Decentralized Investment Platform for Stock-Exchange, Real-Estate and NFTs

Project Report submitted in partial fulfilment of the requirement for the degree of

Bachelor of Technology

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CERTIFICATE

It is certified that the work contained in the project report titled "Decentralized Investment Platform for Stock-Exchange, Real-Estate and NFTs" by "Karthik Sajjan (Roll No: 19BCS049)", "Karusala Deepak Chowdary (Roll No: 19BCS050)", "Kuppa Venkata Krishna Paanchajanya (Roll No: 19BCS063)" and "Vanga Manoj Sahit Reddy (Roll No: 19BCS110)" has been carried out under my/our supervision and that this work has not been submitted elsewhere for a degree.

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Signature of the Supervisor(s)

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We declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, we have adequately cited and references the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misinterpreted or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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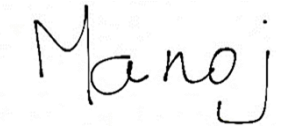

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Approval Sheet

This project report titled “Decentralized Investment Platform for Stock-Exchange, Real-Estate and NFTs” by Karthik Sajjan, Karusala Deepak Chowdary, Kuppa Venkata Krishna Paanchajanya and Vanga Manoj Sahit Reddy is approved for the degree of Bachelor of Technology in Computer Science and Engineering.

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Abstract

The objective of this project is to develop a Decentralized Investment Platform that shall encompass an ensemble of features encouraging investors to invest in unlisted shares of start-up companies that show promising growth and sheer vision, real estate, and NFTs.

This project report initially ponders over the literature review taken up by our team to establish certain facts which could help us draw conclusions on what features are to be considered while developing an investment platform that not only offers a wide range of investment opportunities but also encompasses Customer Loyalty Programs (CLPs) in order to motivate the investors for maintaining a long-term relationship with the company/vendor.

It then proceeds to discuss the research survey that our team has conducted to gather insights into what customers intend to receive as part of a CLP. We had a questionnaire prepared that helped our team understand a customer's perspective of Rewarding Systems better. Based on the inferences drawn from the survey results, we established the fact that the platform ideated afore, if implemented, has huge prospects in the market.

After we have set up the groundwork regarding our project, we next moved on to discussing the implementation of the platform in detail i.e., we discussed various user roles and their enrolment procedure in the platform, the role of administrators, the features and characteristics offered to each user role, the interface of the Dapp, the architecture of the Blockchain Network and Smart Contracts, and the reward systems (CLP). Finally, we pondered over the deployment strategy of the Dapp.

Keywords: *Blockchain Technology, Customer Loyalty Program (CLP), Fungible and Non-Fungible Tokens, Investopolis, Shares, Real-Estate, Admin, Ideator, Investor, Vendor, Registrar, Adamant, Krypton, Vibran, Uru, Xandar, Morag, Sakaar, Titan, Inter-Planetary File System (IPFS).*

Table of Contents

List of Figures

List of Tables

Abbreviation, Notation and Nomenclature

Abbreviation	Full Meaning
CLP	Customer Loyalty Programs
ERC	Ethereum Request for Comment
NFT	Non-Fungible Tokens
DAPP	Decentralized Application
PoA	Proof of Authority
IPFS	Inter-Planetary File System
HTML	Hyper Text Markup Language
CSS	Cascading Style Sheets
JS	JavaScript
AWS	Amazon Web Services
EC2	Elastic Container 2.0

List of Symbols

Symbol	Meaning
ETH	Ethereum Blockchain’s Cryptocurrency

1

Introduction

The terms “Stocks”, “Shares”, “Investment” have always been the ones that induce numerous doubts in any potential investor interested in investing in them, especially in case of budding startups who are unlisted in Stock-Exchange. One of the prime reasons for these doubts might be the fact that investment in budding startups in contrast to well-established listed companies (companies that are part of the stock exchange) works in a slightly haphazard fashion. There are a handful of platforms that offer a way to invest in the unlisted shares that these startups have to offer. Out of these handful, very few are successful in establishing trust, security, and transparency of the highest order which are pivotal to any investor’s interests.

