I	HSE6X2	Language X-II	HSE6X3	Language X-III



Common Pool for HSSE-I, II and III (May be studied on MOOC's)

HSEC01	Film Appreciation	HSEC02	Universal Values
HSEC03	Game Theory	HSEC04	Human Behavior
HSEC05	Ecology and Society	HSEC06	Energy Economics and Policies
HSEC07	Drama Appreciation	HSEC08	Political Ideologies
HSEC09	Justice	HSECXX	Any other Approved Course
HSEXX	Any course from HSSE-I		

ABLL@LLC

- Students are required to earn 6 credits through 8 semesters.
- If student is not able attendance/performance requirements, he/she will be dropped from the course and will have to enroll in additional course in the next semester.
- A student can enroll in maximum 2 courses in a semester.



Table 2: SEVA**SEVA (Social Empowerment through Various Activities)**

Module	Title	Courses	CODE
SEVA-I	SOCHO BHARAT	Study of Green & White Revolutions in India	SV10
		Government Missions [Study of any 2]	SV11
		Study of India's top 2 problems	SV12
		Study of World's top 2 problems	SV13
		How Government Works? [Study of one department of the Central/ State Government]	SV14
		Study of one of the identified Books	SV15
		Study of two National policies	SV16
		Any other activity approved by Dean Academics	SV1X
Module	Title	Courses	CODE
SEVA-II	SWACCH BHARAT	River/Beach/Mohalla/School/Campus/Govt offices Cleaning	SV20
		Waste Segregation Surveys	SV21
		NSS camp in village for a week	SV22
		Medical camps in schools	SV23
		First Aid training for a week	SV24
		Surveys and Estimation for roof top solar	SV25
		NCC participation	SV26
		Any activity approved by Dean Academics	SV2X
Module	Title	Courses	CODE
SEVA-III	SHIKSHIT BHARAT	Mentoring of School Children	SV30
		Digital Literacy for yielders	SV31
		Value addition for deprived schools	SV32
		Mentoring junior (first year) students at SPIT	SV33
		Teaching Assistantship at SPIT	SV34
		Development of learning material for schools/ITIs	SV35
		Participation in "Teach-for-India" movement	SV36



		Any other activity approved by Dean Academics	SV3X
Module	Title	Courses	CODE
SEVA-IV	SAMRUDDHA BHARAT	Great Grass Root Innovations	SV40
		Innovation and Creativity	SV41
		Critical Thinking and Problem solving	SV42
		Team work and collaboration	SV43
		Leadership & Entrepreneurship	SV44
		Design Thinking	SV45
		Study of one of the identified books	SV47
		Work with START-UP at SPIT	SV48
		Any other activity approved by Dean Academics	SV49

A handwritten signature in black ink, appearing to read "Dr. Shashi Chander".



Table 3: SATVA

SATVA (Self Accomplishment Through Various Activities)

Module	Title	Courses	CODE
SATVA-I	SANSKARIT BHARAT	Values and Ethos of Bhavan	ST10
		Essence of Indian traditional knowledge	ST11
		Philosophy of religion (any)	ST12
		Study of Life Management / Kindle Life / Life Empowerment and Enriching Program or any other book cited.	ST13
		Study of any of GREAT sons of INDIA [Ex. Gandhi, Ambedkar, Phule, Savarkar, Sardar Patel, Nehru, Shivaji, JRD Tata etc]	ST14
		Any other course approved by Dean Academics	ST1X
SATVA-II	SAKSHAM BHARAT	Target based Physical Exercise for example-Running [Test 5 kms in a stretch], Swimming [Test 1 km in a stretch], Walking [Test 20 kms in a stretch], Trekking [7days], Cycling	ST20
		Sports – Representation of Institute at University level/Inter college level and above in ANY sport	ST21
		Participation in National Tech Fest, AICTE-Hackathon, Industry floated global and national competitions, Robocon, BAHA etc	ST22
		Yoga vidya -I	ST23
		Any other activity approved by Dean Academics	ST2X
SATVA-III	SUNDER BHARAT	Institute representation in prestigious cultural fests/competitions	ST30
		Dance [Bharatanatyam /Kathak /Lavani /Western Dance]. Only for beginners	ST31
		Learning musical instruments [Any type]. Only for beginners.	ST32
		Film Appreciation/Dramatics/Seeing through Painting	ST33
		Making short film/Photography	ST34



		Yogvidya-II	ST35
		Any other activity approved by Dean Academics and DOSA	ST3X
SATVA-IV	SURAKSHIT BHARAT	Food that Heals	ST40
		Personal and Social Hygiene	ST41
		Intellectual Property Rights	ST42
		Etiquette and Conversational skills	ST43
		Basics of Ayurveda	ST44
		Study of one of the identified Books	ST45
		Any other course approved by Dean Academics	ST4X



Rishabh Jain



Bharatiya Vidya Bhavan's
Sardar Patel Institute of Technology
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
(Autonomous College Affiliated to University of Mumbai)

Course: SEVA/SATVA : SV17:Study of Corona Pandemic in Maharashtra or India

Sem.: EVEN

Academic Year: 2021-2022

Mentor: Harshil Kanakia

Evaluation Pattern:

- 1) A meeting was arranged with students to inform about evaluation pattern.
- 2) Submission is taken in the form of timeline sheet,report and presentation
- 3) Evaluation is done based on presentation,timeline sheet,question answers during presentation and report submitted by the students

Following is the list of Allotted students

Student Name	UCID	Class	Branch
Yash Jadhav	2020400012	SE	IT
Ounkar Vijay Jagtap	2020400013	SE	IT
Kaival Ketan Shah	2020400047	SE	IT
AKHIL SHARMA	2020400051	SE	IT
Rishi Sodhani	2020400060	SE	IT
Durga Warrier	2020400069	SE	IT

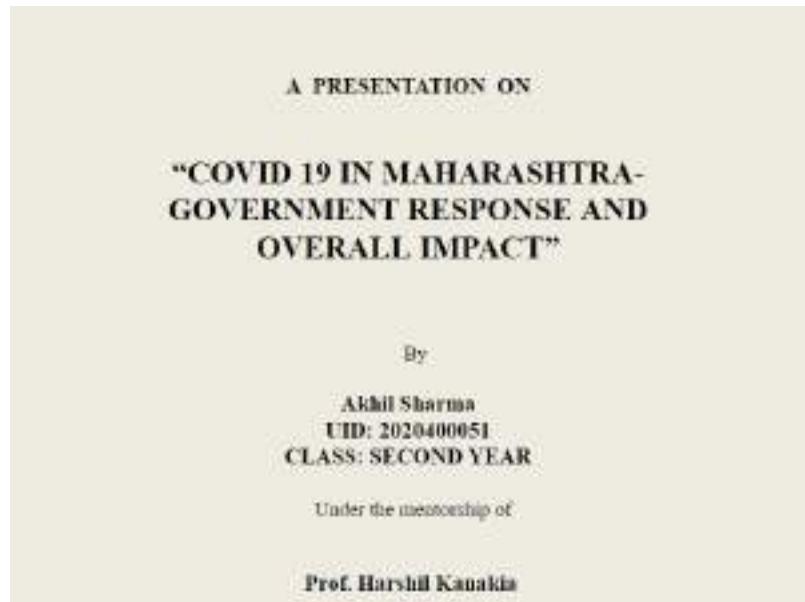
Attachment:

Sample PPT Screenshot
Sample Timeline Screenshot
Sample Report Screenshot
Evaluation Screenshot



Seva Satva Activity

Sample PPT



Sample Timeline sheet

Date	Time spent	LINK
3/12/2022	1hr	PPT Preparation of Covid Pandemic started
3/15/2022	1hr	Refer and prepare research paper on Covid 19
3/17/2022	3hr	Refer and prepare research paper on Covid 19 history
3/22/2022	2hr	Refer and prepare research paper on It's effects
3/26/2022	2hr	Refer notes
4/2/2022	1hr	Refer and prepare research paper on Maharashtra
4/9/2022	2hr	Refer and prepare research paper on Aftereffects on
4/19/2022	1hr	Refer and prepare research paper on Future after Covid 19
4/25/2022	2 hr	Writing Report of Government of Maharashtra Response
5/2/2022	2 hr	Writing Report on overall impact of Covid 19
5/14/2022	1 hr	formatting and uploading File on drive

Sample report



Akhil Sharma

Seva Satva Activity

BHARATIYA VIDYA BHAVAN'S
SARDAR PATEL INSTITUTE OF TECHNOLOGY
(Autonomous Institute Affiliated to University of Mumbai)
MUNSHI NAGAR, ANDHERI (WEST), MUMBAI - 400 058

Department of Information Technology
2021-22

SEVA/SATVA Report

For

COVID-19 IN MAHARASHTRA



By
Akhil Sharma
UID: 2020400051
SECOND YEAR

Under the mentorship of
Prof. Harshil Kanakia

Evaluation Mark sheet

Student Name	UCID	Class	Branch	Grade	Grade Point
Yash Jadhav	2020400012	SE	IT	A	9
Ounkar Vijay Jagtap	2020400013	SE	IT	A	9
Kaival Ketan Shah	2020400047	SE	IT	O	10
AKHIL SHARMA	2020400051	SE	IT	A	9
Rishi Sodhani	2020400060	SE	IT	A	9
Durga Warrier	2020400069	SE	IT	A	9





ABL Activity

Sardar Patel Institute of Technology

Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058, India
(Autonomous College Affiliated to University of Mumbai)

“ABLL@LLC”

(Activity Based Liberal Learning about Life, Literature and Culture)

Academic Year: 2022-23

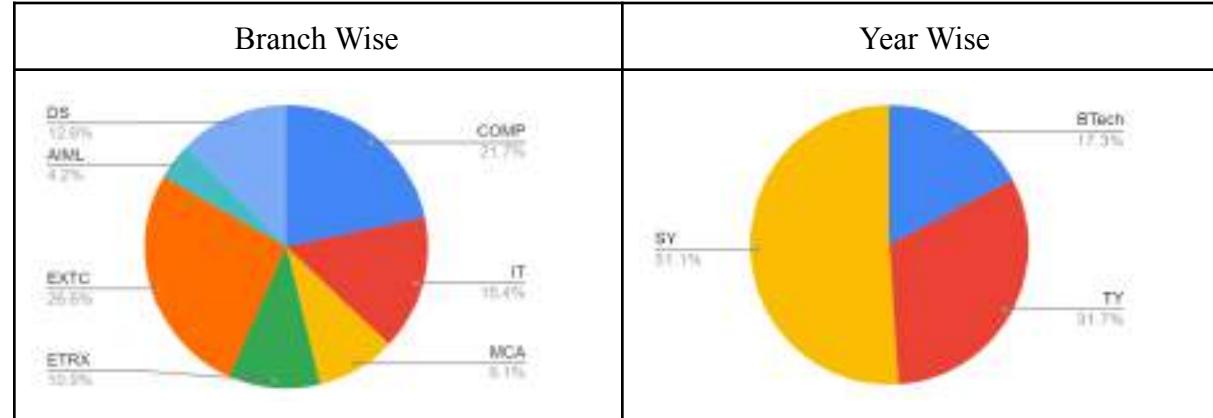
Course Code: ST34

Name of Faculty Coordinator: Kaisar Katchi

Total Number of students registered: 143

Semester: II/III/V/VII

Course Name : Fundamentals of Photography



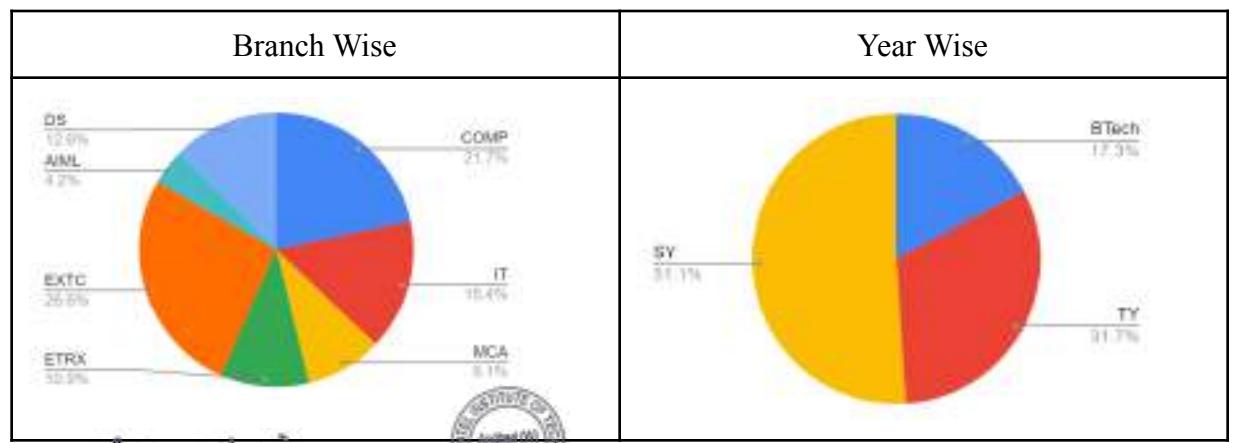
Number of sessions conducted: 10

Duration of the session: **1 hour**

Brief contents taught: Principles of photography, operation of DSLR camera, difference between DSLR and mirrorless camera, photography techniques, special effects and night photography.

Result:

Total Number of students evaluated/graded: 143



ABL Activity

Observations: A lot of students registered for the course, so two batches were prepared of about 70 students each. It was difficult to manage so many students for the instructor. This was further more difficult because most students did not have a DSLR camera, so there wasn't much scope for practical, hands-on experience. The instructor was quite knowledgeable.

Photographs:



S. Shandhar

Volunteering



BHARTIYA VIDYA BHAVANS
SARDAR PATEL INSTITUTE OF TECHNOLOGY
An Autonomous Institute Affiliated to University of Mumbai



BLOOD DONATION

27th OCTOBER, 2023

On the 27th of October, 2023, the Rotaract Club of Sardar Patel Institute of Technology conducted a successful Blood Donation Drive in collaboration with S.L. Raheja Hospital.





Volunteering

Sakina Shaikh <sakina_shaikh@spit.ac.in>

Fwd: Invitation to Participate in Blood Donation Camp at SPIT

1 message

Narendra Bhagat <narendra_bhagat@spit.ac.in>

Wed, Oct 25, 2023 at 3:04 PM

To: invite.comp.2024@spit.ac.in, invite.etrx.2024@spit.ac.in, invite.extc.2024@spit.ac.in, invite.it.2024@spit.ac.in, mca.2024@spit.ac.in, invite.extc1.2025@spit.ac.in, invite.extc2.2025@spit.ac.in, invite.comp1.2025@spit.ac.in, invite.comp2.2025@spit.ac.in, invite.cse.aiml.2025@spit.ac.in, invite.cse.ds.2025@spit.ac.in, comp1.2026@spit.ac.in, comp2.2026@spit.ac.in, cse.aiml.2026@spit.ac.in, cse.ds.2026@spit.ac.in, extc1.2026@spit.ac.in, extc2.2026@spit.ac.in, Kiran Talele <kiran.talele@spit.ac.in>, Rita Das <rita_das@spit.ac.in>, faculty@spit.ac.in

FYI

----- Forwarded message -----

From: Rotaract S.P.I.T <spit.rotaract@gmail.com>

Date: Tue, Oct 24, 2023 at 8:49 PM

Subject: Invitation to Participate in Blood Donation Camp at SPIT

To: <narendra_bhagat@spit.ac.in>

Cc: <sujal.chordia@spit.ac.in>, siddhesh.kirdat@spit.ac.in <siddhesh.kirdat@spit.ac.in>

Dear Sir,

We are delighted to inform you about an upcoming Blood Donation Drive in our college, organized by the Rotaract Club of SPIT in collaboration with Enactus SPIT. We cordially invite you to join us in this noble cause and contribute to saving lives.

Event Details:

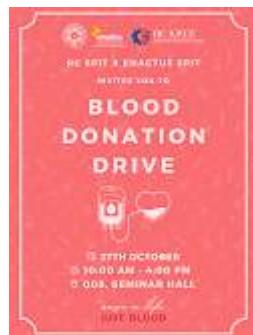
Date: 27th October, 2023

Time: 10 am to 4 pm

Venue: SPIT, 008

We have made arrangements to ensure your safety during the donation process. A team of medical professionals will be present to guide you through every step.

We look forward to your positive response and participation in this noble initiative.



BDD invite_20231022_160410_0000.png
1815K



Student Internship offer letter

NOMURA

Nomura Services India Private Limited

Winchester – 10th Floor, Powai Business District, Powai,
Mumbai - 400 076, India

Telephone +91 22 3053 4626
Facsimile +91 22 3053 2111
Website www.nomura.com

RESHMA KHANNA
VICE PRESIDENT – HUMAN RESOURCES

29 April 2022

Vishal Suhas Parab
Sardar Patel Institute of Technology
Mumbai - 400 058

Dear Vishal,

We are pleased to extend to you this conditional offer of employment to join Nomura Services India Private Limited (the “Company”, which together with Nomura Holdings, Inc. and certain of its subsidiaries is referred to as “Nomura”), on the terms and conditions set out in this Agreement.

Your title and start date will be as indicated in **Annexure A**. You will be based in Mumbai and will be reporting to such person as may be indicated by the Company from time to time. You are required to work exclusively for the Company unless you obtain prior written consent from the Company with respect to outside employment or business activities. Although your employment will be with the Company, you may be seconded to other companies within Nomura from time to time at Nomura’s discretion. During your employment, you may be also required to work in any other office Nomura may have or establish in India, and to work on a temporary basis in any of Nomura’s international offices for training or other purposes. In such circumstances, Nomura will provide you travel assistance in accordance with applicable travel policies.

So long as you remain actively employed by the Company, you will be eligible for the compensation indicated in the attached **Annexure A**, subject to the following terms and conditions:

- The fixed pay is set out in **Annexure A** hereto. Your fixed pay less applicable deductions will be paid in accordance with Nomura’s normal payroll practice.
- Your fixed pay may change at the discretion of the Company, upon advance written notice to you. Please note that your fixed pay includes certain monthly allowances, as specified in **Annexure A**. Certain of these allowances may qualify for tax benefits upon submission of appropriate receipts and other documentation, in accordance with Company policy and applicable tax regulations. For further information, please contact Human Resources.
- All payments described in this letter and **Annexure A** will be made less taxes and other applicable payroll deductions.
- You will also be eligible to participate in the Company’s discretionary bonus award program in effect from time to time. Please note that bonus awards are determined at the Company’s sole discretion, based on numerous factors as determined by the Company from time to time. These factors may include, but are not limited to, Nomura’s performance and profitability, business unit performance and profitability, individual performance and contribution and other factors, which Nomura deems relevant in a given year and for each business. To be eligible for a bonus award under this program you must be employed with the Company and must not have given or received notice of termination of your employment, at the time the bonus awards are made. Entitlement to a bonus payment is, therefore, not automatic and no single award or series of awards, creates an entitlement for further bonus awards. In addition, the entitlement to be considered for the payment of a discretionary bonus award does not confer any entitlement to a payment which accrues on a daily basis.

Student Internship offer letter

NOMURA

Nomura Services India Private Limited

Winchester – 10th Floor, Powai Business District, Powai,
Mumbai - 400 076, India

Telephone +91 22 3053 4626

Facsimile +91 22 3053 2111

Website www.nomura.com

- The nature and amount of such bonus (if any) will be determined at the discretion of Nomura. The payment of any bonus in respect of any year and the amount of such bonus, if paid, shall not give rise to any expectation for the payment or amount of any bonus in any future year of employment. You acknowledge that no representation, assurance or guarantee has been provided by or on behalf of Nomura with respect to the payment of any discretionary bonus and you also acknowledge that you may receive a nil bonus.
- Nomura reserves the right to defer all or part of any bonus award payable to you, either as cash or stock, subject to the rules of the relevant bonus plan in force, from time to time, and to impose reasonable conditions, on the future payment of any such deferral, as Nomura considers appropriate.

In addition to the total compensation indicated above, you will also be eligible for Company contributions to the Provident Fund as indicated in Annexure A.

You will also be eligible to receive a sign-on award of INR 200,000 less applicable deductions. This sign-on award will be included in the second month pay-roll cycle after the start of your employment and would be paid after deduction of applicable taxes. If you are terminated by the Company with Cause (defined below) or your last working date with the Company is at any time before the second anniversary of your start date, you will be required at that time to repay the Company the full gross amount of the sign-on award.

You would be on probation for a period of six months following the commencement of employment. Your confirmation at the end of the probation period is subject to successful completion of employee confirmation review. The notice period applicable during probation for all employees across all titles joining the Company is 1 month. The notice period after confirmation is 3 months.

If you resign from your position with the Company, you are required to provide written notice of resignation and serve a notice period as stipulated above. Further if the Company asks you to leave, it shall follow the process with regard to the notice period as stipulated in the India Employee Handbook. The Company may elect (but shall not be obliged) to terminate your employment prior to the expiry of the notice period and make a payment in lieu of notice, unless your employment is terminated for "Cause".

For purposes of this letter, "Cause" means (i) your material neglect or material failure to perform your job duties and responsibilities, (ii) your failure or refusal, after due notice, to comply with lawful policies or directives of Nomura, (iii) your material breach of any contract or agreement between you and Nomura or your material breach of any statutory duty, fiduciary duty or any other obligation that you owe to Nomura, (iv) your commission of an act of fraud, theft, embezzlement or other criminal offence against Nomura or your engaging in unprofessional, unethical or other intentional acts that materially discredit Nomura or are materially detrimental to the reputation, character or standing of Nomura, or (v) your indictment, conviction or nolo contendere or guilty plea with respect to any felony or crime of moral turpitude.

You will also be eligible for certain other discretionary benefits, as may be announced by the Company during your employment. Such discretionary benefits shall accrue to you subject to the terms and conditions of such benefit programs (which may be withdrawn or varied by the Company from time to time).

You agree that during the term of your employment with the Company and for three (3) months after the cessation thereof, regardless of the reason for the cessation of your employment, you will not, directly or indirectly, on your own behalf or on behalf of or in conjunction with any person or legal entity, recruit, solicit, or induce, or attempt to recruit, solicit, or induce, any employee of the Company, to cease their employment relationship with the Company.

Please note that this offer and any subsequent employment, is conditional upon the following terms and may be withdrawn, rescinded, or terminated as applicable, without liability on our part, should any or all of them not be met.

Student Internship offer letter

NOMURA

Nomura Services India Private Limited

Winchester – 10th Floor, Powai Business District, Powai,
Mumbai - 400 076, India

Telephone +91 22 3053 4626
Facsimile +91 22 3053 2111
Website www.nomura.com

1. You having successfully cleared the examination(s) required to meet the specified educational criterion and provision of a duly certified copy of your mark sheet to the Company, in support of the same.
2. Successful completion of a background investigation, as well as on your satisfactorily meeting all pre-employment requirements. This background investigation will include verification of identity and information provided by you to the Company as part of the application process. The provision of false or misleading information may be grounds for the withdrawal of this offer or once your employment has begun, for disciplinary action against you including termination of employment.
3. Your agreement to comply with and compliance with our policies, which may be amended from time to time, including the "Staff Dealing Rules", "Chinese Wall Policy", "Gifts and Entertainment Policy", "Policies and Procedures for Prevention of Money Laundering and Terrorist Financing" and the "Code of Ethics" (collectively referred to as the "Policies").
4. Your agreement to comply with and compliance with applicable Nomura policies in effect from time to time during your employment, including without limitation to provisions of the India Employee Handbook. It is hereby clarified that the terms of the India Employee Handbook (which includes provisions relating to notice period) may be amended by the Company, in its sole discretion, from time to time and the same shall take precedence over the terms set out in this Agreement. Please take the time to familiarize yourself with these policies and guidelines as they are made available to you.
5. Your agreement to comply with and compliance with the Confidentiality Undertaking and Intellectual Property Agreement both of which are included with this letter.
6. You being free of any restrictions imposed by any current/ previous employer. It is your responsibility to promptly advise us if there are any potential difficulties in this respect, including any notice requirement you may have with your current employer. By signing this letter you are confirming to us that you are not subject to any duty or obligation that would prevent you from taking up employment with us on your start date or which would prevent you from performing all or any duties for the Company relating to your position.
7. Proof of entitlement to work in India.

Please note that, in the event of your failure to meet the aforementioned educational criterion and/or provide a certified copy of the mark sheet pertaining to the same to the Company within 6 months of the date hereof, this offer and any employment pursuant to it, shall automatically stand revoked or terminated, without the Company being required to provide you any further notice for the same.

Please note that employment is for no fixed term and either you or the Company may terminate the employment relationship at any time for any reason, in accordance with applicable Company policy and law. Any payments that may be due to the Company by you may, upon the termination of your employment with the Company, be reduced from any amount payable to you by the Company, at the Company's discretion.

The Company's normal working hours will apply to your employment. Due to business requirements, working hours may vary in different teams or departments which will be informed to the employees from time to time by the reporting manager as required. You agree to provide services exclusively to the Company and not to enter into any form of employment or contract with other organizations. You may also be required to perform services not only for the Company, but also for any company affiliated with the Company without further remuneration.

Student Internship offer letter

NOMURA

Nomura Services India Private Limited

Winchester – 10th Floor, Powai Business District, Powai,
Mumbai - 400 076, India

Telephone +91 22 3053 4626
Facsimile +91 22 3053 2111
Website www.nomura.com

You are required to comply with the India Employee Handbook and any other rules, policies or procedures of the Company as issued and/or amended from time to time. Application of such rules, policies or procedures is at the Company's discretion and is not a contractual entitlement unless otherwise specified in the India Employee Handbook. The Company reserves the right to supplement, change, amend, withdraw or discontinue its policies, guidelines and procedures at its discretion and in accordance with applicable law. Please take the time to familiarize yourself with these policies and guidelines as they are made available to you.

You will keep in strictest confidence the existence, all past and present discussions or correspondence relating to your candidature, this letter, as well as and the terms of this letter and will not disclose this letter or its terms to anyone other than your spouse, parents, attorney or accountant, without the Company's consent. This agreement constitutes the entire agreement between the parties and supersedes any previous written or oral agreement or understanding between them in relation to the matters dealt with in it (including any statements made during your interviews or other recruitment process). You acknowledge that you have not been induced to enter into this agreement by any representation, warranty or undertaking not expressly incorporated into it. No variations to the terms will be valid unless they are authorized in writing by Human Resources.

The terms and conditions of this contract of employment shall be governed and interpreted according to the laws of India. Any dispute, controversy or claim arising out of or in connection with this contract of employment shall be resolved by binding, final arbitration in Mumbai, pursuant to the Rules of Arbitration of the International Chamber of Commerce. The language of the arbitration shall be English.

We are enthusiastic and pleased that you are going to be a part of our organization. To accept this offer of employment, you will need to sign this offer letter, complete all the attached employment forms indicated below and return the materials indicated below to Gaurav Phukan, Human Resources, Winchester – 10th Floor, Powai Business District, Powai, Mumbai - 400 076, India, within such time as requested by the Company. All additional pre-employment documentation provided to you must be completed and returned on or before your start date. An additional copy of this letter is enclosed for your files”.

Please note that you need to meet Sameeksha Dhyani in Human Resources, on your first day, to complete your joining formalities.

We look forward to your joining the Company.

Sincerely,

Reshma Khanna
Vice President – Human Resources

Accepted by:

Vishal Suhas Parab

Date

Student Internship offer letter

NOMURA

Nomura Services India Private Limited

Winchester – 10th Floor, Powai Business District, Powai,
Mumbai - 400 076, India

Telephone +91 22 3053 4626
Facsimile +91 22 3053 2111
Website www.nomura.com

Annexure A

The following compensation items are subject to the terms and conditions of your offer letter, to which this Annexure A is attached. Payments are subject to applicable taxes. Please note that fixed pay and retirement amounts are expressed on an annualized basis.

Name: **Vishal Suhas Parab**

Corporate Title: **Analyst**

Functional Title: **Developer Graduate**

Division: **Corporate Technology Services**

Start Date: **11 July 2022**

		Annum (INR)	Month (INR)
Fixed Pay	Basic Salary	450,000	37,500
	House Rent Allowance	225,000	18,750
	Special Allowance*	225,000	18,750
	Total Fixed Pay	900,000	75,000
Retirement	Company's Contribution to Provident Fund	54,000	4,500
	Total Fixed Pay + Retirement	954,000	79,500

* As part of the Special Allowance, you will be able to declare Leave Travel Allowance (LTA) amount of up to 8.33% of your basic salary. Such expenses will be exempt from taxes and paid to you upon submission of documentary evidence of incurring these expenses in accordance with Nomura's policies.

*As part of special allowance, employees who are "blind or orthopedically handicapped with disability of lower extremities are eligible for an allowance exemption of INR 3,200 per month, subject to submission of requisite documentary evidence.

*You may also contribute up to 10% of your basic salary towards "Corporate National Pension System" which will be deducted from your Special Allowance.

Other Benefits:

- Eligibility for Gratuity as per the Payment of Gratuity Act.
- Medical Insurance for self, spouse, children and any two persons amongst your parents or parents-in-law upto INR 600,000/- per year.
- Personal Accident Insurance for self only (up to 5 times of Total Fixed Pay + Retirement in case of permanent disability / death).
- Life Insurance for self only (5 times of Total Fixed Pay + Retirement), contingent upon medical clearance, if applicable.

Student Internship offer letter

NOMURA

Nomura Services India Private Limited

Winchester – 10th Floor, Powai Business District, Powai,
Mumbai - 400 076, India

Telephone +91 22 3053 4626

Faxsimile +91 22 3053 2111

Website www.nomura.com

Annexure B

Documents Required:

1. Signed copy of Offer Letter along with signed Annexure A;
2. 2 passport size photographs;
3. Forms, statements and agreements :
 - a. Employment Application Form;
 - b. Letter of Authorization;
 - c. Confidentiality Undertaking;
 - d. Compensation Information Confidentiality Form;
 - e. Intellectual Property Agreement;
 - f. Questionnaire – New Employees Form; and
 - g. Personal Information Collection Statement.

Please carry the relieving letter from your current employer (if applicable) on your date of joining.

Student Internship completion letter

NOMURA

Nomura Services India Private Limited

Winchester – 10th Floor, Powai Business District, Powai,
Mumbai - 400 076, India

Telephone +91 22 3053 4626
Facsimile +91 22 3053 2111
Website www.nomura.com

19 September 2022

Internship Completion Letter

This is to certify that Vishal Suhas Parab, a student of Sardar Patel Institute of Technology, Mumbai has completed an internship with the Corporate Technology Services division of Nomura Services India Private Limited (“the firm”). The internship started on 17 January 2022 and ended on 01 July 2022.

The provision of the above information does not imply any comment, negative or positive, about the intern or the course of internship with the firm.

The information provided therein is given in strict confidence and without liability or responsibility on behalf of either the firm or the writer.

We wish him the best in his future career.

Sincerely,

Reshma Khanna
Vice President - Human Resources

Bhartiya Vidya Bhavans, Sardar Patel Institute of Technology**Research Internship Details****Semester: 6****Branch: Electronics Engg****Academic Year: 2022-23**

Sr.	Email Address	Name	UID	Contact Numbr	Internship Organization	Verified
1	atharav.bhagwat@spit.ac.in	Bhagwat Atharav Rajendra	2020100003	8275420185	Indian Institute of Technology (IIT) Bombay	Yes
2	rajas.bhope@spit.ac.in	Rajas Bhope	2020100004	8976011249	IIT Bombay	Yes
3	samuelson.dsouza@spit.ac.in	Samuelson D'souza	2020100013	9167591727	Electrical Engineering dept. of IIT Bombay	Yes
4	tanishq.khairnar@spit.ac.in	Tanishq Khairnar	2020100030	7020470043	IIT PATNA	Yes
5	neeraj.kokane@spit.ac.in	Neeraj Kokane	2020100033	7447447406	Haldex Anand India PVT LTD (R n D)	Yes
6	arpit.patil@spit.ac.in	Arpit Sanjay Patil	2020100042	8010534468	IIT Bombay	Yes
7	devashish.rairikar@spit.ac.in	Devashish Rairikar	2020100046	8104516651	IIT BOMBAY	Yes
8	nidhi.samant@spit.ac.in	Nidhi Samant	2020100050	7506936142	IIT Bombay	Yes
9	nikhil.saraf@spit.ac.in	Nikhil Saraf	2020100051	7977388272	IIT Bombay	Yes
10	chirag.vasani@spit.ac.in	Chirag Vidyut Vasani	2020100063	9595954515	Acuradyne(IIT BOMBAY)	Yes

Internship Coordinator



Principal

Bhartiya Vidya Bhavans, Sardar Patel Institute of Technology**Research Internship Details****Semester: 6****Branch: EXTC****Academic Year: 2022-23**

Sr. No	Email Address	Name	UID	Contact Numbr	Internship Organization	Verified
1	harish.balasubramanian@spit.ac.in	Harish Balasubramanian	2020200003	9833738182	IIT Bombay	Yes
2	atharva.chaudhari@spit.ac.in	Atharva Chaudhari	2020200006	8669624574	IIT Bombay	Yes
3	janhavi.dangle@spit.ac.in	Janhavi Dangle	2020200008	9321260368	IIT Bombay	Yes
4	tanmay.gadgil@spit.ac.in	Tanmay Gadgil	2020200012	8779650675	SPIT (In-house) under Prof. Rajendra Sawant	Yes
5	aarnav.joshi@spit.ac.in	Aarnav Joshi	2020200028	9967068960	IIT Patna	Yes
6	sarthak.kambli@spit.ac.in	Sarthak Kambli	2020200031	8369704695	IIT Bombay	Yes
7	aditya.kulkarni@spit.ac.in	Aditya Charudatta Kulkarni	2020200037	9004430896	IIT-Bombay	Yes
8	guruprasad.parasnisi@spit.ac.in	Guruprasad Parasnis	2020200043	7021676540	IIT Bombay	Yes
9	monish.rane@spit.ac.in	Monish Rane	2020200050	8879978809	SPIT (In-house) under Prof. Rajendra Sawant	Yes
10	rushikesh.sangole@spit.ac.in	Rushikesh Sangole	2020200055	8424036036	IIT Bombay	Yes
11	kunal.thakur@spit.ac.in	Kunal Thakur	2020200060	+91937087936	Inter-University Centre for Astronomy and Astrophysics, Pune	Yes
12	vrushali.varude@spit.ac.in	Vrushali Varude	2020200063	9137904542	IIT Bombay	Yes
13	mitali.sherkhane@spit.ac.in	Mitali Sudhir Sherkhane	2021201072	8452075972	IIT Bombay	Yes
14	rina.pachkale@spit.ac.in	Rina Prakash Pachkale	2021201074	7506042401	Indian Institute of Technology Bombay	Yes
15		Prathamesh Rathod		8855004678	Not doing in 6th Semester	Yes

Internship Coordinator



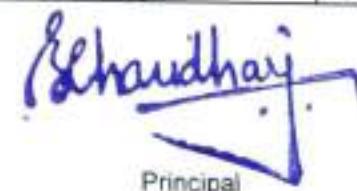
Principal

Bhartiya Vidya Bhavans, Sardar Patel Institute of Technology**Research Internship Details****Semester: 6****Branch: Information Technology****Academic Year: 2022-23**

Sr. No	Email Address	Name	UID	Contact Number	Internship Organization	Verified
1	Anmol Chokshi	Anmol Chokshi	2020400003	9833588946	IIT Bombay	Yes
2	Aryan Gwalani	Aryan Gwalani	2020400010	9930788697	IIT BOMBAY	Yes
3	Vansh Jain	Vansh Jain	2020400014	7021684250	IIT Bombay	Yes
4	Kaustubh Kachare	Kaustubh Kachare	2020400016	8104156989	SPIT (In-house) under Prof. Narendra Bhagat	Yes
5	dhruv.khut@spit.ac.in	Dhruv Khut	2020400020	9326269415	IIT Patna	Yes
6	aaditya.mehar@spit.ac.in	Aaditya Prashant Mehar	2020400022	9811091878	Indian Institute of Technology, Bombay	Yes
7	siddhant.meshram@spit.ac.in	Siddhant Meshram	2020400023	7030070619	Autobuddys	Yes
8	sahil.nawale@spit.ac.in	SAHIL NAWALE	2020400029	7499850363	IIT PATNA	Yes
9	@adish.padalia@spit.ac.in	Adish Padalia	2020400031	8104252600	IIT Bombay	Yes
10	abhishek.pai@spit.ac.in	Abhishek Pai	2020400032	8291824034	IIT Patna	Yes
11	atharv.raotole@spit.ac.in	Atharv Raotole	2020400042	8097977615	IIT PATNA	Yes
12	kaival.shah@spit.ac.in	Kaival Shah	2020400047	9833745132	IIT PATNA	Yes
13	mirat.shah@spit.ac.in	Mirat Shah	2020400049	9870805145	IIT-Bombay	Yes
14	tanish.shah@spit.ac.in	Tanish Shah	2020400050	8104816197	IIT Bombay	Yes
15	dhrushi.sheth@spit.ac.in	Dhrushi Sheth	2020400054	8828188282	SPIT under Dr Pooja	Yes
16	sailee.shirodkar@spit.ac.in	Sailee Shirodkar	2020400057	9930528957	IIT Patna (Research internship)	Yes
17	rahul.shukla@spit.ac.in	RAHUL SHUKLA	2020400058	7498379730	IIT BOMBAY	Yes
18	ayush.singh2@spit.ac.in	Ayush Singh	2020400059	8828397530	J.P. Morgan Chase	Yes
19	bhavisha.sondagar@spit.ac.in	Bhavisha Sondagar	2020400061	7021514063	SPIT under Dr Pooja	Yes



Internship Coordinator

Principal

Bhartiya Vidya Bhavans, Sardar Patel Institute of Technology**Research Internship Details****Semester: 6****Branch: Computer Engineering****Academic Year: 2022-23**

No.	Email Address	Name	UID	Contact Number	Internship Organization	Verified
1	Shreyash.Dhamane	Shreyash Dhamane	2020300006	7977082238	Skinzy	Yes
2	pratik.pujari@spit.ac.in	Pratik Pujari	2020300054	9167421551	Acuradyne Systems(IIT Bombay)	Yes
3	aaryan.purohit@spit.ac.in	Aaryan Purohit	2020300055	9004250737	IIT-PATNA	Yes
4	omkar.rane@spit.ac.in	Omkar Rane	2020300057	9769199334	Indian Institute of Technology, Bombay	Yes
5	krish.shah@spit.ac.in	Krish Shah	2020300061	9619873735	IIT Patna	Yes
6	trisha.shishodiya@spit.ac.in	Trisha Shishodiya	2020300066	9673553379	Indian Institute Of Technology, Bombay (IIT-B)	Yes

Internship Coordinator



Principal



Standalone Laboratory

Sardar Patel Institute of Technology

Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
(Autonomous Institute Affiliated to University of Mumbai)

Course (Category) Code	Course Name	Teaching Scheme (Hrs/week)					Credits Assigned				
		L	T	P	O	E	L	T	P	Total	
SBC MC509	Mobile Programming Lab	-	-	4	4	8	-	-	2	2	
		Examination Scheme									
		Component		ISE		MSE		ESE		Total	
		Theory		--		--		--		--	
		Laboratory		100		--		100		200	

Pre-requisite Course Codes, if any.	Object Oriented Programming concepts
Course Objective: To provide students with good knowledge and training about ionic framework along with databases using firebase and node.	
Course Outcomes (CO): <i>At the End of the course students will be able to</i>	
MC509.1	Install the ionic framework with all the dependencies
MC509.2	Create apps using the components of ionic framework and SASS stylesheet
MC509.3	Create apps using API's of ionic framework
MC509.4	Create apps with backend connectivity

CO-PO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
MC509.1					3		2					
MC509.2			2		3		1					
MC509.3			2		3		1					
MC509.4			2		3		1					

CO-PEO/PSO Correlation Matrix (3-Strong, 2-Moderate, 1-Weak Correlation)

	PEO1	PEO2	PEO3	PSO1	PSO2
MC509.1					1
MC509.2					3
MC509.3					3
MC509.4					3

BLOOM'S Levels Targeted (Pl. Tick appropriate)

Remember	Understand	Apply	Analyze	Evaluate	Create ✓
----------	------------	-------	---------	----------	----------





Standalone Laboratory

Sardar Patel Institute of Technology

Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
(Autonomous Institute Affiliated to University of Mumbai)

Laboratory Component

Sr. No	Experiment Details	Ref.
1	To install ionic and its development environment and run the basic default application to understand the files used.	3
2	To create an Museum app using basic UI components and SASS [Syntactically awesome style-sheet]	3
3	Create an app for MCA department using Tabs Navigation.	3
4	Create an app to upload, download and view pdf in an image.	5
5	Create SPIT app using side navigation drawer and Tabs navigation.	5
6	Create an app for children to study numbers and alphabets.	5
7	Develop Camera and Calendar API integrated in one app.	5
8	Implement HTTP request and response (REST API) to update and retrieve data in JSON File.	5
9	Create an app to store student information using firebase as database	5
10	Create an app for feedback of students along with the ratings and store and retrieve from firebase.	5

Textbooks:

- [1] Arvind Ravulavaru, “*Learning Ionic*”, Second Edition, ISBN: 9781786466051, Packt Publishing,2017.
- [2] Chris Griffith ,” *Mobile App Development with Ionic, Revised Edition: Cross-Platform Apps with Ionic, Angular, and Cordova*”, 1st Edition, O'Reilly Media, Inc, 2017.
- [3] Rodrigo Branas, Chandermanni Arora, Et al, “*Angular JS: Maintaining web applications*”, Packt Publications, 2016.

References:

- [4] Andreas Dormann, “*Ionic 5: Create awesome apps for iOS, Android, Desktop and Web*”, First Edition, D&D Verlag, Germany,2020.

Web Reference:

- [5] <https://ionicframework.com/>
- [6] <https://ionicframework.com/docs/angular/your-first-app>
- [7] <https://sass-lang.com/>
- [8] <https://nodejs.org/en/>
- [9] <https://angular.io/>



MOOC Certificate

This certificate is computer generated and can be verified by scanning the QR code given below. This will display the certificate from the NPTEL repository, <https://nptel.ac.in/noc/>



Sakina Banu Shahrukh Ahmed Salmani

Roll No: NPTEL20CS62S61980441

To

SAKINA BANU SHAHRUKH AHMED SALMANI
22/A, GROUND FLOOR, PREMISES NO-6,
BOMANJI DHUNJIBHOY BUILDING,
SAKERWADI COMPOUND, NAWAB TANK
ROAD, MAZGAON, MUMBAI
MUMBAI
MAHARASHTRA - 400010
PH. NO : 9987655986



No. of credits recommended by NPTEL:3

An additional 1 credit may be awarded if the University deems it fit, based on the actual student effort involved.

Score	Type of Certificate
>=90	Elite+Gold
75-89	Elite+Silver
>=60	Elite
40-59	Successfully Completed
<40	No Certificate



Elite

NPTEL Online Certification

(Funded by the Ministry of HRD, Govt. of India)



This certificate is awarded to
SAKINA BANU SHAHRUKH AHMED SALMANI
for successfully completing the course

Deep Learning

with a consolidated score of **67** %

Online Assignments	18.97/25	Proctored Exam	48/75
--------------------	----------	----------------	-------

Total number of candidates certified in this course: **500**

D.P. Raja Sekhar
Prof. G P Raja Sekhar
Dean, Continuing Education
IIT Kharagpur

Sep-Dec 2020
(12 week course)

Debjani Chakraborty
Prof. Debjani Chakraborty
Coordinator, NPTEL
IIT Kharagpur



Indian Institute of Technology Kharagpur

Roll No: NPTEL20CS62S61980441

To validate and check scores: <https://nptel.ac.in/noc/>



This certificate is computer generated and can be verified by scanning the QR code given below. This will display the certificate from the NPTEL repository, <https://nptel.ac.in/noc/>

MOOC Certificate



Sakina Banu Shahrukh Ahmed Salmani

Roll No: NPTEL20CS73S81980719

To

SAKINA BANU SHAHRUKH AHMED SALMANI
22/A, GROUND FLOOR, PREMISES NO-6,
BOMANJI DHUNJIBHOY BUILDING,
SAKERWADI COMPOUND, NAWAB TANK
ROAD, MAZGAON, MUMBAI
MUMBAI
MAHARASHTRA - 400010
PH. NO : 9987655986



No. of credits recommended by NPTEL:3

An additional 1 credit may be awarded if the University deems it fit, based on the actual student effort involved.

Score	Type of Certificate
>=90	Elite+Gold
75-89	Elite+Silver
>=60	Elite
40-59	Successfully Completed
<40	No Certificate



Elite

NPTEL Online Certification

(Funded by the Ministry of HRD, Govt. of India)



This certificate is awarded to

SAKINA BANU SHAHRUKH AHMED SALMANI

for successfully completing the course

Introduction to Machine Learning

with a consolidated score of **65** %

Online Assignments	20.31/25	Proctored Exam	44.75/75
--------------------	----------	----------------	----------

Devendra Jalihal

Total number of candidates certified in this course: **1150**

Andrew Thangaraj

Prof. Andrew Thangaraj
NPTEL Coordinator
IIT Madras

Prof. Devendra Jalihal
Chairman
Centre for Continuing Education, IITM

Sep-Dec 2020
(12 week course)



Indian Institute of Technology Madras

Roll No: NPTEL20CS73S81980719



To validate and check scores: <https://nptel.ac.in/noc/>

MOOC Certificate



SARDAR PATEL INSTITUTE OF TECHNOLOGY

Munshi Nagar, Andheri (W), Mumbai – 400 058.
(Autonomous Institute Affiliated to University of Mumbai)
Department of Information Technology

Sardar Patel Institute of Technology congratulates Mr. Sagar Badlani from IT Department for topping & securing the elite silver medal in Cloud Computing course conducted by IIT Kharagpur under NPTEL Online Certification.



Sagar Badlani(BE IT)



text here

MOOC Certificate



Swapnil Bhairu Kamble

MOOC Certificate



S. Venkatesh



2. Details of Participative Learning

Participative learning is essential for students as it promotes active engagement, critical thinking, collaboration, and a sense of responsibility for their own learning. It prepares students not only academically but also for the challenges and opportunities they will encounter in their future endeavors. Regular feedback, both from instructors and peers, is integral to participative learning. This feedback loop allows students to reflect on their progress, identify areas for improvement, and adjust enhance their learning experience.

A. Mini Project

Students are encouraged to do mini projects for conducting research to gather information and support findings. Students develop research skills, including data collection, analysis, and interpretation, which are valuable for academic and professional pursuits. Mini projects offer a holistic learning experience that goes beyond traditional classroom instruction, preparing students for the demands of their academic and professional journeys.

B. Project Competition

Students are encouraged to participate in project competitions to enhance their skills and build interpersonal skills. Participating in project competitions offers numerous benefits to students, encompassing academic, personal, and professional development. Competing in projects encourages students to think creatively and innovatively. They often need to come up with original ideas and solutions, fostering a mindset that is crucial in various fields.

C. Paper Presentation

Participating in technical paper presentations, offers a multifaceted learning experience that contributes significantly to a student's academic and professional growth. For students involved in research projects, technical paper presentations provide a platform to showcase their contributions to the academic community, contributing to the dissemination of knowledge. Successfully presenting a technical paper adds a valuable entry to students' portfolios. This can be particularly advantageous when applying for internships, jobs, graduate programs, or research opportunities.

D. Extra-curricular Activities

Students participate in various activities for overall development. There are various activities in the institute for participative learning such as coding competition, skill development program and case studies on various real-world cases.

Participative Learning-Mini Project

Page no 68-96

A Project Report

On

Thrift Store App

Client Name with UCID	UX Team Member with UCID
Sakshi Gadegaonkar (2019130012)	Kalpesh Gadhari (2017140012)
Netal Asawa (2019130003)	Tanmay Suryawanshi (2017140059)
Aryan Dhami (2020301074)	Aniket Garud (2018140022)

Class: BE – IT

Academic Year: 2022-23

Prof. In charge: Prof. Sakina Salmani



A handwritten signature in blue ink, which appears to be "Kalpesh Gadhari".

Department of Information Technology
Sardar Patel Institute of Technology
Andheri (West), Mumbai-400 058

Participative Learning- Mini Project

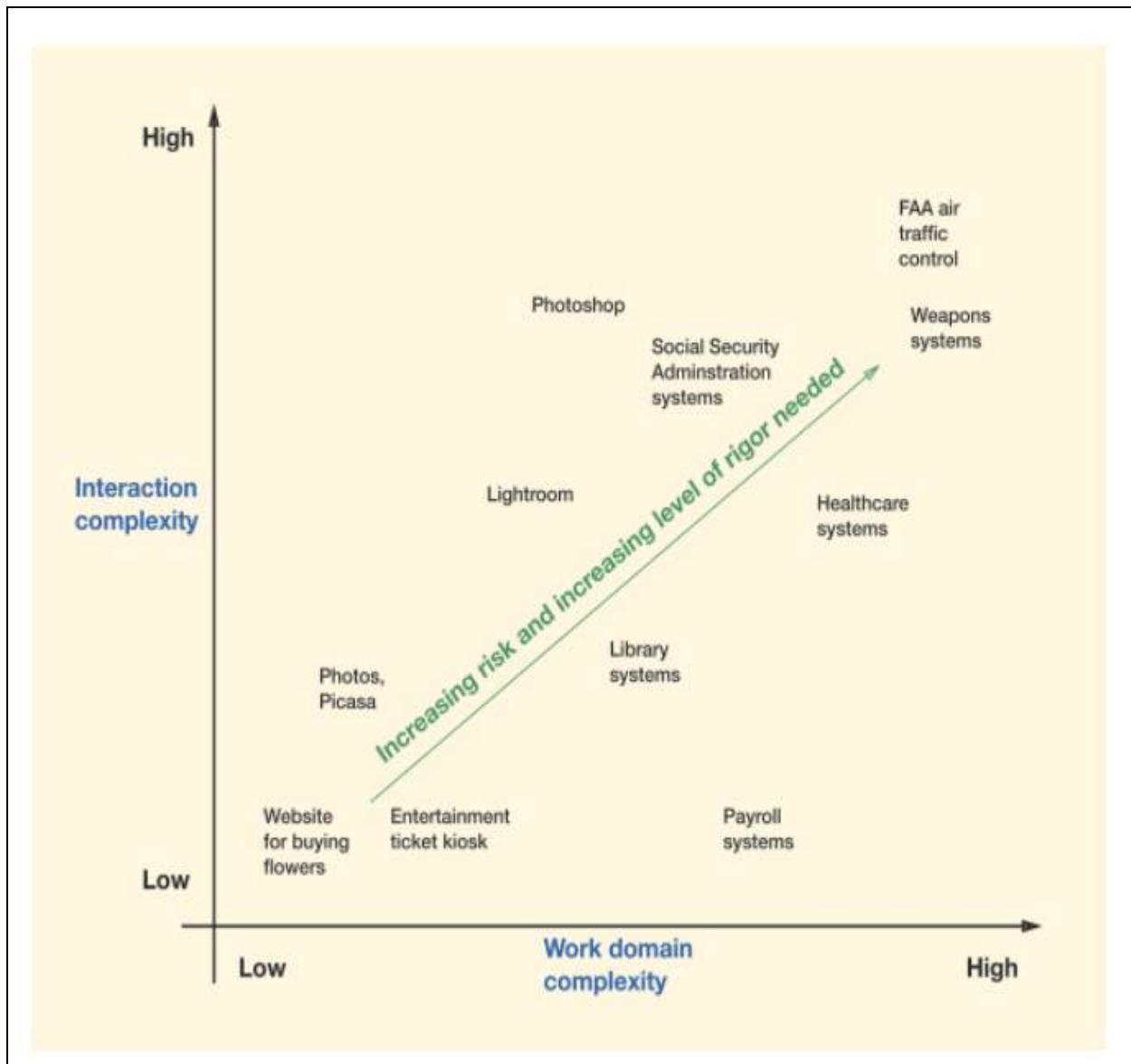
Table of Contents		
Sr. no.	Particulars	Pg no.
1	System Concept Statement	3
2	System Complexity Space	3
3	Questionnaire	4
4	Question and Interview Answers	5
5	Analysis of the answers	7
6	Analysis of the competitors	8
7	Requirement gathering in the standard format	9
8	Design Informing Models	11
9	User Persona	13
10	Wireframe	16
11	Storyboards	17
12	UI Screenshots	18
13	Usability Testing Links	22
14	UX Target Table	28
15	Conclusion	28
16	UX Team Members' Experience	29
17	Client Testimony	29

1. System Concept Statement:

'Fashion Thrift' is an E-commerce app where people buy and sell used products. This type of business has not been explored enough in India. Most similar websites focus on one particular type of product. This app aims to be a one-stop-shop for customers to buy and sell all kinds of second hand products. It has a review system where buyers can review a certain seller and inform fellow buyers regarding the said seller. The app also tries to provide customer support if any buyer or seller runs into issues while using it. As this app is not focused on a particular product it aims to cast a wide net to capture a customer base willing to buy and sell various products.

2. System Complexity Space:

- **Interaction Complexity:** The Fashion Thrift App has simple interaction complexity. This is because the user tasks are relatively simple and easy to understand. The user must follow the interactive UI and perform simple actions like choosing to buy or sell a clothing item.
- **Domain Complexity:** The Fashion Thrift App has a simple work domain. This is because the underlying domain involves the simple actions of one user putting an item they own for sale and other users buying it. Thus the way the system works within its ecology is relatively simple.



3. Questionnaire:

1. We would like to ask you some questions about the Thrift store system. Can you begin by telling us how your system will work?
2. Explain your system from client and users perspective.
3. How would you describe your past and current experience with existing systems?
4. Are there any similar websites that support your needs currently?
5. What are your goals for this platform?
6. What are the most important tasks performing on your website?
7. Who are these people who will be interested in a sustainable solution like this?
8. What type of items users can buy and sell on your platform?

9. Can you explain some features of your project?
10. How important is color and aesthetic in your platform experience?
11. What would make secondhand shopping more appealing?
12. Which Payments mode you are going to use?

4. Questions and Answers:

- 1. We would like to ask you some questions about the Thrift store system.
Can you begin by telling us how your system will work?**

The system will be based on the concept of people buying clothes second hand for lower costs than the original prices. Now-a-days premium clothing brands are selling their clothes for a huge premium and even though the common public has a desire to buy such clothing items they cannot because their budgets don't allow them to. This app will help such people as people who already have these premium clothes can try and sell their clothes on this platform. Not only will this lower the barrier to entry for such clothes, it will also help people sell these types of clothes and accessories easily.
- 2. Explain your system from client and users perspective.**

The client should be able to see the various clothes and accessories to be purchased at the homescreen. They can also choose the category of clothing item they would like to purchase and thus browse through the various items sorted by their categories like shirts, t-shirts,etc. The user can also select the option which will allow them to sell a clothing item. They can also select the category it will be displayed in and the price it will be on sale, they can later edit the price if the item is not selling. For shipping they can either choose to ship the item themselves or they can ship it to the company which will package and ship the item to the buyer, though this will cost the user some premium.
- 3. How would you describe your past and current experience with existing systems?**

Some apps which can be used for selling and buying clothes are ebay, olx, etc. The main problem with these apps is that they allow the buying and selling of all types of products. This does not help in cultivating a community which is more fashionable which leads to less variety of clothes and accessories being able to be bought by the consumers. This may also lead some of the sellers with premium clothes to not sell the clothes on the website all together.

4. Are there any similar websites that support your needs currently?

There are certain niche platforms like 'kaibza' that allows users to buy and sell clothes second hand but even this platform does not allow the seller to ship the clothes/accessories to the buyers directly. Other apps like ebay and olx have a much broader set of users which hinders them from growing a community based on buying and selling clothes.

5. What are your goals for this platform?

The main goal of this platform is to lower the entry barrier to the world of fashionable clothing. This will also in turn help cultivate a community of users that are interested in fashion and helping other users who are new to the hobby. It will also create a place for users who want to sell their premium clothes.

6. What are the most important tasks performed on your website?

The basic task of users viewing clothes and buying them or the basic task of users putting up their own clothes for sale are the most important tasks being performed on the website.

7. Who are these people who will be interested in a sustainable solution like this?

This app will interest people who are looking to get good clothes but do not have the budget to buy them at their original price. It is also for the people who are looking to sell the clothes they bought previously for various reasons like not enough space in their wardrobe, needing money to buy newer clothes, etc.

8. What type of items users can buy and sell on your platform?

On the platform you should be able to buy all different types of clothes and other wearable accessories. These include items like mens clothing, womens clothing, shoes, watches, etc. to name a few.

9. Can you explain some features of your project?

The Users are able to buy and sell images through the same account. They should be able to easily navigate through the UI and find the clothes/accessories they want to buy. The User can choose to ship the items directly to the buyer skipping the hassle of sending the item to the company first or they can choose the traditional path and ship it to the company which will properly package and ship the item to the customer. The Users should also have features like wishlist items and adding multiple items to the cart.

10. How important is color and aesthetic in your platform experience?

We want a red palette and a modern aesthetic for the app.

11. What would make secondhand shopping more appealing?

The main draw of second hand shopping is that people are able to buy clothes from premium brands at not a premium price. It will also provide a place where users who have excess clothes could go by getting rid of a few.

12. Which Payments mode you are going to use?

The app will allow all standard payment methods like Credit/Debit card, UPI and Cash on Delivery.

5. Analysis of Answers:

Work Roles:

1. Users
 - a. Buyer
 - b. Seller
2. System Administrator

Users:

- Users should be able to sign up/register into the system using their email address or by using their social accounts.
- Registered users should be able to log into the system using their user id and password.
- Registered users should have the ability to edit their profiles where they can change their personal information like name, email address, etc.
- Users should have access to a help page if they face any problems while using the app to contact the system admin.

Buyer:

- The buyer should be able to view various items on the home screen available for sale.
- They should be able to choose a category and only see the items from that category.
- They should be able to sort the items according to their price point like from low to high and high to low.
- They should be able to add certain items to the wishlist for which they will receive a notification if that item goes on sale.
- They should be able to add many items to a cart and buy them at once.
- They should have various payment options like Cash on Delivery, UED and Credit/Debit card.

Seller:

- The seller should be able to upload a picture of the item they want to sell.
- They should be able to choose the category of the product and the price at which it should be sold.
- They should be able to change the price of the item if the item is not selling for a long time.
- They should be able to choose a shipping option like shipping the items directly or through the company.

System Admin:

- System Admin should be able to help users facing problems through the help page.
- They should be able to do general moderation for the app like deleting listings ,etc.
- They should be able to see the items that are being shipped through the company.
- They should be able to view various statistics like products sold, order received, total sales of the current month, etc.

6. Analysis of the competitors:

Competitor	Purpose	Weakness	Proposed System
Ebay	To sell and buy electronics items from users.	It is primarily used in foreign countries and does not have a big user base in India.	This system will be focused on Indian users.
Olx	To buy and sell various goods.	It is not focused on clothing.	This platform will be focused on clothing and other wearable accessories.
Kiabza	To buy second hand clothes online.	It does not provide the option for user shipping; the users cannot ship the items to the buyers directly.	This platform provides the option of both user shipping and shipping through the app.

7. Requirement gathering in the standard format:

Sign Up

- Social Media/Email register feature.
- Users should be able to sign up/register into the system using their email address or by using their social accounts.

Authentication

- Log In.
- Registered users should be able to log into the system using their user id and password.

User Profile

- Edit/Update User Profile.
- All users should be able to edit their profiles.

Language Selection

- Selecting language of accessing the application
- All users should be able to select the language in which they want to view and access the “Fashion Thrift” App.

Sorting

- Sort various items by category.
- This feature allows the user to sort the clothing items by categories like shirts, t-shirts, etc.

Filtering

- Filter the items in a category
- This feature allows the user to filter the various items by price, date added, etc.

Wishlist

- Wishlist certain products.
- This feature enables the customers to wishlist certain clothing apparel that they want to buy in the future.

Cart

- Add to cart certain items.
- This feature allows the customers to add various items to the cart so that they can order multiple items at one time.

Payment

- Buy the clothing items.
- This feature should enable the user to purchase the clothes using their desired modes of payment from the options available such as - card, UPI, cash on delivery, etc.

Selling

- Sell clothing items.
- This feature allows the user to set pictures, categories and price for the items they want to sell.

Shipping

- Ship the clothing items.
- This feature allows the user to select what kind of shipping they want, user or company.

Moderating

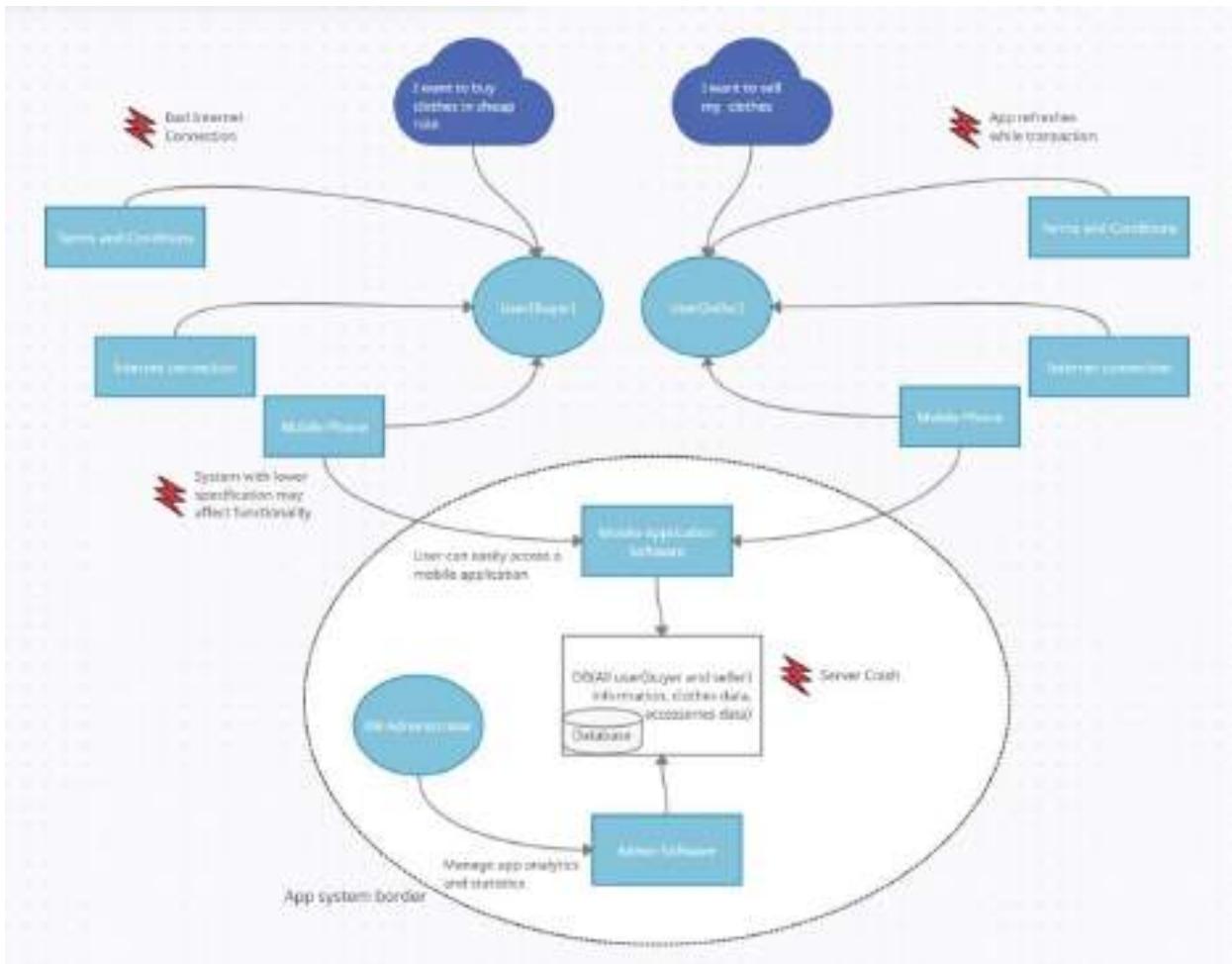
- Moderating the app.
- This allows the system admin to moderate the app for profanities,etc.

Analysis

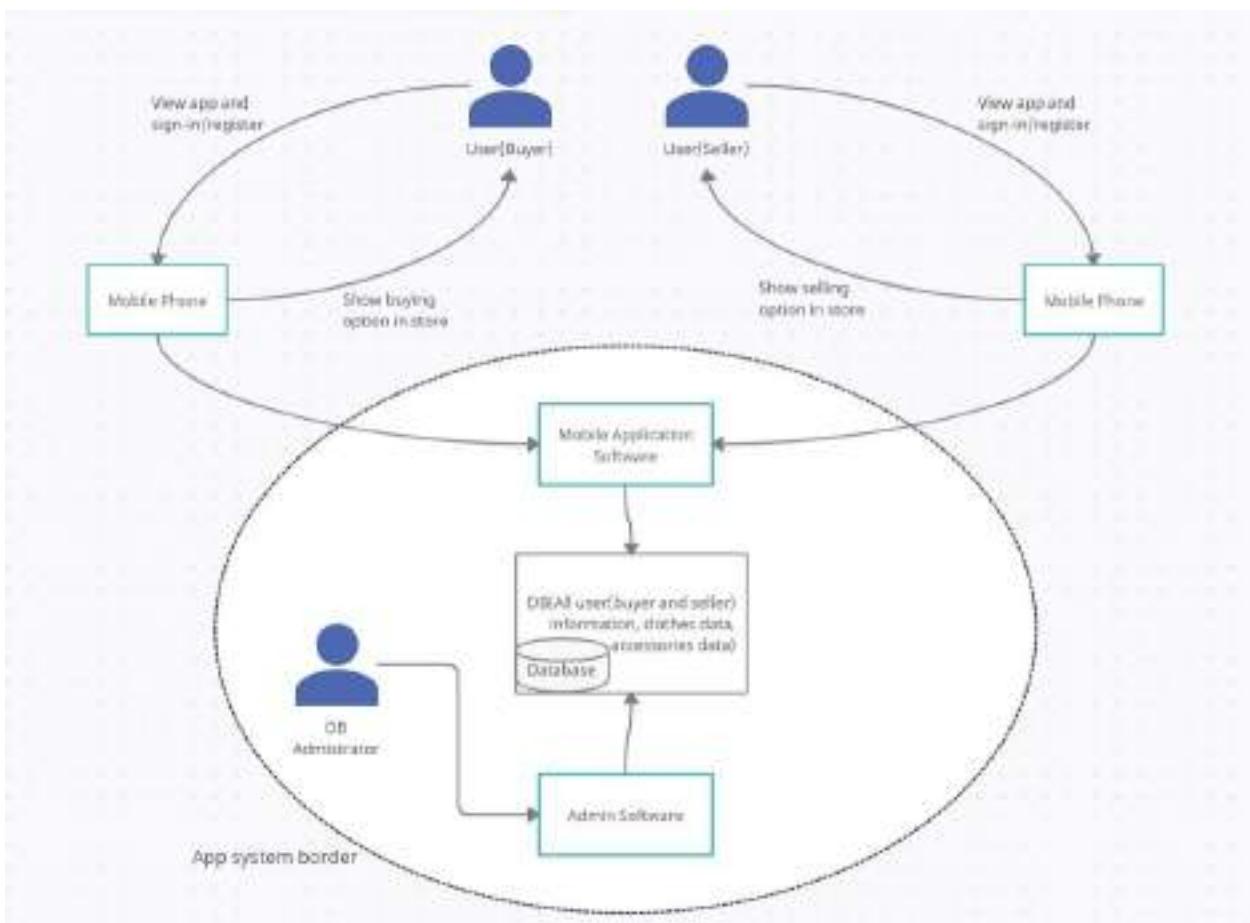
- View Analysis
- This allows the system admin to view various statistics like products sold, order received, total sales of the current month, etc.

8. Design Informing Models

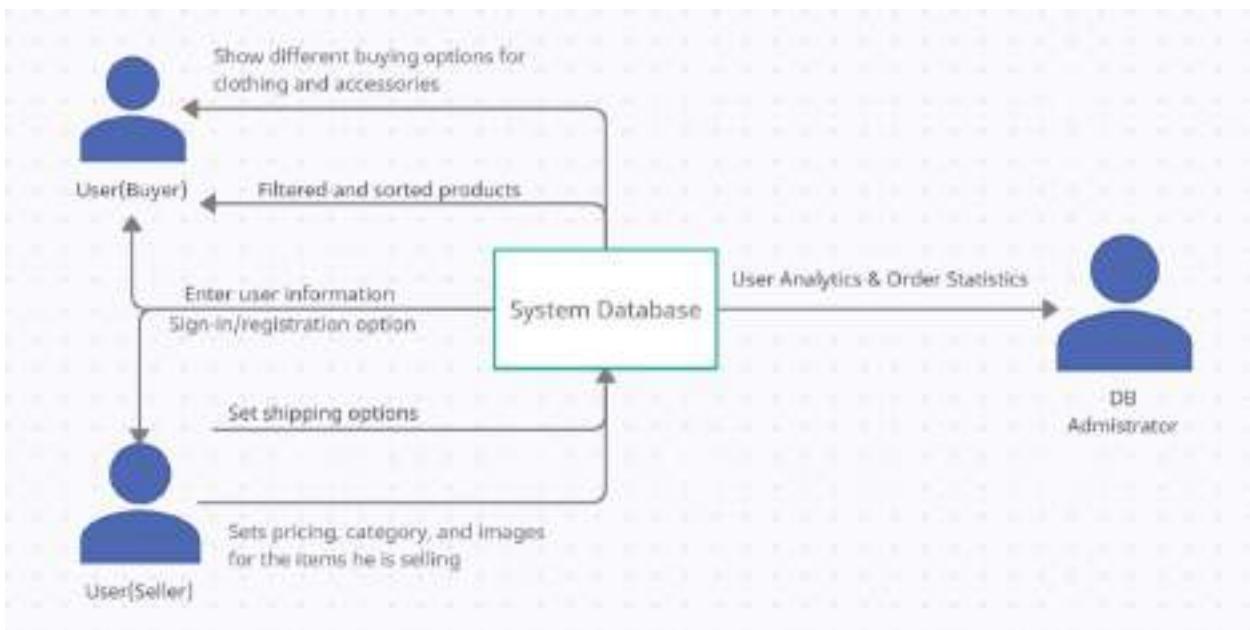
Social Model



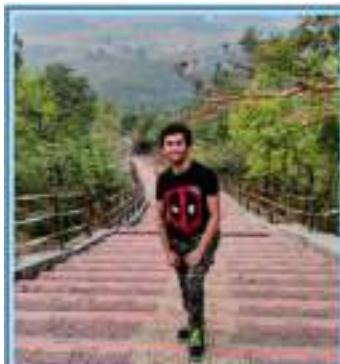
Flow Model



Artifact Model



9.User Persona



KALPESH

A engineering student in his early twenties, located in Badlapur, Maharashtra. He is having a Industrial Visit trip in his college to Uttarakhand.

Goals	To find winter clothes, accessories for his trip
Challenges	He doesn't know where to find right winter clothes for the trip, within his budget. He also has less time for choosing the suitable clothes.
Purchase Behaviour	He usually likes sweatshirt and long t-shirts. He also likes to wear cap.
Interest & Hobbies	He likes to do hiking, skiing and other outdoor activities like playing cricket. He spends majority of the time online watching travel videos.
Purchase Behaviour	Since we offer all types of clothing and accessories in cheap rates, we would like to take pressure off Kalpesh of buying winter clothes for his trip for cheaper rates and also offer discount.



TANMAY

A engineering student in his early twenties, located in Nashik, Maharashtra. His wardrobe is full and wants to make space for new clothes.

Goals	To find a place to sell his clothes.
Challenges	He doesn't know where to find right place to sell his clothes, as his wardrobe is full and he wants to make a space for new clothes.
Purchase Behaviour	He usually likes loose t-shirts, shirts and bomber jacket. He also likes to wear watches and chains.
Interest & Hobbies	He is a outgoing person. He likes to do parties and travel. Along with all these, he also loves to play video games.
Purchase Behaviour	Since we offer all types of clothing and accessories to buyer, we would like to take pressure off Kalpesh of selling his clothes and empty his wardrobe for new clothes.

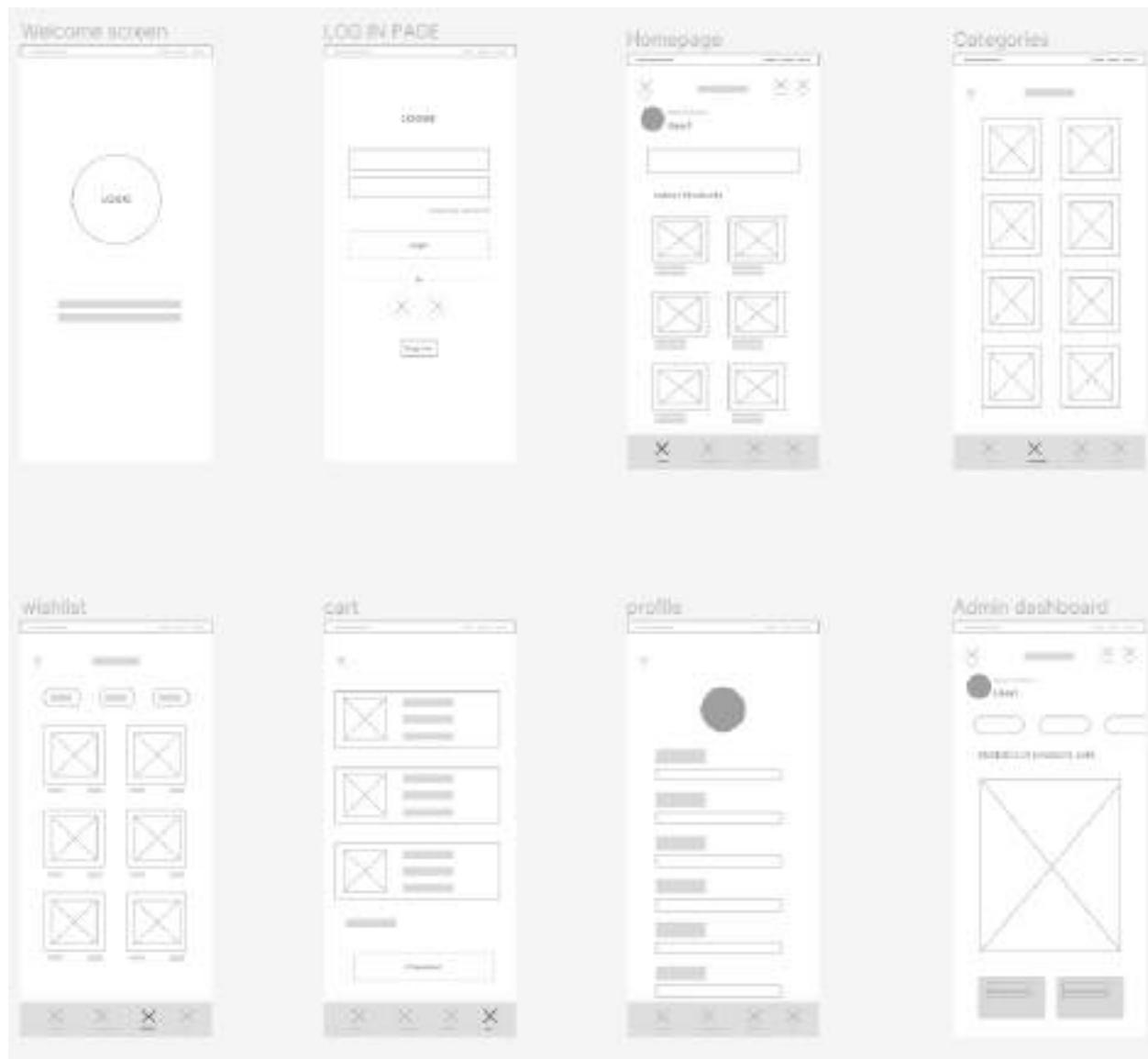


ANIKET

A fashion student in his early twenties, located in Mumbai, Maharashtra. He is in need of fashionable clothes for modeling assignment.

Goals	To find clothes, jackets and accessories for his modeling assignment.
Challenges	He doesn't know where to find right fashionable clothes for modeling, within his budget. He also has less time for choosing the suitable clothes.
Purchase Behaviour	He usually likes denim jeans and leather jacket. He also likes to wear chains and bracelets.
Interest & Hobbies	He likes to party and socialize. He also likes to play guitar. He spends majority of the time partying with people or modeling.
Purchase Behaviour	Since we offer all types of clothing and accessories in cheap rates, we would like to take pressure off Kalpesh of buying fashionable clothes for his modeling assignment for cheaper rates and also offer discount.

10.Wireframe



11. Storyboards

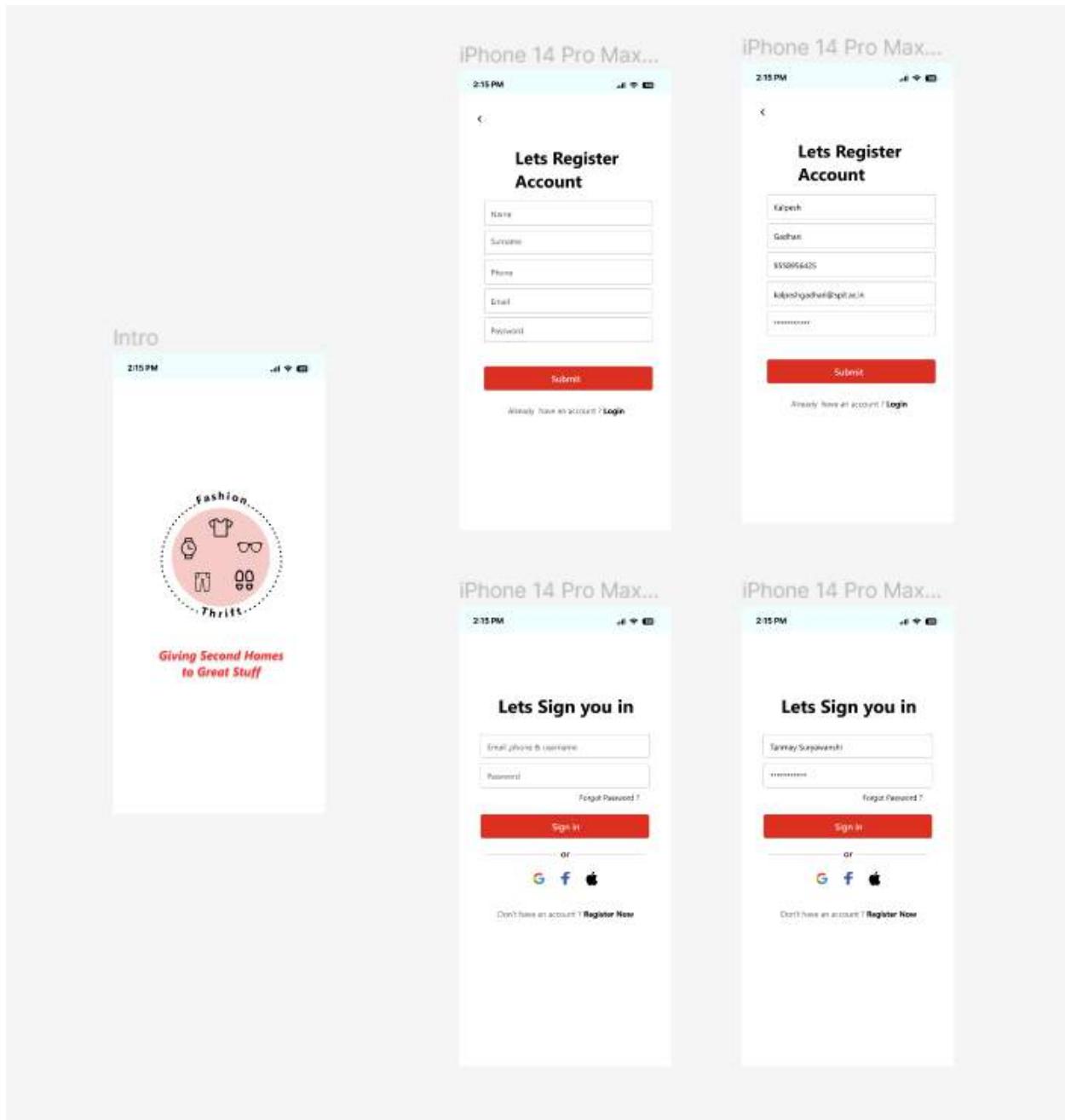
Current scenario

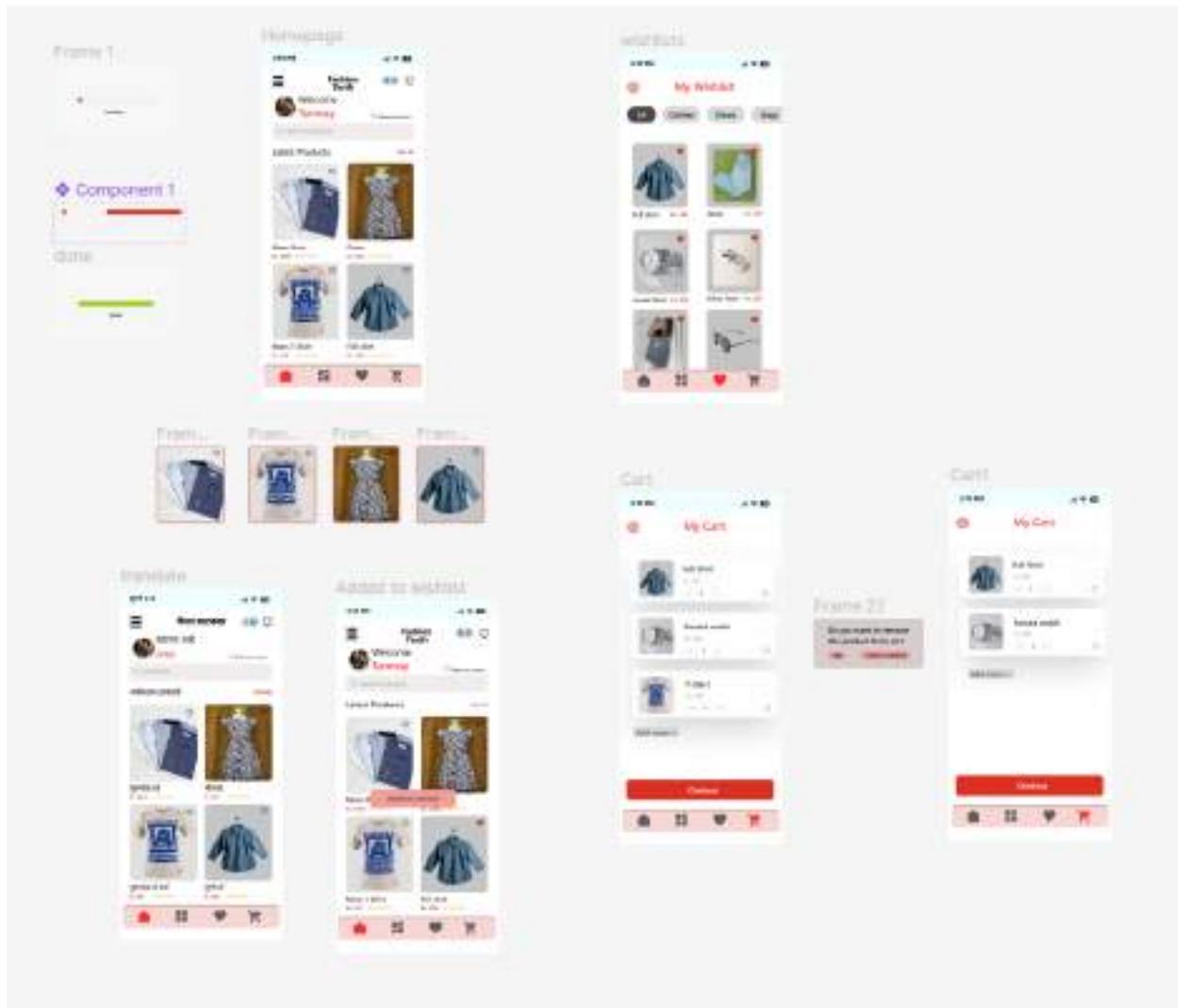


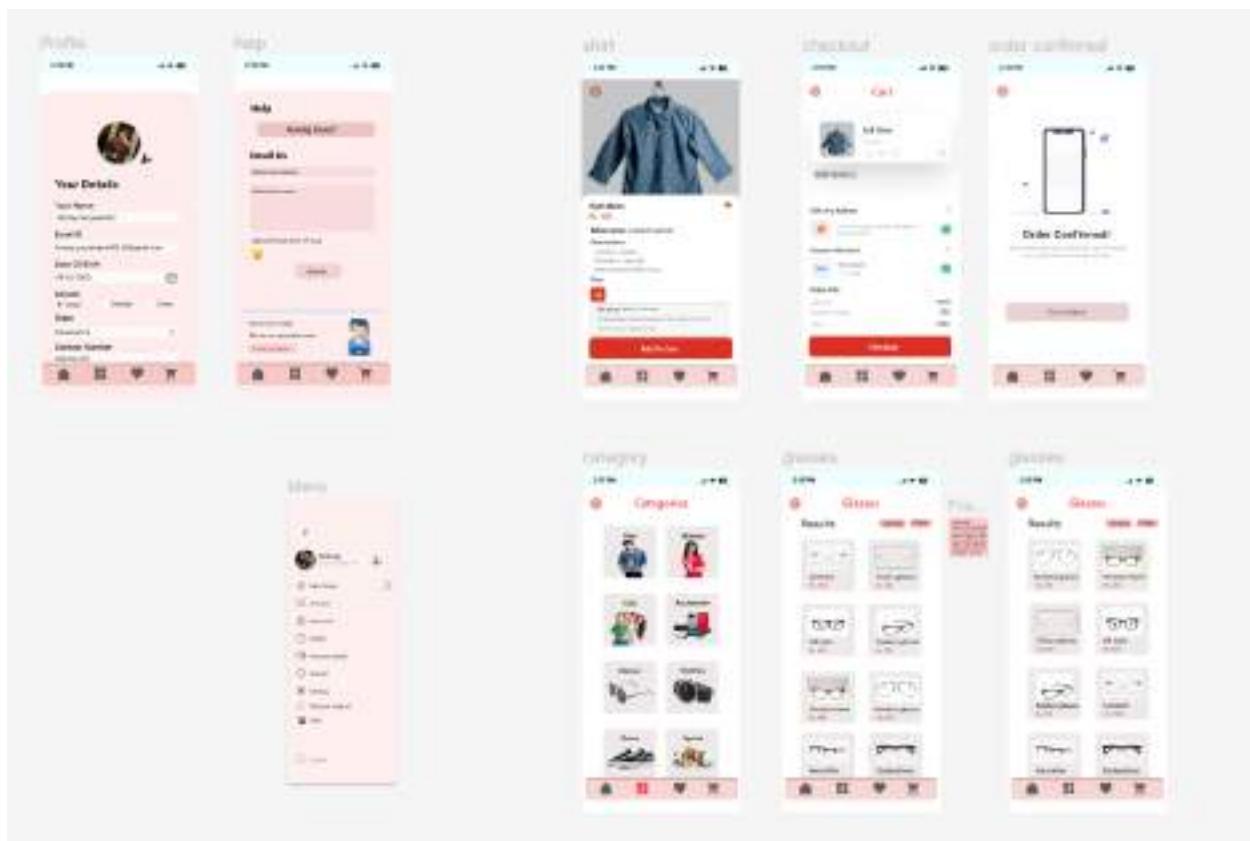
Envisioned System:

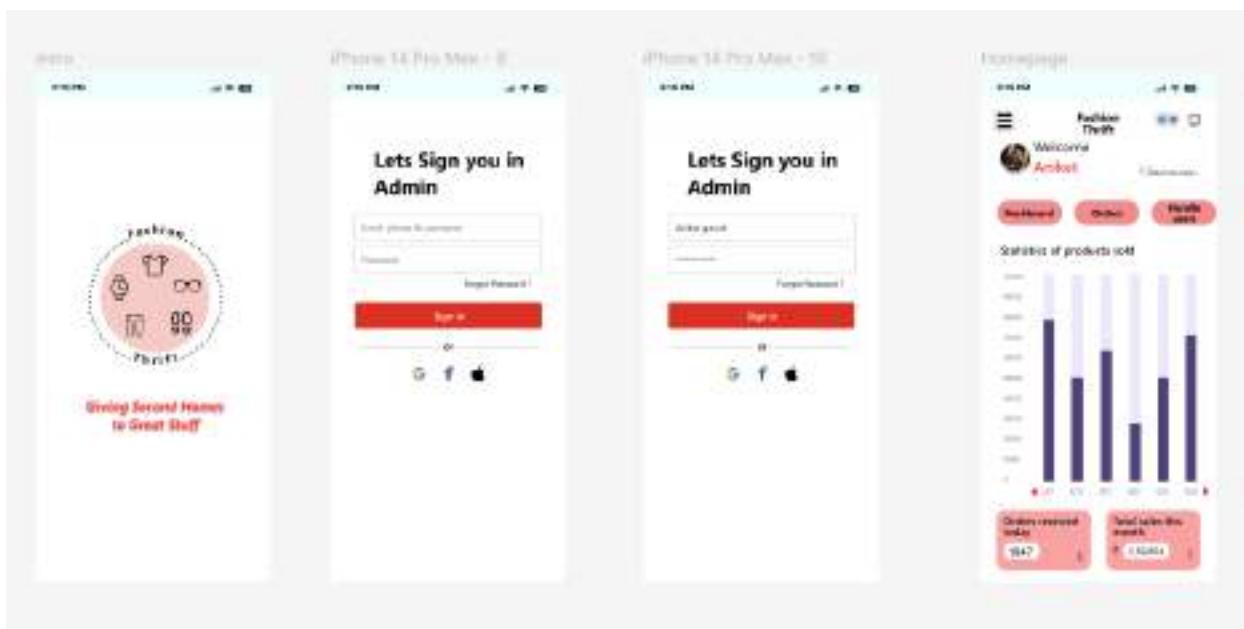
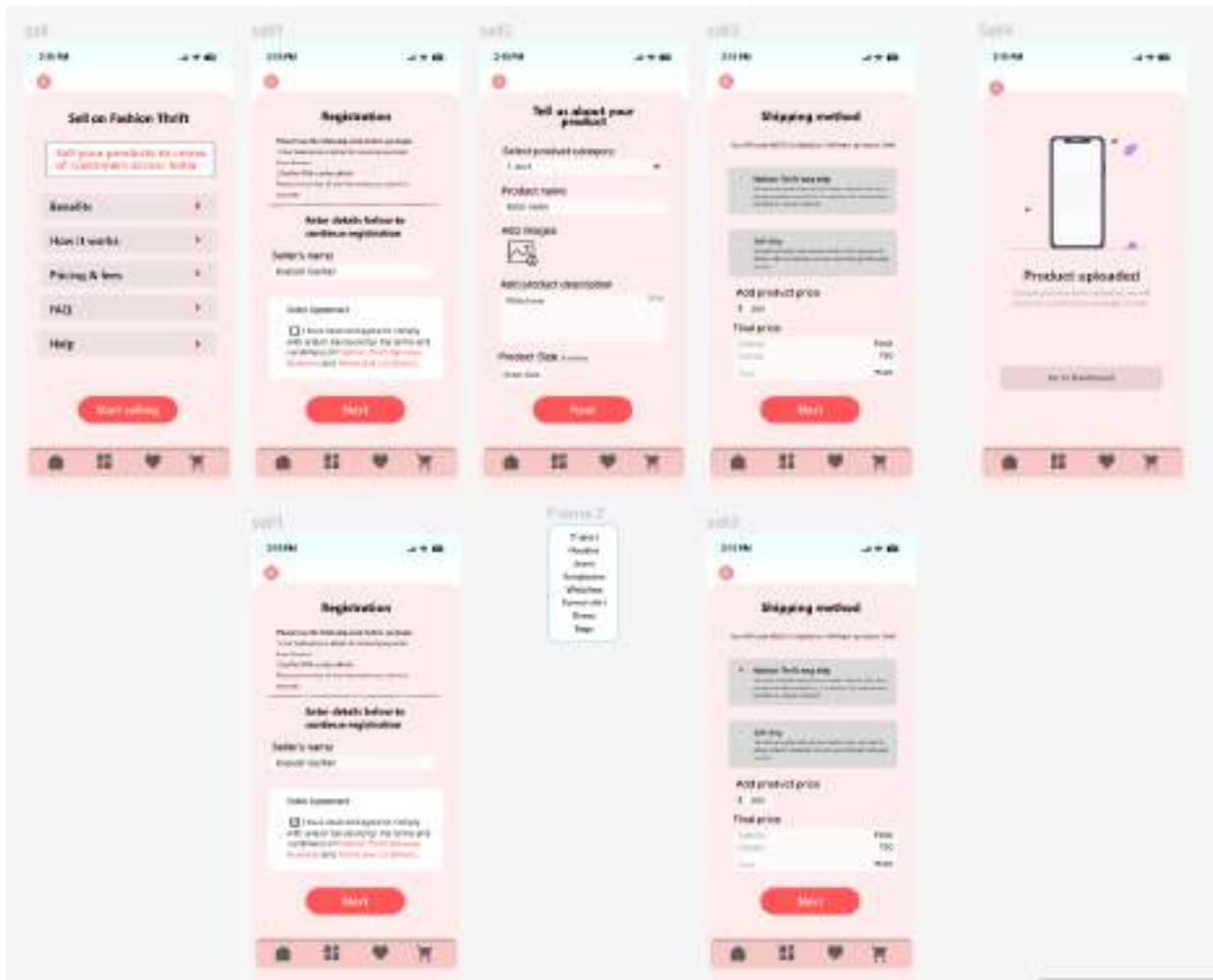


12. UI Screenshots









Figma File link:

<https://www.figma.com/file/EpctDTXA9V1wcGLv8ch3WM/Thrift?node-id=0%3A1&t=UkyxIKG9u0mnp5nY-1>

13. Usability Testing Links

Five Second Test: <https://app.usabilityhub.com/do/72e0a0a66aca/24a4>

First Click Test: <https://app.usabilityhub.com/do/b76b99cfa792/eeae>

Navigation Test 1: <https://app.usabilityhub.com/do/a3f56b954006/ee77>

Navigation Test 2: <https://app.usabilityhub.com/do/884d4b89a39e/c4a7>

Design test: <https://app.usabilityhub.com/do/8c660310380b/e5fa>

Five Second Test:

4 Total participants 4 Responses shown

Share Export 4 results as CSV

1. Five second test (design shown for 5s)



The screenshot shows a 'Help' page from a 'Five second test' interface. At the top, there's a progress bar from 2m 59s to 3m 00s. Below it is a red header bar with the word 'Help' and a 'Picking lesson?' button. The main area contains sections for 'Email Us' (with fields for 'Your Name' and 'Your New Email') and 'Upload screenshot of task' (with a file input field). At the bottom, there's a 'Submit' button and a 'Need more help?' section with links to 'Ask us a question' and 'Community'. A small cartoon character icon is also present.