Blockchain is a technology which has the aforementioned characteristics such as Transparency, Security and the ability to build immunity from adversaries due to its decentralized nature. In case investment platforms are built on emerging technologies like blockchain, it would make them decentralized and more secure, and such platforms would be of great value. Currently, there are only a handful of such decentralized investment platforms.

The term "Customer Loyalty Program" means – they are what we sometimes refer to as coupons, gift cards, vouchers or other kinds of incentives that are given to the customers by a company. They serve as a reward to a customer’s loyalty towards the company as and when they purchase their products thereby strengthening customer’s relationship with the company. In addition, customer loyalty programs also serve as a means of encouragement to the customer to further continue his transactions with the company. An example could be the case of obtaining discounts after repeated purchases at a mall.

Customer loyalty programs, if implemented through traditional mechanisms like coupons and gift cards have some pitfalls. They are as follows:

- **Heavy Cost Burden:** Big stores take on the burden of high costs for setup and maintenance of customer loyalty programs.
- **Liabilities for Brands:** With so many loyalty programs available in the market and being biased towards the company without many favours for them, customers can lose their way and often leave unredeemed reward points.
- **Lack of Security:** Consumers would avoid loyalty programs that collected personal information other than the name and phone number for privacy and other security concerns.

In order to overcome these challenges, customer loyalty programs can be implemented over decentralized applications in a Blockchain network using Tokenization. The term "Tokenization" has multiple meanings in different realms of computer science. In data security, it is referred to as a means through which one can protect sensitive personally identifiable data. In Blockchain Technology, it is referred to as an element through which one can digitize the ownership of assets. Tokenization in the context of this project is used to implement Customer Loyalty Programs on Blockchain. This mechanism will have multiple benefits over its traditional counterpart, some of which are:

- Easy Setup and Maintenance
- Transferable
- Security

In addition to Blockchain Technology, in case tokenization is also employed to implement Customer Loyalty Programs (CLPs) on a decentralized investment platform, it will become one of a kind. Achieving this feat will be the primary aim of this project. In addition to unlisted shares of startups, real estate and NFTs can also be included in such a platform from an investment perspective. Thus, the objective of this project is to develop a Decentralized Investment Platform that shall encompass an ensemble of features encouraging investors to invest in unlisted shares of start-up companies that show promising growth and sheer vision, real estate, and NFTs.

In order to lay a strong foundation for such a platform's development, a myriad of reviews on the available literature and research surveys from potential investors should be taken up. These operations will aid us in fixating upon the features we must implement to tackle the problem statement using Blockchain Technology.

2

Review of Literature

Decentralized investment platforms, also known as decentralized finance (DeFi) platforms, have gained significant attention in recent years. These platforms employ blockchain technology to enable users to participate in various investment opportunities without the need for intermediaries like banks or traditional financial institutions. Here is an overview of decentralized investment platforms and their key features gathered from literature:

- **Decentralized Exchanges (DEXs):** DEXs facilitate peer-to-peer trading of digital assets directly on the blockchain. They eliminate the need for a central authority to control the trading process and provide enhanced security and transparency. Examples of DEXs include Uniswap, SushiSwap, and PancakeSwap.
- **Decentralized Lending and Borrowing:** These platforms allow users to lend their cryptocurrencies and earn interest or borrow assets by collateralizing their existing holdings. The lending and borrowing operations are typically governed by smart contracts. Compound, Aave, and MakerDAO are popular decentralized lending and borrowing platforms.
- **Yield Farming and Liquidity Mining:** Yield farming involves providing liquidity to decentralized platforms in return for earning rewards, usually in the form of additional tokens. Liquidity mining incentivizes users to contribute to liquidity pools, promoting the efficient functioning of decentralized exchanges. Platforms like Yearn finance, Curve Finance, and Balancer offer yield farming and liquidity mining opportunities.
- **Decentralized Asset Management:** Decentralized asset management platforms enable users to create and manage investment portfolios composed of various digital assets. These platforms automate the process of portfolio rebalancing and often incorporate algorithmic

trading strategies. Melon Protocol and Enzyme Finance are examples of decentralized asset management platforms.