1a. Multiple Choice question

What is the purpose of this page?

Totals Answers 4

Help

Help

Help

Help

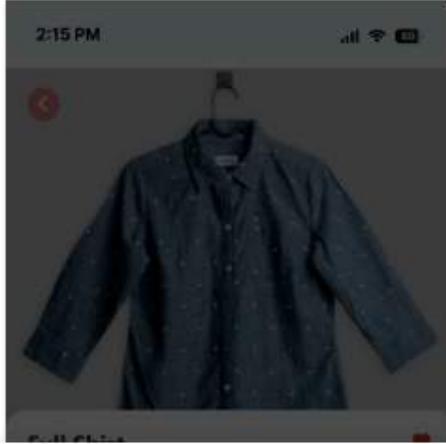
First Click Test:

5 Total participants 5 Responses shown Share Export 5 results as CSV

1. First click

Click on Add to Cart button.

Image Heat map Click map Export heat map as image



Expand image

Other 100% 5

← 1a. Linear scale question

How easy was it to locate the button?

Very Difficult Very Easy

1	2	3	4	5
0%	0%	0%	0%	100%
0	0	0	0	5
1	2	3	4	5

Mean: 5.00

Navigation test 1:

5 Total participants 5 Responses shown

Share Export 5 results as CSV

1. Navigation test

Navigate to Glasses category.

Step 1 2s 80% 20% Show details

Step 2 8s 100% 0% Show details

A total 80% of participants completed all steps in an average of 10 seconds.

← 1a. Linear scale question

How easy was it to navigate to Glasses category?

Very Difficult Very Easy

1	2	3	4	5
0%	0%	0%	0%	100%
0	0	0	0	5
1	2	3	4	5

Mean: 5.00

Navigation Test 2:

5 Total participants 5 Responses shown Share Export 5 results as CSV

1. Navigation test

Add the gray shirt to favourites.

Step 1 3s 100% 0% Show details

Step 2 2s 100% 0% Show details

A total 100% of participants completed all steps in an average of 5 seconds.

← 1a. Linear scale question

How easy was it to favourite the gray shirt?

Very Difficult Very Easy

0%	0%	0%	0%	100%
0	0	0	0	5
1	2	3	4	5

Mean: 5.00

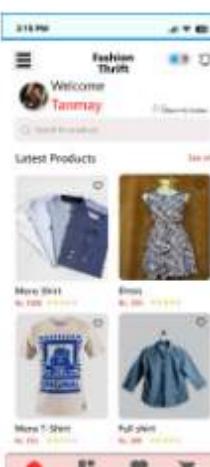
Design Test:

5 Total participants

5 Responses shown

Share Export 5 results as CSV

1. Design survey



← 1a. Linear scale question

Is the Design in above image good?

Very Bad

0%	0%	0%	0%	100%
0	0	0	0	5
1	2	3	4	5

Very Good

Mean: 5.00

14. UX Target Table

Work Role	UX Goal	UX Measure	Measuring Instrument	UX Metric	Baseline Level	Target Level	Observed Results
User	User satisfaction	Retainability & Learnability	Identify the use of this page	Average rating	3/5	4/5	5/5
User	User satisfaction	First Impression	Find 'Add to cart' Button	Average rating	3/5	4/5	5/5
User	Ease of Use	Initial User Experience	Select 'Glasses' category	Average time on task	<1 min	<30 sec	10 sec
User	Ease of Use	Initial User Experience	Select 'Heart icon' on gray shirt	Average time on task	<1 min	<30 sec	5 sec
User	User satisfaction	First Impression	UI design clarity	Average rating	3/5	4/5	5/5

15. Conclusion

Our team has successfully implemented the requirements and the case as provided by our clients. The UX team went through the entire lifecycle beginning with designing the system concept statement, analysis phase, design phase, prototype and final evaluation phase. The UX design prototype was subjected to numerous usability tests that were completed by the clients. The results of these tests are shown in the UX target table. The users are able to accurately perform the desired tasks. The clients were satisfied with the interface and the functionality provided to them by the 'Fashion Thrift' app.

16. UX Team Members' Experience:

Aniket Garud(Researcher):

As a UX Researcher, I had the responsibility to deliver the best possible experience for the users of the application and make it straightforward for the users. The inputs provided by the clients were quite straightforward. My teammates were also very helpful throughout the process.

Kalpesh Gadhari(Designer):

In my role as a UX Designer, I worked with customers to understand their goals, presented the results of user research to stakeholders, created user personas and usage scenarios, wireframes, storyboards, UI screen flows, and helped with content creation. I felt that analyzing user input and activity, and iterating on it, was necessary to improve the Fashion Thrift app's user experience. The overall experience of dealing with Tanmay and Aniket was great. My experience with them was incredibly pleasant.

Tanmay Suryawanshi(Evaluator):

I was actively involved in every stage of the UX Design lifecycle and was crucial to its success. I designed the system concept statement, complexity space, questionnaires, client interviews, storyboarding, UI designing, and testing, all the way up to the creation of the target table.

17. Client Testimony:

Sakshi Gadegaonkar:

The UI they came up with is what we had envisioned. The color selection is excellent as well.

Netal Asawa:

I am very satisfied with the documentation and the UI that were created by the team. Additionally, I enjoyed the overall feel of the app. Amazing work!

Aryan Dhami:

The UI has excellent images, design and colors. The app's general navigations and flow are fantastic.





Project Competition

Bhartiya Vidya Bhavan's
Sardar Patel Institute of Technology
Autonomous Institute Affiliated to Mumbai University

Congratulations

To Winning Team - **Semicolon**

We are thrilled to announce that a team of our college, **Team Semicolon**, has emerged victorious at the prestigious **Kavach 2023 Cybersecurity Hackathon** organized by the Ministry of Education and Ministry of Home Affairs at five different locations across the nation. **Team Semicolon** Participated at **Centurion University of Technology and Management, Bhubaneswar** from 08/08/23 to 10/08/2023. Out of a staggering **3,900 participating teams**, ours were among the **106 shortlisted** for the **grand finale**.

This achievement earned them a
Cash Prize of Rs. 50,000



Vedant Panchal



Prathamesh Paradkar



Stephen Vaz



Malay Phadke



Prathamesh Mundada



Aakanksha Dhawale

Abhaudhay



Prof. Dayanand Ambawade
Mentor

Dr. Nataasha Raul
Mentor

Paper Presentation



Bharatiya Vidya Bhavan's SARDAR PATEL INSTITUTE OF TECHNOLOGY

Munshi Nagar, Andheri (W), Mumbai – 400 058.
(Autonomous Institute Affiliated to University of Mumbai)



Sardar Patel Institute of Technology congratulates Siddiqui Hawaiza Sabeel Mohd Sultan from SE CSE [DS] for Participating in the State Level Technical Paper Presentation Organised by St. Xavier's Technical Institute, Sponsored by MSBTE on 10th June, 2021



A handwritten signature in black ink, which appears to be "Siddiqui Hawaiza Sabeel".

Reimbursement of Research Paper Publication



Sakina Shaikh <sakina_shaikh@spit.ac.in>

Process for applying for research Reimbursement for Faculty /Student.

2 messages

Yerramreddy Srinivasa Rao <ysrao@spit.ac.in>

Mon, Dec 9, 2019 at 3:53 PM

To: etrx.2020@spit.ac.in, etrx.2021@spit.ac.in, etrx.2022@spit.ac.in, etrx.2023@spit.ac.in, comp.2020@spit.ac.in, comp.2021@spit.ac.in, comp.2022@spit.ac.in, comp.2023@spit.ac.in, it.2020@spit.ac.in, it.2021@spit.ac.in, it.2022@spit.ac.in, it.2023@spit.ac.in, extc.2020@spit.ac.in, extc.2021@spit.ac.in, extc.2022@spit.ac.in, extc.2023@spit.ac.in, mca.2020@spit.ac.in, mca.2021@spit.ac.in, mca.2022@spit.ac.in, mtech.comp.2020@spit.ac.in, mtech.comp.2021@spit.ac.in, mtech.extc.2020@spit.ac.in, mtech.extc.2021@spit.ac.in, allteachingfaculty <allteachingfaculty@spit.ac.in>

Process for applying for research Reimbursement for Faculty /Student.

Link for Research paper : <https://research.spit.ac.in>

1. Post Paper

a. Add following information

General

- A. Type: UG/PG/PhD
- B. Year: Year of applying
- C. Type of Applicant: Faculty/Student
(if a faculty is a student in Phd then they need to select student and type as Phd.
For faculty they can select UG/PG as per their paper of publication)
- D. Department of Applicant: COMPS/EXTC/IT/ETRX/MCA
- E. Class of Applicant:FE/SE/TE/BE/Faculty

Applicants

- F. UCID of Appli. 1* -(if faculty, they can keep this field as faculty)
- G. Name of Appli. 1*
- H. Email of Appli. 1*
- I. Mb. No. of Appli. 1*
(if more than one applicant is present add their information here)

Guide

- J. Depart. of Guide 1*
- K. Name of Guide 1*
- (if more than one guide is present add their name. For faculty if they have published their paper with guide mention their name here.)

Paper Details

- L. Paper Title *
- M. Type *
- N. Paper Type *
- O. Name (Conf / Jour) *
- P. Action *



- Q. Action Details *

(if conference following information need to be filled)

- R. Date_of_Conference
- S. Month_of_Publication
- T. Conference_Type
- U. Hosting Institute of the Conference
- V. Addr_Institute
- (if journal following information need to be filled)
- W. ISBN
- X. Indexed
- Y. DOI
- Z. Citation of Journal
- AA. Journal from

Amount

- BB. Amount of Registration
- CC. Travelling Amtount
- DD. Accommodation Amtount
- EE. Other Expenses
- FF. Other Expenses Amtount

Upload

- GG. Copy of paper *- Soft copy of research paper
- HH. Certificate of Publication * - Certificate obtained after publishing paper
- II. Supporting Proof *- applying for reimbursement supporting pdf showing bills of registration, travelling and etc

b. Save changes: this button will save your information and will give you a link to download your pdf file.

c. Take the print of this file, attach the proof of like hard copy of paper, certificate of publication and expenses made.

d. Submit this to your R&D coordinator.

2. View paper: This link will show your paper as per the year / dept/ course.

Note: * indicate mandatory information

Following are the list of R & D coordinator

Computer: Prof. Abhijit Salunke

EXTC: Dr. Amol Deshpande

ETRX: Prof. Najib Ghatte

IT: Prof. Nikahat Kazi

MCA: Dr. Aarti Karande



Regards,

Dr. Y S Rao, PhD (ES-IIT-Bombay)
 Vice-Principal,
 Sardar Patel Institute of Technology,
 Munshi Nagar, Bhavans Campus, Andheri (W), Mumbai-58
 022-26708520/2628 7250 (Ext: 380).
 Mob: 9820962870

Lecture Videos: <https://www.youtube.com/user/EMTRONTechnologies>

S.P.I.T. Vision

To build a renowned institute which will produce graduate engineers with global competency and social sensitivity.

Sakina Shaikh <sakina_shaikh@spit.ac.in>
 To: Aarti Karande <aartimkarande@spit.ac.in>

Wed, Feb 7, 2024 at 1:01 PM

Dear Ma'am,
 PFA.

Regards,
 Sakina Banu Salmani,
 Assistant Professor,
 Sardar Patel Institute of Technology (S.P.I.T.)
 Mumbai

Contact: 9987655986
Youtube Channel: Eduvid-Learn Use Share
Linkedin Profile: [Sakina Salmani](#)
ISTE Membership no: LM102080
IEEE Membership no: 9809982

S.P.I.T. Vision

To build a renowned institute which will produce graduate engineers with global competency and social sensitivity.

[Quoted text hidden]



A handwritten signature in blue ink, appearing to read "Aarti Karande".



Sakina Shaikh <sakina_shaikh@spit.ac.in>

Reimbursement Process for Research Paper Publication for Faculty and Student

1 message

Yerramreddy Srinivasa Rao <ysrao@spit.ac.in>

Fri, Mar 25, 2022 at 4:18 PM

To: students@spit.ac.in

Cc: faculty@spit.ac.in

Dear All,

Warm Greetings

S.P.I.T. The R & D committee encourages students and faculty to publish the research paper in good conferences affiliated with IEEE/Springer/ACM. For selected good quality research papers published in a good conference under the guidance of S.P.I.T. faculty, Students will get reimbursement in publication fees up to Rs. 5000/-

Students need to follow the following procedure while applying for reimbursement in offline mode.

1. Students has to apply for reimbursement using the link www.research.spit.ac.in
2. Download the generated PDF of the application after filling in all relevant details and supporting uploads.
3. Take the printout of the above-generated PDF along with Bills of payment and Certificate of Publication/acceptance research paper. Take the signature of your respective HOD, your mentor/Guide (with whom the paper is published), and the R & D Coordinator of the department. Submit this complete document to the R & D coordinator.

Faculty need to follow the following procedure while applying for reimbursement in offline mode.

1. faculty have to apply for reimbursement using the link www.research.spit.ac.in
2. Download the generated PDF of the application after filling in all relevant details and supporting uploads.
3. Take the printout of the above-generated PDF along with Bills of payment and Certificate of Publication/acceptance. And follow the permission process from the Principal office.

Students will get notified about the approval of reimbursement applications in the month of April of the academic year. All the applications are collected up to the month of February. Students whose conference notification/conduction is scheduled after February will be considered in the next academic cycle.

for any further queries, you can connect with department-wise Coordinators.

1. Dr. Aarti Karande, MCA
2. Dr. Amol Deshpande, EXTC
3. Prof. Nikahat Mulla, IT
4. Prof. Anand Godbole / Prof. Abhijit Salunke COMP
5. Prof. Najib Ghatte, ETRX

PFA, the process for reimbursement in the image format.



--
Regards,

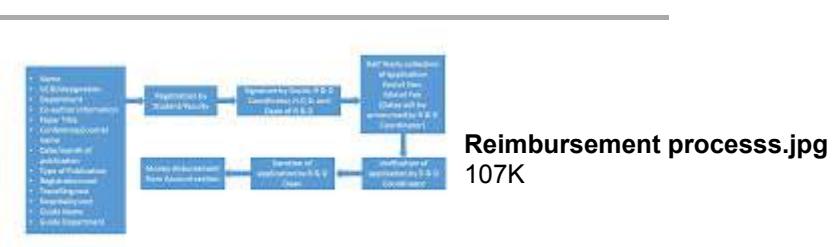
Dr. Y S Rao, PhD (ES-IIT-Bombay)
Vice-Principal,
Sardar Patel Institute of Technology,
Munshi Nagar, Bhavans Campus, Andheri (W), Mumbai-58
022-26708520/2628 7250 (Ext: 380).
Mob: 9820962870

www.linkedin.com/in/dr-y-s-rao-4b223130

Lecture Videos: <https://www.youtube.com/user/EMTRONTechnologies>

S.P.I.T. Vision

To build a renowned institute which will produce graduate engineers with global competency and social sensitivity.





OCL: Bootcamp

Technical • March 2023

[Register Now](#)[Summary](#)[Rules](#)[FAQ](#)

- ✓ It is a 6 hour long python bootcamp which will be taken up by seniors who have won various hackathons.
- ✓ The bootcamp will additionally include 2 sessions "Python for Data Science" and "Python for Competitive Programming"
- ✓ Participants will be provided with daily question banks to keep a track of their progress.
- ✓ At the end of the Bootcamp there will be one to one doubt sessions for all participants.
- ✓ Once the bootcamp is over there will be offline coding round- "CODATRON" to determine the winner of the bootcamp.



EVENTS

Seconddrinks

CONTACT

 Instagram  LinkedIn
 Twitter  YouTube

Mobile App
@oculus



SCHEDULE

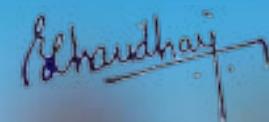
Registration

LOGIN

Privacy Policy
Terms and Conditions
Refund Policy

© Oculus The Fest 2023. All rights reserved




Rishabh Jain



Home

Events

Team

Extra Curricular Activities

Our Events



*Circular Economy X Blog
Writing Competition*



IEEE DAY 2023



AARAMBH 2023

BLOG WRITING 2023

Previous Events



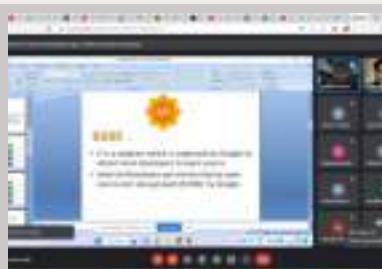
PERIPHERATHON 2023



CODEHUNT 2023



INNOVATION CUP 2023



GSOC WEBINAR 2023



TACKLING PLACEMENTS 2023



WEBINAR ON BLOCKCHAIN

Anand W.
Munde





AARAMBH 2022



TECHBRAWL 2022

Extra Curricular Activities

**Address**

Bhavans Campus, Old DN Nagar,
Munshi Nagar, Andheri West,
Mumbai, Maharashtra 400058

Contacts

Email : ieee@spit.ac.in
Phone: 82914 03220

Feedback

Please send us your ideas,
bug, reports, suggestions!.
Any feedback would be appreciated



Extra Curricular Activities



Bharatiya Vidya Bhavan's
Sardar Patel Institute of Technology
(An Autonomous Institute Affiliated to University of Mumbai)
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India.



Events Details

Events Details From January 2023

Sr. No.	Event Name	Type of Event (FDP, Skill Program... etc.)	Start Date	End Date	Total No. of Participants
1	Internship program for diploma students on product development cycle	Skill Program	01-01-2023	28-05-2023	22
2	Orientation Program in "Real Time Software" (Batch-1)	Skill Program	14-01-2023	14-01-2023	44
3	One Day Faculty Orientation Program on "Internet of Things (IoT) Hardware Setup"	Faculty Development Programme	18-01-2023	18-01-2023	15
4	Orientation Program in "Real Time Software" (Batch - 2)	Skill Program	21-01-2023	21-01-2023	24
5	Orientation Program in "Real Time Software" (Batch - 3)	Skill Program	04-02-2023	04-02-2023	10





UNLEASH THE **ENTREPRENEUR**
WITHIN YOU

Panel Discussion

December 2022

E-Cell S.P.I.T conducted 'Panel discussion 2022' - an event where people who are successful in their respective domains, share their experiences with the young minds of our college.

[Read More](#)

Extra Curricular Activities



November 2022

E-Cell S.P.I.T in association with IIC S.P.I.T. & E-Cell IIT Bombay conducted 'Illuminate 2022' - a 6 hr long workshop that introduced the students to what is entrepreneurship & various topics related to it like pitching, BMCs, Marketing, Finance, etc

[Read More](#)

Food Challenge



November 2022

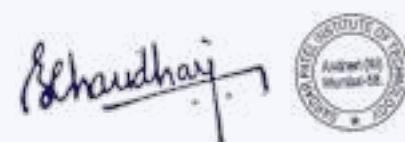
PAST EVENTS



-August 2020

E-Cell S.P.I.T organised an Olympic Bid Case Study competition in the month of August. Every participating team had to select a country and pitch why the 2032 olympics should be held in their country. The competition was divided into 2 rounds. The first round involved preparing a PPT and submitting it to the panel. The finals being scheduled on 23rd August involved tons of hard work and research done by the finalists. After a round of pitch Team SAS representing Canada were crowned champions followed by Team Concept (Turkey) followed by Team Vanguard (Singapore).

[Read More](#)



E-CELL S.P.I.T

-August 2020

Even though they seem like a day to day thing, investments can be pretty confusing and more often than not, outright devastating. In order to clear all doubts when it comes to investments, E-Cell S.P.I.T in accordance with Institute Innovation Council held a workshop...

[Read More](#)[Read More](#)

competition, and so on. He was joined by Mr Varun Agnihotri whose achievements include- Runner up National round, KPMG Ideation challenge, Runner up at BITS Hyderabad National case study competition.

Business Case Study

-Feb 2020

Clearly being able to present case studies is an important skill for an engineer, so SPIT E-Cell and IR cell came up with the Case Study competition. The panel of judges consisted of Prof. Kaisar Katchi (Faculty Mentor, E-Cell S.P.I.T.), Mr. Asif Panjwani (Risk Consultant at KPMG), Ms Kejal Parekh (Senior Marketing Manager Nyka) and Jatin Malhotra (Project Manager JIO).

[Read More](#)**Business Workshop**

-July 2020

E-CELL S.P.I.T

-Jan 2020

On the evening of 25th July, IIC SPIT along with MentorNext and E-Cell SPIT organised a webinar on MBA after engineering. The webinar was hosted by two alumni of SPIT, Akhil Sardesai who completed his MBA from IIM Indore and has recently joined PepsiCo in a sales & marketing role and Aditya Menon who has completed his MBA from ISB and is an incoming consultant at McKinsey along with Mohit Joshi from MentorNext. They gave an overview of how one can prepare for GMAT and ultimately land into ISB.

[Read More](#)[Read More](#)**E-CELL S.P.I.T**

-Jan 2020

This edition of our flagship event saw students set up stalls and sell food which they made to their friends and faculty. With over INR 42,000 sales recorded in the first 4 hours, the 2020 edition of food challenge was the biggest ever with students selling brownies, pastas, burgers, sandwiches, burritos etc. and participants were allowed to take home all their profits.

[Read More](#)

E-CELL S.P.I.T



-Dec 2019

The E Cell of SPIT organised a visit to the slums of Mumbai namely Versova with a motive to educate the people. The students were assigned locations with the aim to spread awareness amongst them. The children were educated over how they could contribute in making their locality clean. Slogans and attractive posters made by the students also helped in conveying the message amongst them.

[Read More](#)

E-CELL S.P.I.T



-Oct 2019

E-Cell SPIT in collaboration with E-Cell ICT conducted this day long workshop where Mr. Saurabh Jambure spoke on how to transform an idea into a start-up. He spoke about idea validation, team building and working out your finances using lean startup canvas.

[Read More](#)

E-CELL S.P.I.T



-Oct 2019

An Industrial Visit to Technology and Business Incubation Center (SP-TBI) was organised where the students got a chance to interact with experts in the field of Technology and marketing associated with budding startups there and also visited the workspace of startups.

[Read More](#)




Bharatiya Vidyabhawan

Sardar Patel Institute of Technology

Autonomous Institute Affiliated to Mumbai University


[HOME](#) [ABOUT ▾](#) [EVENTS](#) [GALLERY](#) [CONTACT](#) [LOGIN ▾](#)

Extra Curricular Activities



Personality Development and Resume Writing Seminar

Objective of the Event: The seminar was organized for all Third-Year students of the college, especially those who are targeting placements. The seminar's objective was to brush the communication skills, interview skills and resume writing skills of students.

Event Date:
From : 2024-02-09

To: 2024-02-09


Abhimat-2024

Event Theme: Lok Sabha To test the effective speaking, critical thinking and communication skills of students

Event Date:
From : 2024-02-09

To: 2024-02-09

Registration Open :
From : 2024-02-01

To: 2024-02-06


WIE Health Talk

Objective of the Event: To improve the understanding of female students on mental health, personality development and grooming.

Event Date:
From : 2024-02-07

To: 2024-02-07

Registration Open :
From : 2024-02-07

To: 2024-02-07


Celebrating Savitribai Phule and Jijamata Jayanti

To celebrate the legacy of Savitribai Phule and Jijamata Jayanti . The event was a reminder of India's rich history and the struggle of these brave women to make a mark in society.

Event Date:
From : 2024-01-19

To: 2024-01-19

Registration Open :
From : 2024-01-19

<https://wie.spit.ac.in/events.php>

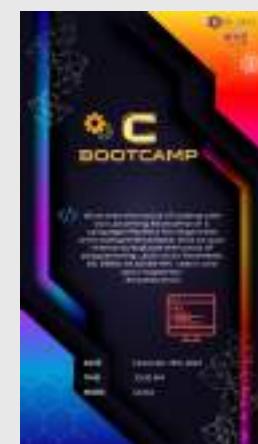
1/2

3/10/24, 11:30 AM

Registration Open :
From : 2024-02-09
To: 2024-02-09

To: 2024-01-19

IEEE WIE SPIT | Events



WIE C Coding camp

To teach C programming from basic to advanced concepts in order to boost the preparation of first-year students for their PSIPL exams.

Event Date:
From : 2023-11-19

To: 2023-11-19

Registration Open :
From : 2023-11-09

To: 2023-11-16


AnimeToon

This is a fun quiz about the newest Generation Z cartoons and the anime trend in Japanese animation. This test will take place in 008 offline starting at 4. The greatest method to relax and have fun is to participate in these trivia questions on cartoons and anime. It will undoubtedly make everyone nostalgic for their youth and can even strengthen friendships.

Event Date:
From : 2023-10-20

To: 2023-10-20

Registration Open :
From : 2023-10-17

To: 2023-10-19


Extra Curricular Activities

IPR Cell Of SPIT



IPR Cell was established in SP-IT in 2012 to protect the invention of students and faculty. Campus has taken the initiative to promote innovations and to facilitate protection of Intellectual Property (IP) created at the campus. The Intellectual Property Rights Cell(IPR Cell) at campus is formed to provide guidance, support and resources to all campus personnel and facilitates protection and deployment of intellectual property. IPR-Cell conducts workshops to enhance awareness on related issues, it also provides templates and guidelines for the contracts, agreements and MOUs governing the effective exploitation of the IP produced by faculties and students. Towards this goal an Intellectual Property Policy of the Institute has been formulated. SP-IT has published a total of 88 patents since June 2013 till now.

VISION

“Secure innovative ideas of inventors to create an ambience of research and innovation for the future leaders and innovators”

MISSION

“To create environment for development of IPR through research innovation”



Sardar Patel Institute of Technology,
Bhavans Campus, Munshi Nagar,
Andheri West, Mumbai-400 058
Mobile: 09987030881
Email: ktvtalele@spit.ac.in

© 2020 Copyright: spit.ac.in.com

Schandhai



3. Problem solving Methodology

A. Research Paper as outcome of problem solving

The production of a research paper through problem-solving methodologies confers substantial benefits upon students. Through problem solving strategy students systematically navigate complex issues, cultivating skills essential for critical analysis and profound comprehension. Students refine their cognitive abilities, improving their capacity to unravel complex problems and synthesize information judiciously. Beyond its evaluative implications, the research paper becomes a manifestation of intellectual growth, as students contribute meaningfully to the scholarly discourse, underscoring the educational value derived from their systematic approach to problem-solving.

B. Major Projects

Major projects play a pivotal role in fostering the overall development of students. Beyond the acquisition of subject-specific knowledge, engaging in substantial projects cultivates a spectrum of skills essential for personal and professional growth. Students are compelled to enhance their critical thinking, problem-solving, and project management abilities, as they deal with real-world challenges.

C. Research Internships

Engaging in research internships provides students with invaluable opportunities for academic and professional development. Through active participation in ongoing projects, students develop critical thinking, communication, and teamwork skills, positioning them as well-rounded individuals ready to navigate the complexities of their chosen field.

D. Hackathon

Students participate in various hackathons which provide an opportunity for students to develop and enhance a wide range of skills, including coding, problem-solving, critical thinking, time management, and collaboration. Hackathons encourage participants to think outside the box and come up with innovative solutions to problems. Hackathons offer students a dynamic and impactful learning experience, helping them develop technical and soft skills while exposing them to real-world challenges and industry connections.

Research Paper as Problem Solving Technique

M-JAW: Mobility-Based Jamming Avoidance in Wireless Sensor Networks

Sudip Misra^{ID}, Senior Member, IEEE, Ayan Mondal^{ID}, Student Member, IEEE, Prasenjit Bhavathankar, and Mohamed-Slim Alouini^{ID}, Fellow, IEEE

Abstract—In this work, we study the problem of jamming avoidance for ensuring quality-of-service (QoS) in terms of the network lifetime and overhead in wireless sensor networks (WSNs). We propose a mobility model using *Single-Leader-Multiple-Followers Stackelberg game theory* to avoid the jamming affected region. In the proposed model, the centralized unit (CU) identifies the jamming affected region based on the locations of the affected nodes and acts as the leader. On the other hand, the jamming affected nodes act as followers and decide the mobility pattern, including the angle of movement, while minimizing the energy consumption and delay in packet delivery. A scheme, named M-JAW, for ensuring QoS, while avoiding jammers in WSNs, is proposed using the stated game-theoretic mobility model. Using M-JAW, the energy consumption of the overall network reduces by up to 20.36%, and the network overload reduces by 44.13–50.12%, which, in turn, increases the lifetime of WSNs.

Index Terms—Quality-of-service, jammer, mobility model, mobile wireless sensor network, Stackelberg game.

I. INTRODUCTION

WSNs are prone to various attacks [1]. Among them, jamming [2] is one of the important issues. A jammer [2] emits signals in the same frequency as the communication frequency of the deployed sensor nodes to restrict communication among them. This leads to the higher energy consumption of the sensor nodes [3], because of multiple unsuccessful packet re-transmissions. Consequently, the network lifetime gets reduced, as WSNs are energy resource-constrained. The effect of jamming is not permanent over the sensor nodes. Therefore, if the jamming affected nodes get out of the affected region or the jammer stops transmitting, the nodes start to behave normally.

In the existing literature, researchers studied different types of jammers such as one with single transmitter or another with multiple transmitters. Mpitzopoulos *et al.* [4] classified the jammers to be divided into four jamming categories – proactive or

constant, deceptive, random, and reactive. In this work, we consider *proactive* or *constant* jammer [5] only. In other words, the jammers transmit continuously having random bit sequences. In the process, the jammer causes interference and keeps the wireless channel busy. Additionally, it corrupts the transmitted packets. In the existing literature [6]–[8], researchers proposed different jammer detection schemes. On the other hand, some of works focused on designing schemes to counter jamming. However, these proposed schemes are not implementable in real-life, because of high cost and limited energy. Mpitzopoulos *et al.* [4] surveyed the difficulties encountered with the proposed jamming avoidance schemes involving antenna polarization, direct-sequence spread spectrum, frequency-hopping spread spectrum, regulated transmitted power, ultra-wideband (UWB) technology, and directional transmission. However, in the existing literature, no mobility model is developed for countering jamming while taking strategies rationally. In other words, for jamming avoidance, no mobility model is proposed considering the stochastic decision of the jamming affected nodes, where the decision of each node is dependent on the environmental parameters and other jamming affected nodes.

We focus on ensuring QoS, in terms of the network overhead and lifetime, in the presence of jammers. In this work, we consider that all nodes are mobile. Initially, we detect the jammed zone with the help of a CU and propose a mobility model to avoid jamming while affecting the network lifetime minimally. The contributions of this work are briefly illustrated as follows:

- The proposed scheme, named M-JAW, ensures QoS in terms of network lifetime and network overhead in the presence of jammers. M-JAW ensures jamming affected region identification with minimal energy consumption. In this process, the CU aims to detect the jamming affected area based on the received incremental flow-table updates.
- In the next part of the proposed scheme, M-JAW, we propose a mobility model, named *Rational Mobility Model* (RMM), for jamming affected nodes to get away from the effects of jamming.
- For RMM, we use the *Single-Leader-Multiple-Follower Stackelberg game*. The CU and the jamming affected nodes act as the leader and the followers, respectively. Accordingly, we propose a jamming avoidance algorithm based on the proposed RMM.

Manuscript received May 13, 2019; revised September 30, 2020 and January 30, 2020; accepted March 9, 2020. Date of publication April 3, 2020; date of current version May 14, 2020. The review of this article was coordinated by Dr. M. Elkashlan. (*Corresponding author: Sudip Misra*)

Sudip Misra, Ayan Mondal, and Prasenjit Bhavathankar are with the Department of Computer Science and Engineering, Indian Institute of Technology Kharagpur, West Bengal 721302, India (e-mail: smisra@sit.iitkgp.ernet.in; ayanmondal@iitkgp.ac.in; pbhavathankar@gmail.com).

Mohamed-Slim Alouini is with the Computer, Electrical, and Mathematical Science and Engineering Division, King Abdullah University of Science and Technology, Thuwal 23955, Saudi Arabia (e-mail: slim.alouini@kaust.edu.sa).

Digital Object Identifier 10.1109/TVT.2020.2982966

Research Paper as Problem Solving Technique

II. RELATED WORK

In the last few years, a lot of research work on jamming in WSN emerged, viz., [4], [6], [9]–[12]. Some of the existing literature are discussed in this Section. Garnaev *et al.* [12] studied jammer type identification using Bayesian game. In this problem, a dual linear programming problem, based on the jamming attack history, the nodes identify the type of attack and reduce the jamming effect. Aziz *et al.* [7] proposed a jammer type estimation scheme in LTE/LTE-A networks using a non-zero-sum repeated game.

Mamaghani *et al.* [13] proposed a time-switching architecture for bi-directional data-relay in the presence of jammers. Additionally, the authors also evaluated a closed-form performance metric with a high signal-to-noise ratio. He *et al.* [14] considered mobile relays in the presence of static nodes and intelligent jammer and designed the single and multi-commodity flow problem. The authors used spectral graph theory for maximizing network flow.

Nguyen *et al.* [15] proposed a jamming scheme to ensure privacy of the secondary users in the presence of multiple primary users by transmitting noise signals in cognitive radio networks. Amuru and Buehrer [16] studied an optimal jamming scheme with an additive white Gaussian noise channel. However, they did not propose any anti-jamming scheme.

Tague [17] studied that mobility affects the jamming attack. The authors proposed mobility control mechanism to achieve high performance. However, none of these works proposed any novel mobility model in a mobile sensor network. In the case of sensor networks, it is required to have some efficient mobility model which will be energy efficient, as sensor nodes are energy constrained in nature.

On the other hand, Misra *et al.* [8] studied the problem of jamming area identification. In Ref. [18], the authors proposed anti-jamming scheme with varying transmission power. Ma *et al.* [11] proposed a random mobility model for the jamming affected nodes in the presence of single jammer. Xu *et al.* [19] proposed a frequency multiplexing scheme for avoiding jamming. Ahmed and Faulkner [20] developed a hardware prototype to reduce the effects of a jammer. Mpitsiopoulos *et al.* [21] studied a mobility scheme for jamming avoidance. However, these works do not consider the energy-constrained nature of the nodes. In addition, they fail to propose a novel mobility model for mobile WSNs.

In contrast to the existing literature, we aim to design a game-theoretic mobility scheme for ensuring QoS, in terms of network lifetime, in the presence of jammers in WSNs.

III. SYSTEM MODEL

We consider a wireless network consisting of multiple (a) *proactive jamming* nodes (JN), and (b) *normal* nodes (NNs). The jamming nodes are considered to be stationary and the normal nodes mobile in nature. Therefore, in the presence of a subset of active jamming nodes, the NNs use M-JAW to escape from the jamming region and ensure network connectivity. We define the bounds of M-JAW by outlining the *assumptions* below:

- a) We consider a CU in the network, which ensures QoS in the presence of active jammers.

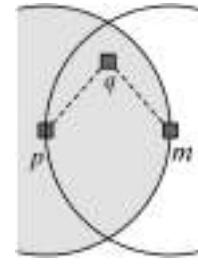


Fig. 1. Relative neighborhood graph formation.

- b) Each JN is static, behaves as a proactive jammer, and can block one frequency channel at a time.
- c) Each NN is mobile and moves to a direction strategically, i.e., rationally, to avoid jamming affected region. In other words, while making the directional strategy, each jamming affected node takes into consideration the environmental parameters as well as the decision of other affected nodes.
- d) The NNs are homogeneous in terms of communication range. In other words, they all have the same range.
- e) The sender node, $S \in \mathbb{N}$, always has a packet to send.
- f) The network is considered to be ideal, and the channels follow the free space model [22]. Hence, we argue that a packet can be lost, if and only if the sender node, S , or the forwarder node, F , where $S, F \in \mathbb{N}$, is within the communication range of a JN $J \in \mathbb{J}$.
- g) Each node $n \in \mathbb{N}$ uses two different frequency channels – CH_d and CH_c – on a sharing basis. The channel CH_d is used for sending data packets by the NNs. On the other hand, the channel CH_c is used by the NNs and the CU for sending control packets. The CU uses CH_c for communicating with the jamming affected nodes.

Neighborhood Graph Formation: We consider that, initially, when the NNs are deployed over the network, there is no active jamming node. Therefore, initially, each NN $n \in \mathbb{N}$ explores its neighbors \mathcal{N}_n and populates the corresponding edges \mathcal{E}_n , where $\mathcal{E}_n = \{e_1^n, \dots, e_{n-1}^n, 0, e_{n+1}^n, \dots, e_{|\mathbb{N}|}^n\}$, and e_i^n defines the edge between nodes n and i , where $n, i \in \mathbb{N}$. Additionally, we express e_i^n as follows:

$$e_i^n = \begin{cases} 1, & \text{if there exists an edge between nodes } i \text{ and } n \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

In M-JAW, we consider that the graph G is formed by considering the available edges $\mathcal{E}_n, \forall n \in \mathbb{N}$ in the network.

Relative Neighborhood Graph Formation: In order to reduce the number of edges, we use the concept of *Relative Neighborhood Graph* (RNG) [23]. We consider that the graph having reduced number of edges is denoted as G_{rng} . Further, G and G_{rng} have the same number of vertices. However, the set of edges in G , i.e., $\bigcup_n \mathcal{E}_n$, is a superset of the edges in G_{rng} , which is denoted as E_{rng} . RNG formation is a distributed approach.¹ We consider that there are three nodes over the terrain – p , q , and m , as shown in Fig. 1. We get $q, m \in \mathcal{N}_p$ and $p, q \in \mathcal{N}_m$. We evaluate E_{rng} while satisfying the following constraint:

$$E_{rng} = \left\{ e_p^m \in \bigcup_n \mathcal{E}_n \mid \nexists q \in (\mathcal{N}_p \cap \mathcal{N}_m) \right\} \quad (2)$$

Research Paper as Problem Solving Technique

MISRA *et al.*: M-JAW: MOBILITY-BASED JAMMING AVOIDANCE IN WIRELESS SENSOR NETWORKS

5383

Thereafter, we estimate the quality of the available links or edges in $G(|\mathbb{N}|, E_{rng})$. In other words, we estimate the link quality of each edge $\{(p, q)\} \in E_{rng}$, where d_{pq} denotes the Euclidean distance between the nodes p and q , and

$$\max \{d_{pq}, d_{qm}\} \geq d_{pm} \quad (3)$$

Lemma 1: The set of edges available in $G(\mathbb{N}, E)$ is a superset of the set of edges available in $G_{rng}(\mathbb{N}, E_{rng})$, i.e., $E_{rng} \subseteq E$.

Proof: In Fig. 1, nodes p , q , and m are within the communication range of one another. Therefore, in G ,

$$\{(p, q), (q, m), (p, m)\} \in E, \text{ where } \{p, q, m\} \in \mathbb{N} \quad (4)$$

However, we find that:

$$\max \{d_{pq}, d_{qm}\} \not\geq d_{pm} \quad (5)$$

Equation (5) does not satisfy the constraint mentioned in Equation (3). Therefore, we conclude that $\{(p, m)\} \notin E_{rng}$. However, $\{(p, q), (q, m)\} \in E_{rng}$, as it follows the constraint given in Equation (3). Hence, we establish the fact claimed earlier, i.e., $E_{rng} \subseteq E$. ■

Lemma 2: RNG $G(\mathbb{N}, E_{rng})$ is a superset of the Minimum Spanning Tree (MST), i.e., $MST(\mathbb{N}, E_{mst})$.

Proof: As shown in Fig. 1, if node q belongs to the intersection region of nodes p and m , i.e., $q \in (\mathcal{N}_p \cap \mathcal{N}_m)$, we argue that $d_{pm} \notin E_{mst}$ as well as $d_{pm} \notin E_{rng}$.

On the other hand, $q \notin (\mathcal{N}_p \cap \mathcal{N}_m)$ and $d_{pm} \leq \max \{d_{pq}, d_{qm}\}$ are ample for considering $d_{pm} \in E_{rng}$. However, for MST, these conditions are *necessary, but not sufficient*, for considering $d_{pm} \in E_{mst}$. Therefore, we conclude that $MST(\mathbb{N}, E_{mst}) \subseteq G(\mathbb{N}, E_{rng})$. ■

Theorem 1: If there are $|\mathbb{N}|$ nodes deployed, RNG, i.e., $G_{rng}(\mathbb{N}, E_{rng})$, formed from the graph $G(\mathbb{N}, E)$, can have at least $(|\mathbb{N}| - 1)$ edges and at most $(3|\mathbb{N}| - 6)$ edges. Mathematically,

$$(|\mathbb{N}| - 1) \leq |E_{rng}| \leq (3|\mathbb{N}| - 6) \quad (6)$$

Proof: In an MST consisting of $|\mathbb{N}|$ nodes, there must be $(|\mathbb{N}| - 1)$ edges. Additionally, from Lemma 2, we get that $E_{mst} \subseteq E_{rng}$. Therefore,

$$(|\mathbb{N}| - 1) \leq |E_{rng}| \quad (7)$$

According to Euler's Theorem [24], we have:

$$|\mathbb{N}| - |E_{rng}| + F_{rng} = 2 \quad (8)$$

where $|\mathbb{N}|$, $|E_{rng}|$, and F_{rng} denote the number of nodes/vertices, the number of edges, and the number of faces, respectively, in a connected and planar graph, without having any edge intersecting with other edges. In an RNG, we need at least three edges to form a face. In between two faces, there exists a common edge. Therefore, we get:

$$3F_{rng} \leq 2|E_{rng}| \quad (9)$$

Hence, we can re-write Equation (8), as follows:

$$\begin{aligned} 2 - (|\mathbb{N}| - |E_{rng}|) &\leq \frac{2}{3}|E_{rng}| \\ \Rightarrow \frac{1}{3}|E_{rng}| &\leq (|\mathbb{N}| - 2) \end{aligned}$$

$$\Rightarrow |E_{rng}| \leq (3|\mathbb{N}| - 6) \quad (10)$$

Therefore, from Equations (7) and (10), we have: ■

$$(|\mathbb{N}| - 1) \leq |E_{rng}| \leq (3|\mathbb{N}| - 6).$$

Link Quality Estimation: For prioritizing the neighbor links, each node $n \in \mathbb{N}$ estimates the quality for each link $e_n^m \in E_{rng}$ based on the *Link Quality Estimation* (LQE) scheme, i.e., the *Triangle Metric* proposed by Boano *et al.* [25]. We estimate the link quality and predict the *Packet Reception Rate* (PRR), of each link $e_n^m \in E_{rng}$ based on the *Received Signal Strength* (RSS) and *Signal to Noise Ratio* (SNR). Using the *Triangle Metric* [25], we calculate the *window mean* of SNR and RSS, i.e., $\overline{SNR_{nm}^w}$ and $\overline{RSS_{nm}^w}$, over window size w , for each link $e_n^m \in E_{rng}$, while using the equations shown below:

$$\overline{SNR_{nm}^w} = \frac{\sum_{k=1}^{b_{nm}} snr_{ij}^k}{a_{nm}} \quad \text{and} \quad \overline{RSS_{nm}^w} = \frac{\sum_{k=1}^{b_{nm}} rss_{ij}^k}{a_{nm}} \quad (11)$$

where a_{nm} and b_{nm} denote the total number of packets sent and successfully delivered over the link $e_n^m \in E_{rng}$. snr_{ij}^k and rss_{ij}^k denote the SNR and RSS values for packet k over the link e_n^m while considering the radio-propagation path loss model [26]. Thereafter, using the Triangle Metric [25], the quality \mathcal{LQ}_{nm} of the link $e_n^m \in E_{rng}$ is calculated as:

$$\mathcal{LQ}_{nm} = \sqrt{\overline{SNR_{nm}^w}^2 + \overline{RSS_{nm}^w}^2} \quad (12)$$

IV. M-JAW: THE PROPOSED RATIONAL MOBILITY MODEL

In M-JAW, the interaction between the CU and the NNs is modeled using the Single-Leader-Multiple-Followers Stackelberg game. The NNs act as the followers and the CU acts as the leader. In M-JAW, initially, the source or destination nodes identify the presence of jamming nodes and informs the CU. Thereafter, each node updates its neighbor list on obtaining a request from the leader. The NNs inform the change in the neighbor list to the CU, based on which the leader decides the center of the jamming affected region and the optimal radius of the jamming affected area. On the other hand, each jamming affected nodes decides its mobility pattern after receiving the aforementioned information calculated by the CU. Thus, the proposed scheme, M-JAW, ensures the mobility-based jamming avoidance in WSN.

A. The Justification for Using Stackelberg Game

In M-JAW, we aim to model the interaction between the CU and the nodes. Additionally, we consider that the nodes decide their strategies distributively, i.e., non-cooperatively. Hence, it gives rise to a market scenario of individuals where their decisions are independent. Therefore, the presence of the CU is considered to ensure that the individuals can decide strategies, i.e., avoiding the jamming, based on the global information of the network. The strategy decided by each node gets affected by the information provided by the CU. Therefore, we argue that the Stackelberg game is well suited in this problem to model the interaction among the CU and the nodes.

B. Strategy of the Centralized Unit: Jamming Affected Region Identification

In M-JAW, for introducing a strategic mobility model, initially, the jamming affected region needs to be identified by the CU, i.e., the leader, which acts as the coordinator. In order to identify the jamming affected region, we consider a scenario with a *sender node* S , a *destination node* D , and a set of forwarder nodes \mathcal{F} , where $\mathcal{F} = \{f_1, f_2, \dots, f_n\}$, where $i \leq (|\mathbb{N}| - 2)$.

In this situation, we infer the presence of JN(s), if one of the following statements is true:

- i) Destination node D does not get any data packet for a TimeOut duration.
- ii) Sender node S does not get any ACK packet within a TimeOut duration.

Hence, we infer that a subset of *active edges*, as mentioned in Definition 1, is affected by jamming.

Definition 1: We define an edge to be active if the edge connects the following pair of nodes:

- Sender node S and Forwarder Node $n \in \mathcal{F}$
- Forwarder nodes $n, m \in \mathcal{F}$
- Forwarder node $n \in \mathcal{F}$ and Destination node D
- Sender node S and Destination node D

After detecting the presence of the jamming effect, the sender node S or the destination node D sends an ERROR message to the CU. Thereafter, the CU requests the NNs in the network to initiate the neighbor finding approach. After updating the neighbor list, a subset of nodes which detect a change in the neighbor list, informs the CU about the change in the neighbor list. Thereafter, the CU detects the set of jamming affected nodes, which is denoted by $\Delta\mathcal{N}$ based on the change in the neighbor list informed by the normal nodes. Thereafter, the CU calculates the jamming affected area.

The CU aims to obtain a convex hull of the jamming affected region. Hence, it needs to draw a circle with minimum area while ensuring that the jamming affected area is covered by the circle. The CU calculates the Euclidean distance d_{nm} between each pair of nodes $n, m \in \Delta\mathcal{N}$. Thereafter, based on the maximum d_{nm} , which is denoted by d_{nm}^{\max} , the CU considers a circle having a radius r_c and center at a point (x_c, y_c) . We calculate r_c and (x_c, y_c) using the following equations:

$$r_c = \frac{d_{nm}^{\max}}{2}, \quad x_c = \frac{|x_n - x_m|}{2}, \quad \text{and} \quad y_c = \frac{|y_n - y_m|}{2} \quad (13)$$

where (x_n, y_n) denotes the Cartesian coordinates of node n .

C. Strategies of the Jamming Affected Nodes: Mobility Model

After getting (x_c, y_c) and r_c from the CU using the CH_c channel, each node $n \in \Delta\mathcal{N}$ decides an angle θ_n , and a velocity v_n . We note that θ_n and v_n need to satisfy the following inequalities:

$$0 \leq \theta_n < \frac{\pi}{2}, \quad \forall n \in \Delta\mathcal{N} \quad (14)$$

$$0 \leq v_n \leq v_n^{\max}, \quad \forall n \in \Delta\mathcal{N} \quad (15)$$

where v_n^{\max} defines the maximum velocity node n can achieve, while assuming that the nodes are heterogeneous in nature. Each node aims to ensure that it is out of the jamming affected region, while consuming the minimum amount of energy. The strategic form of the utility function is denoted as $\mathbb{U}_n(v_n, \theta_n)$. Each component of the strategic form is discussed as follows:

- i) θ_n defines the mobility direction, i.e., an angle with the X-axis, for each node n .
- ii) $\rho_n(\theta_n)$ denotes the Euclidean distance to be covered by node $n \in \Delta\mathcal{N}$ in order to avoid the jamming affected region.
- iii) E_n^{res} defines the residual energy of node $n \in \Delta\mathcal{N}$ at the time of the jamming affected region detection.
- iv) r_c , which is calculated by the CU, is the radius of the curve-fitted circle of jamming affected area.
- v) α_n denotes the amount of energy to be consumed for moving an unit distance. Therefore, we consider that α_n needs to satisfy the following constraint:

$$\alpha_n > 0 \quad (16)$$

Additionally, each node n needs to satisfy the following constraints to avoid the inter-node collision.

$$\frac{v_n}{v_{n'}} \neq \frac{\tan \theta_n}{\tan \theta_{n'}} \sqrt{\frac{1 + (x - x_n)^2}{1 + (x - x_{n'})^2}}, \quad \forall x \in \rho_n(\theta_n), \rho_{n'}(\theta_{n'}) \quad (17)$$

where $n, n' \in \Delta\mathcal{N}$ and are in same quadrant. Additionally, the nodes need to ensure that $v_n \leq v_{n'}, \forall n' \in -n$, where $\rho_n(\theta_n) \geq \rho_{n'}(\theta_{n'})$.

We consider that the utility function $\mathbb{U}_n(v_n, \theta_n, v_{-n}, \theta_{-n})$ signifies the satisfaction of each node $n \in \Delta\mathcal{N}$, while considering that the node aims to reduce energy consumption due to mobility and packet loss, where $v_{-n} = \{\dots, v_{(n-1)}, v_{(n+1)}, \dots\}$ and $\theta_{-n} = \{\dots, \theta_{(n-1)}, \theta_{(n+1)}, \dots\}$. We define the utility function $\mathbb{U}_n(v_n, \theta_n, v_{-n}, \theta_{-n})$ of each node n as the difference between the *revenue function* $\mathbb{R}_n(v_n, \theta_n, v_{-n}, \theta_{-n})$ and the *cost function* $\mathbb{C}_n(v_n, \theta_n, v_{-n}, \theta_{-n})$. The revenue function $\mathbb{R}_n(v_n, \theta_n, v_{-n}, \theta_{-n})$ of node n signifies the satisfaction of each node n by moving from the jamming affected region. The nodes try to increase the revenue function, while losing some amount of energy due to mobility, and aim to ensure the normal communication in the presence of jamming nodes. We consider that $\mathbb{R}_n(v_n, \theta_n, v_{-n}, \theta_{-n})$ varies inversely with the distance covered $\rho_n(\theta_n)$. Moreover, the energy consumption α_n for moving per unit distance has an linear negative effect on $\mathbb{R}_n(v_n, \theta_n, v_{-n}, \theta_{-n})$. Therefore, we define $\mathbb{R}_n(v_n, \theta_n, v_{-n}, \theta_{-n})$ as follows:

$$\mathbb{R}_n(v_n, \theta_n, v_{-n}, \theta_{-n}) = 1 - \frac{\alpha_n \rho_n(\theta_n)}{2r_c E_n^{\text{res}}}, \quad \text{where } n \in \Delta\mathcal{N} \quad (18)$$

On the other hand, $\mathbb{C}_n(v_n, \theta_n, v_{-n}, \theta_{-n})$ of node n signifies energy consumption for transmission of packets which is lost due to jamming effect. We define the cost function $\mathbb{C}_n(v_n, \theta_n, v_{-n}, \theta_{-n})$ as the ratio of the amount of energy E_n^{con} consumed due to movement and the residual amount of energy E_n^{res} before the move.

Research Paper as Problem Solving Technique

We define E_n^{con} of node n as follows:

$$E_n^{con} = \left\lfloor \frac{t_n}{\text{PTI}_n} \right\rfloor E_{Tx} \text{PS} \quad (19)$$

where $\left\lfloor \frac{t_n}{\text{PTI}_n} \right\rfloor$ defines the number of packets transmitted by node n within a jamming affected area; PTI_n defines the packet transmission interval of node n ; E_{Tx} is the transmission energy consumption per bit[27]; and PS defines the packet size. Hence, t_n defines the amount of time spent by node n in the jamming affected region, and expressed as $t_n = \frac{\rho_n(\theta_n)}{v_n}$. Hence, we get:

$$\mathbb{C}_n(v_n, \theta_n, v_{-\mathbf{n}}, \theta_{-\mathbf{n}}) = \left[\frac{E_{Tx} \times \text{PS}}{v_n \times \text{PTI}_n} \right] \frac{\rho_n(\theta_n)}{E_n^{\text{res}}} \quad (20)$$

The first part of Equation (20), i.e., $[\cdot]$, is a constant which is defined it as α . Therefore, from Equation (20), we get:

$$\mathbb{C}_n(v_n, \theta_n, v_{-\mathbf{n}}, \theta_{-\mathbf{n}}) = \Lambda_n \frac{\rho_n(\theta_n)}{v_n} \quad (21)$$

where $\Lambda_n = \frac{E_{Tx} \text{PS}}{E_n^{\text{res}} \text{PTI}_n}$.

Lemma 3: Λ_n satisfies the constraint — $0 < \Lambda_n < \infty$.

Proof: The energy required to transmit one bit, i.e., E_{Tx} , is always greater than zero. Additionally, in any protocol, the size of a packet must be greater than zero. Therefore, we conclude that $\Lambda_n > 0$.

On the other hand, the denominator part of Λ_n is also greater than zero, as $E_n^{\text{res}} > 0$ and $\text{PTI} > 0$. Therefore, we conclude that $\Lambda_n < \infty$. ■

Hence, using Equations (18) and (21), the utility function $\mathbb{U}_n(v_n, \theta_n, v_{-\mathbf{n}}, \theta_{-\mathbf{n}})$ of each follower n is defined as follows:

$$\mathbb{U}_n(v_n, \theta_n, v_{-\mathbf{n}}, \theta_{-\mathbf{n}}) = \left(1 - \frac{\alpha_n \rho_n(\theta_n)}{2r_c E_n^{\text{res}}} \right) - \Lambda_n \frac{\rho_n(\theta_n)}{v_n} \quad (22)$$

Therefore, in the presence of jamming node(s), each follower n , i.e., each NN $n \in \Delta\mathcal{N}$, tries to *maximize its utility function* $\mathbb{U}_n(v_n, \theta_n, v_{-\mathbf{n}}, \theta_{-\mathbf{n}})$ while satisfying the following constraints along with the constraints mentioned in Equations (14), (15), and (17):

$$\begin{aligned} \rho_n(\theta_n) &\leq 2r_c, \quad 0 < \alpha < \infty, \\ 0 &< E_n^{\text{res}} \geq [\Lambda_n \rho_n(\theta_n) + \alpha_n \rho_n(\theta_n)]. \end{aligned} \quad (23)$$

V. EXISTENCE OF STACKELBERG-NASH EQUILIBRIUM

In M-JAW, each node $n \in \Delta\mathcal{N}$ decides their strategy in a distributed fashion, i.e., non-cooperatively. We define the generalized Stackelberg-Nash equilibrium (GSNE) [28], [29] of M-JAW in Definition 2. In a Stackelberg game, each follower decides his/her strategy non-cooperatively. On the other hand, the leader decides its strategy to ensure a high payoff of its own and the overall system. Therefore, the Stackelberg game cannot always ensure the presence of GSNE. Hence, we investigate the existence of GSNE in the context of M-JAW, in Theorem 2.

Definition 2: We define the generalized Stackelberg-Nash equilibrium (GSNE) of M-JAW as the tuple $< v_n^*, \theta_n^* >$, where v_n^* signifies the optimum velocity of the jamming affected node

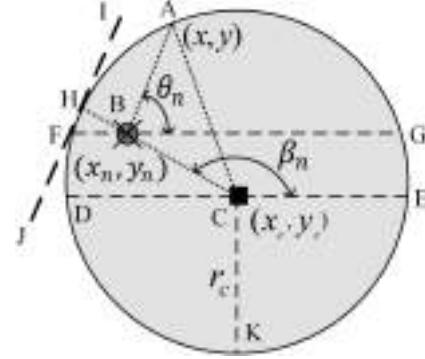


Fig. 2. The direction movement of an affected node.

n and θ_n^* denotes the optimum angle of mobility of node n , which satisfies the following inequality.

$$\mathbb{U}_n(v_n^*, \theta_n^*, v_{-\mathbf{n}}^*, \theta_{-\mathbf{n}}^*) \geq \mathbb{U}_n(v_n, \theta_n, v_{-\mathbf{n}}, \theta_{-\mathbf{n}}) \quad (24)$$

Theorem 2: Given the center (x_c, y_c) and radius r_c of the curve-fitted circle, there exists a GSNE, where each node $n \in \Delta\mathcal{N}$ satisfies the following inequality mentioned in Equation (24).

Proof: We consider that the center of the curve-fitted circle is at point C having coordinate (x_c, y_c) , and jamming affected node $n \in \Delta\mathcal{N}$ is at point B having coordinate (x_n, y_n) . Thereafter, node n moves with an angle θ_n towards point A having coordinate (x, y) , as shown in Fig. 2. The distances \overline{AB} , \overline{BC} , and \overline{CA} are denoted as $\rho_n(\theta_n)$, $\mu_n(\beta_n)$, and r_c , respectively. Mathematically,

$$\rho_n(\theta_n) = \sqrt{(x - x_n)^2 + (y - y_n)^2} \quad (25)$$

$$\mu_n(\beta_n) = \sqrt{(x_c - x_n)^2 + (y_c - y_n)^2} \quad (26)$$

From Fig. 2, we get that $\angle ECB = \beta_n$ and $\angle GBA = \theta_n$. Therefore, $\angle GBC = (180^\circ - \beta_n)$, as \overline{DE} and \overline{FG} are parallel. Hence,

$$\angle ABC = \angle GBA + \angle GBC = \theta_n + (180^\circ - \beta_n) \quad (27)$$

We consider that $\angle BCA = \gamma$. Therefore, from $\triangle ABC$, we get:

$$\begin{aligned} lcl \angle BAC &= 180^\circ - (\angle ABC + \angle BCA) \\ &= (\beta_n - \theta_n - \gamma) \end{aligned} \quad (28)$$

According to the *Law of Sines* [30], we observe that in a triangle, the ratio of the length of the sides and the sine of corresponding opposite angle is the same. Hence, from Fig. 2, we get:

$$\begin{aligned} \frac{\sin \angle BCA}{\rho_n} &= \frac{\sin \angle ABC}{r_c} = \frac{\sin \angle BAC}{\mu_n} \\ \Rightarrow \frac{\sin \gamma}{\rho_n} &= \frac{\sin(\beta_n - \theta_n)}{r_c} = \frac{\sin(\beta_n - \theta_n - \gamma)}{\mu_n} \end{aligned} \quad (29)$$

From Equation (29), we get:

$$\begin{aligned} \sin \gamma &= \frac{\rho_n(\theta_n)}{r_c} \sin(\beta_n - \theta_n) \\ \cos \gamma - \cot(\beta_n - \theta_n) \sin \gamma &= \frac{\mu_n(\beta_n)}{r_c} \end{aligned} \quad (30)$$

Research Paper as Problem Solving Technique

From Equation (30), we get:

$$\begin{aligned}
 & \sqrt{1 - \left[\frac{\rho_n(\theta_n)}{r_c} \sin(\beta_n - \theta_n) \right]^2} - \frac{\rho_n(\theta_n)}{r_c} \cot(\beta_n - \theta_n) \\
 & \times \sin(\beta_n - \theta_n) = \frac{\mu_n(\beta_n)}{r_c} \\
 & \Rightarrow r_c^2 - \rho_n(\theta_n)^2 \sin^2(\beta_n - \theta_n) \\
 & = [\rho_n(\theta_n) \cos(\beta_n - \theta_n) + \mu_n(\beta_n)]^2
 \end{aligned} \tag{31}$$

Therefore, taking the first order partial derivative of Equation (31) with respect to θ_n , we get:

$$\frac{\partial \rho_n(\theta_n)}{\partial \theta_n} = -\frac{\rho_n(\theta_n) \mu_n(\beta_n) \sin(\beta_n - \theta_n)}{\rho_n(\theta_n) + \mu_n(\beta_n) \cos(\beta_n - \theta_n)} \tag{32}$$

On the other hand, taking the first order partial derivative of Equation (22) with respect to $\rho_n(\theta_n)$, we get:

$$\frac{\partial \mathbb{U}_n(v_n, \theta_n, v_{-n}, \theta_{-n})}{\partial \rho_n(\theta_n)} = -\left[\frac{\alpha_n}{2r_c} + \frac{\Lambda_n}{v_n} \right] \tag{33}$$

Hence, from Equations (32) and (33), we get:

$$\frac{\partial \mathbb{U}_n(\cdot)}{\partial \theta_n} = \left[\frac{\alpha_n}{2r_c} + \frac{\Lambda_n}{v_n} \right] \left[\frac{\rho_n(\theta_n) \mu_n(\beta_n) \sin(\beta_n - \theta_n)}{\rho_n(\theta_n) + \mu_n(\beta_n) \cos(\beta_n - \theta_n)} \right] \tag{34}$$

We compute the second order partial derivative of Equation (22) with respect to θ_n , as shown in Equation (35).

$$\begin{aligned}
 & \frac{\partial^2 \mathbb{U}_n(v_n, \theta_n, v_{-n}, \theta_{-n})}{\partial \theta_n^2} \\
 & = -\left[\frac{\alpha_n \Lambda_n}{2r_c v_n} \right] \left[\frac{1}{[\rho_n(\theta_n) + \mu_n(\beta_n) \cos(\beta_n - \theta_n)]^2} \right] \\
 & \left[\rho_n(\theta_n) \mu_n(\beta_n) \cos(\beta_n - \theta_n) - [\mu_n(\beta_n)]^2 \cos^2(\beta_n - \theta_n) \right. \\
 & \quad \left. - \rho_n(\theta_n) [\mu_n(\beta_n)]^2 \sin^2(\beta_n - \theta_n) \right. \\
 & \quad \left. + \frac{[\mu_n(\beta_n)]^2}{2} \sin 2(\beta_n - \theta_n) \frac{\partial \rho_n(\theta_n)}{\partial \theta_n} \right]
 \end{aligned} \tag{35}$$

We argue that the second order partial derivative of $\mathbb{U}_n(v_n, \theta_n)$ with respect to θ_n has a negative value, as $\frac{\partial \rho_n(\theta_n)}{\partial \theta_n} < 0$. Therefore, we conclude that the generalized Stackelberg-Nash equilibrium (GSNE) exists for the proposed scheme, M-JAW. ■

Corollary 1: In order to get out of the jamming affected region, each jamming affected node $n \in \delta \mathcal{N}_n$ has to cover minimum distance ρ_n^{\min} , and has to travel for minimum t_n^{\min} amount of time. Mathematically,

$$\left. \begin{aligned}
 \rho_n^{\min} &= r_c - \sqrt{(x_c - x_n)^2 + (y_c - y_n)^2} \\
 t_n^{\min} &= \frac{\rho_n^{\min}}{v_n^{\max}}
 \end{aligned} \right\} \tag{36}$$

Proof: From Theorem 2, we calculate the minimum distance to be covered by a node n , i.e., $\rho_n = \rho_n^{\min}$, which is evaluated from:

$$\frac{\partial \mathbb{U}_n(v_n, \theta_n, v_{-n}, \theta_{-n})}{\partial \theta_n} = 0 \Rightarrow \theta_n = \beta_n, (180^\circ - \beta_n) \tag{37}$$

It may be noted that $(180^\circ - \beta_n)$ and β_n belong to two different quadrants. We consider that θ_n has the only viable

Algorithm 1: RNG Formation Algorithm.

INPUTS

1: $G(\mathbb{N}, E)$ ▷ Neighborhood graph of network

OUTPUT:

1: $G_{rng}(\mathbb{N}, E_{rng})$ ▷ Updated RNG of network

PROCEDURE:

```

1:  $E_{rng} \leftarrow \{\emptyset\}$  ▷ Initialization of  $E_{rng}$ 
2: for each  $n \in \mathbb{N}$  do
3:    $E_{rng} \leftarrow \{\emptyset\};$  ▷ Initialization of  $E_{rng}$ 
4:   for (each  $p \in \mathcal{N}_n$ ) && ( $\{(p, n)\} \notin E_{rng}$ ) do
5:     for each  $q \in \mathcal{N}_p$  do
6:       if ( $q \notin \mathcal{N}_n$ ) && ( $\max(d_{pq}, d_{qn}) \geq d_{pn}$ ) then
7:          $E_{rng} \leftarrow E_{rng} \cup \{(p, n)\};$ 
8:       end if
9:     end for
10:   end for
11:    $E_{rng} \leftarrow E_{rng} \cup E_{rng};$ 
12: end for
13: return  $G_{rng}(\mathbb{N}, E_{rng});$ 

```

solution $\theta_n = \beta_n$, as by moving at an angle $(180^\circ - \beta_n)$, node n has to cover the maximum distance, as depicted in Fig. 2. Therefore, from Fig. 2, we get $\rho_n^{\min} = \overline{BH}$, where $\theta_n = \beta_n$. On the other hand, \overline{BH} and \overline{CB} form a single line \overline{CH} , where $\overline{CH} = r_c$. Therefore, we get:

$$\rho_n^{\min} = r_c - \sqrt{(x_c - x_n)^2 + (y_c - y_n)^2} \tag{38}$$

As mentioned in Section IV-C, the maximum velocity of node n is denoted by v_n^{\max} . Therefore, the minimum time, t_n^{\min} , node n needs to travel is evaluated as — $t_n^{\min} = \frac{\rho_n^{\min}}{v_n^{\max}}$ ■.

VI. PROPOSED ALGORITHMS

In M-JAW, after the deployment of nodes over a terrain, each node evaluates the neighborhood graph, and accordingly forms the RNG using Algorithm 1. Thereafter, to circumnavigate the jamming effect, the *jamming affected region* (JAR) needs to be identified using Algorithm 2. After identifying the jamming affected region, each node needs to choose its action *rationally*, based on the available strategies, i.e., the action needs to be taken based on the rational mobility model (RMM), as depicted in Fig. 3. Hence, we propose three different algorithms, which are needed to be executed sequentially, to ensure QoS in the presence of a proactive or constant jamming node. These algorithms are as follows — (a) *RNG Formation*, (b) *JAR Identification*, and (c) *RMM Implementation* Algorithms, i.e., Algorithms 1, 2, and 3, respectively.

A. RNG Formation Algorithm

Algorithm 1 is executed by each node $n \in \mathbb{N}$, distributively. Using this algorithm, each node $n \in \mathbb{N}$ optimizes the number of edges available over the terrain to ensure QoS in terms of packet loss and energy consumption for successful communication.

Research Paper as Problem Solving Technique

MISRA et al.: M-JAW: MOBILITY-BASED JAMMING AVOIDANCE IN WIRELESS SENSOR NETWORKS

5387

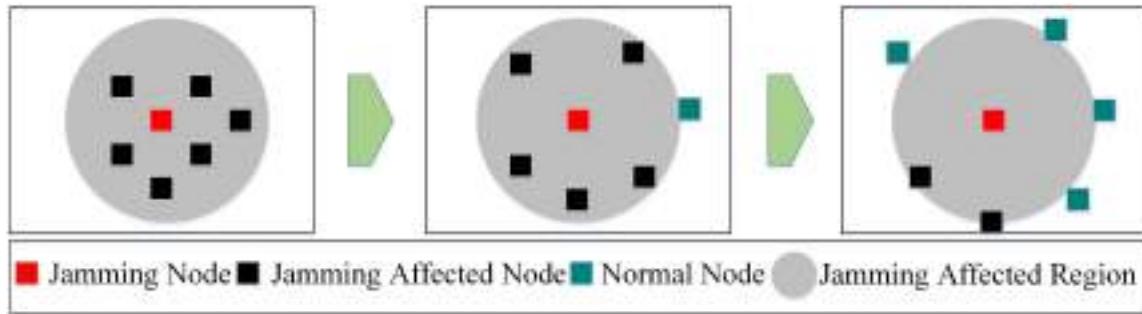


Fig. 3. Graphical snapshot of the proposed RMM.

Algorithm 2: JAR Identification Algorithm.

INPUTS

- 1: $\mathcal{N}_n|_{t_2}, \forall n \in \mathbb{N}$
- 2: $\mathcal{N}_n|_{t_2}, \forall n \in \mathbb{N}$

OUTPUT:

- 1: $\Delta\mathcal{N}$

PROCEDURE:

- 1: $\Delta\mathcal{N} \leftarrow \{\emptyset\}$
 - 2: **for** each $n \in \Delta\mathcal{N}$ **do**
 - 3: Calculate $\Delta\mathcal{N}|_{\delta t=(t_2^- - t_2)}$; \triangleright Set of change in neighbor nodes within time instants t_2^- and t_2
 - 4: Calculate $\Delta\mathcal{N}|_{\delta t=(t_2^- - t_2)}^+$; \triangleright Set of newly discovered neighbor nodes at time instant t_2
 - 5: Calculate $\Delta\mathcal{N}_n$;
 - 6: $\Delta\mathcal{N} \leftarrow \Delta\mathcal{N} \cup \Delta\mathcal{N}_n$ \triangleright Set of jamming affected nodes at time instant t_2
 - 7: **end for**
 - 8: **return** $\Delta\mathcal{N}$;
-

B. JAR Identification Algorithm

The proposed *JAR Identification Algorithm*, i.e., Algorithm 2, is executed by the *CU*. If the *CU* gets any *ERROR* message from any node $n \in \mathbb{N}$ deployed over a terrain, it initiates Algorithm 2. Considering that at time instant t_0 , the *CU* receives an *ERROR* message, at time instant t_1 , where $t_1 > t_0$, the *CU* requests each node to explore its neighbor nodes. Hence, at time instant t_2 , where $t_2 > t_1$, if any node finds mismatch in its neighbor node table from its earlier neighbor node table, i.e., neighbor node table at time instant $t_2^- < t_2$.

At node n , the set of neighbor nodes in the neighbor node table at time instants t_2^- and t_2 are defined as $\mathcal{N}_n|_{t_2^-}$ and $\mathcal{N}_n|_{t_2}$, respectively. Hence, node n calculates $\Delta\mathcal{N}_n$. For any node $n \in \mathbb{N}$, if $\Delta\mathcal{N}_n$ is an empty set, the node n sends an *UPDATE* message to the *CU* with null value. Otherwise, node $n \in \mathbb{N}$ sends an *UPDATE* message to the *CU* having information of sets $\Delta\mathcal{N}_n$. After receiving responses from each node $n \in \mathbb{N}$, the *CU* calculates the change $\Delta\mathcal{N}_n, \forall n \in \mathbb{N}$ in the neighbor list, i.e., the elements of $\Delta\mathcal{N}|_{\delta t=(t_2^- - t_2)}$, and $\Delta\mathcal{N}|_{\delta t=(t_2^- - t_2)}^+$, which are

Algorithm 3: RMM Implementation Algorithm.

INPUTS

- 1: $\theta_{min}, \theta_{max}, (x_c, y_c), r_c, \alpha, E_n^{res}$

OUTPUTS:

- 1: v_n^*, θ_n^*

PROCEDURE:

- 1: Choose a value for θ_n , where $\theta_{min} \leq \theta_n \leq \theta_{max}$;
 - 2: Calculate $\mathbb{U}_n(v_n, \theta_n, v_{-n}, \theta_{-n})$ using Equation (22);
 - 3: **do**
 - 4: Choose an optimum value for θ_n^* ;
 - 5: Calculate $\mathbb{U}_n^*(v_n^*, \theta_n^*, v_{-n}, \theta_{-n})$ using Equation (22);
 - 6: **While**
 $(\mathbb{U}_n^*(v_n^*, \theta_n^*, v_{-n}, \theta_{-n}) \geq \mathbb{U}_n(v_n, \theta_n, v_{-n}, \theta_{-n}))$;
 - 7: $\theta_n^* \leftarrow \theta_n^*$;
 - 8: $v_n^* \leftarrow v_n^*$;
 - 9: **return** v_n^*, θ_n^* ;
-

TABLE I
SIMULATION PARAMETERS

Parameter	Value
Simulation area	1000 m×1000 m
Number of jammers	4
Number of normal nodes	200-800
Initial energy of each node	20 J [23]
Communication range	100 m
Node velocity	2-10 m/s
Packet interval	4-10 sec
Packet size	2034 bytes
Energy consumption at Tx and Rx	50 nJ/bit [27]
Energy consumption at amplifier	100 pJ/bit-m ² [27]
Energy consumption due to mobility	0.1v mW-meter/s

defined as follows:

$$\Delta\mathcal{N}_n|_{\delta t=(t_2^- - t_2)} = \left[(\mathcal{N}_n|_{t_2^-}) - (\mathcal{N}_n|_{t_2}) \right] \quad (39)$$

$$\Delta\mathcal{N}_n|_{\delta t=(t_2^- - t_2)}^+ = \left[(\mathcal{N}_n|_{t_2}) - (\mathcal{N}_n|_{t_2^-}) \right] \quad (40)$$

where $\Delta\mathcal{N}_n|_{\delta t=(t_2^- - t_2)} \neq \Delta\mathcal{N}_n|_{\delta t=(t_2^- - t_2)}^+$. Hence, we evaluate the set of jamming affected nodes in the terrain, i.e., $\Delta\mathcal{N}$,

Research Paper as Problem Solving Technique

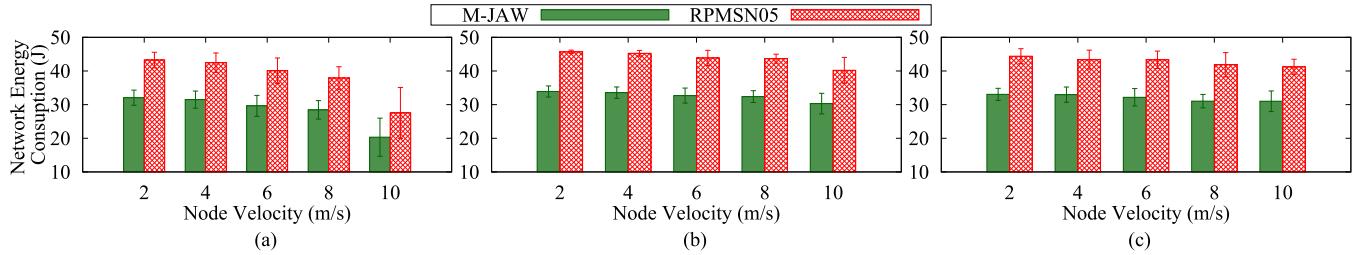


Fig. 4. Overall energy consumption of network with 200 nodes. (a) Packet Interval: 4 Sec. (b) Packet Interval: 8 Sec. (c) Packet Interval: 10 Sec.

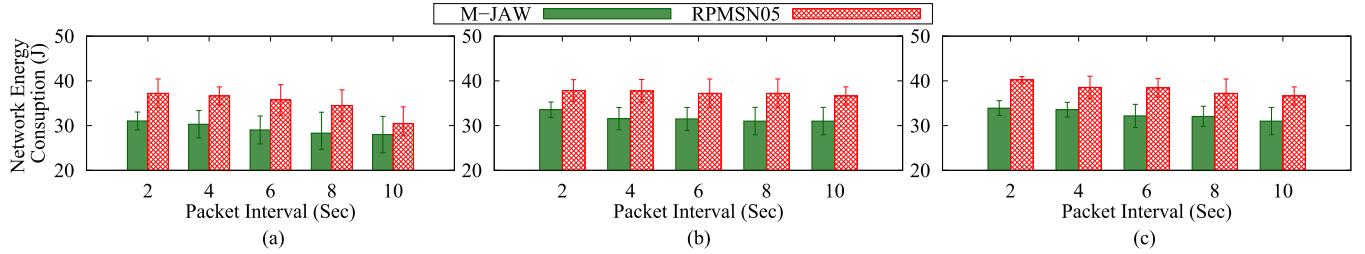


Fig. 5. Overall energy consumption of network with 200 nodes. (a) Node Velocity: 2 m/s. (b) Node Velocity: 6 m/s. (c) Node Velocity: 10 m/s.

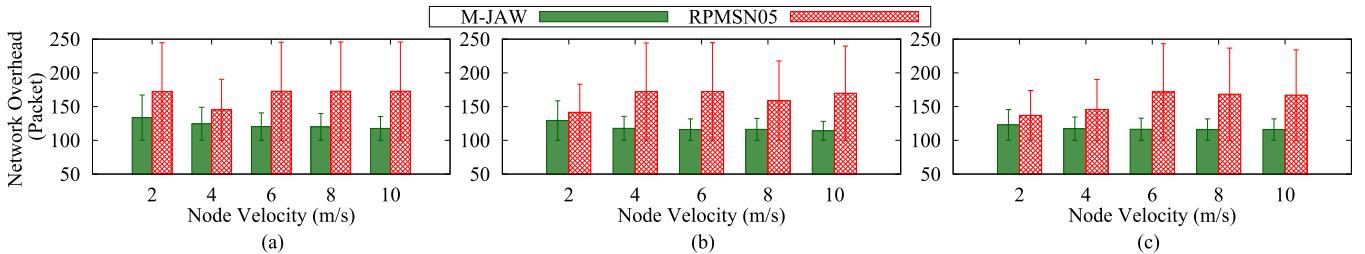


Fig. 6. Network overhead with 200 nodes. (a) Packet Interval: 4 Sec. (b) Packet Interval: 8 Sec. (c) Packet Interval: 10 Sec.

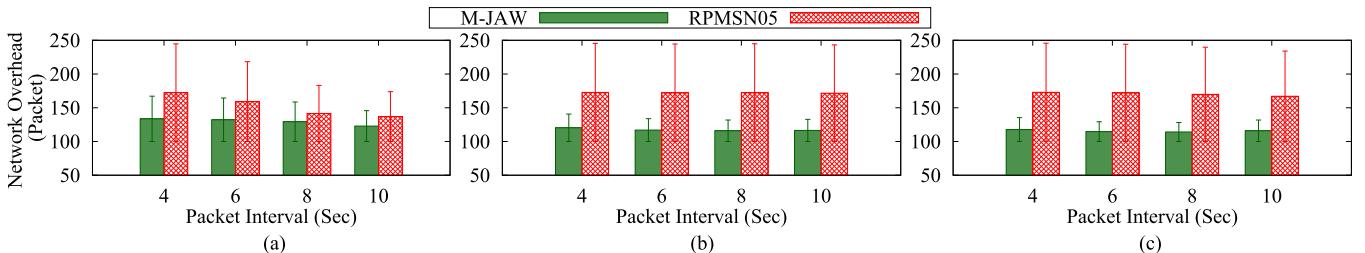


Fig. 7. Network overhead with 200 nodes. (a) Node Velocity: 2 m/s. (b) Node Velocity: 6 m/s. (c) Node Velocity: 10 m/s.

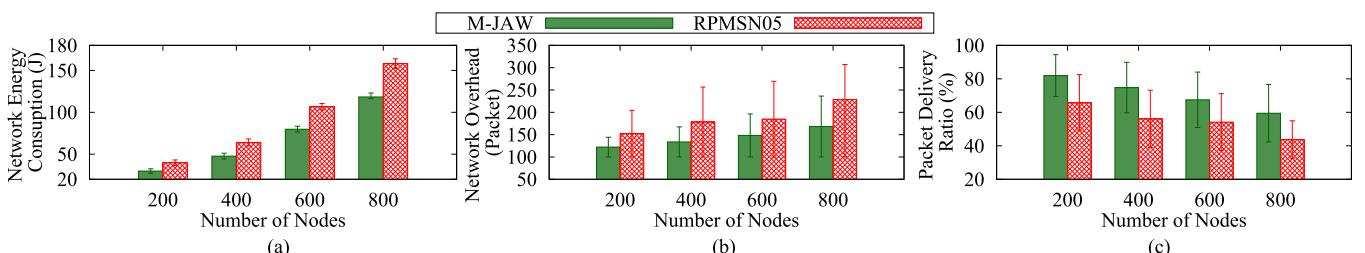


Fig. 8. $v = 4$ m/s, packet interval = 6 second. (a) Network Energy Consumption. (b) Network Overhead. (c) Packet Delivery Ratio.

Research Paper as Problem Solving Technique

as follows:

$$\Delta\mathcal{N}_n = \left(\Delta\mathcal{N}_n|_{\delta t=(t_2^- - t_2)}^- \right) / \left(\Delta\mathcal{N}_n|_{\delta t=(t_2^- - t_2)}^+ \right) \quad (41)$$

Thereafter, the CU finds the location of each jamming affected node $n \in \Delta\mathcal{N} \subseteq \mathbb{N}$, i.e., (x_n, y_n) at time instant t_2^- , where $\Delta\mathcal{N} = \bigcup_{n \in \Delta\mathcal{N}} \Delta\mathcal{N}_n = \bigcup_{n \in \Delta\mathcal{N}} (\Delta\mathcal{N}_n|_{\delta t=(t_2^- - t_2)}^- \cup \Delta\mathcal{N}_n|_{\delta t=(t_2^- - t_2)}^+)$. Thereafter, the CU evaluates the center and radius of the circle covering the jamming affected region using Equation (13), respectively.

C. RMM Implementation Algorithm

This algorithm takes the outcome of the rule-based approach performed by the CU. Thereafter, Algorithm 3 is executed by each node $n \in \Delta\mathcal{N}$, distributively. Using this algorithm, each node n decides its strategy, rationally, while choosing an optimum strategy, i.e., direction, to avoid the jamming affected region. Hence, considering the strategy of the CU, each node n aims to maximize the payoff of $\mathbb{U}_n(\theta_n, v_n)$.

VII. PERFORMANCE EVALUATION

A. Simulation Parameters

For evaluating the performance of M-JAW, we deployed the nodes and jammers, randomly, over the region specified in Table I. We performed the simulation in MATLAB platform. Additionally, we chose the source-destination pair, randomly. We assumed that each sender node has packets to transmit, and initial 10 packets are successfully delivered to the destination node.

B. Benchmark

The performance of the proposed scheme, M-JAW, is evaluated by comparing it with a state-of-the-art mobility-based jamming avoidance approach—the RPMSN05 [11]. In RPMSN05, Ma *et al.* [11] considered a network with mobile nodes in the presence of single jammer. The authors proposed a random mobility model for the jamming to affected nodes. However, they did come up with a novel mobility model for avoiding jamming in the WSN environment. Thus, we can improve the energy consumption of each node and network overload using the proposed scheme, M-JAW over RPMSN05.

C. Performance Metrics

The performance of M-JAW is evaluated using the following metrics.

Energy Consumption of Network: Each time a packet is sent or received by a node, the residual energy of that node gets depleted. If the residual energy of a node becomes very small, the node is considered as ‘dead’ node. Additionally, when the first node dies in the network, is considered as the network lifetime. As an energy-constrained network, the energy consumption of a WSN is one of the important performance metrics.

Network Overhead: The number of packets sent by the nodes over the network is defined as network overhead. With an

increase in network overhead, the network gets more congested. Additionally, packet delivery probability gets reduced.

Packet Delivery Ratio: It is calculated as a quantified value of packets delivered to the total number of packets sent.

D. Results and Discussions

In simulation, we consider that the maximum packet rate of each node is 15 packets/min. We considered a topology with 200 normal nodes and 4 jammers. Using M-JAW, the network energy consumption is improved by 11.42–20.36%, than using RPMSN05. From Fig. 4, we observe that with varying packet interval, M-JAW performs better than RPMDN05. Similarly, from Fig. 5, we observe that with varying node velocity, M-JAW consumes a reduced amount of energy than RPMSN05. Therefore, we conclude that M-JAW performs better than RPMSN05 in terms of energy consumption. On the other hand, we observe that with the increase in node velocity and packet interval, respectively, the network energy consumption reduces, because of the reduction in packet re-transmission path length covered during mobility.

On the other hand, the proposed scheme, M-JAW, reduces the network overhead by 44.13–50.12% than RPMSN05. Fig. 6 illustrates that the network overhead is less using M-JAW than using RPMSN05. Similarly, from Fig. 7, we observe that the network overhead is at least 44.13% less using M-JAW than using RPMSN05. Hence, we can conclude that the network overhead reduces significantly using M-JAW. Additionally, it reflects that network lifetime increases using M-JAW than using RPMSN05. Additionally, we see that with the increase in node velocity and packet interval, respectively, the network overhead gets reduced as a result of a reduction in the number of packets transmitted in a jammer affected area during a certain period.

We varied the number of nodes placed over the terrain while considering that the velocity of each node is 4 m/s and the packet interval is 6 seconds. In Fig. 8(a), we observe that the network energy consumption reduces by 23.7–26.0% using M-JAW than using RPMSN05. On the other hand, Fig. 8(b) reflects that the network overhead reduces by 24.64–35.88% using M-JAW than using RPMSN05. On the contrary, Fig. 8(c) depicts that the packet delivery ratio improves by 41.07% using M-JAW than using RPMSN05. Additionally, we see that with the increase in the number of available nodes, the network energy consumption and overhead increases, because of the energy consumption and control (hello) packet transmission by each node during the neighbor finding phase. Additionally, the network energy consumption decreases using M-JAW due to the optimized mobility of nodes than using RPMSN05. On the other hand, with the increase in the number of nodes, the packet delivery ratio gets reduced, because of an increase in the available paths between the sender and the destination nodes.

VIII. CONCLUSION

In this paper, we formulated a game-theoretic approach to ensure QoS in the presence of jammer in mobile WSN. We

Research Paper as Problem Solving Technique

used single leader multiple follower Stackelberg game. Based on the proposed approach, M-JAW, we show how using the proposed mobility model, i.e., RMM, each node ensures QoS, while consuming less energy and less network overhead. The simulation results show that the proposed scheme outperforms the existing scheme.

Future extension of this work includes understanding how QoS can be improved while considering the channel fading and predicting jamming phenomena in advance in mobile WSN for increasing in network lifetime by reducing energy consumption and network overhead. This work also can be extended to understand how QoS of the network will be ensured while considering the mobile jammers instead of considering static jammers. Additionally, we can investigate the effect of mobile jammers, while ensuring QoS of the network.