Based on the above overview, it is worth mentioning that the concept of decentralized investment platforms that deal with unlisted shares of budding startups is seldom mentioned in the literature. Coming to the concept of decentralized real-estate investment platforms, [1] states that the utilization of blockchain technology can improve efficiency and streamline cross-border operations, potentially serving as a means to enforce property agreement registrations while establishing connections with tax authorities, registries, courts, and other administrative bodies.

In [2], a system is presented that suggests a secure method for storing property ownership and transfer transactions on a private blockchain. The blockchain is designed to be unchangeable, ensuring that once a record is inserted, it remains immutable. The system utilizes a combination of private and public keys, along with smart contracts, to enable a universally accessible yet highly secure transfer of ownership.

Research papers have explored various aspects of Decentralized Non-Fungible Token (NFT) marketplaces, focusing on their architecture, functionality, and benefits. Some of them are:

- Architecture
- Interoperability
- Governance and Community Involvement
- Scalability
- Security and Trust
- Market Dynamics and Economics

Overall, research papers on decentralized NFT marketplaces provide insights into the technical, economic, and social aspects of these platforms. They offer valuable contributions to the design, implementation, and understanding of the decentralized NFT ecosystem, paving the way for further innovation and development in this space.

As we have covered the crux of decentralized investment platforms with the aforementioned overview, let us move on to illustrating some common methodologies involving the development of decentralized investment platforms.

- **Smart Contract Development:** Papers [3], [4] discuss the design and implementation of smart contracts to automate investment processes, ensuring secure and reliable execution of investment strategies.

- **Algorithmic Trading Strategies:** Some papers such as [5] focus on the development and evaluation of algorithmic trading strategies within decentralized investment platforms, leveraging data analysis, machine learning, and statistical models to optimize investment decision-making.
- **Risk Management and Governance:** Research papers such as [6] explore methodologies to assess and manage risks associated with decentralized investment platforms, including protocols for decentralized governance, decentralized risk management strategies, and incentivization mechanisms.
- **Market Dynamics and Liquidity:** Some papers such as [7] analyse the market dynamics and liquidity provision in decentralized investment platforms, exploring factors such as liquidity pools, yield farming incentives, and their impact on market efficiency.

With the above discussion, we have covered the review of literature with respect to the development of Decentralized Investment Platforms in the context of unlisted shares, real-estate and NFTs. Moving on to the concept of Tokenization of Customer Loyalty in Blockchain, there have been many frameworks in the literature that leverage blockchain-based smart contracts and ERC20 tokens to implement Customer Loyalty Programs. Now-a-days, several companies have started using Blockchain technology to enhance the brand recognition of their products and services.

[8] has performed a detailed study to obtain an in-depth understanding of the impact of blockchain on customer loyalty programs in an airline business. The authors concluded that significant evidence that blockchain does enhance the effectiveness of customer loyalty programs of an airline business set in Nigeria has been found.

[9] suggests that blockchain might be significant in developing better customer engagement, fraud prevention, effective digital advertising through Customer Loyalty Programs thereby inducing the effectiveness of various marketing processes. [10] presents a new repurchase motivation-driven scheme in e-commerce markets to encourage customers to purchase products of a particular band repeatedly effectively increasing profits through customer relationship management with the aid of blockchain technology. Based on the understanding our team has attained from the literature survey on development of Decentralized Investment Platforms employing Customer Loyalty Programs, we have proceeded further.

3.

Research Survey

A research survey is planned to be conducted by our team in order to gather insights into what customers intend to receive as part of a CLP. We had a questionnaire prepared that helped our team understand a customer's perspective of Rewarding Systems better. They are as follows:

- Were you familiar with the concept of "Customer Loyalty Programs" or other equivalents such as Coupons, Vouchers, Rewards, etc., before?
- Have you ever participated in a loyalty program i.e., have you ever received a voucher, gift card, coupon, or any other equivalent reward from purchases from a company before?
- If the answer to the previous question is yes, did you redeem (use) the reward?
- If the answer to the previous question is no, can you share why?
- If you receive any rewards from loyalty programs, will it influence your investment behavior (e.g. repeat purchases, referrals, etc.)
- What type of rewards do you expect from a loyalty program offered by a company?
- If you are willing to actively participate in loyalty programs and obtain rewards, how frequently do you wish to receive them?
- How comfortable are you sharing your personal information while enrolling for a loyalty program offered by a company?
- Would you be willing to invest on a product of a company with a larger amount in order to participate in the loyalty program?
- How important the presence of a reward or any other equivalent loyalty program is to you while purchasing a product/ obtaining service from a company?
- How easy do you expect the process of enrolling in and using the loyalty program to be?
- Would you be more likely to recommend a company or its products to friends and family if it offered a loyalty program?

- How important the transparency of the loyalty program and rewards system i.e., the process of "how customers are rewarded" is to you?
- Have you faced any challenges while participating in a CLP offered to you?
- If the answer to the above question is yes, please describe the challenges
- What is your understanding of tokenization and blockchain technology?
- How likely are you to participate in a reward system or a loyalty program that is digitized and employs emerging technologies like blockchain in the future?
- If a loyalty program is indeed implemented using emerging technologies like blockchain, what would you expect from it in contrast to what is being offered to you now as rewards which would encourage you to continue your transactions with the company further?
- Are you currently enrolled in any investment platform or are you interested in enrolling in the near future?
- Will the presence of a loyalty program in the investment platform motivate you in enrolling and performing investments on promising start-up companies?
- Will the presence of a loyalty program in the investment platform motivate you in enrolling and performing investments on real-estate (property dealing)?
- Will the presence of a loyalty program in the investment platform motivate you in enrolling and performing investments on digital arts and paintings?

The complete response sheet generated as part of this research survey is placed in the Appendices. The following pictorial representations indicate which aspects does the customer find problematic with respect to traditional Customer Loyalty Programs and whether he will be interested in enrolling in an investment platform offering investment opportunities in unlisted shares, real-estate, and NFTs in case those issues are eradicated with the use of blockchain Technology, respectively.

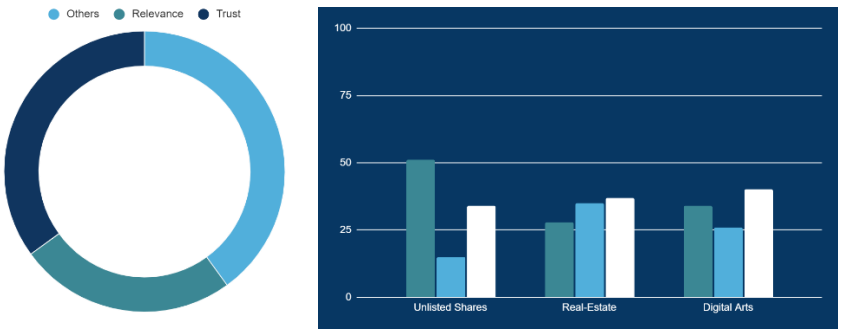


Fig 3.1: Pictorial Representation of Inferences from Survey Results

Based on the inferences drawn from the survey results, we established the fact that the platform ideated afore, if implemented, has huge prospects in the market.

4.

Ideation of Investopolis

4.1 Objective

The objective of the dApp referred to as “Investopolis” we were to implement was to develop a customer loyalty program based decentralized investment platform wherein investors could invest in certain products ideators ideate by obtaining ownership of the shares the ideators float, register and transfer ownership of real-estate properties, and mint and sell digital arts in the form of NFTs. The ideators who participate in the platform shall be start-ups who still have not procured their place in the stock market, hence, are not listed. The investors obtain tokens for their participation in the market using which they can reap various incentives.

4.2 The Blockchain Network

Investopolis will be deployed on a private permissionless blockchain network. Thus, the interested customers shall require prior permission and verification by administrators of the network before they could enter the network and perform transactions. The stakeholders who already a part of the network do not require any permission whenever they perform a read/write transaction within the network.