REFERENCES

- [1] K. Grover, A. Lim, and Q. Yang, "Jamming and anti-jamming techniques in wireless networks: A survey," *Int. J. Ad-Hoc Ubiquitous Comput.*, vol. 17, no. 4, pp. 197–215, Dec. 2014.
- [2] J. Dai, X. Hao, P. Li, Z. Li, and X. Yan, "Antijamming design and analysis of a novel pulse compression radar signal based on radar identity and chaotic encryption," *IEEE Access*, vol. 8, pp. 5873–5884, 2020.
- [3] H. Wang, Y. Fu, R. Song, Z. Shi, and X. Sun, "Power minimization precoding in uplink multi-antenna NOMA systems with jamming," *IEEE Trans. Green Commun. Netw.*, vol. 3, no. 3, pp. 591–602, Sep. 2019.
- [4] A. Mpitsiopoulos, D. Gavalas, C. Konstantopoulos, and G. Pantziou, "A survey on jamming attacks and countermeasures in WSNs," *IEEE Comm. Surv. Tut.*, vol. 11, no. 4, pp. 42–56, Oct.–Dec. 2009.
- [5] H. B. Salameh, S. Otooni, M. Aloqaily, R. Derbas, I. A. Ridhawi, and Y. Jararweh, "Intelligent jamming-aware routing in multi-hop IoT-based opportunistic cognitive radio networks," *Ad Hoc Netw.*, vol. 98, 2020, Art. no. 102035.
- [6] E. D. Skiani, S. A. Mitilinios, and S. A. Thomopoulos, "A study of the performance of wireless sensor networks operating with smart antennas," *IEEE Antennas Propag. Mag.*, vol. 54, no. 3, pp. 50–67, Jun. 2012.
- [7] F. M. Aziz, J. S. Shamma, and G. L. Stber, "Jammer-type estimation in LTE with a smart jammer repeated game," *IEEE Trans. Veh. Tech.*, vol. 66, no. 8, pp. 7422–7431, Aug. 2017.
- [8] S. Misra, R. Singh, and S. V. R. Mohan, "Geomorphic zonalisation of wireless sensor networks based on prevalent jamming effects," *IET Commun.*, vol. 5, no. 12, pp. 1732–1743, Aug. 2011.
- [9] L. Bras, N. B. Carvalho, and P. Pinho, "Pentagonal patch-excited sectorized antenna for localization systems," *IEEE Trans. Antennas Propag.*, vol. 60, no. 3, pp. 1634–1638, Mar. 2012.
- [10] S. P. Weber, X. Yang, J. G. Andrews, and G. de Veciana, "Transmission capacity of wireless ad-hoc networks with outage constraints," *IEEE Trans. Inf. Theory.*, vol. 51, no. 12, pp. 4091–4102, Dec. 2005.
- [11] K. Ma, Y. Zhang, and W. Trappe, "Mobile network management and robust spatial retreats via network dynamics," in *Proc. IEEE Int. Conf. Mobile Adhoc Sens. Syst.*, Nov. 2005, pp. 1–8.
- [12] A. Garnaev, Y. Liu, and W. Trappe, "Anti-jamming strategy versus a low-power jamming attack when intelligence of adversarys attack type is unknown," *IEEE Trans. Signal Inf. Proc. Over Netw.*, vol. 2, no. 1, pp. 49–56, Mar. 2016.
- [13] M. T. Mamaghani, A. Kuhestani, and K. Wong, "Secure two-way transmission via wireless-powered untrusted relay and external jammer," *IEEE Trans. Veh. Tech.*, vol. 67, no. 9, pp. 8451–8465, Sep. 2018.
- [14] X. He, H. Dai, and P. Ning, "Dynamic adaptive anti-jamming via controlled mobility," *IEEE Trans. Wireless Commun.*, vol. 13, no. 8, pp. 4374–4388, Aug. 2014.
- [15] V. D. Nguyen, T. Q. Duong, O. Dobre, and O. S. Shin, "Joint information and jamming beamforming for secrecy rate maximization in cognitive radio networks," *IEEE Trans. Inf. Forensics Secur.*, vol. 11, no. 11, pp. 2609–2623, Nov. 2016.
- [16] S. Amuru and R. M. Buehrer, "Optimal jamming against digital modulation," *IEEE Trans. Inf. Forensics Secur.*, vol. 10, no. 10, pp. 2212–2224, Oct. 2015.
- [17] P. Tague, "Improving anti-jamming capability and increasing jamming impact with mobility control," in *Proc. IEEE Int. Conf. Mobile Adhoc Sens. Syst.*, Nov. 2010, pp. 501–506.
- [18] M. Li, I. Koutsopoulos, and R. Poovendran, "Optimal jamming attack strategies and network defense policies in wireless sensor networks," *IEEE Trans. Mobile Comput.*, vol. 9, no. 8, pp. 1119–1133, Aug. 2010.
- [19] W. Xu, T. Wood, W. Trappe, and Y. Zhang, "Channel surfing and spatial retreats: Defenses against wireless denial of service," in *Proc. ACM Workshop Wireless Secur.*, New York, NY, USA, 2004, pp. 80–89.
- [20] S. Ahmed and M. Faulkner, "Optimized interference canceling for colocated base station transceivers," *IEEE Trans. Veh. Tech.*, vol. 60, no. 9, pp. 4175–4183, Nov. 2011.
- [21] A. Mpitsiopoulos, D. Gavalas, C. Konstantopoulos, and G. Pantziou, "JAID: An algorithm for data fusion and jamming avoidance on distributed sensor networks," *Pervasive Mobile Comput.*, vol. 5, no. 2, pp. 135–147, 2009.
- [22] L. Nassef, "On the effects of fading and mobility in on-demand routing protocols," *Egyptian Inf. J.*, vol. 11, no. 2, pp. 67–74, 2010.
- [23] S. Misra, G. Mali, and A. Mondal, "Distributed topology management for wireless multimedia sensor networks: Exploiting connectivity and cooperation," *Int. J. Commun. Syst.*, vol. 28, no. 7, pp. 1367–1386, 2015.
- [24] M. Golumbic, *Algorithmic Graph Theory and Perfect Graphs*, 2nd ed., Annals of Discrete Mathematics. Amsterdam, The Netherlands: Elsevier, 2004.
- [25] C. A. Boano, M. A. Zúñiga, T. Voigt, A. Willig, and K. Römer, "The triangle metric: Fast link quality estimation for mobile wireless sensor networks," in *Proc. Int. Conf. Comput. Commun. Netw.*, Aug. 2010, pp. 1–7.
- [26] V. Erceg et al., "An empirically based path loss model for wireless channels in suburban environments," *IEEE J. Sel. Areas Commun.*, vol. 17, no. 7, pp. 1205–1211, Jul. 1999.
- [27] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless microsensor networks," in *Proc. Annu. Hawaii Int. Conf. Syst. Sci.*, Jan. 2000, pp. 1–10.
- [28] S. Misra, T. Ojha, and A. Mondal, "Game-theoretic topology control for opportunistic localization in sparse underwater sensor networks," *IEEE Trans. Mobile Comput.*, vol. 14, no. 5, pp. 990–1003, May 2015.
- [29] W. Tushar, W. Saad, H. V. Poor, and D. B. Smith, "Economics of electric vehicle charging: A game theoretic approach," *IEEE Trans. Smart Grid*, vol. 3, no. 4, pp. 1767–1778, Dec. 2012.
- [30] R. Smith and J. Peterson, *Mathematics for Machine Technology*, 6th ed. Cengage Learning Inc., Florence, United States, 2009.

Major Project page no 116-178

ResMintage: Leveraging Blockchain Technology to Share Hardware Resources

submitted in partial fulfillment of the requirement
for the award of the Degree of

Bachelor of Technology
in
Information Technology

by

**Meet Shah
Ankit Vishwakarma
Krish Sukhani**

under the guidance of

Prof. Nikahat Mulla



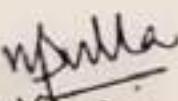
Department of Information Technology
Bharatiya Vidya Bhavan's
Sardar Patel Institute of Technology
(Autonomous Institute Affiliated to University of Mumbai)
Munshi Nagar, Andheri-West, Mumbai-400058
University of Mumbai
2021-2022



Approval Certificate

This is to certify that the Project entitled "ResMintage: Leveraging Blockchain Technology to Share Hardware Resources" by Meet Shah, Ankit Vishwakarma and Krish Sukhani is approved for the partial fulfillment of Major Project - I for the Final Year Project towards obtaining the Degree of Bachelor of Technology in Information Technology from University of Mumbai.

Project Guide


(signature)

Name: Prof. Nikahat Mulla

Date: May 19, 2022

External Examiner


(signature)

Name: Pramit Baru

Date: May 19, 2022

Head of Department

Principal



Seal of the Institute

Declaration

I wish to state that the work embodied in this work titled “ResMintage: Leveraging Blockchain Technology to Share Hardware Resources” forms my own contribution to the work carried out under the guidance of Prof. Nikahat Mulla at the Sardar Patel Institute of Technology. I declare that this written submission represents my ideas in my own words and where others’ ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission.

Meet Shah
2018140055

Ankit Vishwakarma
2018140062

Krish Sukhani
2018140059

Abstract

Data storage and protection are key concerns in today's world. Organizations have increased their network infrastructure to provide cloud storage and resource access to as many individuals as possible, which raises issues about the privacy of data stored or shared over a network. A centralized authority cannot manage such a vast data network. Cloud storage and other data infrastructure are becoming increasingly expensive as demand grows. Cases of data breaches and attacks have been recorded year after year, and the numbers continue to grow. Many firms, including LinkedIn and Facebook, have experienced massive data breaches in recent years. Another issue discovered was that idle hardware was not being used by many local computers. Although there are people and organizations with surplus local storage capacity, many organizations are looking for additional cloud storage. To address the aforementioned issues, this paper proposes a solution that uses Blockchain Technology to enable individuals or organizations to share hardware resources. Blockchain employs a peer-to-peer design. As Blockchain employs cryptographic techniques, it has the highest security factor of any system. This paper proposes a system in which users can share their local resources with users in need via a blockchain because there is a clear supply and demand requirement for resources. Users that share hardware resources will also be rewarded. There will be no need for any central authority to manage the data or the data kept with the shared resource with blockchain, preserving user privacy and security

List of Figures

1	Class Diagram	12
2	Data Flow Diagram 0	13
3	Data Flow Diagram 1	14
4	Use Case Diagram	15
5	Block Diagram	17
6	Architecture Diagram	18
7	Buyer Flowchart	22
8	Seller Flowchart	23
9	Buyer Flowchart	25
10	Home Page	26
11	Seller Registration	27
12	Seller Registration Filled	28
13	Seller Registration Successful	29
14	Seller Login	30
15	Login Successful	31
16	Seller Dashboard before vd Created	32
17	Seller Dashboard before vd Created Filled	33
18	Seller FTP Server	34
19	Seller Dashboard after vd Created	35
20	Buyer Registration	36
21	Buyer Registration Filled	37
22	Buyer Registration Successful	38
23	Buyer Login	39
24	Buyer Login Filled	40
25	Buyer Dashboard before VD Bought	41
26	Buyer Buy Vd	42
27	Buyer Buy Vd filled	43
28	Buyer Dashboard after vd bought	44
29	Buyer vd list	45
30	Buyer inside vd	46
31	Buyer upload to vd	47
32	Buyer upload success	48
33	Buyer view files in vd	49
34	Buyer storage full	50
35	Buyer delete file	51
36	Buyer delete file success	52
37	Balances before execution	53

List of Tables

1	Literature Survey	11
---	-----------------------------	----

Contents

1	Introduction	7
1.1	Problem Statement	7
1.2	Objectives	7
1.3	Scope	7
1.4	Technologies Used	8
1.5	Assumptions And Constraints	8
2	Literature Survey	9
3	Analysis	12
3.1	Class Diagram	12
3.2	Data Flow Diagrams	13
3.3	Use Case Diagram	15
4	Design and Methodology	16
4.1	System Architecture	17
4.2	Smart Contract	19
4.3	Virtual Drives Management	19
4.4	File Management	20
4.5	Session Management	20
4.6	Project Flow	21
5	Conclusion and Future Work	24
5.1	Conclusion	24
5.2	Future Work	24
6	Results and Outputs	25
6.1	Output of the complete implementation	25
7	Research Paper	54
8	Plagiarism Report	60

1 Introduction

1.1 Problem Statement

There is no ideal system that can help sharing of hardware resources other than cloud, also there is no system where a normal person could utilize their idle hardware to get incentivized. There are trust issues and privacy concerns in cloud solutions and there is lack of transparency.

1.2 Objectives

- To efficiently share and access remote storage from one system to another using blockchain
- To provide a secure and efficient way of data storage
- Being able to provide a transparent mode of remote data storage without the involvement of any middle man.
- To cut extra charges when buying/selling storage directly from one system to another.

1.3 Scope

- The system will leverage the blockchain technology to maintain security, scalability and monetization.
- Our proposed system will enable its users to consume computer resources at nominal costs.
- Users will also be able to share their computer resources if they have some extra and they will be able to earn some money for that.
- The users will also be able to share their files to other users if required.
- A recommendation system will help buyers to buy the perfect solution according to their needs

1.4 Technologies Used

- The criteria for developing this project were a language to code the smart contract, a language to write the client side of the project, i.e. the buyer and seller sides of the project, and an Ethereum client to connect to the Ethereum blockchain network. Solidity is used for the smart contract as it provides JavaScript-like syntax for constructing distributed apps, Solidity is the de facto choice for writing Ethereum smart contract programs. Smart contracts are written in Solidity, a high-level object-oriented computer programming language. In the Ethereum state, smart contracts are computer programs that govern how accounts work. Solidity is a language of programming for the Ethereum Virtual Machine that uses curly brackets (EVM). Python, C++ and JavaScript all have an impact on it. In the linguistic influences section, you may learn much more about languages that have influenced Solidity. Solidity is statically typed and, among other things, enables inheritance, libraries, and powerful user-defined types. Solidity helps you to design contracts for polling, crowdsourcing, blind bidding, and multi-signature wallets, among other things.
- The Ethereum client, known as Go Ethereum or Geth, was utilized. One of the three original Ethereum implementations, along with Python and C++, is Go Ethereum. It was written in Go and is free and open source under the GNU LGPL v3 license. Geth is available and runs on almost any operating system and as a library that can be linked into your Go, Android, or iOS apps.
- The system uses Python for the client-side programming. Python is a versatile, easy-to-code programming language. Python is a computer language that is both powerful and easy to learn. It contains high-level data structures that are efficient and an object-oriented programming style that is simple yet effective. Python's appealing syntax, interpreted nature and dynamic typing, make it a great language for scripting and quick application development on a wide range of systems. The Python interpreter and standard library are freely accessible from the Python website in source or binary form for all operating systems and may be freely distributed.

1.5 Assumptions And Constraints

- That our private network simulates the ethereum mainnet
- Buyers and Sellers are operating on different hardware device
- Buyer and Seller are using Windows operating system
- Not made for other operating systems

2 Literature Survey

No.	Paper Title	Work Done	Observations/Findings
1	Application of Blockchain Technology in Dynamic Resource Management of Next Generation Networks	Blockchain-based solution that allows Network Providers to trade their resources. Network infrastructures become exceedingly large and hence need a trusted authority to govern it. To solve this, the paper talks about using blockchain as it provides advantage in such untrusted environment.	The usage of blockchain in the network infrastructure for resource sharing and other network application enables decentralized solutions ensuring integrity and immutability. Uses a distributed broker mechanism by describing an architecture that includes the NPs as nodes, oracles for interaction to send and receive transactions.
2	User-Controlled Privacy-Preserving User Profile Data Sharing based on Blockchain	Demonstrates a decentralized data sharing architecture with Multi-Chain blockchain in the travel domain. To share the users' profile data in a decentralized fashion, the concept of streams from the Multichain has been successfully interpreted by taking as an example the case of travel domain. This eliminates the single point of failure and centrality issues which are often present in the centralized user model servers.	This paper gave us an analysis of also focussing on the latency and the memory usage in blockchain. How each node is connected and the working is not affected even in case of increase in the number of nodes. Also the memory usage remains same.
3	User Acceptance of Usable Blockchain-Based Research Data Sharing System: An Extended TAM-Based Study	This paper focuses on the acceptance of blockchain systems as a whole in researchers. Blockchain is an unknown technology, many people might be reluctant to accept it due to the unknown nature of it. Extended Technology Acceptance Model.	This paper motivated us to identify the problem and use the Blockchain technology to solve that problem. Based on the research in this paper, we can say that blockchain is a future technology and it is here to stay.

4	Customer Data Sharing Platform: A Blockchain-Based Shopping Cart	An approach to allows customers to connect to the seller directly, share personal data without losing control and ownership. It tracks who shared what, with whom, when, by what means and for what purposes in a verifiable fashion.	Helped us to think around monetizing data sharing(or file sharing) and how do we implement the same for data storage sharing. This data is secured and only restricted people have access to it. With this a file will be shared to restricted users. The data will be shared to restricted enterprises and in the similar way the storage will be shared among the user who buys it.
5	User Data Sharing Frameworks: A Blockchain-Based Incentive Solution	A blockchain based system to securely share research data without losing the ownership of the data. A review of the existing work of research data sharing, the proposed blockchain-based framework and an evaluation of the framework by measuring the transaction cost for smart contracts deployment.	Inspired us to implement the file sharing system in our system. Describes a way to share locally stored files securely without losing ownership.
6	A General Framework for the Study of Decentralized Distribution Systems	A coopetitive for the sequential decisions of inventory and allocation. This decentralized system handles holding of stocks at multiple locations by N retailers. It shows that there exists an allocation mechanism that achieves the first best solution for inventory deployment and allocation..	This paper helps us understand the ways in which we can develop a competitive as well as cooperative environment for having optimized decisions of inventory and its allocation So with this, the smart contract can hold data of all the storage space and then allocated them sequentially in an optimized way.
7	A Blockchain-based Decentralized Data Sharing Infrastructure for Off-grid Networking	Presents a platform for decentralised data exchange across untrusted players in off-grid networks. The suggested architecture achieves this goal by combining existing blockchain frameworks with a distributed file system and an off-grid network device.	This paper gives us new ideas to work off grid. It also gave us ideas like everybody cannot be trusted so security and privacy is important.

8	Measuring Decentralization in Bitcoin and Ethereum using Multiple Metrics and Granularities	Presents a comparison study of the degree of decentralization in Bitcoin and Ethereum, the two most prominent blockchains, with various decentralization metrics and different granularities within the time dimension. Specifically, it measures the degree of decentralization in the two blockchains during 2019	Helped us learn more about the different ways in which Bitcoin and Ethereum work Learned the ways in which one is better than the other or vice versa.
9	Toward Multiple Federated Learning Services Resource Sharing in Mobile Edge Networks	A system for the sharing of CPU resources for federated learning services At each mobile device for the local training process and allocating communication resources among mobile devices for exchanging learning information.	Helped us understand a different perspective about resource sharing in mobile edge networks With this we can try to identify a way to implement the federated learning (Data local - prediction global) in our system
10	Evaluation of Distributed Databases in Hybrid Clouds and Edge Computing: Energy, Bandwidth, and Storage Consumption	Analyses the performance, energy bandwidth and storage consumption of four popular open source databases on Hybrid Clouds and Edge Computing. This paper educates us on how traditional cloud based systems work.	Gave us an overview of traditional cloud systems Having knowledge of cloud systems is essential to our project This paper helped us understand how cloud systems perform in general and how the database performance compares on cloud.

Table 1: Literature Survey

3 Analysis

3.1 Class Diagram

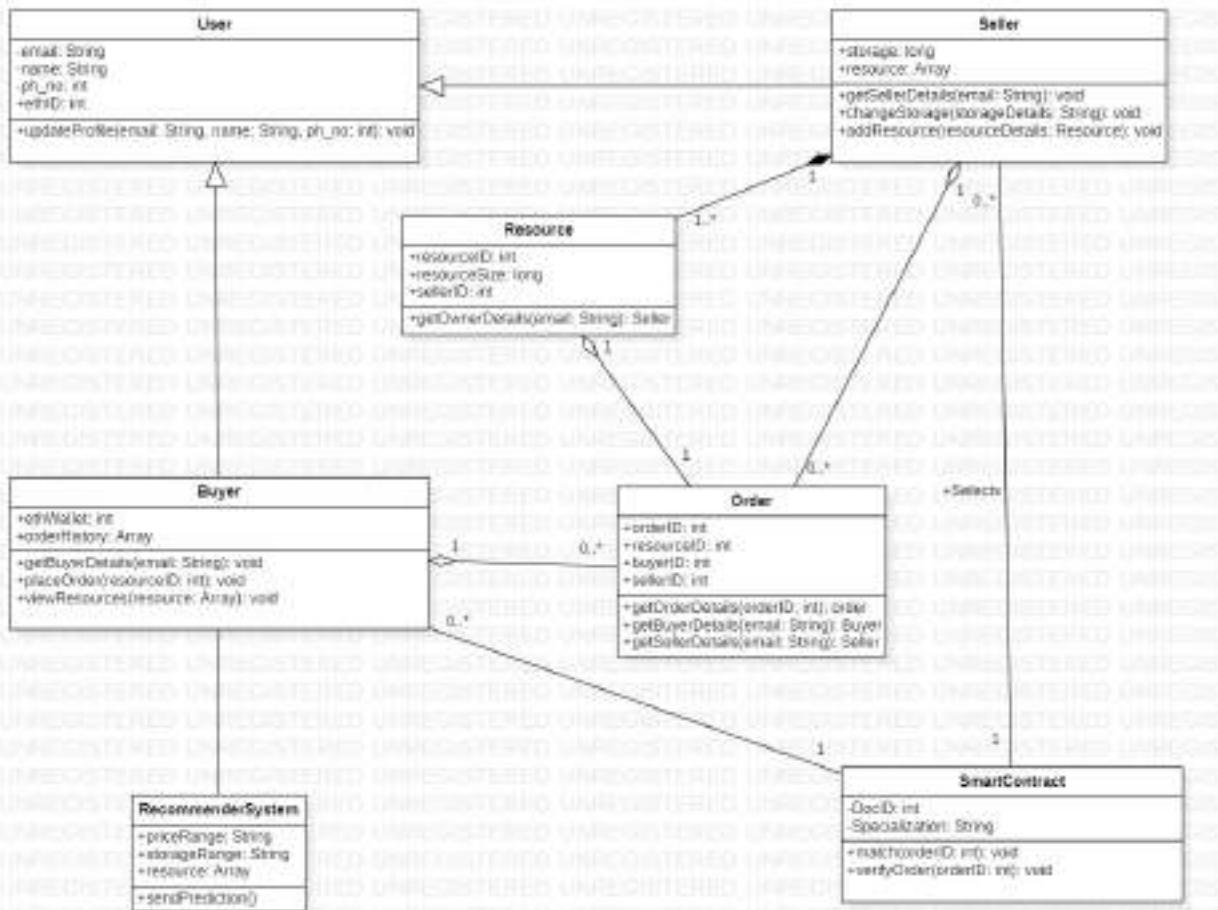


Figure 1: Class Diagram

3.2 Data Flow Diagrams

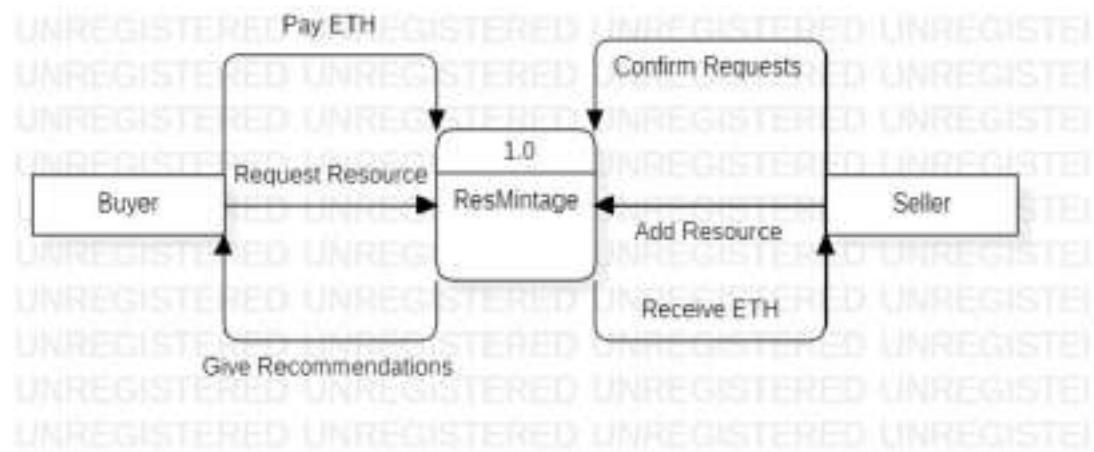


Figure 2: Data Flow Diagram 0

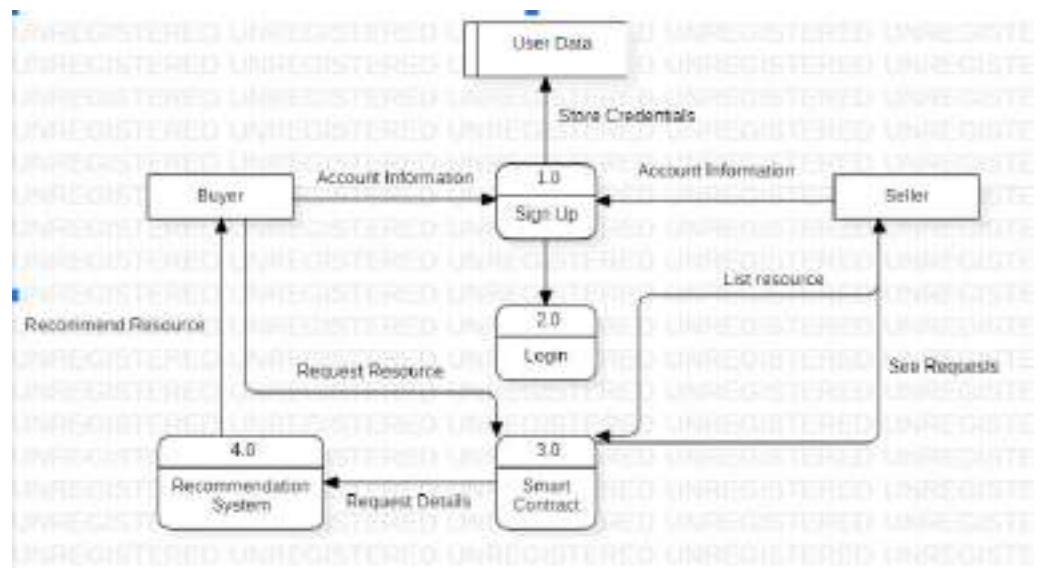


Figure 3: Data Flow Diagram 1

3.3 Use Case Diagram

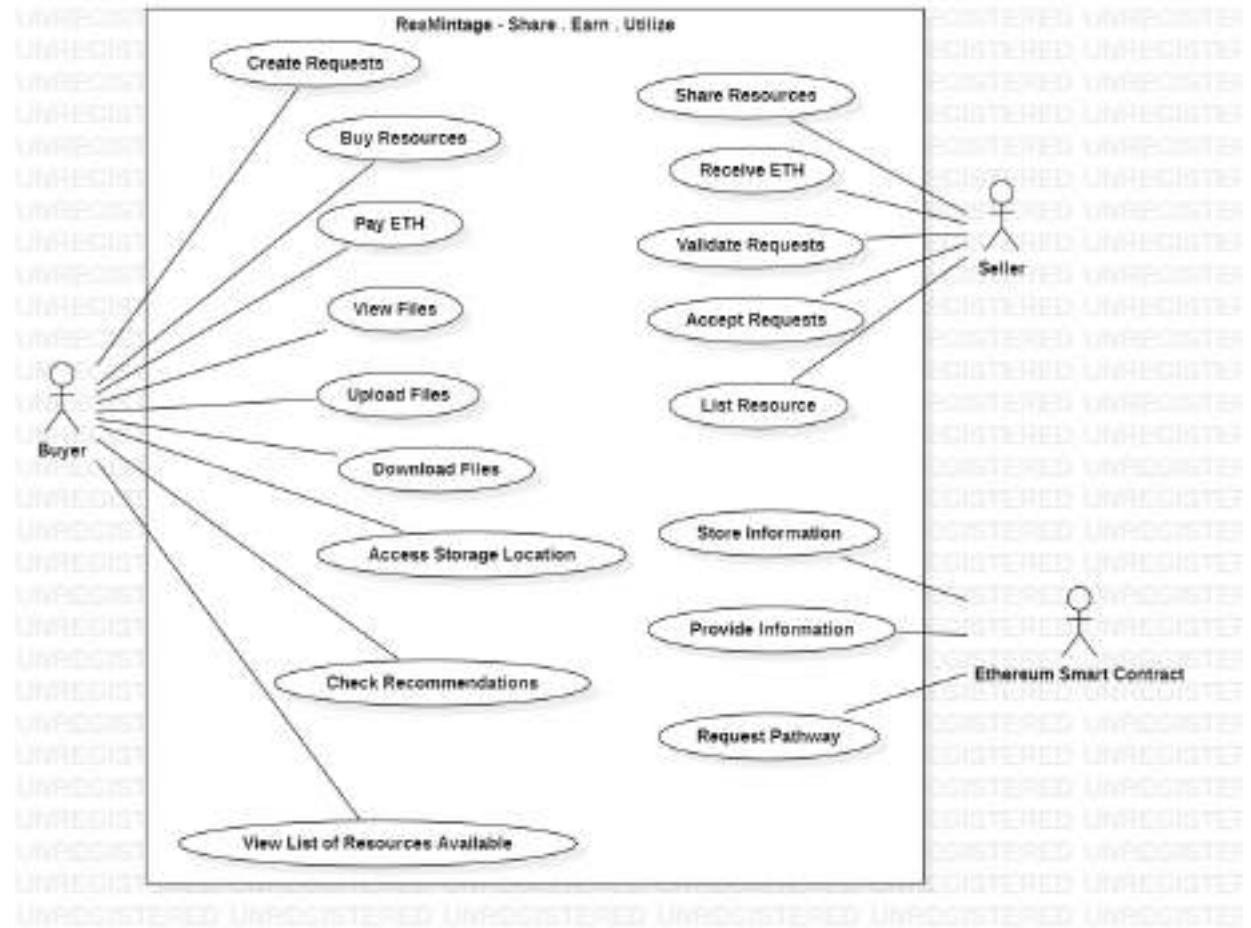


Figure 4: Use Case Diagram

ResMintage's use case diagram is depicted in the figure. The system is composed of three actors. The buyer, the seller, and the Ethereum smart contract are all involved. The buyer is the individual who wants to purchase storage from the ResMintage system. The seller is the person who wants to be compensated for selling his storage space, and the Ethereum smart contract is the piece of code. It runs on the blockchain and guarantees that resource sharing runs smoothly. So the buyer can request a resource, buy it, pay ETH for it, and then upload and download files, create and remove folders, and check the list of folders and files in their remote storage. The seller might share the resources in exchange for ETH. All virtual drives, buyers' and sellers' metadata are stored in the smart contract. It can retain and provide such information, as well as function as a validator when logging in and signing up for the system

4 Design and Methodology

The basic goal of ResMintage is to give the user a means to sell unused hard disc space and get paid for it. A user can pay for the use of one or more sellers' hard drive space to store data. Once the ETH transaction is completed successfully, that specific hard drive space will be allocated for the buyer and can be accessed from any location because the storage space will be secured with the buyer's private key. The data required to validate the successful completion of a transaction will necessitate the storage of certain basic information on the blockchain, which will include basic user information, virtual drive details, a list of virtual drives, and metadata. The seller is motivated to market the unused space, and the buyer is motivated to purchase because the cost is lower than that of cloud storage

4.1 System Architecture

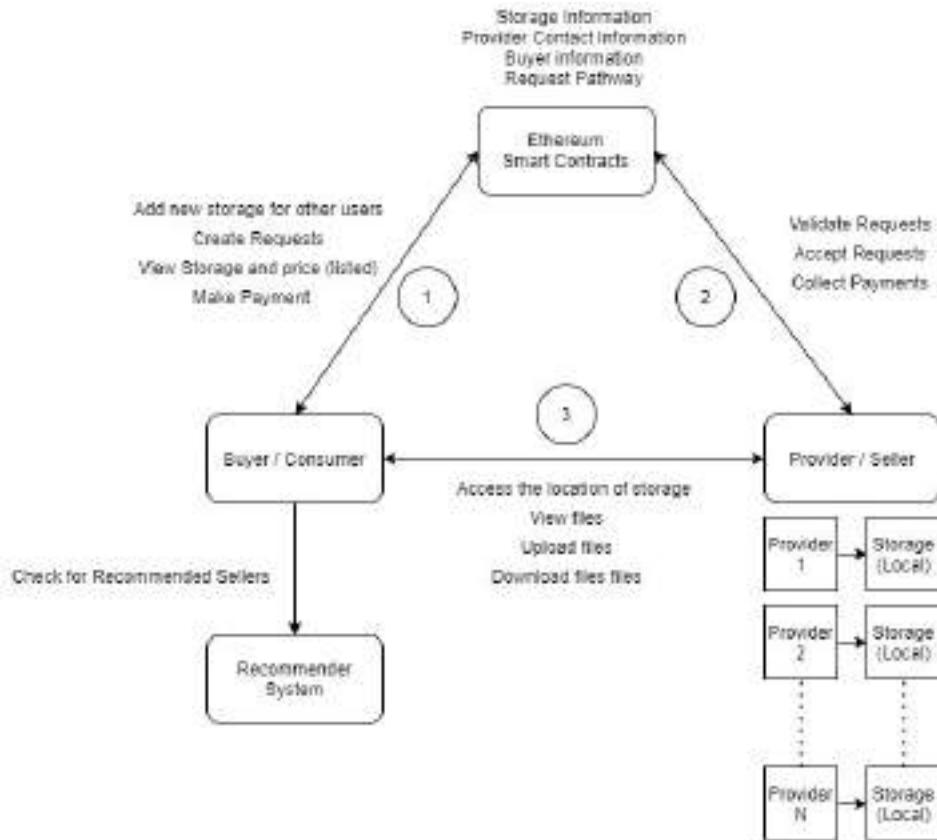


Figure 5: Block Diagram

The figure depicts the basic system architecture of ResMintage. It provides a high-level summary of how the system works. The smart contract records the transactions between the buyer (User purchasing storage via ResMintage) and the seller (User supplying resources via ResMintage). When a buyer, for example, generates a request to upload or download files, a transaction is sent to save the record for the request. Other than the hash, the file's metadata, particularly the name and size, is required for uploading and storing it in the virtual drive. The buyer can then use a web service call to contact the seller by querying the smart contract for their contact information. This will send a notification to the seller about the new request. The vendor can then check the request and, once validated, accept it. When downloading, the buyer can validate the data from the seller's virtual drive by directly comparing the hash of the file to the one saved in Ethereum. The recommender system will match the buyer with the requested storage, and the buyer can then choose from the matches based on reviews, transaction speed, and cost, among other factors

Architecture Diag

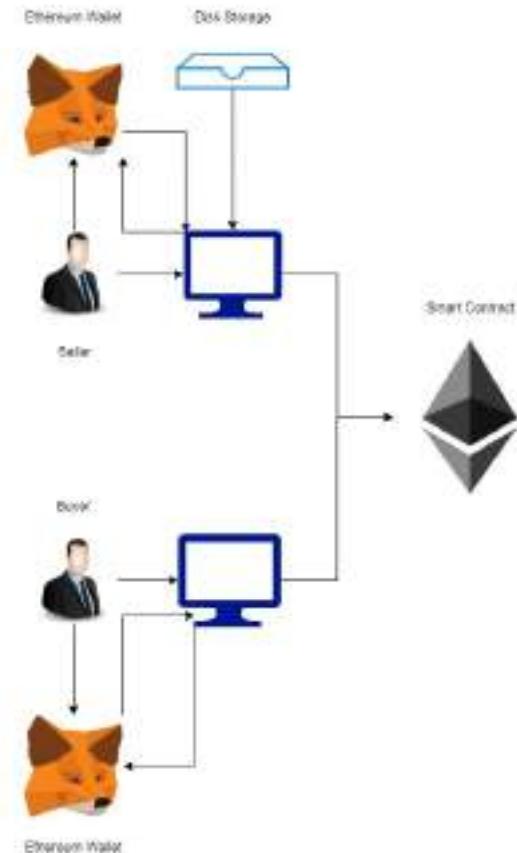


Figure 6: Architecture Diagram

The architecture diagram depicts a high-level overview of the system, as well as the components that will interact with it and their linkages. As depicted, there will be a buyer and a seller, each with a PC or laptop and an Ethereum wallet. The seller consists of the disc storage because he is the one who provides the storage to the buyer for purchase. Furthermore, the computers are linked to the smart contract, which serves as the primary link between the buyer and seller.

4.2 Smart Contract

The core code that manages all blockchain transactions between the buyer and seller is the ResMintage smart contract. The smart contract also preserves the metadata for all virtual drives produced by all merchants. This metadata includes the seller who owns the storage as well as the seller's PC's IP address. It also keeps the buyer and seller data required for validation when signing up for or logging into the system, as well as when transferring ETH from buyer to seller. It contains all of the features that will aid in many elements of the system, such as sign up, log in, establishing a virtual drive, purchasing it, ETH transfer, and validation at each stage. This smart contract is operating on a private Ethereum blockchain on the private network. This blockchain was created with Go Ethereum.

4.3 Virtual Drives Management

A logged-in user can establish a virtual drive by inputting the necessary information as well as the desired size. The drive has been created and added to the list. Currently, the price is predetermined for the scope of these projects, but when they are put on the main net, the price can be calculated depending on the current market value, transfer speed, user reviews, and ratings for a certain seller. Based on the market environment, this can be set as the default and updated by the user. The essential information, such as the name, size, and seller, will be included in the virtual drive list. The user can receive more information by clicking on the drive. When a user clicks on a drive, the files, folders, and directories are displayed. By specifying a name and a path, the directory can be established. The directory's goal is to keep data organized, so it takes up no space on the virtual drive.

4.4 File Management

To upload a file, first select the drive to which the file should be added, then the directory. Once the location has been determined, the user will upload the file from his or her local computer. The smart contract validation function is called when the upload button is pressed, and the request is processed. If the validation is successful, the IP address and port number of the web service operating on the seller side are returned to the buyer side. The buyer then invokes the web service, which transmits the file to the seller's computer. This file is then encrypted and saved at the physical place on the seller's computer where the buyer's virtual disc is located.

4.5 Session Management

The session will be established using the private key generated when the user's account is created for the first time. The account will keep track of the generated drives, Ethereum amount (Ether), and virtual drives held in addition to the basic account information. The lower the transaction cost, the more likely the transaction will be handled quickly

4.6 Project Flow

The figure explains the typical flow of buyer activity on the installed system. As a result, the buyer first joins the ResMintage portal with his Ethereum private key. The user information is then saved in the session, as mentioned in the methodology section. After this, if the buyer has already purchased certain virtual drives, he or she will be able to view and select one of those virtual drives. Otherwise, the customer will be required to input their virtual drive requirements if they choose to purchase a new one. When this request is completed, it will be added to the current list of virtual drive requests. This request will then be mapped to the virtual drives listed, and the best-fit drive will be assigned to the customer at a fixed fee. If mapping is not completed, the buyer will have the opportunity to remove the request or check its status. The figure is the flow of a seller's activity on the established system. As a result, the seller first logs onto the ResMintage interface with his Ethereum private key. The user information is then saved in the session, as mentioned in the Methodology section. Following that, if the seller has not yet created a virtual drive, there will be an option to do so. When the seller selects this option, he or she will be required to input the amount of storage to be assigned to the virtual drive. Once entered and submitted, it will be verified to see if that much storage is indeed available on the seller's computer. If validation is successful, the virtual drive is added to the smart contract's list of virtual drives. When a buyer order matches a virtual drive, the virtual drive is assigned to that buyer. Following that, the ETH is sent from the buyer's account to the seller's account.

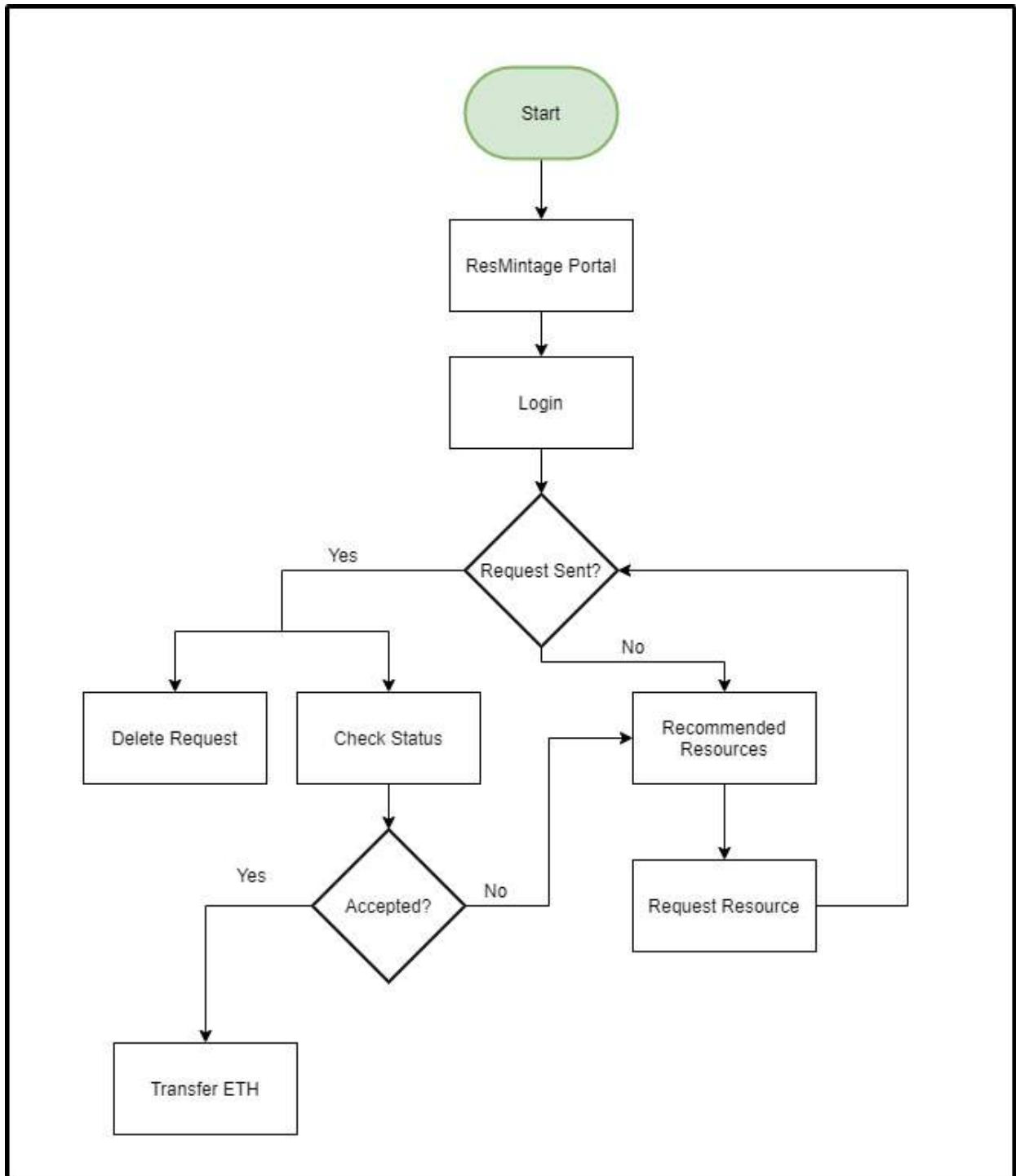


Figure 7: Buyer Flowchart

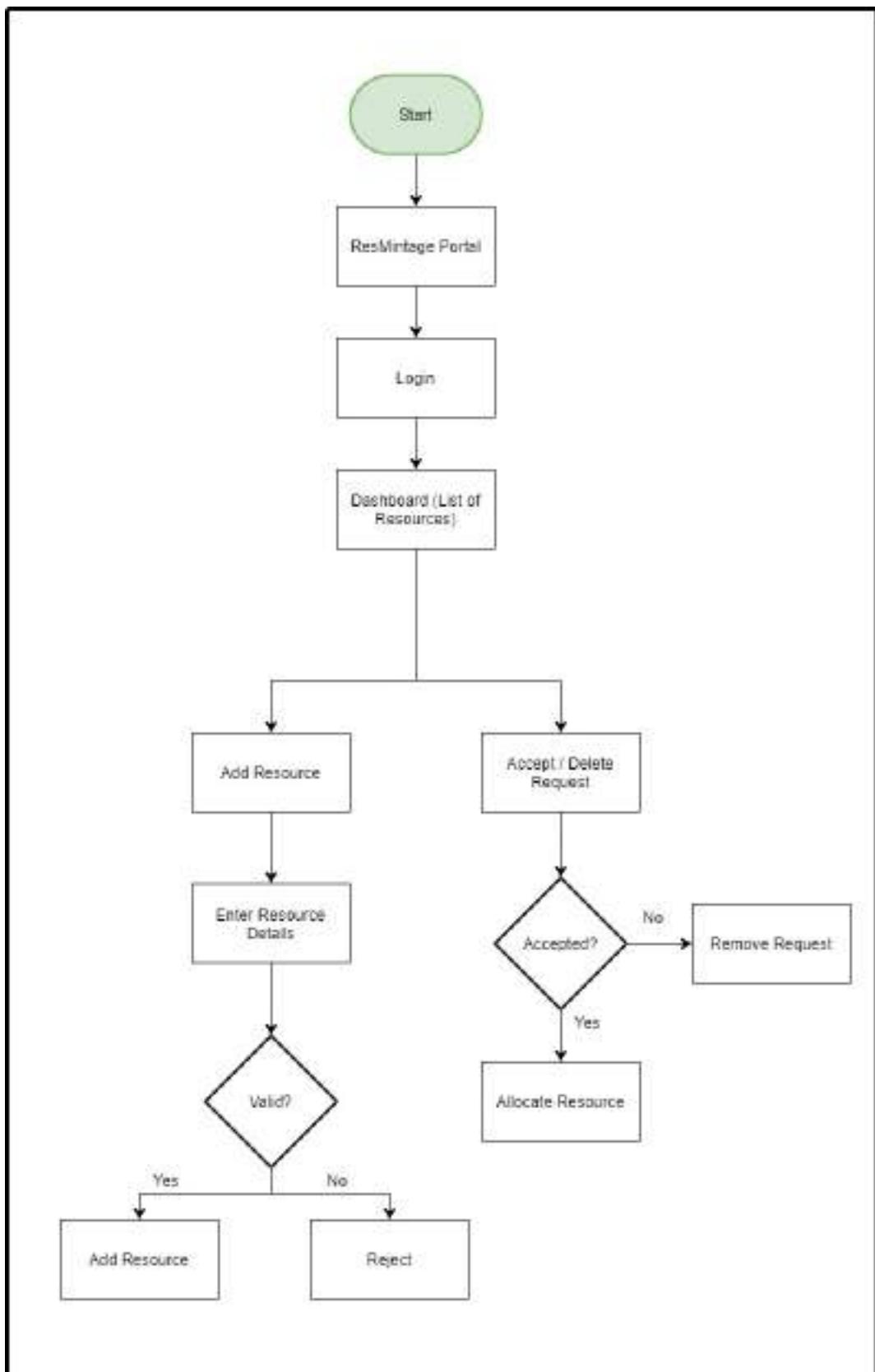


Figure 8: Seller Flowchart

5 Conclusion and Future Work

5.1 Conclusion

As we rely more on cloud services to handle computing problems, alternative designs must be studied to guarantee that the solutions provided are the best fit for our needs. With Amazon and Google providing the vast bulk of public cloud storage systems, the peer-to-peer cloud appears to be ideal for exploration. The proposed method was intended to be a tiny stepping stone toward that reality by proving that idle storage resources may be used by a peer-to-peer system without the use of a middle man. The proof of concept includes a client application for communicating with smart contracts built for Ethereum's distributed application framework. Through this interaction, users may buy or sell unwanted idle hardware storage from other users. The sold space is utilized to store user data and serves as a distributed cloud storage solution. When customers purchase storage capacity, they do it from a group of individuals and use it to build their own decentralized storage, reusing a resource that would otherwise be wasted, and they do so without the intervention of a central body.