The consensus mechanism that Investopolis encompasses is Proof of Authority (PoA). This mechanism is used in cases where identity/reputation can be kept as a stake. The ideators and investors, as they are verified, will act as validators of new blocks. As the number of stakeholders in the network increase, the extent of decentralization increases proportionally.

4.3 Stakeholders of the Network

There are five kinds of stakeholders in the Investopolis' private permissionless blockchain network. They are:

- **Administrators (Admin):** These users are involved in verification of new users of the dApp and broadcasting important announcements to the already existing network participants. Administrators can also aid verified users towards various actions that can be performed in the platform. As the number of administrators in the network increase, the decentralization of authority over verification and allowance of new users to the network increase.
- **Ideators:** Ideators are verified start-ups or unlisted companies who need investors who can buy their shares and contribute towards the upliftment of their company.
- **Vendors:** Vendors are verified NFT creators who need investors who can buy their digital arts or photographs.
- **Registrars:** Registrars are verified government officials from the Sub-Registrar offices of various localities who perform verification of property registration and transfer of ownership transactions.
- **Investors:** Investors are verified users who wish to invest on shares of unlisted companies in order to obtain long term profits as the market value of the shares the company offers increase; who wish to buy/sell real-estate properties; who wish to buy/sell NFTs minted on the platform. These users are eligible to various rewards based on different actions they perform on the platform. These rewards act as incentives which encourage them to invest again on other ideators.

4.4 Features and Characteristics

The Investopolis Platform offers various features to each stakeholder in the network. We shall ponder over each of them below.

4.4.1 Features offered to Administrators

- **Verification of New Users:** The Administrator can get the information about recently registered new users along with identity proofs (Aadhar in this case) in order to perform verification before they are allowed to perform transactions within the network. This is implemented to eliminate anonymity of users that can shield the network from potential money laundering cases.

- **List of Verified Users:** The Administrator can obtain entire information about all the participants of Investopolis so that it could help him analyse the way Investopolis is tackling the problem statement. PS: Personal Information of users like mobile numbers, addresses and Aadhar numbers will not be visible even to the admin in this case.
- **Broadcast:** The administrators can broadcast announcements either to all the users in the network/ only to ideators/ only to investors or can even offer assistance to a particular user through this feature.

4.4.2 Features offered to Ideators

- **Network Inspection:** Ideators can view the metadata of the last 10 blocks which have been mined into the Investopolis network. Metadata includes Block Height, Block Hash, Parent Hash, Gas used, Gas Limit, Transaction hashes, etc.
- **Post Company Valuation:** The ideators can post information about their company such as the number of shares they offer, the face value of each share and the assets and liabilities that the company pertains. The current market value will be automatically computed every time the ideator updates his current assets and liabilities value after proper valuation from the auditors
- **Chat with Investors:** An ideator can personally chat with their potential investors to let them know more about the company and understand the projects/other works they are currently pursuing which might prove to be significant in the investors deciding whether or not to invest on them.

4.4.3 Features offered to Vendors

- **Network Inspection:** Vendors can view the metadata of the last 10 blocks which have been mined into the Investopolis network. Metadata includes Block Height, Block Hash, Parent Hash, Gas used, Gas Limit, Transaction hashes, etc.
- **NFTs:** The Vendors can mint new NFTs on the blockchain network and view them whenever the wish to. In case they decide on selling an NFT to an investor, they can mark it as “Interested to sell” at a certain price.
- **Chat with Investors:** A vendor can personally chat with their potential investors to let them know more about the artwork or photograph that he/she has minted and make the investors understand its value.

4.4.4 Features offered to Registrars

- **Transaction Verifications:** The Registrars can get the information about recently registered/pending transfers of ownership in his locality in order to perform verification and validation of transactions before they are appended to the network.
- **Communicate with Investors:** A Registrar can perform one-way communication with a chosen investor in case he/she needs to indicate changes in application towards a property transaction whose request the investor has submitted prior.
- **Profile:** The registrar can set up his regional restrictions, current value of Stamp Duty, Transfer Duty, and Registration fees at his locality using this feature.