5.2 Future Work

Blockchain technology is still in its infancy. Our proposal has the potential to replace cloud storage. The next goal is to completely replace the cloud. Cloud computing is a mature and established technology that has grown through time. Cloud computing is no longer only about storage; it is also about SaaS, PaaS, and IaaS. (or XaaS). The eventual goal of this research study is to implement GPU, CPU, and RAM sharing via blockchain. This may appear difficult, but it is only a matter of time until blockchain technology develops enough to be able to achieve this.

6 Results and Outputs

6.1 Output of the complete implementation

```
0xad7d86e9c8ccbf524067e5c3a9d51db6048b4758  
0xd886d6e4f311f3a8ed7576106414e3e425c65f3a  
0xf7407fb04da0469638c252a787f7a924c1e5bf55  
0x254053d450e337119cf0fdb8933100729fa211df  
0x4ce6e3176883942ce4c53a6145bd87e1d7c75648  
0x56be07e33a096265e96ab2180aed7a58dd799929
```

Figure 9: Buyer Flowchart



Figure 10: Home Page



Figure 11: Seller Registration



Figure 12: Seller Registration Filled



Figure 13: Seller Registration Successful



Figure 14: Seller Login



Figure 15: Login Successful

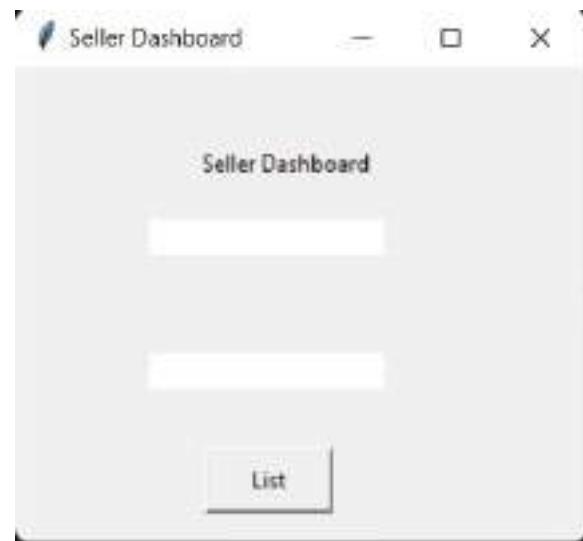
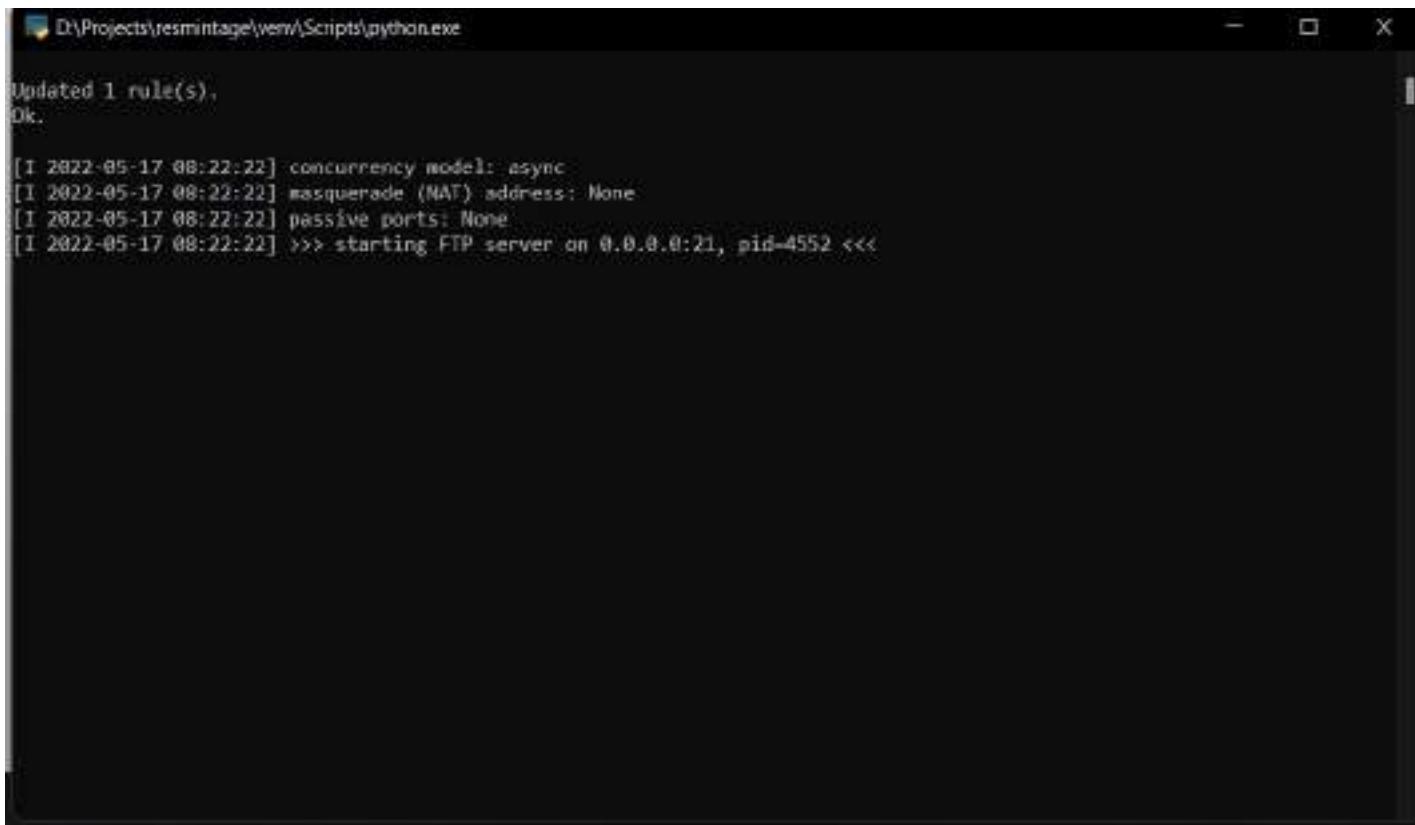


Figure 16: Seller Dashboard before vd Created



Figure 17: Seller Dashboard before vd Created Filled



D:\Projects\resmintage\wem\Scripts\python.exe

```
Updated 1 rule(s),  
Ok.  
[I 2022-05-17 08:22:22] concurrency model: async  
[I 2022-05-17 08:22:22] masquerade (NAT) address: None  
[I 2022-05-17 08:22:22] passive ports: None  
[I 2022-05-17 08:22:22] >>> starting FTP server on 0.0.0.0:21, pid=4552 <<<
```

Figure 18: Seller FTP Server

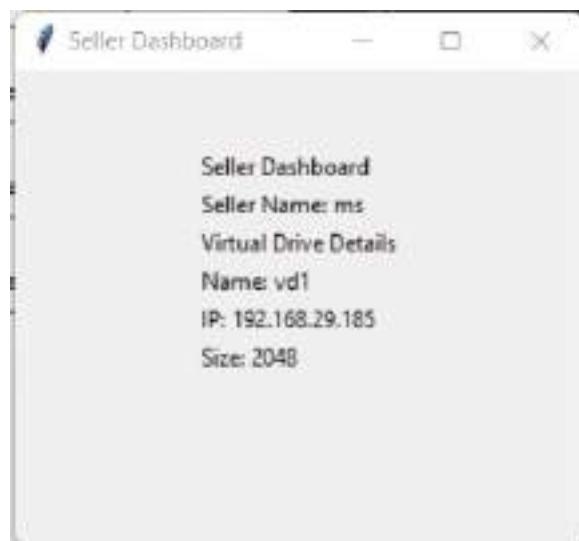


Figure 19: Seller Dashboard after vd Created

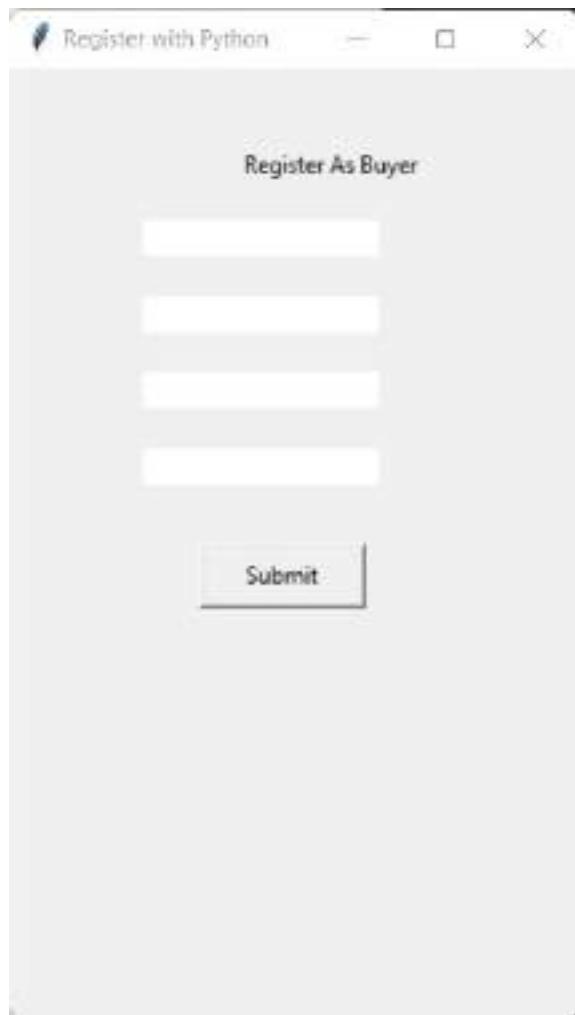


Figure 20: Buyer Registration

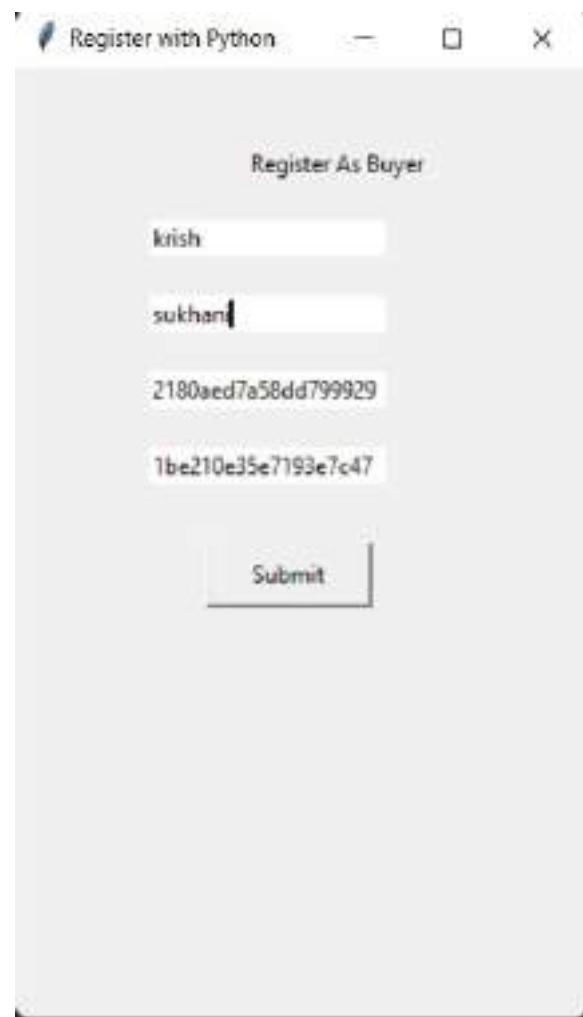


Figure 21: Buyer Registration Filled



Figure 22: Buyer Registration Successful

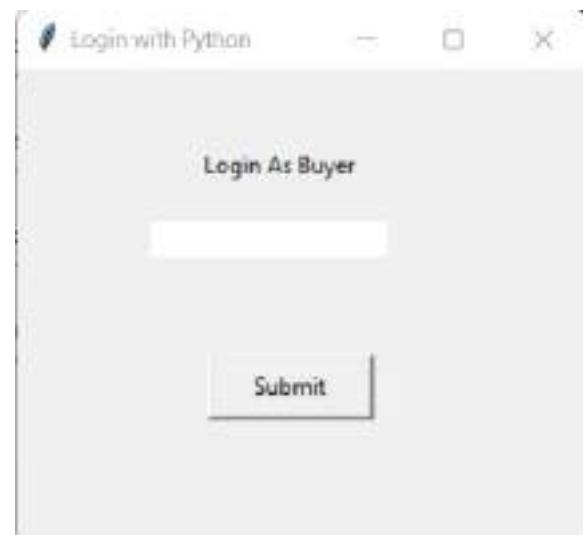


Figure 23: Buyer Login

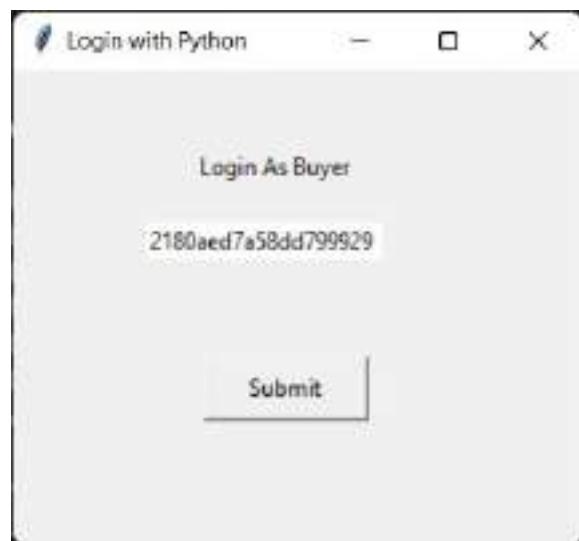


Figure 24: Buyer Login Filled

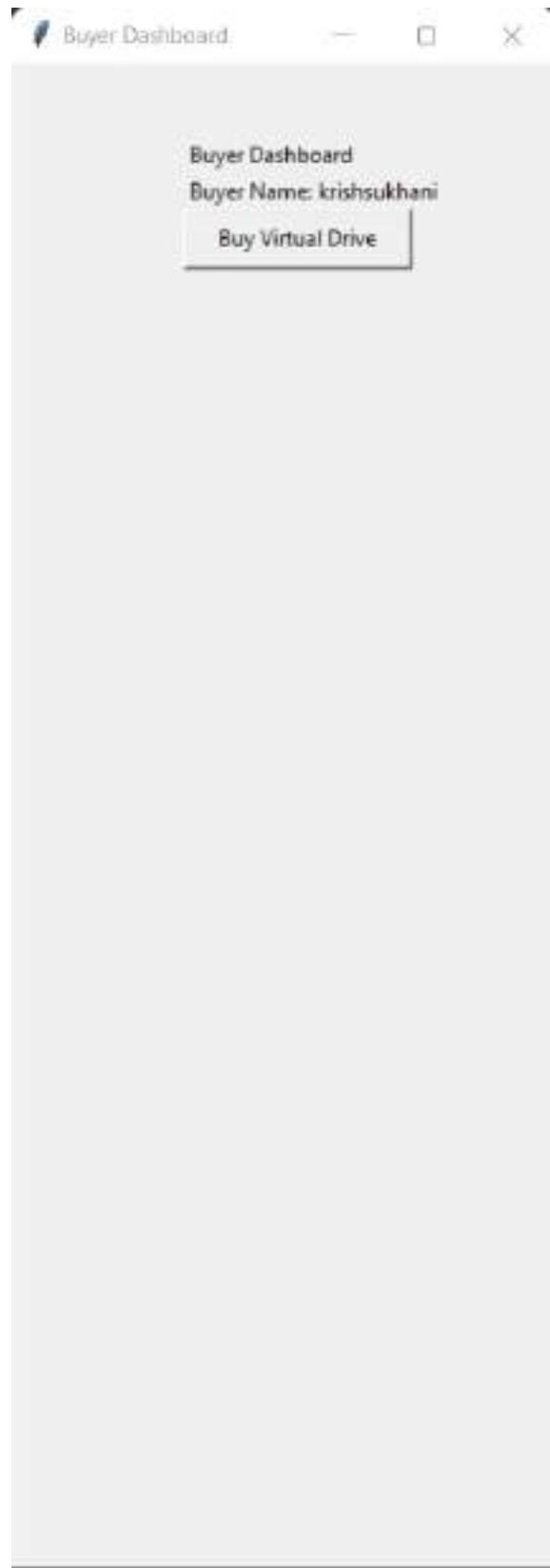


Figure 25: Buyer Dashboard before VD Bought

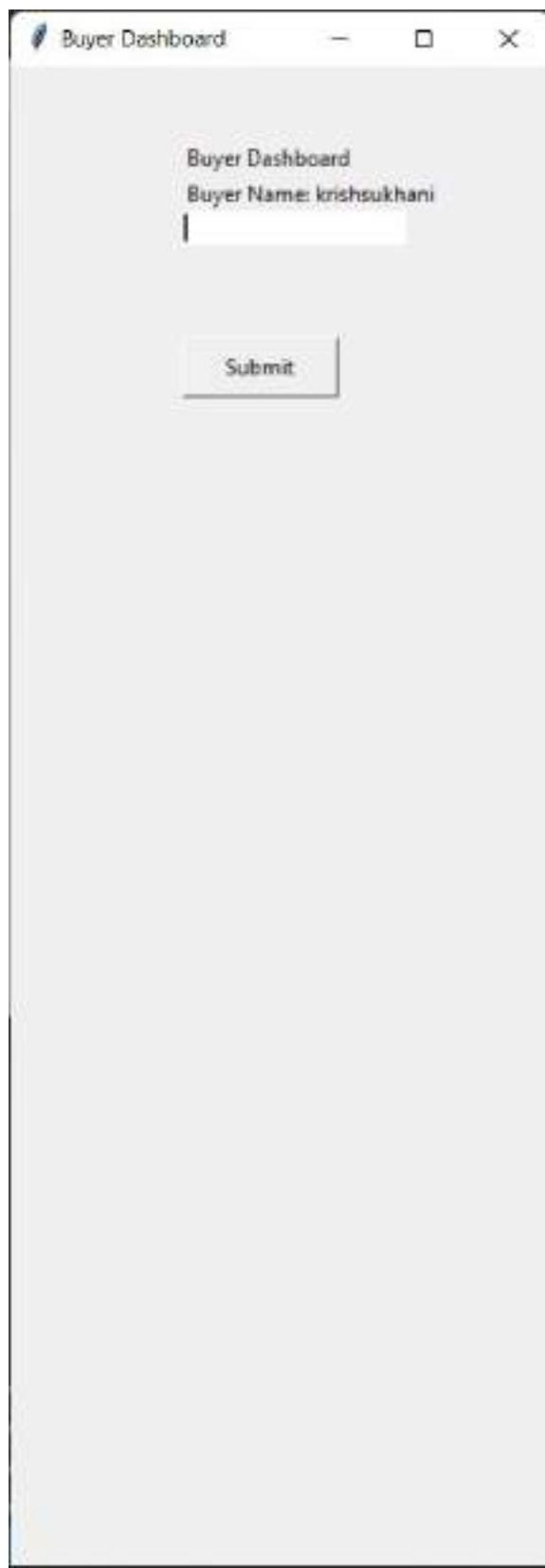


Figure 26: Buyer Buy Vd

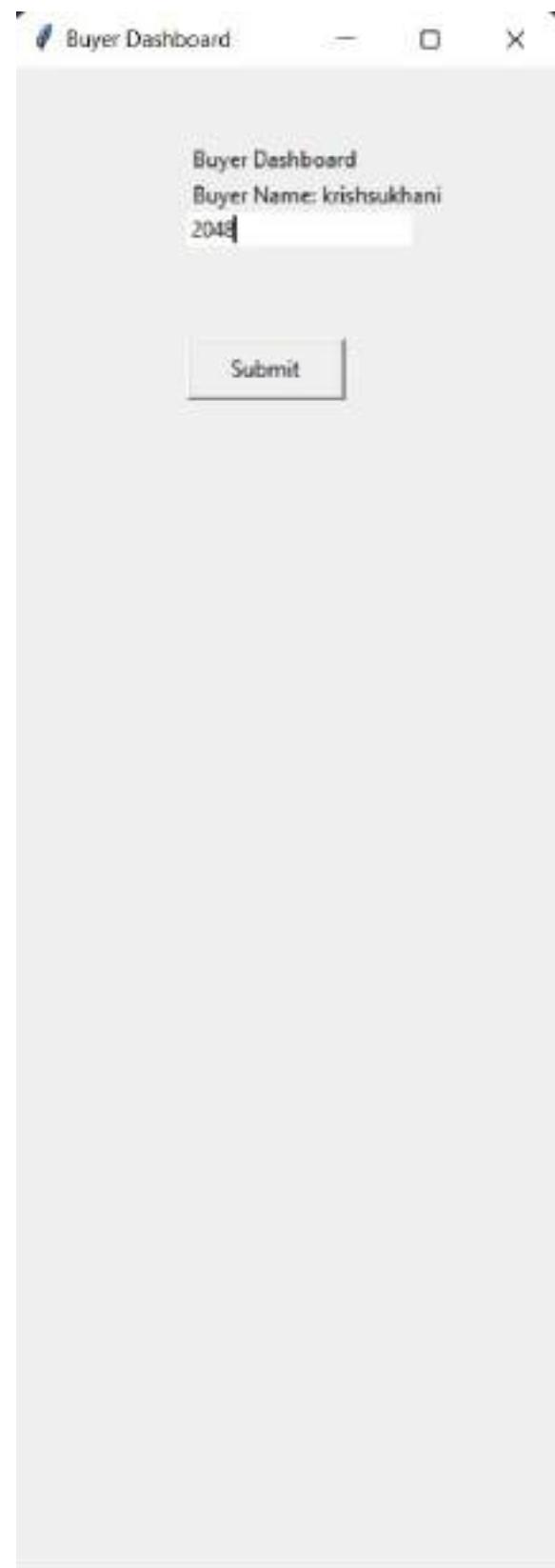


Figure 27: Buyer Buy Vd filled

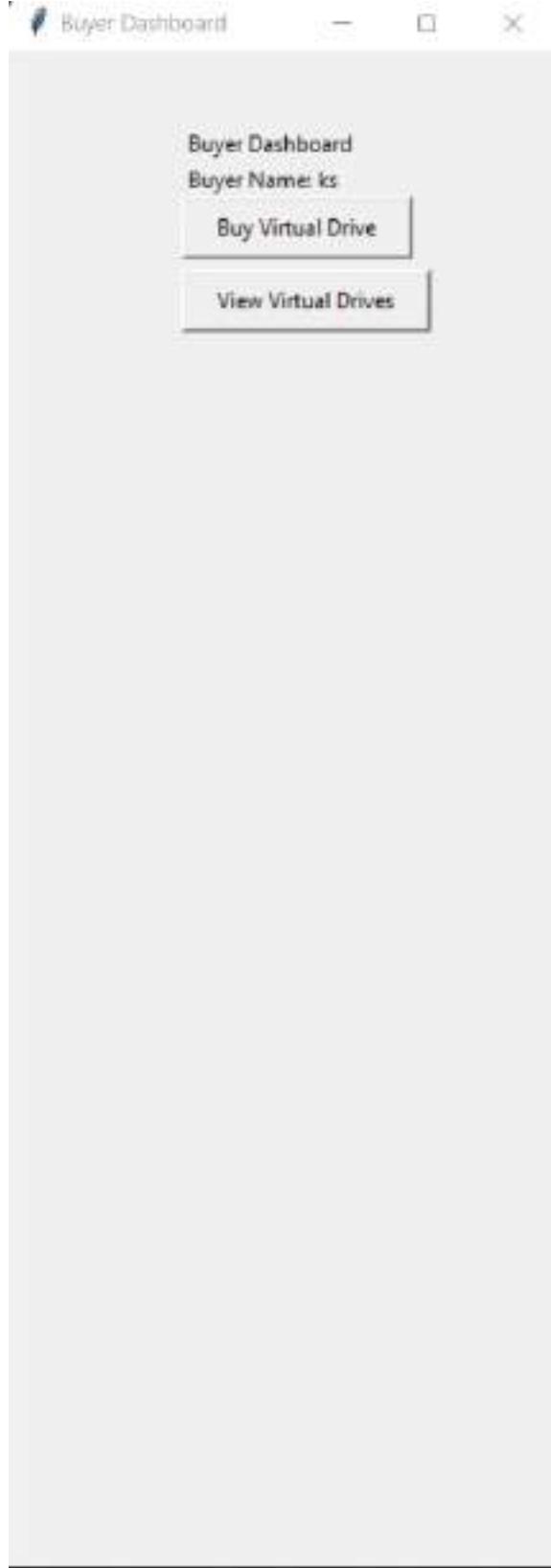


Figure 28: Buyer Dashboard after vd bought

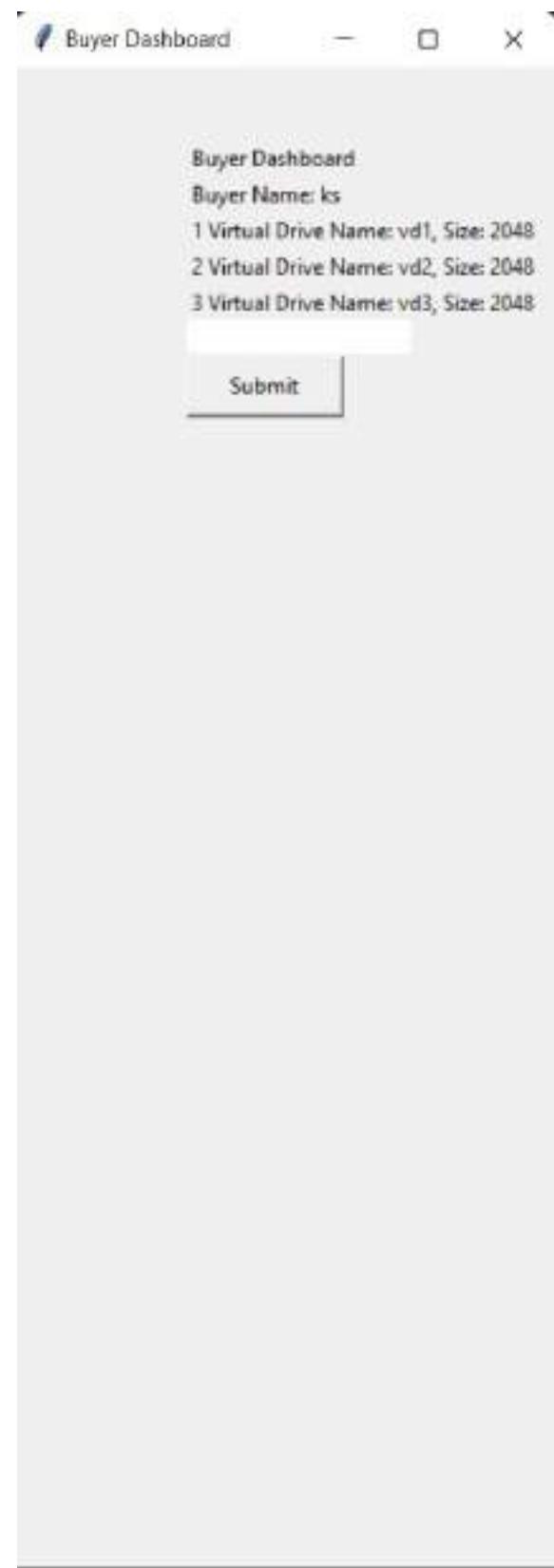


Figure 29: Buyer vd list

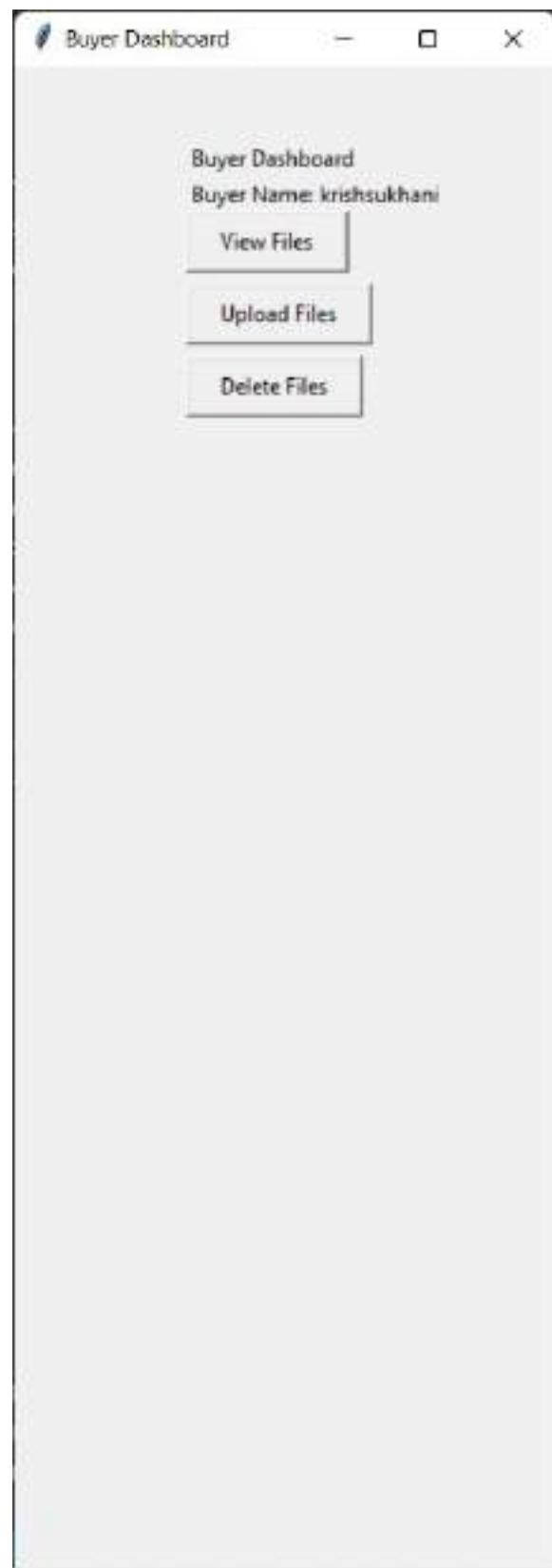


Figure 30: Buyer inside vd

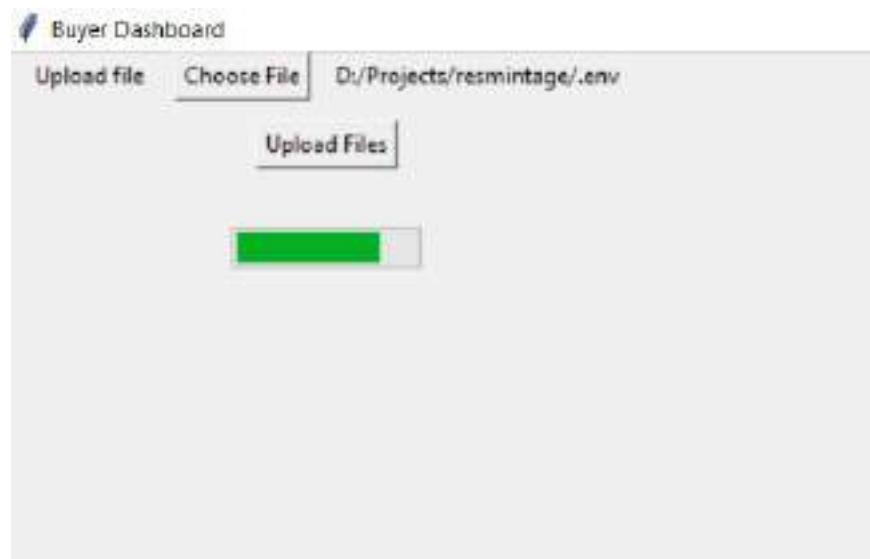


Figure 31: Buyer upload to vd

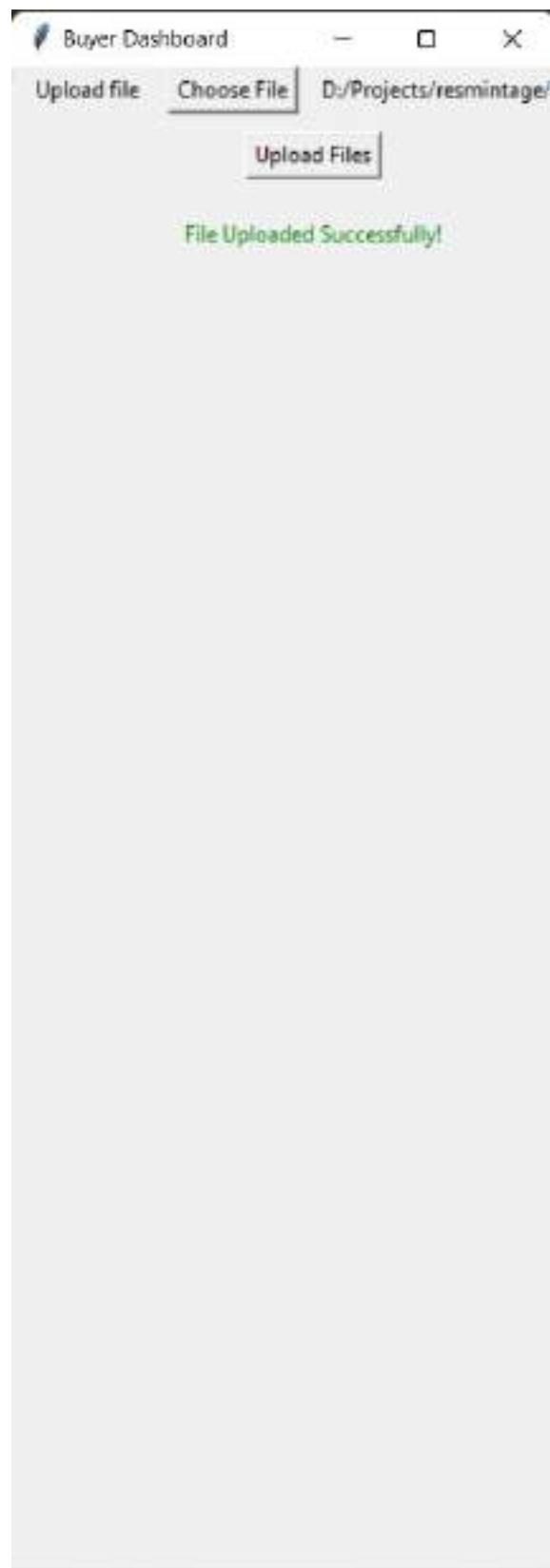


Figure 32: Buyer upload success



Figure 33: Buyer view files in vd



Figure 34: Buyer storage full

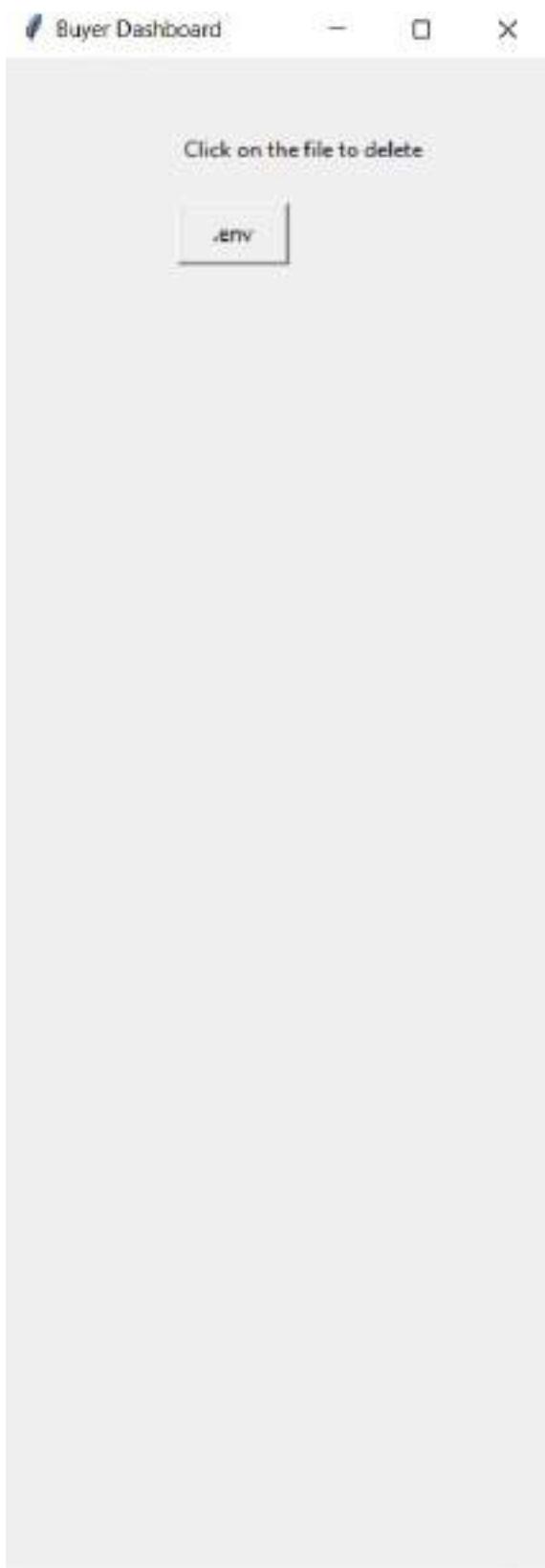


Figure 35: Buyer delete file



Figure 36: Buyer delete file success

```
> web3.fromWei(eth.getBalance(eth.accounts[0]))  
4296.944565843  
> web3.fromWei(eth.getBalance(eth.accounts[1]))  
722.996226316  
> web3.fromWei(eth.getBalance(eth.accounts[2]))  
3795.01938669  
> web3.fromWei(eth.getBalance(eth.accounts[3]))  
3968.080659757  
> web3.fromWei(eth.getBalance(eth.accounts[4]))  
1052.007648139  
> web3.fromWei(eth.getBalance(eth.accounts[5]))  
7650.031513055
```

Figure 37: Balances before execution

7 Research Paper

ResMintage: Leveraging Blockchain Technology to Share Hardware Resources

Meet Shah

Department of Information Technology
Sardar Patel Institute of Technology
Mumbai, India
meet8june@gmail.com

Krish Sukhani

Department of Information Technology
Sardar Patel Institute of Technology
Mumbai, India
krish.sukhani2000@gmail.com

Ankit Vishwakarma

Department of Information Technology
Sardar Patel Institute of Technology
Mumbai, India
ankitvishwakarma85@gmail.com

Nikahat Mulla

Department of Information Technology
Sardar Patel Institute of Technology
Mumbai, India
nikahat_kazi@spit.ac.in

Abstract — Data storage and protection are key concerns in today's world. Organizations have increased their network infrastructure to provide cloud storage and resource access to as many individuals as possible, which raises issues about the privacy of data stored or shared over a network. A centralized authority cannot manage such a vast data network. Cloud storage and other data infrastructure are becoming increasingly expensive as demand grows. Cases of data breaches and attacks have been recorded year after year, and the numbers continue to grow. Many firms, including LinkedIn and Facebook, have experienced massive data breaches in recent years. Another issue discovered was that idle hardware was not being used by many local computers. Although there are people and organizations with surplus local storage capacity, many organizations are looking for additional cloud storage. To address the aforementioned issues, this paper proposes a solution that uses Blockchain Technology to enable individuals or organizations to share hardware resources. Blockchain employs a peer-to-peer design. As Blockchain employs cryptographic techniques, it has the highest security factor of any system. This paper proposes a system in which users can share their local resources with users in need via a blockchain because there is a clear supply and demand requirement for resources. Users that share hardware resources will also be rewarded. There will be no need for any central authority to manage the data or the data kept with the shared resource with blockchain, preserving user privacy and security.

Keywords — *Blockchain, Cloud, Cryptography, peer-to-peer, Resources, Security, Sharing*

I. INTRODUCTION

When one considers purchasing additional storage, the first solution that comes to mind is cloud storage. On the other hand, some have an abundance of local storage space and have no need for that storage for themselves. Both of these cases demonstrate that there is an underused supply of storage from one type of user and increasing demand for storage from

another. There is currently no appropriate infrastructure in place to facilitate the sharing of hardware resources across these types of users. Those who require storage have their needs met by using cloud storage, whereas users who have surplus local storage are only adding to the electronic storage waste. There is no structure in place where a regular individual may use their idle hardware to be incentivized. There are challenges with trust and privacy with cloud solutions, as well as a lack of transparency. This paper proposes a system in which users in need of extra storage can have their requirements met by users who have spare idle hardware storage. The proposed solution can efficiently share and access remote storage from one system to another.

A blockchain is a form of shared database [11] that is stored differently than traditional databases. Data is stored in blocks in the case of blockchain, which are then connected together via cryptography. New information is added to a new block when it becomes available. Once the block is filled with data, it is chained onto the preceding block, forming a data chain in chronological sequence. A blockchain may hold a broad variety of data, although its most popular use to date has been as a transaction ledger.

Blockchain can be public or private, depending on the application. A public blockchain is decentralized, accessible to anybody, and retains a public ledger of all network activity. Bitcoin is a nice example of a public blockchain [12]. The blockchain is employed in this situation in a decentralized manner, which implies that no single person or organization has authority; rather, all users have collective control. Decentralized blockchains are immutable, which implies that no changes can be made to the data entered. This implies that all Bitcoin transactions are permanently recorded and accessible to everyone. The private blockchain is diametrically opposed to the public blockchain. It's equivalent to a personal blockchain for the person in charge of it. A private group that

builds and maintains a private blockchain controls the mining process and consensus technique. The private organization decides who can join the network and download the nodes.

The proposed system hence makes use of blockchain to create a decentralized resource-sharing platform from one peer to another. Its main objectives include:

1. To provide a secure and efficient way of data storage.
2. Being able to provide a transparent mode of remote data storage without the involvement of any middle man.
3. To cut extra charges when buying/selling storage directly from one system to another.

To guarantee security, scalability, and monetization, the system will use blockchain technology. Users of the system being proposed will be able to utilize computer resources at a low cost. Users will also be able to contribute their computer resources if they have extra and receive money for it. If necessary, users can share their files with other people.

The paper is structured as follows: Section II gives a summary of the literature review; Section III explains the methodology and the architecture of the system; section IV briefly explains the implementation and the flow; section V concludes the paper followed by section VI which outlines the future scope.

II. LITERATURE REVIEW

The research in [1] suggests a blockchain-based solution for Network Providers to exchange their resources. As network infrastructures grow in size, they require a trustworthy authority to regulate them. The study discusses the use of blockchain as a benefit in such an untrustworthy environment. It employs a distributed broker technique by describing an architecture that incorporates NPs as nodes, oracles for interaction, and transaction senders and receivers. The study [2] uses the MultiChain blockchain to demonstrate a decentralized data sharing architecture in the tourism sector. The Multichain's concept of streams has been effectively interpreted by utilizing the travel domain as an example to share users' profile data in a decentralized fashion. This eliminates the single point of failure and centrality issues that centralized user model servers are prone to.

[3] focuses on the acceptance of blockchain systems as a whole in researchers. Blockchain is a new and unknown technology, and while it is extremely valuable, many people may be hesitant to accept it owing to its unknown nature. This paper investigates the topic using the Extended Technology Acceptance Model. [4] Outlines a strategy for allowing consumers to connect to the vendor directly and share personal data while maintaining control and ownership. It verifiably tracks who shared what, with whom, when, by what channels, and for what objectives.

The authors of [5] suggest a blockchain-based method for securely sharing research data while maintaining data ownership. The paper examines previous research data sharing research, proposes a blockchain-based framework, and assesses the system by calculating transaction fees for smart contract deployment. [1] Proposes a Blockchain-based solution for Network Providers to trade resources. As network infrastructures grow in size, they require a trustworthy authority to regulate them. To address this, the research suggests utilizing blockchain, which has advantages in such an untrustworthy environment.

[6] Paper proposes a competitive for the sequential decisions of inventory and allocation. This decentralized system manages N retailers' stock holdings across numerous locations. It demonstrates that an allocation technique exists that achieves the best answer for inventory deployment and allocation. [7] This study proposes a secure and privacy-preserving architecture for decentralized data sharing across untrusted parties in off-grid networks. This goal is met by merging current blockchain frameworks (Hyperledger Fabric, Indy, and Aries) with a distributed file system and an off-grid network device.