4.4.5 Features offered to Investors:

- **Network Inspection:** Investors can view the metadata of the last 10 blocks which have been mined into the Investopolis network. Metadata includes Block Height, Block Hash, Parent Hash, Gas used, Gas Limit, Transaction hashes, etc.
- **Invest Upon Ideators:** The investors can view information about an ideator such as the number of shares they offer, the face value of each share and its current market value. The investors can even inspect and analyse the market growth of the ideator over a period of time. This shall aid them in their decision-making of whether to invest on the ideator.
- **Invest Upon Real-Estate:** The investors can register information about already existing properties that he/she own on the platform and thereafter transfer the ownership of that property as and when he chooses to. The registrar assigned to his locality will review the application submitted, and might call the investor to the SRO (Sub-Registrar Office) for further formalities. After successful verification of the transaction, the registrar shall allow the transaction to be appended into the blockchain thereby causing the necessary changes in the property's metadata in the network to take place.
- **Invest Upon NFTs:** The investors can view information about NFTs that are minted and listed for sale by vendors. In case they wish to buy a particular NFT, they can do so in simple steps. Subsequently, they will be able to view their collection and can also perform listing for sale of any NFT they own from there on.
- **Chat with others:** An investor can personally chat with ideators, vendors or the Administrators to know more about the investment scenario.
- **Collect Tokens for Rewards:** As soon as the investor invests on the ideator, he will be awarded a token which can later be used to redeem a reward.

All these features implement a dApp which encompasses Verification, Security, and Loyalty

4.5 Transaction Fees

In addition to the gas fees that will be charged for every state change in the blockchain network, an investor charged a transaction fees of 1% on total investment and 0.001% on registration fees for every investment on unlisted shares and transfer of ownership transaction he/she does. There will be no transaction fees charged on all other transactions.

4.6 Tokens and Rewards

It has been illustrated in section 4.4 that every time an investor performs an investment on an ideator, he will be awarded a token. Whenever the count of tokens he/she has collected eventually reaches a certain number, he/she will be eligible to certain rewards.

Classification of Rewards for Stock-Exchange

- **URU:** Investors who invested on over 100 ideators are eligible for this reward. Redeeming the 100 tokens obtained provides immunity towards the transaction fee overhead for the next 20 investments. It is important to note that the investor must not have claimed any reward over the 100 investments made.
- **VIBRAN:** Investors who invested on over 50 ideators are eligible for this reward. Redeeming the 50 tokens obtained provides 80% immunity towards the transaction fee overhead for the next 10 investments. It is important to note that the investor must not have claimed any reward over the 50 investments made.
- **KRYPTON:** Investors who invested on over 20 ideators are eligible for this reward. Redeeming the 20 tokens obtained provides 50% immunity towards the transaction fee overhead for the next 5 investments. It is important to note that the investor must not have claimed any reward over the 20 investments made.
- **ADAMANT:** Investors who invested on over 10 ideators are eligible for this reward. Redeeming the 10 token can provides 10% immunity towards the transaction fee overhead for the next 10 investments. It is important to note that the investor must not have claimed any reward over the 10 investments made.

Classification of Rewards for Real-Estate

- **TITAN:** Investors who invested on over 16 times are eligible for this reward. Redeeming the 16 tokens obtained provides immunity towards the transaction fee overhead for the next

20 investments. It is important to note that the investor must not have claimed any reward over the 16 investments made.

- **SAKAAR:** Investors who invested on over 8 times are eligible for this reward. Redeeming the 8tokens obtained provides 80% immunity towards the transaction fee overhead for the next 10 investments. It is important to note that the investor must not have claimed any reward over the 8 investments made.
- **MORAG:** Investors who invested on over 4 times are eligible for this reward. Redeeming the 4 tokens obtained provides 50% immunity towards the transaction fee overhead for the next 5 investments. It is important to note that the investor must not have claimed any reward over the 4 investments made.
- **XANDAR:** Investors who invested on over 2 times are eligible for this reward. Redeeming the 2 token can provides 10% immunity towards the transaction fee overhead for the next 10 investments. It is important to note that the investor must not have claimed any reward over the 2 investments made.

The phenomenon of awarding these incentives over transaction fees for investments will induce customer loyalty in the Investopolis Network.