[8] Using numerous decentralization metrics and distinct temporal granularities, this study gives a new comparative analysis of the degree of decentralization in Bitcoin and Ethereum, the two most well-known blockchains. It determines the degree of decentralization in the two blockchains in 2019 by computing the distribution of mining power. It also suggests using a sliding window-based measurement strategy to gather cross-interval data that is missed in fixed window-based measurements. [9] The research proposes a mechanism for spreading communication resources among mobile devices for exchanging learning data and sharing Computation resources for federated learning operations at each mobile device for the localized training process. [10] The performance, energy bandwidth, and storage consumption of four major open source databases on Hybrid Clouds and Edge Computing are examined. This paper explains how traditional cloud-based systems operate.

III. METHODOLOGY

The basic goal of ResMintage is to give the user a means to sell unused hard disc space and get paid for it. A user can pay for the use of one or more sellers' hard drive space to store data. Once the ETH transaction is completed successfully, that specific hard drive space will be allocated for the buyer and can be accessed from any location because the storage space will be secured with the buyer's private key. The data required to validate the successful completion of a transaction will necessitate the storage of certain basic information on the blockchain, which will include basic user information, virtual drive details, a list of virtual drives, and metadata. The seller is motivated to market the unused space, and the buyer is

motivated to purchase because the cost is lower than that of cloud storage



Fig. 1. Use Case Diagram

ResMintage's use case diagram is depicted in the fig. 1. The system is composed of three actors. The buyer, the seller, and the Ethereum smart contract are all involved. The buyer is the individual who wants to purchase storage from the ResMintage system. The seller is the person who wants to be compensated for selling his storage space, and the Ethereum smart contract is the piece of code. It runs on the blockchain and guarantees that resource sharing runs smoothly. So the buyer can request a resource, buy it, pay ETH for it, and then upload and download files, create and remove folders, and check the list of folders and files in their remote storage. The seller might share the resources in exchange for ETH. All virtual drives, buyers' and sellers' metadata are stored in the smart contract. It can retain and provide such information, as well as function as a validator when logging in and signing up for the system

A. System Architecture

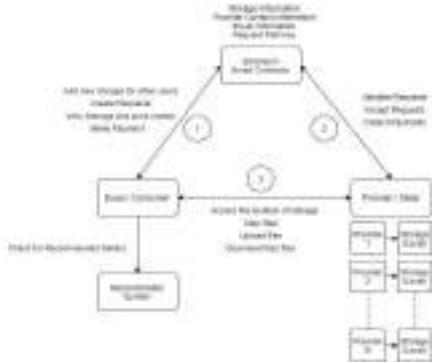


Fig. 2. Block Diagram

The fig. 2 depicts the basic system architecture of ResMintage. It provides a high-level summary of how the system works. The smart contract records the transactions

between the buyer (User purchasing storage via ResMintage) and the seller (User supplying resources via ResMintage). When a buyer, for example, generates a request to upload or download files, a transaction is sent to save the record for the request. Other than the hash, the file's metadata, particularly the name and size, is required for uploading and storing it in the virtual drive. The buyer can then use a web service call to contact the seller by querying the smart contract for their contact information. This will send a notification to the seller about the new request. The vendor can then check the request and, once validated, accept it. When downloading, the buyer can validate the data from the seller's virtual drive by directly comparing the hash of the file to the one saved in Ethereum. The recommender system will match the buyer with the requested storage, and the buyer can then choose from the matches based on reviews, transaction speed, and cost, among other factors.

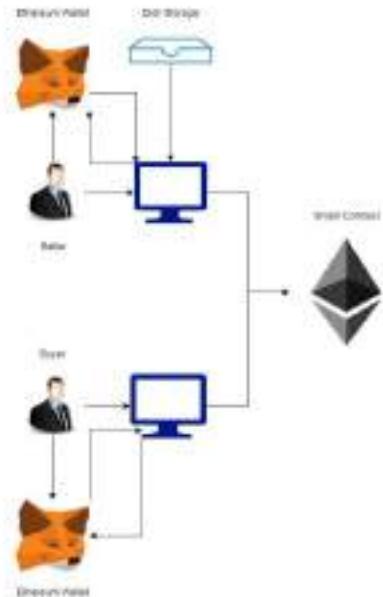


Fig. 3. Architecture Diagram

The architecture diagram in fig. 3 depicts a high-level overview of the system, as well as the components that will interact with it and their linkages. As depicted, there will be a buyer and a seller, each with a PC or laptop and an Ethereum wallet. The seller consists of the disc storage because he is the one who provides the storage to the buyer for purchase. Furthermore, the computers are linked to the smart contract, which serves as the primary link between the buyer and seller.

B. Smart Contract

The core code that manages all blockchain transactions between the buyer and seller is the ResMintage smart contract. The smart contract also preserves the metadata for all virtual drives produced by all merchants. This metadata includes the seller who owns the storage as well as the seller's PC's IP address. It also keeps the buyer and seller data required for validation when signing up for or logging into the system, as well as when transferring ETH from buyer to seller. It contains all of the features that will aid in many elements of the system, such as sign up, log in, establishing a virtual drive, purchasing it, ETH transfer, and validation at each stage. This smart contract is operating on a private Ethereum blockchain on the private network. This blockchain was created with Go Ethereum.

C. Virtual Drives Management

A logged-in user can establish a virtual drive by inputting the necessary information as well as the desired size. The drive has been created and added to the list. Currently, the price is predetermined for the scope of these projects, but when they are put on the main net, the price can be calculated depending on the current market value, transfer speed, user reviews, and ratings for a certain seller. Based on the market environment, this can be set as the default and updated by the user. The essential information, such as the name, size, and seller, will be included in the virtual drive list. The user can receive more information by clicking on the drive. When a user clicks on a drive, the files, folders, and directories are displayed. By specifying a name and a path, the directory can be established. The directory's goal is to keep data organized, so it takes up no space on the virtual drive.

D. File Management

To upload a file, first select the drive to which the file should be added, then the directory. Once the location has been determined, the user will upload the file from his or her local computer. The smart contract validation function is called when the upload button is pressed, and the request is processed. If the validation is successful, the IP address and port number of the web service operating on the seller side are returned to the buyer side. The buyer then invokes the web service, which transmits the file to the seller's computer. This file is then encrypted and saved at the physical place on the seller's computer where the buyer's virtual disc is located.

E. Session Management

The session will be established using the private key generated when the user's account is created for the first time. The account will keep track of the generated drives, Ethereum amount (Ether), and virtual drives held in addition to the basic account information. The lower the transaction cost, the more likely the transaction will be handled quickly.

IV. IMPLEMENTATION

A. Technology Stack

The criteria for developing this project were a language to code the smart contract, a language to write the client side of the project, i.e. the buyer and seller sides of the project, and an Ethereum client to connect to the Ethereum blockchain network. Solidity is used for the smart contract as it provides JavaScript-like syntax for constructing distributed apps, Solidity is the de facto choice for writing Ethereum smart contract programs. Smart contracts are written in Solidity, a high-level object-oriented computer programming language. In the Ethereum state, smart contracts are computer programs that govern how accounts work. Solidity is a language of programming for the Ethereum Virtual Machine that uses curly brackets (EVM). Python, C++ and JavaScript all have an impact on it. In the linguistic influences section, you may learn much more about languages that have influenced Solidity. Solidity is statically typed and, among other things, enables inheritance, libraries, and powerful user-defined types. Solidity helps you to design contracts for polling, crowdsourcing, blind bidding, and multi-signature wallets, among other things.

The Ethereum client, known as Go Ethereum or Geth, was utilized. One of the three original Ethereum implementations, along with Python and C++, is Go Ethereum. It was written in Go and is free and open source under the GNU LGPL v3 license. Geth is available and runs on almost any operating system and as a library that can be linked into your Go, Android, or iOS apps.

The system uses Python for the client-side programming. Python is a versatile, easy-to-code programming language. Python is a computer language that is both powerful and easy to learn. It contains high-level data structures that are efficient and an object-oriented programming style that is simple yet effective. Python's appealing syntax, interpreted nature and dynamic typing, make it a great language for scripting and quick application development on a wide range of systems. The Python interpreter and standard library are freely accessible from the Python website in source or binary form for all operating systems and may be freely distributed.

A. Project flow

The fig. 4 explains the typical flow of buyer activity on the installed system. As a result, the buyer first joins the ResMintage portal with his Ethereum private key. The user information is then saved in the session, as mentioned in the methodology section. After this, if the buyer has already purchased certain virtual drives, he or she will be able to view and select one of those virtual drives. Otherwise, the customer will be required to input their virtual drive requirements if they choose to purchase a new one. When this request is completed, it will be added to the current list of virtual drive requests. This request will then be mapped to the virtual drives listed, and the best-fit drive will be assigned to the customer at

a fixed fee. If mapping is not completed, the buyer will have the opportunity to remove the request or check its status.

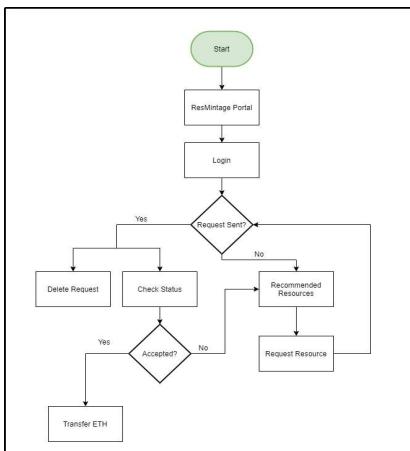


Fig. 4. Buyer Flow Diagram

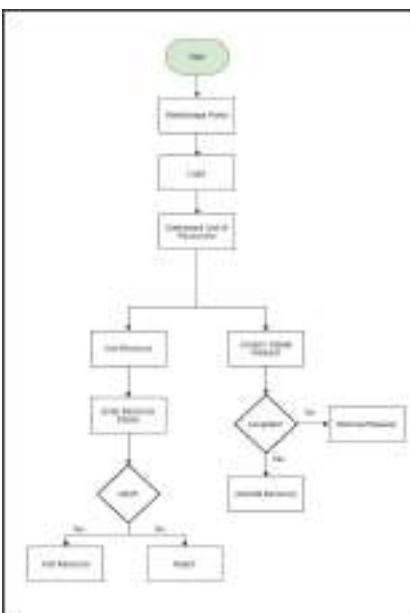


Fig. 5. Seller Flow Diagram

The fig. 5 is the flow of a seller's activity on the established system. As a result, the seller first logs onto the ResMintage interface with his Ethereum private key. The user information is then saved in the session, as mentioned in the Methodology section.

Following that, if the seller has not yet created a virtual drive, there will be an option to do so. When the seller selects this option, he or she will be required to input the amount of storage to be assigned to the virtual drive. Once entered and submitted, it will be verified to see if that much storage is indeed available on the seller's computer. If validation is successful, the virtual drive is added to the smart contract's list of virtual drives. When a buyer order matches a virtual drive, the virtual drive is assigned to that buyer. Following that, the ETH is sent from the buyer's account to the seller's account.



Fig. 6. Seller Flow Diagram

The fig. 6 shows the dashboard that appears on the buyer side. It lists all the virtual drives and its details owned by the user. It includes information such as Drive Name, Drive Size, Space Available and Date Of Purchase of the Virtual Drive. It also shows the basic details of the buyer like the Ethereum address and the amount of ether owned by the buyer.



Fig. 7. Seller Flow Diagram

When clicked on a particular virtual drive, the buyer is directed to a new window displaying the information about the files stored and the folder structures contained in that virtual drive. The fig. 7 shows files and folder information in a virtual drive named 'drive 1'. It displays the file names and the space occupied by it on the drive and similarly for folders as well.



Fig. 8. Seller Flow Diagram

The fig. 8 shows the seller side of the drive 1 from fig. 6 and fig. 7. On the seller portal, if a virtual drive is not added already, there is a button to add a virtual drive. Else, if it is already added, the details of that virtual drive are shown. That is what the fig. 8 represents. It shows the basic details of the virtual drive like the name, IP address, size, date of issue and amount received in the transaction.

V. CONCLUSION

As we rely more on cloud services to handle computing problems, alternative designs must be studied to guarantee that the solutions provided are the best fit for our needs. With Amazon and Google providing the vast bulk of public cloud storage systems, the peer-to-peer cloud appears to be ideal for exploration.

The proposed method was intended to be a tiny stepping stone toward that reality by proving that idle storage resources may be used by a peer-to-peer system without the use of a middle man. The proof of concept includes a client application for communicating with smart contracts built for Ethereum's distributed application framework. Through this interaction, users may buy or sell unwanted idle hardware storage from other users. The sold space is utilized to store user data and serves as a distributed cloud storage solution. When customers purchase storage capacity, they do it from a group of individuals and use it to build their own decentralized storage, reusing a resource that would otherwise be wasted, and they do so without the intervention of a central body.

VI. FUTURE SCOPE

Blockchain technology is still in its infancy. Our proposal has the potential to replace cloud storage. The next goal is to completely replace the cloud. Cloud computing is a mature and established technology that has grown through time. Cloud computing is no longer only about storage; it is also about SaaS, PaaS, and IaaS. (or XaaS). The eventual goal of this research study is to implement GPU, CPU, and RAM sharing

via blockchain. This may appear difficult, but it is only a matter of time until blockchain technology develops enough to be able to achieve this.

REFERENCES

- [1] M. Xevgenios, D. G. Kogias, P. Karkazis, H. C. Leligou, and C. Patrikakis, "Application of Blockchain Technology in Dynamic Resource Management of Next Generation Networks," *Information*, vol. 11, no. 12, p. 570, Dec. 2020, doi: 10.3390/info11120570.
- [2] A. K. Shrestha, R. Deters, and J. Vassileva, "User-Controlled Privacy-Preserving User Profile Data Sharing based on Blockchain", arXiv, 2019.
- [3] A. K. Shrestha and J. Vassileva, "User Acceptance of Usable Blockchain-Based Research Data Sharing System: An Extended TAM-Based Study," 2019 First IEEE International Conference on Trust, Privacy and Security in Intelligent Systems and Applications (TPS-ISA), 2019, pp. 203-208, doi: 10.1109/TPS-ISA48467.2019.900033.
- [4] A. K. Shrestha, S. Joshi, and J. Vassileva, "Customer Data Sharing Platform: A Blockchain-Based Shopping Cart," 2020 IEEE International Conference on Blockchain and Cryptocurrency (ICBC), 2020, pp. 1-3, doi: 10.1109/ICBC48266.2020.9169421.
- [5] A. K. Shrestha and J. Vassileva, "User Data Sharing Frameworks: A Blockchain-Based Incentive Solution," 2019 IEEE 10th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON), 2019, pp. 0360-0366, doi: 10.1109/IEMCON.2019.8936137.
- [6] R. Anupindi, Y. Bassok, and E. Zemel, "A General Framework for the Study of Decentralized Distribution Systems", *Manufacturing & Service Operations Management*, vol. 3, pp. 349-368, 10 2001.
- [7] H. Niavis, N. Papadis, and L. Tassiulas, "A Blockchain-based Decentralized Data Sharing Infrastructure for Off-grid Networking". arXiv, 2020.
- [8] Q. Lin, C. Li, X. Zhao and X. Chen, "Measuring Decentralization in Bitcoin and Ethereum using Multiple Metrics and Granularities," 2021 IEEE 37th International Conference on Data Engineering Workshops (ICDEW), 2021, pp. 80-87, doi: 10.1109/ICDEW53142.2021.00022.
- [9] M. N. H. Nguyen, N. H. Tran, Y. K. Tun, Z. Han and C. S. Hong, "Toward Multiple Federated Learning Services Resource Sharing in Mobile Edge Networks," in *IEEE Transactions on Mobile Computing*, 2021, doi: 10.1109/TMC.2021.3085979.
- [10] Y. Mansouri, V. Prokhorenko, F. Ullah, and M. A. Babar, "Evaluation of Distributed Databases in Hybrid Clouds and Edge Computing: Energy, Bandwidth, and Storage Consumption". arXiv, 2021.
- [11] S. Leible, S. Schläger, M. Schubotz, en B. Gipp, "A Review on Blockchain Technology and Blockchain Projects Fostering Open Science", *Frontiers in Blockchain*, vol 2, 2019.
- [12] Nakamoto, S., "Bitcoin: A Peer-to-Peer Electronic Cash System", J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73., 2008.

8 Plagiarism Report

ResMintage

ORIGINALITY REPORT



PRIMARY SOURCES

- | | | |
|---|---|----|
| 1 | Submitted to Sardar Patel Institute of Technology
Student Paper | 2% |
| 2 | Submitted to National College of Ireland
Student Paper | 1% |
| 3 | Qinwei Lin, Chao Li, Xifeng Zhao, Xianhai Chen. "Measuring Decentralization in Bitcoin and Ethereum using Multiple Metrics and Granularities", 2021 IEEE 37th International Conference on Data Engineering Workshops (ICDEW), 2021
Publication | 1% |
| 4 | Viren Patil, Vasvi Gupta, Rohini Sarode. "Blockchain-Based Crowdfunding Application", 2021 Fifth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2021
Publication | 1% |
| 5 | Sahil Sawant, Ankit Vishwakarma, Prerana Sawant, Prasenjit Bhavathankar. "Analytical and Sentiment based text generative | 1% |

References

- [1] M. Xevgenis, D. G. Kogias, P. Karkazis, H. C. Leligou, and C. Patrikakis, "Application of Blockchain Technology in Dynamic Resource Management of Next Generation Networks," *Information*, vol. 11, no. 12, p. 570, Dec. 2020, doi: 10.3390/info11120570.
- [2] A. K. Shrestha, R. Deters, and J. Vassileva, "User-Controlled Privacy-Preserving User Profile Data Sharing based on Blockchain". arXiv, 2019.
- [3] A. K. Shrestha and J. Vassileva, "User Acceptance of Usable Blockchain-Based Research Data Sharing System: An Extended TAM-Based Study," 2019 First IEEE International Conference on Trust, Privacy and Security in Intelligent Systems and Applications (TPS-ISA), 2019, pp. 203-208, doi: 10.1109/TPS-ISA48467.2019.00033.
- [4] A. K. Shrestha, S. Joshi, and J. Vassileva, "Customer Data Sharing Platform: A Blockchain-Based Shopping Cart," 2020 IEEE International Conference on Blockchain and Cryptocurrency (ICBC), 2020, pp. 1-3, doi: 10.1109/ICBC48266.2020.9169421
- [5] A. K. Shrestha and J. Vassileva, "User Data Sharing Frameworks: A Blockchain-Based Incentive Solution," 2019 IEEE 10th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON), 2019, pp. 0360-0366, doi: 10.1109/IEMCON.2019.8936137
- [6] R. Anupindi, Y. Bassok, and E. Zemel, "A General Framework for the Study of Decentralized Distribution Systems", *Manufacturing Service Operations Management*, vol. 3, pp. 349–368, 10 2001.
- [7] H. Niavis, N. Papadis, and L. Tassiulas, "A Blockchain-based Decentralized Data Sharing Infrastructure for Off-grid Networking". arXiv, 2020.
- [8] Q. Lin, C. Li, X. Zhao and X. Chen, "Measuring Decentralization in Bitcoin and Ethereum using Multiple Metrics and Granularities," 2021 IEEE 37th International Conference on Data Engineering Workshops (ICDEW), 2021, pp. 80-87, doi: 10.1109/ICDEW53142.2021.00022
- [9] M. N. H. Nguyen, N. H. Tran, Y. K. Tun, Z. Han and C. S. Hong, "Toward Multiple Federated Learning Services Resource Sharing in Mobile Edge Networks," in *IEEE Transactions on Mobile Computing*, 2021, doi: 10.1109/TMC.2021.3085979
- [10] Y. Mansouri, V. Prokhorenko, F. Ullah, and M. A. Babar, "Evaluation of Distributed Databases in Hybrid Clouds and Edge Computing: Energy, Bandwidth, and Storage Consumption". arXiv, 2021.
- [11] S. Leible, S. Schlager, M. Schubotz, en B. Gipp, "A Review on Blockchain Technology and Blockchain Projects Fostering Open Science", *Frontiers in Blockchain*, vol 2, 2019.
- [12] Nakamoto, S., "Bitcoin: A Peer-to-Peer Electronic Cash System", J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73., 2008
- [13] <https://www.2brightsparks.com/resources/articles/an-introduction-to-ftp.pdf>
- [14] <https://geth.ethereum.org/>
- [15] Rajiv Lal, Manohar. (2010). Web 3.0 in Education Research. *BVICAM's International Journal of Information Technology (BIJIT)* ISSN 0973-5658. 3. 6.

- [16] <https://www.ganttpointer.biz/>
- [17] <https://app.diagrams.net/>
- [18] <https://staruml.io/>
- [19] <https://www.lucidchart.com/pages/>
- [20] <https://docs.python.org/3/library/tkinter.html>
- [21] <https://remix.ethereum.org/>
- [22] Dannen, Chris. (2017). Introducing Ethereum and Solidity. 10.1007/978-1-4842-2535-6.
- [23] Van Rossum, G., Drake, F. L. (2009). Python 3 Reference Manual. Scotts Valley, CA: CreateSpace.



Research Internship at AutoBuddy

Dear All,

We are glad to introduce you to research internship opportunities as part of the collaborative research project between S.P.I.T., University of Mumbai and Tata Institute of Social Sciences(Under Process) (TISS), starting from January 2022. The project, undertaken by Dr. Dhananjay R. Kalbande and Dr. Surendra Rathod, entitled "*An Intelligent Life Companion*" and aims to provide an AI-based solution that assists the elderly and children with disabilities, with their day-to-day chores.

During these 6 months, interns will be actively collaborating with various teams and research groups, and working on this AI and ICT enabled socially relevant project. In the first week, we will explain the scope of the project and set the timeline. In the second and third weeks, we will conduct a formal training for the interns and cover the basic concepts related to the technologies required for the project such as, Flutter, Web Development, NLP, Neural Networks, Deep Learning, embedded system, IoT and so on. In the following weeks, interns will be mentored by industry experts and researchers to work on an end-to-end project.

Following is a brief description of the two proposals:

1. Adaptive educational game for Autistic children: Autism is a learning disorder falling in the ADHD (Attention Deficit Hyperactivity Disorder) spectrum, varying from being slightly autistic to severe. The level of autism is judged by a specialist after close examination of the child's activities. We propose a solution that can not only automate this assessing process, but also develop an educational game that can further develop the learning ability of autistic children. By automating the assessment as well as generating educational games, we intend to make the learning process adaptive and customized to cater to every individual for fast and optimal development.
2. Fall detection and activity recognition for elderly people: Elderly people are prone to falls that can cause major injuries which are sometimes fatal. We propose a solution to detect the possibility of an older person falling, in order to assist them in time and prevent major damage. Our solution would not only involve external monitoring using activity recognition, but also tracking internal body vitals such as blood pressure, temperature, oxygen levels and so on. Furthermore, an application will be developed to maintain regular reports that can be shared with medical professionals and family, apart from features like Emergency SOS, connecting with the concerned medical professional, etc.

Some of the broad areas that interns will be focusing on are given below:

1. App design using UX tools (Adobe XD, Figma) for Autistic and elderly people for better understanding of day-to-day work/activities. Wireframe designing for various tasks. Interns need to spend time reading articles and research papers describing new ideas to include in the current research. These ideas are developed by interns after their understanding about the two subjects "Autism" and "Elderly". The interface components are meant for providing learning aid via application and should cause meaningful interaction between machine and users.



Research Internship at AutoBuddy

2. Natural Language Processing for set activities recognition for children with disabilities and elderly people. Interns need to study NLP in the context of understanding the design of sign language notations to be used by the users in front of the system so that system can easily recognize the intended operations to be asked and its interpretation in local language and finally store those responses in database for future reference to conclude an inference at the end. Need to learn how users can interact with the system.

This will be an API call for Point no.3

3. Real-time audio and video processing for fall detection and alert systems for elderly people. Interns need to understand the design issues of the existing tab which will be used at home as a monitor for recognizing fall movement, and 5 vital activities like pulse, BP, humidity, temperature any other important which will be feasible to do. Interns will also make use of IoT equipment like sensors to fetch the data regarding the body vitals, and subsequent cleaning, normalization and preprocessing for further use.

4. Object Detection using Deep Learning methods : Interns need to study various deep learning approaches for object detection and come up with new innovative approaches which will be feasible, cost effective, minimum hardware and network support for recognizing day to day activity objects like newspapers, food, mobile, medicine, and so on.

This will be an API call for Point No.3.

5. App and Website design for Mentor/Mentee interaction:

Interns need to design mobile and web apps for providing information and support to daily activities monitoring from teaching aid to support tools. The application will act as a digital companion for the users, and will provide features for tracking body vitals (for Elderly project) and learning progress (for Autism), Emergency SOS, creating statistical representation of the patient's progress, entertainment options, and so on. This will be performed along with the app/web designing, a state in Point No.1. Interns would be expected to do considerable research on the feature requirements by interacting with stakeholders as well as mentors and TISS volunteers.

6. Research on advanced learning methods (e.g., GANs, Reinforcement Learning, etc.) for adaptive educational games for Autistic children: Interns are expected to study advanced learning methods for developing educational games for autistic children. For example, for pictorial games like mazes, GANs can be useful in creating unique and adaptive versions of it. However, they would also require establishing a performance metric, with insights from pediatricians, child psychologists and neurologists. Similarly, preparing multiple games that adapt to the child's learning curve would involve using Reinforcement Learning agents to play the games similar to their human counterparts, and accordingly optimize the GANs to produce levels that aligns with the child's progress.

7. Unity development for the educational games for Autism project: Interns are expected to research the different educational games to enhance the cognitive abilities of Autistic children. For games involving continuous, active involvement of the users through animated graphics, interns need to develop these games through Unity and integrate with the applications. Furthermore, a performance rubric needs to be studied and established to evaluate the user's development. This would require interacting with neurologists, child psychologists and pediatricians to get insights from their expertise in treating Autism and evaluating the patient's progress.



Research Internship at AutoBuddy

8. Cloud services for deployment, computing and storage for both projects: Interns will be working on cloud technologies like GCP, AWS and Azure to provide a data storage and staging area for sensor data for analysis and reports through the application. Additionally, they would be actively working on data cleaning and preprocessing services from the raw data, deploying the Machine Learning models, generating email reports and so on. Interns will have to utilize knowledge of the audio-video processing techniques and the data fetched from the sensors (as stated in Point No.3), coordinate with the mobile/web application requirements as well as the machine learning aspects.

Expected Tech Stack:

1. App/Web Development: Flutter, Unity, Adobe XD (Wireframe design), Web Frameworks (Django, Angular, Flask, etc.)
2. Cloud services (GCP, AWS, Azure)
3. Machine Learning: Deep learning/Neural Networks, NLP, Computer Vision, Reinforcement Learning, etc.
4. Hardware Interface design for various sensors and IoT.

Interested students may register through the following link:

Link : <https://forms.gle/1eFSQgvcp6kWFpJw8>

For any queries, please feel free to reach out to me at drkalbande@spit.ac.in(9820383928) and surendra_rathod@spit.ac.in(9920228275)

Thanks, and regards,

Dr. Dhananjay R. Kalbande and Dr. Surendra Rathod

AutoBuddy Research Project
*Sardar Patel Institute of Technology
University of Mumbai, India.*





Bharat Vida
Bhavan's

(Founded in 1958 by Kulapati Dr. K. M. Munshi with the blessings of Mahatma Gandhi)

आ नो मद्दा : करत्वे धन्तु विश्वतः।
Let noble thoughts come to us from every side

Tel : 91-22- 2670 8520

2670 7440

2628 7250

Fax : 91-22- 2670 1422

SARDAR PATEL INSTITUTE OF TECHNOLOGY

(Autonomous Institute)

Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai - 400 058, India

E mail: principal@spit.ac.in Website: www.spit.ac.in

Research Internship Offer Letter

29/12/2021

Dear Mr. Dhananjay Joshi,

I am delighted & excited to welcome you as Intern (Hardware Designer) for **AutoBuddy : An Intelligent Life Companion**. We believe that our team is our biggest strength and we take pride in hiring ONLY the best and the brightest. We are confident that you would play a significant role in the overall success of this project and wish you the most enjoyable, learning packed and truly meaningful job experience with us. Below you can read details about the terms and conditions (Annexure-A) of your anticipated job with this project. We are offering a Six months Research Internship position for you as Hardware Designer, reporting to Dr.Dhananjay Kalbande and Dr.Surendra Rathod starting on 10th Jan 2022 till 10th July 2022 at Mumbai. You will get certificate of completion based on your performance after the six month tenure.

Happy to have you onboard!

Sincerely,

Dhananjay Kalbande

Surendra Rathod

AutoBuddy Project Mentors, S.P.I.T., Mumbai.



Role of Students

Students from SPIT

Name	Field of work	Subject	Roles
Shraddha Bhagyawant	S/W	Autism+ Elderly	UX Designer To design various wireframes and UX prototype using UX tool. for Autism and Elderly on one Autobuddy Dashboard
Mansi Dwivedi	S/W	Autobuddy	Fullstack Developer Requirement analysis of educational application for Autism. To design database for both Autism and Elderly using phpmysql and Django framework. Deployment using AWS, Python programming. Development of dashboard for Autism as well as elderly activities.
Mayuri Maruti Ghuge	S/W	AutoBuddy	Fullstack Developer Requirement analysis of educational application for Autism To design database for both Autism and Elderly using phpmysql and Django framework. Deep learning model development for analyzing learning ability of autism and elderly both from the dataset.
Apoorva Limaye	S/W	Autism plus elderly	ML and Flutter Developer App design for Mentor/Mentee interaction: Deep learning model development for analyzing learning ability of autism and elderly both from the dataset and integrate with backend and frontend.
Aryan Solanki	S/W	Autism	Flutter Developer App design for Mentor/Mentee interaction Validation and testing of product and feedback analysis.
Dhananjay Joshi	H/W	Autism and Elderly	ML-developer and API integrator Requirement analysis of activities monitoring of elderly people.



Role of Students

			Deep learning model development for analyzing learning ability of autism and elderly both from the dataset and integrate with backend and frontend.
Divija Pankaj Shringarpure	H/W	Autism and Elderly	<p>Field Engineer: Requirement analysis of activities for Autism as well as elderly people.</p> <p>NGO connect ,Agreement sign (Consent) with NGO or training institute providing mentoring to autism and elderly.</p> <p>Validation and testing of product and feedback analysis.</p>
Aditya Patwardhan	H/W	Elderly	<p>Hardware Engineer: Requirement analysis of activities monitoring of elderly people. Hardware Interface design for various sensors and IoT for health monitoring.</p>
Vaishnavi Bhore	S/W and H/W	Elderly	<p>Hardware Engineer Requirement analysis of activities monitoring of elderly people. Hardware Interface design for various sensors and IoT for health monitoring.</p>
Siddhant Hemant Kamlaskar	H/W	Elderly	<p>Hardware Engineer: Requirement analysis of activities monitoring of elderly people. Hardware Interface design for various sensors and IoT for activities monitoring for fall detection and day to day activities recognition and its analysis.</p>




Role of Students

Students from TSEC:

Name	Field of work	Subject	Roles
Mayank K	S/W	Autism	Flutter Developer and ML : App design for Mentor/Mentee interaction
Parth Shah	S/W	Autism	Flutter Developer and ML : App design for Mentor/Mentee interaction



LIST OF STUDENTS SELECTED FOR 6-MONTHS INTERNSHIP ON RESEARCH PROJECT "AUTOBUDDY"

"An Intelligent Life Companion" which aims to provide an AI-based solution that assists the elderly and children with disabilities, with their day-to-day chores.

Sr.No.	Name of the student	Branch	Email	Domain
1	Dhananjay Joshi	ETRX	dhananjay.joshi@spit.ac.in	Hardware design: Sensor and API design , Integration with Deep Learning
2	Divija Pankaj Shringarpure	ETRX	divija.shringarpure@gmail.com	Hardware design: Sensor and API design.
3	Aditya Patwardhan	ETRX	aditya.patwardhan@spit.ac.in	Hardware design: Sensor and API design
4	Vaishnavi Bhore	ETRX	vaish.navibhore260@gmail.com	Hardware design: Sensor and API design
5	Siddhant Hemant Kamlaskar	EXTC	siddhant.kamlaskar@spit.ac.in	Hardware design: Sensor and API design
6	Mansi Dwivedi	IT	mansi.dwivedi@spit.ac.in	Software design: Flutter, backend and AWS
7	Mayuri Maruti Ghuge	IT	ghugemayuri1996@gmail.com	Software design: Flutter, Web Development,AWS
8	Apoorva Limaye	ETRX	apoorva.limaye@spit.ac.in	Software design: Web Development ,AWS
9	Aryan Solanki	ETRX	aryansolanki47731@gmail.com	Software design: Web Development ,AWS
10	Shraddha Bhagyawant	ETRX	shraddha.bhagyawant@spit.ac.in	Software design: UX designer

Project Mentors

Dhananjay Kalbande

Surendra Rathod



Research Paper from Research Internship

2023 11th International Conference on Emerging Trends in Engineering & Technology - Signal and Information Processing (ICETET - SIP)

Detecting the Attention Span of Autistic Children

Dr. Dhanajay Kalbande

Computer Science & Engineering
Sardar Patel Institute of Technology
Mumbai, India
drkalbande@spit.ac.in

Dr. Surendra Singh Rathod

Computer Engineering
Fr. Conceicao Rodrigues College of
Engineering
Mumbai, India
rathodss@fragnel.edu.in

Riddhi Dinesh Oza

Computer Engineering
Fr. Conceicao Rodrigues College of
Engineering
Mumbai, India
riddhioza1779@gmail.com

Shreyash Dhamane

Computer Engineering
Sardar Patel Institute of Technology
Mumbai, India
shreyash.dhamane@spit.ac.in

Abstract—This study investigates methods for detecting and monitoring the attention span of autistic children in real-time, with the goal of improving learning outcomes. The study involved monitoring the movements and reactions of a group of autistic children during various activities, using specialized sensors and software to capture and analyze data related to their attention span. The results showed that the attention span of autistic children varied significantly across different activities and stimuli, and certain types of games and learning exercises were more effective at capturing and maintaining their attention than others. The attention span of autistic children also tended to improve gradually over time, particularly when they were engaged in activities that were interesting and stimulating. These findings have important implications for the design of effective interventions and learning activities for autistic children, and highlight the importance of personalized and evidence-based approaches for improving attention span and learning outcomes.

Keywords—autism, attention span, real-time monitoring

I. INTRODUCTION

The main problem faced by autistic children which hampers their development is their limited attention span. This is more prevalent when they are asked to do something that doesn't interest them or something which requires shared attention. To enable them to focus more we can engage them in some games which are interesting and not much complicated. However, it would be difficult to determine whether the child is actually learning and concentrating on the game. This paper proposes an approach through which the attention span of the child can be detected and its progress can be recorded so that the development and increase in attention span can be captured. For this, we take into account various parameters such as: eye moment, head moment, background noise and the time for which the game has been played.

II. LITERATURE REVIEW

Children with autism may have fleeting attention when they are engaged in the activities such as labelling, matching pictures, or building something with blocks. To make sure that

their attention is monitored in an efficient way, there is a need to take into account various eye moments and head moments for the same. The study presented in [1] found that online learners participate in a variety of educational activities, such as reading, writing, watching video tutorials, taking online exams, and participating in online meetings. These activities elicit different levels of engagement, such as boredom, frustration, delight, neutrality, confusion, and learning gain. The paper provides a review of current methods for engagement detection in the context of online learning, classifying them into three categories: automatic, semi-automatic, and manual. The automatic category, which uses computer vision-based methods to analyse facial expressions from video data, is examined in more detail as it is considered to be a promising approach for online learning. These methods are non-intrusive and the hardware and software used to capture and analyse video data are cost-effective and easily accessible.

Different algorithms and their accuracies:

1. Eye-tracking algorithms [7]: Eye-tracking technology can provide valuable insights into the attention span of autistic children by measuring where they look and for how long. According to a study published in the journal Autism Research, eye-tracking technology has an accuracy of about 70-80% in detecting the attention span of children with autism. Eye-tracking technology can also be combined with other algorithms, such as machine learning algorithms, to improve accuracy.
2. EEG-based algorithms [8]: EEG (electroencephalography) measures brain activity and can be used to detect changes in attention span. EEG-based algorithms have shown promising results in detecting the attention span of children with autism. For example, a study published in the Journal of Autism and Developmental Disorders found that an EEG-based algorithm had an accuracy of 83% in detecting the attention span of children with autism.

3. Wearable sensor-based algorithms [9]: Wearable sensors can be used to detect changes in physiological data, such as heart rate and skin conductance, which may be indicative of changes in attention span. However, wearable sensor-based algorithms have been found to have lower accuracy compared to other algorithms. For example, a study published in the Journal of Autism and Developmental Disorders found that a wearable sensor-based algorithm had an accuracy of about 62% in detecting the attention span of children with autism.
4. Machine learning algorithms [10]: Machine learning algorithms can be used to analyse multiple sources of data, such as eye-tracking, EEG, and sensor data, to detect changes in attention span over time. Machine learning algorithms have shown promising results in detecting attention span in children with autism. For example, a study published in the journal Scientific Reports found that a machine learning algorithm had an accuracy of 85% in detecting the attention span of children with autism.

Overall, no single algorithm can be considered the "best" or most accurate for all situations. The choice of algorithm will depend on the specific research question and context. However, EEG-based and machine learning algorithms have shown the highest accuracy in detecting attention span in children with autism.

A novel approach for automatically estimating students' attention during lectures in a classroom setting has been proposed in [2]. The method utilizes data from a Kinect One sensor to gather 2D and 3D data to develop a range of features that identify both facial and body cues of students, such as gaze point and body posture. By using machine learning algorithms, the approach trains classifiers that estimate students' attention levels in real-time. Human observers' attention level estimations are used as a baseline to validate the method. Recently, as noted in [3], certain institutions have adopted shorter lecture formats, lasting only 15 minutes, due to the perception that students' attention span dwindles after 10-15 minutes. However, research has demonstrated that lecture content, rather than format, is the primary driver of variability in student attention. It is up to the instructor to ensure that the material is presented in an engaging and interactive manner. By improving their teaching abilities, instructors can create a more stimulating and fulfilling learning experience for their students.

According to Article [4], online teaching can be a difficult medium for both teachers and students to adapt to. Due to its shortcomings, students may fail to pay attention during the lecture, which can lead to ineffective teaching. Therefore, it is important to implement an effective teaching system that can quantify the attention of individual students and the entire class during online lectures. This can not only encourage students to pay attention but also assist the teacher in determining the effectiveness of their teaching and making changes to increase the attention of the entire class. Processing visual stimuli in a scene are essential for the human brain to make situation-aware decisions. These stimuli, which are prevalent subjects of diagnostic eye-tracking studies, are commonly encoded as rectangular areas of interest (AOIs) per frame. According to the

approach discussed in [5], two methods are implemented to automatically detect visual attention to AOIs using pre-trained deep learning models for image classification and object detection. Article [6] focuses on calculating the attention span score taking into consideration blink rate, facial expression, eye gaze, background noise, and body posture, and is updated continuously for a window length of 5 seconds.

III. PROPOSED METHODOLOGY

To calculate the attention span score in real-time for autistic children, four parameters are taken into consideration, including head movement, background noise, number of times the game is paused or exited, and eye movements and blinking. These parameters are continuously monitored during engagement with the game, and a report is generated displaying the required scores and parameters to record the development in attention span of the child. Eye movements and blinking are important indicators of attention and can provide valuable insights into the child's level of engagement. By including these additional parameters in the analysis, we can obtain a more comprehensive understanding of the child's attention span and its development over time.

Initially, when the child starts playing the game, it asks for access to the microphone and a webcam. Webcam is used for capturing eye movements and head movements, and the microphone is used for capturing the background noise. Through the head movements, it can be determined whether the child is focusing on the game or looking here and there. When the eyes of the child are focused on the game, i.e., they are accessible by the webcam, the two circles are filled with green color, as shown in (Figure. 1). As soon as a child looks either left or right, such that his/her front face isn't visible, the green circles are filled with red and the game is paused, indicating that child isn't focused on the game. This is shown in (Figure. 2). Whenever the child quits the game, it is recorded using the vis() function which checks for the visibility of the current window. If current window is not visible, it will increase the count of the number of times the tab is switched (stored in a variable).



Figure 1: Circles filled with green color indicates that the child is paying attention

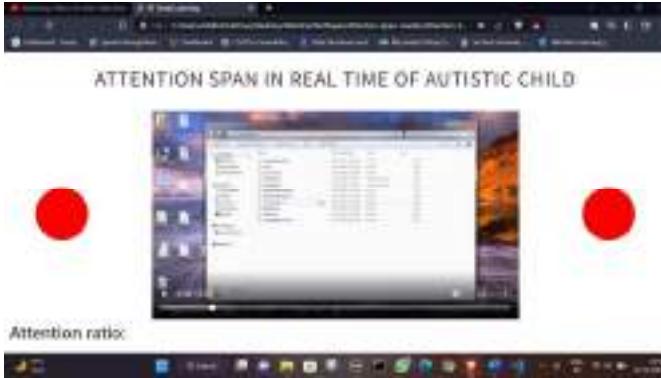


Figure 2: Circles filled with green color indicate that the child is not paying attention

While all these movements are being captured, simultaneously, the graphs indicating Time vs Face Attention Span, Time vs Background Noise and Number of times the game is quitted are captured. Through these graphs, the final accuracy of the child is determined, which accounts for the overall attention span score. The sections that follow give in depth details about how each of the three parameters are calculated and their significance in determining the attention span score. The process flow diagram of the Span attention system is shown in (Figure. 3). When the child starts paying game and access to the webcam and microphone is given, following procedure takes place.



Figure 3: The Process flow for the span attention system

A. Head Movement Detection

To detect the head movements of the child who is playing the game, we have used Haar feature-based cascade classifiers of OpenCV. Under this we take into account the front face movement along with the eye movement. The web browser asks the user to grant access to the camera and the microphone.

Once the access has been granted, the user's face is identified using the OpenCV library that forms a rectangle around the face which is detected. This is shown in (Figure. 4). To reduce the processing time the landmarks are limited to the following features: edge features, line features and four-rectangle features.

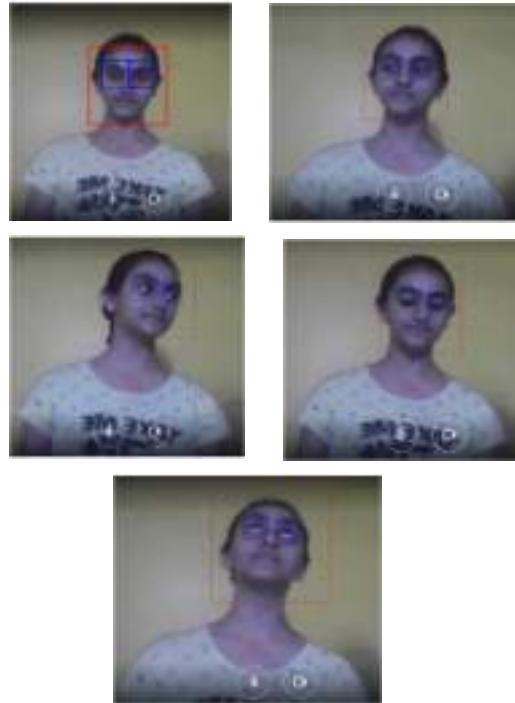


Figure 4: Child is looking in different directions and simultaneously the face and eye movements are captured

B. Background Noise Detection

For detection of background noise, we have made use of Web Audio API (Application Program Interface). Instance of AudioContext is used so that it can support the audio inputs from the background and help to display complex audio graphs. AudioContext instance, requests access to the user's microphone, and creates an AnalyserNode to analyze the audio data. The circle's radius is set according to the audio's amplitude. If amplitude is greater than the threshold, the circle's radius is increased, else it remains the same.

C. Number of times the game is quitted

This is one of the most important attributes that needs to be taken into consideration while detecting attention span of the child. This is done using various properties under the visibility state. Following are the possible values of visibility states:

- (1) Visible: This property shows that the window is not minimized or is at least partially visible to the user.
- (2) Hidden: This property indicates that the window is either minimized or is not visible to the user.

If the value is set to "hidden", the number of times the game is quitted is incremented, which is initially set to zero. This parameter is stored in the variable *total_pause*, which indicates

the total time for which the game has been paused. The variable *total play* stores the time for which the game is being played.

D. Calculation Overall Attention Span Score (Accuracy)

The final score is calculated using the following formula:

$$\text{Accuracy} = \text{total play} \div (\text{total play} + \text{total pause}) \quad (1)$$

where,

(1) total play = time for which the game is played and

(2) total pause = time for which the game is paused

IV. RESULTS

Once the child stops playing game, a report is generated in PDF (Portable Document Format), which is used to record child's development. The report records the following features:

- (1) Time vs Amplitude graph (shown in (Figure. 8))
- (2) Time vs Face Attention Span (shown in (Figure. 9))
- (3) Total number of times the game is quitted (shown in (Figure. 10))
- (4) Attention Span Ratio which is determined using (1) (shown in (Figure. 8))

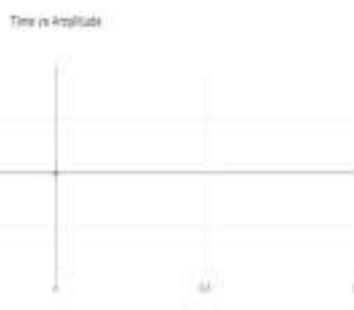


Figure 5: Time vs Amplitude graph (without background noise)

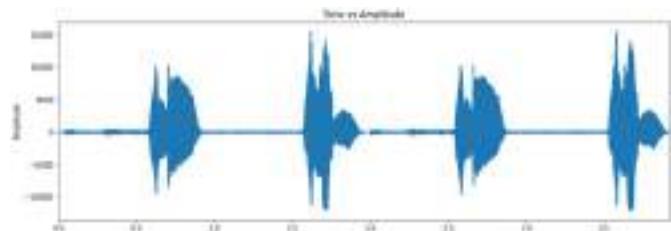


Figure 6: Time vs Amplitude graph (with background noise)

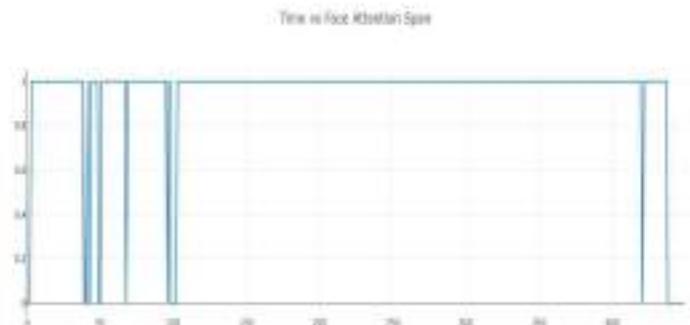


Figure 7: Time vs Face Attention Span

Attention ratio:

0.93987

Audio Noise: 0.338

Total times tab switched:

0

Figure 8 : Showing other two detected parameters on the webpage

These parameters recorded in the report can be used to:

- (1) Detect attention span
- (2) Capture the performance of the child.
- (3) Increase the development of the child.

V. CONCLUSION AND FUTURE SCOPE

In this study, we have focussed on determining the attention span of the children with autism while engaged in activities that interest them and do not require them to perform complex tasks preferably easy games. To capture the development of the child, there is a need to notice the increase in attention span as short attention span duration is responsible for poor development of the child. To record these gradual changes, we have developed a system to record the attention span which takes into consideration three parameters. Using these parameters engagement detection of the child can be recorded and a report is printed once the child stops playing the game, which can be used to track the development of the child.

This study can be extended to the posture detection of the child who is playing the game. Future more, the number of times the child successfully completed the game without quitting the game before it is finished is one of the significant parameters to be taken into consideration. The complexities of the games can gradually be increased such as including the tasks that ask the child to repeat a word, to perform some actions: stand up, sit down, look towards the left, right, up, down, etc., and simultaneously the actions of the child can be recorded and determined if the actions are correct or not using posture detection.

2023 11th International Conference on Emerging Trends in Engineering & Technology - Signal and Information Processing (ICETET - SIP)

VI. REFERENCES

- [1] Dewan, M. Ali Akber, Murshed, Mahbub, Lin, Fuhua , “Engagement detection in online learning: a review”. 2019
- [2] Zaletelj, Janez, Košir, Andrej, “Predicting students’ attention in the classroom from Kinect facial and body features.” 2017
- [3] Bradbury, Neil, “Attention span during lectures: 8 seconds, 10 minutes, or more?.” (2016).
- [4] V. Karthikraj, V. Patil, S. Thanneermalai and T. Yadav, "Attention Span Detection for Online Lectures." 2021
- [5] Barz, Michael and Sonntag, Daniel, “Automatic Visual Attention Detection for Mobile Eye Tracking Using Pre-Trained Computer Vision Models and Human Gaze.” 2021
- [6] Rahul RK, Shanthakumar S, Vykunth P, Sairamnath K, “Real-time Attention Span Tracking in Online Education.” 2017
- [7] Frazier, T. W., Strauss, M. S., Klingemier, E. W., Zetzer, E. E., Hardan, A. Y., Eng, C., & Youngstrom, E. A, “A meta-analysis of gaze differences to social and non-social information between individuals with and without autism”. 2017
- [8] Friedman, L., & Sterling-Turner, H. E., “Attentional biases and autism spectrum disorders: Information processing in a neurocognitive framework. In Autism Spectrum Disorders”. 2011
- [9] Sikka, K., Forsyth, R., Mar, S., Wilcox, M. A., & Agrawal, S. K., “Wearable sensors for monitoring the physiological and emotional responses of children with autism in educational settings”. 2012
- [10] Sukhodolsky, D. G., & Sechill, L., “Cognitive-behavioral therapy for anger in children with autism: a therapist manual”. 2014

Hackathon

WINNER OF SMART INDIA HACKATHON 2019



CODE BLOODED INNOVATORS

Mithil Dani TE Comps
Chinmay Rane TE Comps
Damnik Jain TE Comps
Ira Kawthalkar TE Comps
Rithvika Iyer TE Comps
Tejas Chheda TE Comps

RI2, Udaipur

Cash Prize : ₹ 1,00,000



Hackathon

WINNERS OF SMART INDIA HACKATHON 2019



HACKING BAD

Poojan Turakhia - TE Comps
Bhavya Meghnani - TE Comps
Jinay Parekh - TE Comps
Rebecca D'souza - TE Comps
Shruti Rampure - SE Comps
Shreya Oak - SE Comps



4. ICT enabled tools

A. Content Creation by faculties

Content creation empowers faculties to take a student-centric approach, focusing on the needs and learning preferences of the students. This can contribute to a more positive and engaging learning experience. Content creation by faculties in ICT-enabled environments enhances the quality of education by providing tailored, engaging, and up-to-date learning materials. It supports various learning styles, fosters critical thinking, and contributes to a more dynamic and effective educational experience for students.

B. Learning Management System

An LMS provides a centralized platform where students can access course materials, lecture notes, assignments, and additional resources. This ensures that all necessary information is readily available in one location. This includes organizing content, setting up assignments, creating quizzes, and managing grades. The course management features provide flexibility in designing diverse learning experiences. It offers robust assessment tools, including quizzes, assignments, and surveys. Instructors can create various question types, set time limits, and use advanced grading methods. The platform also allows for efficient grading and feedback.

Content Creation by Faculties

Sr. No.	Name of the teacher	Name of the module developed	Link to the relevant document
Department of Computer Engineering			
1	Dr. Nataasha Raul	Introduction to data structures and its types	https://drive.google.com/file/d/1YPU0HiHLo2vrBj8CVoeJnorINC6F_TXU/view?usp=drive_link
2	Dr. Nataasha Raul	Stack as Data Structure	https://drive.google.com/file/d/15wB39paQQAIcl6-ss9LLMpjF16zIEfK/view?usp=drive_link
3	Dr. Nataasha Raul	Stack application	https://drive.google.com/file/d/1toLF_EodUH-1_P9K5_wP8OeJFtdrzgDKa/view?usp=drive_link
4	Dr. Nataasha Raul	Polish Notation Conversion and Evaluation	https://drive.google.com/file/d/1KauyCp7Xr_A1BC2GwHU7vSWcHuc-aGIR/view?usp=drive_link
5	Dr. Nataasha Raul	Linear Queue	https://drive.google.com/file/d/1YuPWPZD-6ahqDoymFH7I0o5UPf9So-Gq/view?usp=drive_link
6	Dr. Nataasha Raul	Circular Queue	https://drive.google.com/file/d/1lhqCdKuejHLnRwC06sJls0qFckLrzvgP/view?usp=drive_link
7	Prof. Anand Godbole	Data Structures (2020-21)	https://drive.google.com/file/d/1iLAo0ubAa89GBzOPD0hCHF7TqOkJ82U4/view
8	Prof. Anand Godbole	Data structures Lab(2020-21)	https://drive.google.com/file/d/1oWP0wc-WZqBvr6PJVqpdvF6jdvOjH82D/view
9	Prof. Anand Godbole	Design and Analysis of Algorithm (2020-21)	https://drive.google.com/file/d/1k0AuN_EG2i1pEb8MoUbVDVZoWe_hkXXw/view
10	Prof. Anand Godbole	Design and Analysis of algorithm labs (2020-21)	https://drive.google.com/file/d/1Tcu8tqUPwGzJKufX5qQXxV3VcH-jP2j1/view?userstoinvite=sanskruti.bade@spit.ac.in&ts=602fd535

Rashaudhaiji

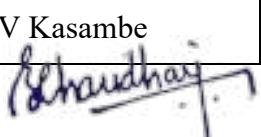


Department of Electronics and Telecommunication Engineering

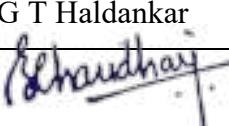
11	Dr Rajendra R Sawant	Illustration of Thevenin, Norton, maximum power transfer theorems	https://youtu.be/6L_f0aDQy8M
12	Dr Rajendra R Sawant	Star connected systems	https://youtu.be/6caziVUwqEs
13	Dr Rajendra R Sawant	Delta connected systems	https://youtu.be/1klS5lt_LbA
14	Dr Rajendra R Sawant	Basic SMPS circuits	https://youtu.be/kY1B87AOSfU
15	Dr. Reena Sonkusare	Digital Signal Processing	https://drive.google.com/drive/folders/1gi5tQa9NDqgtt0SZJGECmkCuA3wf6iej
16	Dr. Reena Sonkusare	Fundamental of Antenna	https://drive.google.com/drive/folders/1a7vDbIeqWd689d2n9Q4u-8-djNghclqC

Department of Electronics Engineering

17	Dr S S Rathod	Manage and Improve Lab experiences	https://www.youtube.com/watch?v=jR5gHdNnChw
18	Dr S S Rathod	CMOS Analog VLSI Design course	https://www.youtube.com/channel/UCeX4IryXvui6MRIJA6WJ98Q
19	Prof. G T Haldankar	DC motor under Electrical and Mechanical Load	https://www.youtube.com/watch?v=_sa_jneDFLOg
20	Prof. G T Haldankar	Project sponsored by HITech	https://www.youtube.com/watch?v=szhsv8PC1eI
21	Prof. G T Haldankar	Constructional details of DC motor	https://www.youtube.com/watch?v=LXgJGDMQ29g
22	Prof. G T Haldankar	Speed control of DC motor	https://www.youtube.com/watch?v=6VwFq69N9tU&feature=youtu.be
23	Prof. G T Haldankar	RLC Parallel Circuits & Parallel Resonance	https://www.youtube.com/watch?v=nYXfBC6l0SM
24	Prof. G T Haldankar	RLC Series Circuits & Series Resonance	https://www.youtube.com/watch?v=bXWECS29m8Y
25	Prof. P V Kasambe	Siemens S7 -1500 PLC Configuration	https://www.youtube.com/watch?v=uBLc-2XoghM




26	Prof. P V Kasambe	Ladder logic program for blinking LED using Siemens S7 1500	https://www.youtube.com/watch?v=LIA7EOmoI1M
27	Prof. P V Kasambe	Ladder Logic Program for Arithmetic and Compare operations using Siemens S7 1500	https://www.youtube.com/watch?v=Ij-2f6S2oc
28	Prof. P V Kasambe	Ladder Logic Program for 1 way Traffic Signal Model using Siemens S7 1500	https://www.youtube.com/watch?v=sXLoHEXglEE
29	Prof. P V Kasambe	Ladder Logic Program for VFD - SINAMIC G120C Control using Siemens S7 1500	https://www.youtube.com/watch?v=lNgRyGRhAwg
30	Prof. P V Kasambe	HMI Configuration Part 1	https://www.youtube.com/watch?v=eiUPTV0rKQM
31	Prof. P V Kasambe	HMI Configuration Part 2	https://www.youtube.com/watch?v=WXAmikWmw6A
32	Dr S S Rathod	Learning material for Outcome Based Education (AICTE approved STTP)	https://www.youtube.com/watch?v=OxRYJh6-6GM&list=PLV1oI4JD-NyW1-wWY5O4xK7QiZbcc1SL
33	Dr S S Rathod	Learning material for Machine Learning and Data Science (AICTE approved STTP)	https://www.youtube.com/channel/UCVh7M7AddFXpIkIVFh0Awdg/videos
34	Dr S S Rathod	Learning material for VLSI Design using CADENCE tools (AICTE approved STTP)	https://www.youtube.com/channel/UCoXfrfQgQktCq9p65ANTccw/videos
35	Prof. P V Kasambe	Laboratory Sessions for the subject of Analog Circuits Sem IV	https://drive.google.com/drive/folders/1fe_Tc2bNzEkFzd1rKGSX5MtDu6GLzaOG?usp=sharing
36	Prof. P V Kasambe	Theory Sessions for the subject of Analog Circuits Sem IV	https://drive.google.com/drive/folders/1S7f4Jho1fEoznOIwZjOJRKOCKhAQKjhQ?usp=sharing
37	Prof. P V Kasambe	Laboratory Sessions for the subject of Electronic Devices Sem III	https://drive.google.com/drive/folders/1tZu1JbdbenP8jIj5l7EIZTDjox-fgQun?usp=sharing
38	Prof. G T Haldankar	Skewness and Kurtosis	https://www.youtube.com/watch?v=L2

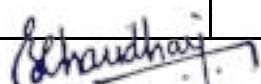



			j2ZhVEx_g
39	Prof. G T Haldankar	Transmission line VSWR max min Part 2	https://www.youtube.com/watch?v=1kTYJV7qUw
40	Prof. G T Haldankar	Transmission line VSWR & Maxima Minima	https://www.youtube.com/watch?v=Ux fd7gLbxo4
41	Prof. G T Haldankar	Transmission line length	https://www.youtube.com/watch?v=Ff UFKF50CVY
42	Prof. G T Haldankar	Numerical problems transmission line 1	https://www.youtube.com/watch?v=z1i ZYXxoENI
43	Prof. Priya Deshpande	Microcontrollers	https://drive.google.com/drive/folders /1SK3V5-QjrfznaymRX9ustXFgXsLzIAG?usp=sharing
44	Prof. Priya Deshpande	Electronic System Design	https://drive.google.com/drive/u/0/folders/1AYYFi3SQ96qRSi2BgT22k-PfD93WmFEL
45	Prof. Priya Deshpande	Computer Architecture and Organization	https://drive.google.com/drive/folders /1nasGrZciM9Bfb2sXZXI5v3PcVdWmZJeW?usp=sharing
46	Prof. Priya Deshpande	Computer Architecture and Organization	https://www.youtube.com/watch?v=Bj-Tdpf7vxo
47	Prof. Najib Ghatte	Foundation of Signal Processing	https://www.youtube.com/watch?v=pr r6OI35Z_c&list=PLMtOBqZDQ8ca1s14CST2VJ5X414ZPSpZ8&pp=gAQB iAQB
48	Prof. Najib Ghatte	Instrumentation LAB	https://www.youtube.com/watch?v=T Dtjiy9Tikg&list=PLMtOBqZDQ8cb-fhUYVRT1TWCAAtSK-vz1f&pp=gAQBiAQB
49	Prof. Najib Ghatte	Control System	https://www.youtube.com/watch?v=i HuECyQk2Vg&list=PLMtOBqZDQ8cb8Zu8ZijjZbJbJpVCky8-3&pp=gAQBiAQB
50	Prof. Najib Ghatte	Signals and Systems	https://www.youtube.com/watch?v=zJ sa7fYyAIE&list=PLMtOBqZDQ8cb4n-puGmBor9HeH8cEQtt6&pp=gAQBiAQB



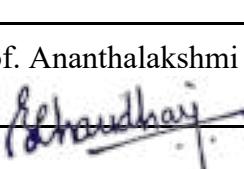
Department of Information Technology

51	Prof. Sheetal Chaudhari	Operating systems	https://www.youtube.com/watch?v=hwTYDQ0zZ0w
52	Prof. Sheetal Chaudhari	Operating systems	https://www.youtube.com/watch?v=xHu7qI1gDPA
53	Prof. Sheetal Chaudhari	Data Structures	https://www.youtube.com/watch?v=AESI0xACpZs
54	Prof. Sheetal Chaudhari	Computer Networks	https://www.youtube.com/watch?v=-6Uoku-M6oY
55	Prof. Varsha hole	Artificial Intelligence: Types of Agent	https://www.youtube.com/watch?v=FJTLNpNZEmY
56	Prof. Varsha Hole	Artificial Intelligence	https://drive.google.com/drive/folders/1ffgLToruAVXLu6Y4Efo6aWaDNA8tmEB
57	Prof. Varsha Hole	Design and Analysis of Algorithms Topic: Branch and Bound	https://drive.google.com/drive/folders/1LZhaprUclg1RJ5n9PiZr9QthWaMtC8u5
58	Prof. Varsha Hole	Design and Analysis of Algorithms Topic: Time complexity Analysis	https://drive.google.com/drive/folders/1Q4El_IL9yvjejDHUjpgvSLy4jYnZ_Ve7
59	Prof. Varsha Hole	Design and Analysis of algorithms Topic: Greedy Methodology	https://drive.google.com/drive/folders/1nJaRTdUhOQ0wP6NGH8EHWmrzZ_kAGIYD
60	Prof. Varsha Hole	Data Structures	https://drive.google.com/drive/folders/1w_0825vWArJEAr5adIpC3EOWRgLhxq-N
61	Prof. Nikahat Mulla	Problem solving using Imperative Programming	https://www.youtube.com/playlist?list=PLkeiGAzmDWmRnfT0z7JiytyOCqO4MVqeo
62	Prof. Nikahat Mulla	Soft Computing	https://www.youtube.com/playlist?list=PLkeiGAzmDWmQm1Nb883rXHckB04LQt8f
63	Prof. Nikahat Mulla	Structures and Unions in C	https://www.youtube.com/playlist?list=PLkeiGAzmDWmSSHst0Qf1s6YrBus_7t-5F
64	Prof. Nikahat Mulla	Pointers in C	https://www.youtube.com/playlist?list=PLkeiGAzmDWmRnuUF9elHBpa




			MegYPfQ_VD
65	Prof. Aparna Halbe	Authentication using OAuth	https://drive.google.com/file/d/1i4_p-0oy0Xgp6vnH_0jRVCAh_hLeHV/view?usp=sharing

Department of Applied Science and Humanities

66	Prof. Meghana Naik	Homogeneous Functions	https://drive.google.com/file/d/1Z5Uz2bUIxEVjWAgly_hTo55Js-LVz4w/view?usp=drive_link
67	Prof. Meghana Naik	Euler's Theorem for homogeneous functions	https://drive.google.com/file/d/117zNAyflk61TRI-vy_mzh4Px9OcFiHv/view?usp=drive_link
68	Prof. Meghana Naik	Application of partial derivative to find maxima and minima	https://drive.google.com/file/d/1G5gBLzcwnEuNu3IJlnHjzKo--yq_FEd1/view?usp=drive_link
69	Prof. Meghana Naik	Maxima minima for more than 2 variable function using Lagrange's Multiplier Method	https://drive.google.com/file/d/1XEMKTzRL2a6iLdDwdx2xXK3KXYkA4EC/view?usp=drive_link
70	Prof. Meghana Naik	Successive Differentiation to find n times derivative of a function	https://drive.google.com/file/d/1XEMKTzRL2a6iLdDwdx2xXK3KXYkA4EC/view?usp=drive_link
71	Prof. Meghana Naik	Leibniz Rule to find n-th derivative of a product of a function	https://drive.google.com/file/d/1fUxL1T8IHcOIgLr7_AOOe7yBjpOwFgIE/view?usp=drive_link
72	Prof. Meghana Naik	Expansion of a function using Maclaurin's series	https://drive.google.com/file/d/17lyPhdO3KmvCl4HiC_VOKMW9ufEFzVHJ/view?usp=drive_link
73	Prof. Meghana Naik	Expansion using standard series	https://drive.google.com/file/d/165-tXoiIuclf9_DHYJH9YJMiIsCceF/view?usp=drive_link
74	Prof. Meghana Naik	Lectures on series, beta and gamma, multiple integrals	https://drive.google.com/drive/folders/1-Lr3p7keyAC7udkfjyyH8ZWdQxi1Sdrw?usp=drive_link
75	Prof. Ananthalakshmi V	Alternate Fuels	https://drive.google.com/file/d/1rH29b5KXgQfv9yBi4ASqte9PYF3C3A6l/view?usp=sharing
76	Prof. Ananthalakshmi V 	Carnot Cycle	https://classroom.google.com/c/MjcwOTMzMtuzMjg5/p/MzExNja0Mze

			1Mjkx/details
MCA Department			
77	Dr. Aarti Karande	DBMS	https://www.youtube.com/watch?v=WRusBpSpGZo&t=1s
78	Dr. Aarti Karande	Session on Business Model Canvas	Session on Business Model Canvas by Dr. Aarti Karande
79	Dr. Aarti Karande	FDP3-Day5-Evening-Hands-on-session: CNN and Deep Autoencoder	https://www.youtube.com/watch?v=UH99QzUGPY8
80	Sakina Banu Salmani	understand various commands to work with ionic easily.	https://youtu.be/BRTuD4zV6Vk?si=W30Q0SNuuibAs0Iv
81	Sakina Banu Salmani	create Components and Pages in Ionic and how to link one page to another page .	https://youtu.be/V2J4xPcB1x4?si=QIkuE7rBmydlsZxd
82	Sakina Banu Salmani	Working with Tabs Navigation in ionic	https://youtu.be/SXAX_2lFJj4?si=EnoI6ERq9cJU3le4
83	Sakina Banu Salmani	Structure of project files in ionic part-1	https://youtu.be/GWq-b5FiXek?si=LzvhcN2V4Bhe8Seo
84	Sakina Banu Salmani	Structure of project files in ionic part-2	https://youtu.be/UBaJ04BKMEI?si=r3sppB-LVoXiTjto
85	Sakina Banu Salmani	First ionic Application Build and Running	https://youtu.be/vSARGGtbOxM?si=Eh1ffxAfoxBnYzYL
86	Sakina Banu Salmani	Step by Step installation of Ionic Framework	https://youtu.be/JkT2nnIg_No?si=BNrYDdGGAvA0AaVc
87	Sakina Banu Salmani	Basics of Ionic framework	https://youtu.be/ZZCMf1PBDvk?si=GiotP2Gz7G8PCnGm

(Signature)



88	Sakina Banu Salmani	Drawbacks of Agile Method	https://youtu.be/ADnUfrRIRqg?si=nuTBjTH4fRgZ03iU
89	Sakina Banu Salmani	Agile Software Engineering methods	https://youtu.be/gRUg3ofvEC4?si=WptPcm23-Ksxm9vY
90	Sakina Banu Salmani	UX Inspection-A Practical Approach	https://youtu.be/DMidCefey7k?si=JNAsuArooqEc-HXm
91	Sakina Banu Salmani	Fidelity of Prototyping	https://youtu.be/f2ZPr2WdVS0?si=rYNiqOkupugMJWyG
92	Sakina Banu Salmani	Basics of Agile SE method	https://youtu.be/R5N1y7DyRCA?si=b2pm581kVaUgoWK
93	Sakina Banu Salmani	New Features added in Usability Hub	https://youtu.be/muPUpmON2qA?si=MIaxVSEP36ZmNeL6
94	Sakina Banu Salmani	UX Design Life Cycle Process	https://youtu.be/He1JzHhikqg?si=PIV0LfzqXaS2Cfpn
95	Sakina Banu Salmani	2D Scene using Blender	https://youtu.be/OWWr-eQyjaY?si=6ZyZZgyvWzeDPMhB
96	Sakina Banu Salmani	2D cat creation using blender	https://youtu.be/ppmazLZK1c8?si=m-1-T-E6Jh4VVNPb
97	Sakina Banu Salmani	Importance of Marker in Video Editing in Blender	https://youtu.be/_jm35df9Z-4?si=1ZCRECnOUK241IvF
98	Sakina Banu Salmani	Video Editing Part-1 using Blender	https://youtu.be/_6ycHpl63W4?si=C6SbuWTC7KbAHgH1
99	Sakina Banu Salmani 	To create Stickman using Blender	https://youtu.be/JzAllZi-n50?si=keYlun3L9Ef1TQMq
100	Sakina Banu Salmani 	To create various structure of Vase using modifiers and Bezier	https://youtu.be/1o-_pUmOCs?si=bybw13znEPuAhghP

		Curve	
101	Sakina Banu Salmani	Creating Vase using subdivision and solidify modifier	https://youtu.be/RaFqDRtMdIg?si=-9uG1vKpEFcRHYK5
102	Sakina Banu Salmani	To create Dice cube using Boolean and beveling modifier	https://youtu.be/VRTb8BHulRo?si=aljIgC3vHkQ1XVft
103	Sakina Banu Salmani	Beveling modifier using blender	https://youtu.be/yZr7X38GSm8?si=QL5syyQ97iEk3eYp
104	Sakina Banu Salmani	Boolean modifier operations	https://youtu.be/GAZJ2VirI-g?si=OWs5EC1OWJey-lxj
105	Sakina Banu Salmani	Python script for animating a sphere	https://youtu.be/fayK14kxi98?si=27J6IxKwLMyJ2k_z
106	Sakina Banu Salmani	To create text and add effects to it using blender	https://youtu.be/VCQ7tTzmDjo?si=T0toHAVnsjgYEIrt
107	Sakina Banu Salmani	Introduction to basic UI of blender	https://youtu.be/Gb5BfspeoK0?si=IFarxAK6anPcn5to
108	Sakina Banu Salmani	Usability Hub design questions and preference test	https://youtu.be/mQrx6jApKNk?si=6PttnUYBQ050gquXP
109	Sakina Banu Salmani	Affordance and its types	https://youtu.be/IAq2-sHtSQ?si=M5uX_jAVP-ihX0pI
110	Sakina Banu Salmani	Design Paradigm	https://youtu.be/4fEnCRRITX8?si=C-JYX87ko3FbhA6B
111	Sakina Banu Salmani	Overview of Design Thinking	https://youtu.be/4fEnCRRITX8?si=C-JYX87ko3FbhA6B
112	Sakina Banu Salmani	5 second test method	https://youtu.be/va1KOTl_oa0?si=3tepz8VeI-JP10t
113	Sakina Banu Salmani 	First click test method	https://youtu.be/zQB3_9Bqib8?si=Zb7Jn6YI2G3lqS2

114	Sakina Banu Salmani	Ux goal metric and Target	https://youtu.be/tQa-Gn8ppAc?si=06oc2hJCYWdNyRv0
115	Sakina Banu Salmani	Types of evaluation data	https://youtu.be/6kZg8h9kVxg?si=HLQ00L5cPmlqtNHr
116	Sakina Banu Salmani	UX evaluation	https://youtu.be/wN5v4NZODXY?si=_btZmbAuJ78Znf4U
117	Sakina Banu Salmani	Depth and breadth of prototyping	https://youtu.be/h-yqSWacr3U?si=mnavnTGl9dMtRqj9
118	Sakina Banu Salmani	Introduction to Autoencoders	https://drive.google.com/file/d/1oSfBUJuaR5SvvYRnQWZziPReWJTOiAh8/view?usp=sharing
119	Sakina Banu Salmani	Overcomplete and under complete autoencoders	https://drive.google.com/file/d/1vKGsP9yoBeFVn54cbUaUXfZjyomc6KQN/view?usp=sharing
120	Sakina Banu Salmani	Regularization and Sparse autoencoders	https://drive.google.com/file/d/1KsItbGMRYLcMOcC9bAypUWrR1gAWpBwy/view?usp=sharing
121	Sakina Banu Salmani	Denoising Autoencoders	https://drive.google.com/file/d/1IR3jTU_vM7SHiZUq3hRH1TrGoRtZybdS/view?usp=sharing
122	Sakina Banu Salmani	Contractive Autoencoders	https://drive.google.com/file/d/1BtuGsvVKDSK5GQL4CFSxukePN2Up3GOa/view?usp=sharing
123	Sakina Banu Salmani	Manifold and Stochastic Autoencoder	https://drive.google.com/file/d/1CSKos9SyY9DxA3542sBveNYQmNkWzjZ/view?usp=sharing
124	Sakina Banu Salmani	Learning Material for AI and RPA FDP	https://drive.google.com/drive/folders/1kzRLQJbXiXKfLEa4SYI6CR96yGHZ8S9v?usp=sharing
125	Pallavi Thakur	Angular Basics	https://drive.google.com/file/d/1LfBzTpYvZ1jNbRltHqfMjvYFEkUIhHZ/view
126	Pallavi Thakur <i>Bhawna</i>	Service & Routing in Angular	https://drive.google.com/file/d/1x8_KQQPR18ofHh22YpA6HVYyj7sa4Qob/view
127	Pallavi Thakur	Building REST API using Node	https://drive.google.com/file/d/1qk3oU4kM_Ih_OvbBl5iL_kbDzFjpgOlJ/vi

		& Express	ew
128	Pallavi Thakur	Sampling technique,EDA	https://drive.google.com/file/d/1gn0NIw1tgcE6HoLCEQdTORoZLEGgPNI8/view?usp=drive_link
129	Pallavi Thakur	Supervised learning :Decision tree	https://drive.google.com/file/d/1MB0aCsLYX7gp0jG_VkSad2C3QWQGJwre/view?usp=drive_link
130	Pallavi Thakur	Hypothesis testing:T test	https://drive.google.com/file/d/1e_Et0FPbZ843NfmO97KLNPtmmTv8xaYN/view?usp=drive_link
131	Pallavi Thakur	Recommendation System	https://drive.google.com/file/d/1zXStAB2x4GXW5txoxPxcF00M5X02V5ca/view?usp=drive_link
132	Pallavi Thakur	Decision Tree	https://drive.google.com/file/d/1uBGkpBvs5ftInHW1QjizkB7xCEl9Qvi/iew?usp=drive_link
133	Pallavi Thakur	Data Preprocessing	https://drive.google.com/file/d/1nPgLXqbZLnpjV2XkPAEoKUD1EdsUWcGH/view?usp=drive_link
134	Pallavi Thakur	Machine learning basics:Types	https://drive.google.com/file/d/1sjfF2toqUk4yTEUWnClmXjg7uoV0d4Iz/iew?usp=sharing
135	Pallavi Thakur	Filtering techniques ,SNA	https://drive.google.com/file/d/1xWSNA1wdRXiY7M53MICFhc7OEkcXeA9d/view?usp=sharing
136	Pallavi Thakur	Clustering	https://drive.google.com/file/d/1bEaEonrVd7-bbQyV6WdurC1Y3dn1xmJp/view?usp=sharing
137	Pallavi Thakur	Naive Bayes Algorithm	https://drive.google.com/file/d/1N7iT45TdBdWs16zKkHzyyZ4g5VvzCy5k/view?usp=sharing
138	Pallavi Thakur	Introduction to Data Science	https://drive.google.com/file/d/1D7LIwGej7-RUsaX_eZQSSA5-N19okHrP/view?usp=sharing
139	Harshil Kanakia 	Data Structures Introduction 	https://www.youtube.com/watch?v=48N6VOq88D8&list=PLEXVMJ4LDI1ond2l2H1WMvXIS5ku98aOy&index=2

140	Harshil Kanakia	Database Languages	https://www.youtube.com/watch?v=UMA3mF43Fu0&list=PLEXVMJ4LDIqmrNQmFjdGC2zkkn1sT0cg&index=2
-----	-----------------	--------------------	---





Main menu

Navigation

Administration

Sardar Patel Institute of Technology

Search courses:

[Expand all](#)

Computer Engineering (3)

Computer Science & Engineering

Electronics & Telecommunication (4)

Electronics Engineering (8)

Information Technology (3)

Applied Science & Humanities

MCA (2)

ABL (12)

EXAM (1)



STTP (2)

RPE (1)

Open Elective (3)

Industry (1)

CALENDAR



March 2024



Sun	Mon	Tue	Wed	Thu	Fri	Sat
(Sunday)	(Monday)	(Tuesday)	(Wednesday)	(Thursday)	(Friday)	(Saturday)
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

You are logged in as sakina shaikh (Log out)



Moodle for ICT



Main menu

Navigation

Administration



Recent Jams

Google Jamboard

Owned by anyone

C

AZ

≡

🔗

P&S Jun 13, 2023	OS Apr 11, 2023	CDF Sep 29, 2022	Untitled Jam Jan 20, 2022	Untitled Dec
Untitled Jam Aug 5, 2021	Probability & Statistics- SK (zxm... Jul 7, 2021	Untitled Jam Apr 7, 2021	FP Growth Apr 6, 2021	Untitled Apr
Avg Link Mar 22, 2021	complete Link Mar 17, 2021	Untitled Jam Mar 16, 2021	DWM Tutorial (xkg-zprm-kiy - M... Mar 8, 2021	Juno E Mar
Untitled Jam Mar 5, 2021	Regression Mar 2, 2021	gini Index Feb 24, 2021	Untitled Jam Feb 17, 2021	Untitled Feb
Untitled Jam Feb 16, 2021	Untitled Jam Feb 15, 2021	naive bayes Feb 12, 2021	SE(COMP/IT): AVS: Probability an... Oct 29, 2020	SE(CO) Oct



Google Classroom



-  Home
-  Calendar
-  Teaching
-  To review
-  FYMCA 2022 Project report
-  Cyber Security
MCA
-  SEVA SATVA
-  FYMCA 2021 mini project
Mini Project
-  UED-LAB
BE-IT/COMPS
-  USER EXPERIENCE DESIGN
-  MINI PROJECT LAB
SYMCA SEM IV
-  Project LAB Batch D
TYMCA Sem V
-  Deep Learning
TYMCA Sem V
-  Graphics and Animation Lab
TYMCA Sem V

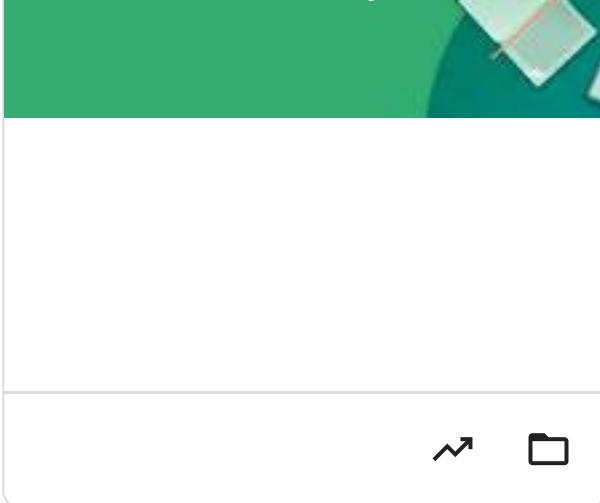


 Classroom

Google Classroom



-  Home
-  Calendar
-  Teaching
-  To review
-  FYMCA 2022 Project report
-  Cyber Security
MCA
-  SEVA SATVA
-  FYMCA 2021 mini project
Mini Project
-  UED-LAB
BE-IT/COMPS
-  USER EXPERIENCE DESIGN
-  MINI PROJECT LAB
SYMCA SEM IV
-  Project LAB Batch D
TYMCA Sem V
-  Deep Learning
TYMCA Sem V
-  Graphics and Animation Lab
TYMCA Sem V



SEVA SATVA



↗ └



FYMCA 2021 mini pro...
Mini Project



↗ └



UED-LAB

⋮



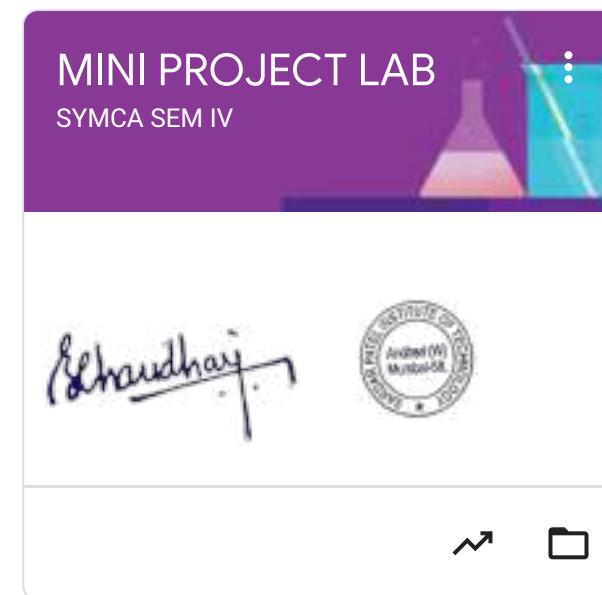
USER EXPERIENCE D...
?

 Classroom

Google Classroom



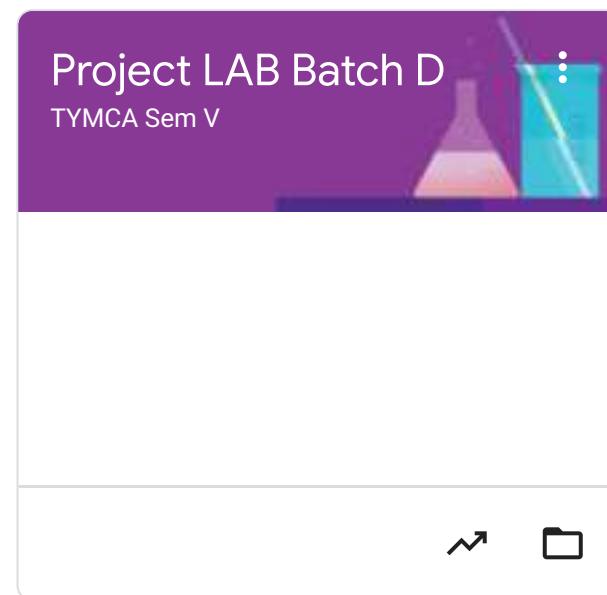
-  Home
-  Calendar
-  Teaching
-  To review
-  FYMCA 2022 Project report
-  Cyber Security MCA
-  SEVA SATVA
-  FYMCA 2021 mini project Mini Project
-  UED-LAB BE-IT/COMPS
-  USER EXPERIENCE DESIGN
-  MINI PROJECT LAB SYMCA SEM IV
-  Project LAB Batch D TYMCA Sem V
-  Deep Learning TYMCA Sem V
-  Graphics and Animation Lab TYMCA Sem V



MINI PROJECT LAB
SYMCA SEM IV







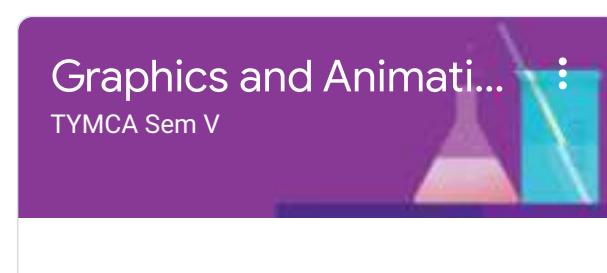
Project LAB Batch D
TYMCA Sem V





Deep Learning
TYMCA Sem V



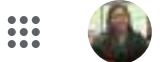


Graphics and Animati...
TYMCA Sem V

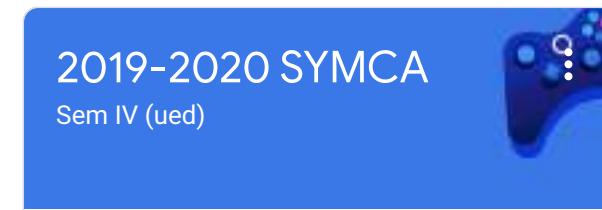
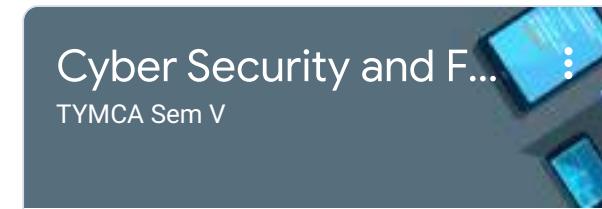




Google Classroom



- [Home](#)
- [Calendar](#)
- [Teaching](#)
- [To review](#)
- [FYMCA 2022 Project report](#)
- [Cyber Security
MCA](#)
- [SEVA SATVA](#)
- [FYMCA 2021 mini project
Mini Project](#)
- [UED-LAB
BE-IT/COMPS](#)
- [USER EXPERIENCE DESIGN](#)
- [MINI PROJECT LAB
SYMCA SEM IV](#)
- [Project LAB Batch D
TYMCA Sem V](#)
- [Deep Learning
TYMCA Sem V](#)
- [Graphics and Animation Lab
TYMCA Sem V](#)



S. Bhawna



Google Classroom



-  Home
-  Calendar
-  Teaching
-  To review
-  FYMCA 2022 Project report
-  Cyber Security
MCA
-  SEVA SATVA
-  FYMCA 2021 mini project
Mini Project
-  UED-LAB
BE-IT/COMPS
-  USER EXPERIENCE DESIGN
-  MINI PROJECT LAB
SYMCA SEM IV
-  Project LAB Batch D
TYMCA Sem V
-  Deep Learning
TYMCA Sem V
-  Graphics and Animation Lab
TYMCA Sem V



Quiz on integration of UX in agile method

Google Form as ICT Tool

* Indicates required question

1. Email *

2. Which one of the following is not the drawback of Agile SE method? * 2 points

Mark only one oval.

- It uses no upfront analysis
- It is light weight and fast
- its for the programmers and by the programmers
- They do not consider real users

3. Which upfront analysis is considered while integrating UX in planning phase of Agile SE method? * 2 points

Mark only one oval.

- Small upfront analysis
- Big Design Upfront analysis
- Big Upfront analysis
- Rough upfront analysis



4. In Planning phase of agile SE method, UX role is to help customer write user stories. * 2 points

Mark only one oval.

True

False

5. Which UX methods is not done in Sprint phase of agile method? * 2 points

Check all that apply.

- User Research
- Creating Wireframes
- Prototyping
- Writing user stories
- Developing design informing models
- Ideation
- Sketching

6. What is the difference between Extreme programming and Scrum? * 2 points

Check all that apply.

- Extreme programming takes 1 to 2 weeks to complete the task, whereas scrum takes 3 weeks to complete the task.
- Extreme programming takes 3 weeks to complete the task, whereas scrum takes 1 to 2 weeks to complete the task.
- In Extreme Programming changes can be incorporated whenever the user wishes for, whereas in scrum once the task is done changes cannot be incorporated .
- In Extreme Programming changes cannot be incorporated whenever the user wishes for, whereas in scrum once the task is done changes can be incorporated .



This content is neither created nor endorsed by Google.

Google Forms



ICT Enabled Classrooms and Labs





Sardar Patel Institute of Technology

Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India

(Autonomous Institute Affiliated to University of Mumbai)

Academic Year: 2022-23



Latitude - 19.123

Longitude - 72.835

4RFP+9C9 Bhavan's Campus, Old D N
Nagar, Munshi Nagar, Andheri West,
Mumbai, Maharashtra 400058, India.

27/10/23 12:59 PM GMT +05:30



Latitude - 19.123

Longitude - 72.835

4RFP+9C9 Bhavan's Campus, Old D N
Nagar, Munshi Nagar, Andheri West,
Mumbai, Maharashtra 400058, India.

27/10/23 12:59 PM GMT +05:30





Sardar Patel Institute of Technology

Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India

(Autonomous Institute Affiliated to University of Mumbai)

Academic Year: 2022-23



Latitude - 19.123

Longitude - 72.835

4RFP+9C9 Bhavan's Campus, Old D N Nagar, Munshi Nagar, Andheri West, Mumbai, Maharashtra 400058, India.

27/10/23 12:59 PM GMT +05:30





Sardar Patel Institute of Technology
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
(Autonomous Institute Affiliated to University of Mumbai)
Academic Year: 2022-23

High End Machine, Smart TV

Central Computing Lab - 003





Sardar Patel Institute of Technology
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
(Autonomous Institute Affiliated to University of Mumbai)
Academic Year: 2022-23

Projector, White Board

Seminar Hall - 008





Sardar Patel Institute of Technology

Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India

(Autonomous Institute Affiliated to University of Mumbai)

Academic Year: 2022-23

Language Laboratory - 009





Sardar Patel Institute of Technology
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
(Autonomous Institute Affiliated to University of Mumbai)
Academic Year: 2022-23

Classroom F.E EXTC - 108



Conference Room - 105



S. Chaudhari





Sardar Patel Institute of Technology
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
(Autonomous Institute Affiliated to University of Mumbai)
Academic Year: 2022-23

Classroom - 203



white board and green board







Sardar Patel Institute of Technology

Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India

(Autonomous Institute Affiliated to University of Mumbai)

Academic Year: 2022-23

Research and Development Lab - 310



Latitude - 19.122563

Longitude - 72.83627

Bhavan's Campus, Old D N Nagar, Munshi Nagar, Andheri West, Mumbai, Maharashtra 400058, India.

13/10/23 03:27 PM GMT +05:30





Sardar Patel Institute of Technology
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
(Autonomous Institute Affiliated to University of Mumbai)
Academic Year: 2022-23

Classroom S.Y (MCA) - 401

Computer in Classroom, White board, Green board, Projector



A handwritten signature in blue ink, which appears to read "S. Bhandarkar".





Sardar Patel Institute of Technology
Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India
(Autonomous Institute Affiliated to University of Mumbai)
Academic Year: 2022-23

7. FIFTH FLOOR:

Classroom – 509



Latitude - 19.123161

Longitude - 72.836306

Bhavan's Campus, Old D N Nagar, Munshi Nagar, Andheri West, Mumbai, Maharashtra 400058, India.

13/10/23 03:30 PM GMT +05:30





Sardar Patel Institute of Technology

Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India

(Autonomous Institute Affiliated to University of Mumbai)

Academic Year: 2022-23

Tutorial Room – 506 B





Sardar Patel Institute of Technology

Bhavan's Campus, Munshi Nagar, Andheri (West), Mumbai-400058-India

(Autonomous Institute Affiliated to University of Mumbai)

Academic Year: 2022-23



Latitude - 19.122748

Longitude - 72.835304

Bhavan's Campus, Old D N Nagar,
Munshi Nagar, Andheri West,
Mumbai, Maharashtra 400058, India.
13/10/23 03:16 PM GMT +05:30