5.

Implementation of Investopolis

As we have discussed about the working principles, features, and characteristics of the platform we developed, we shall now ponder over the implementation of such a platform.

5.1 Tech Stack

In order to implement any platform, one needs to fixate upon the technologies he/she is going to employ. Here are the technologies our team used to implement Investopolis:

- **dApp Frontend:** The frontend of the decentralized application is developed using regular web technologies like HTML, CSS, JavaScript, and jQuery JS Framework. For showcasing the market growth of an ideator, DESMOS Graphing API has been used. For establishing the connection between the frontend and the blockchain network, a node package referred to as web3.js has been used. For showcasing maps in Real-estate related features, Google Maps API has been employed. To avoid encroachment of properties while registering them on the platform, Turf.js has been used for topography analysis. To download files stored on IPFS, DownloadJS has been used. For animation of particles on the welcome page, ParticleJS has been used.
- **Blockchain Network:** Investopolis has been targeted to be deployed in the Ethereum Blockchain Network. For testing the working of the decentralized application through the development, Ganache has been used. In the final stages of the network, GETH (Go Ethereum) Client has been used to analyse the working of Proof of Authority in a Private Permissionless Network.
- **Smart Contracts:** For the development of Smart Contracts, Remix Ethereum IDE has been used. All the smart contracts have been written in Solidity. Open-Zeppelin smart contract templates have been used to implement ERC20 Tokens.
- **Wallet:** Metamask has been used to import accounts and perform transactions

- **IPFS:** The Beta Version of IPFS.IO's JavaScript CDN has been employed previously to store and access Identity Proof Documents of the new users during verification stage. But, it has its limitations with respect to availability of files. Thus, web3storage has been employed as an IPFS solution for this project as it ensures availability of files by broadcasting the file to multiple peers in the network.

5.2 User Interface

Snapshots in the following subsections illustrate the UI of Investopolis in various use case scenarios.

5.2.1 Welcome Page

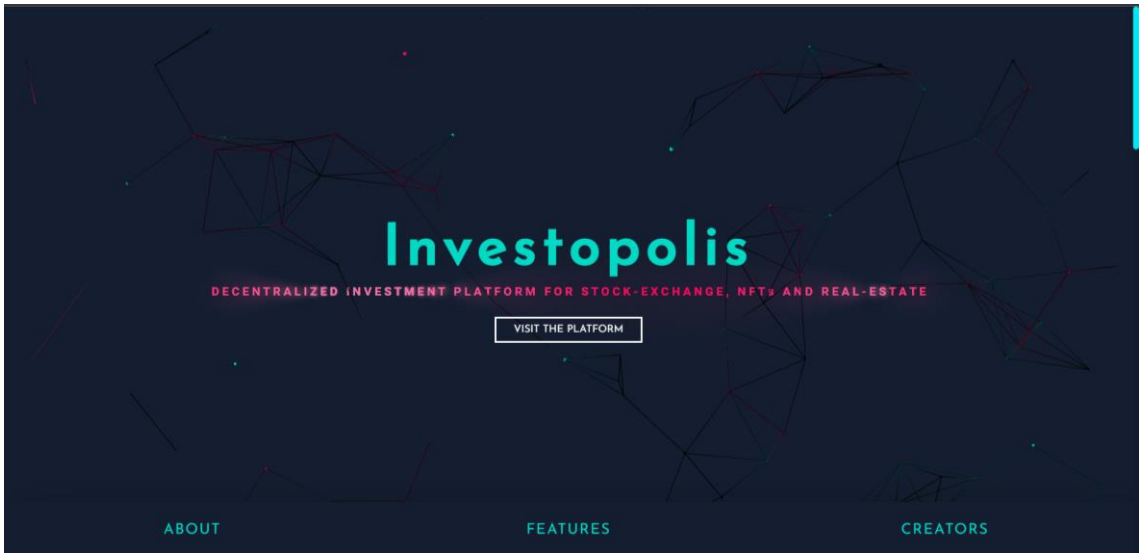


Fig 5.1: User Interface of the Welcome Page

5.2.2 Login/Registration Page

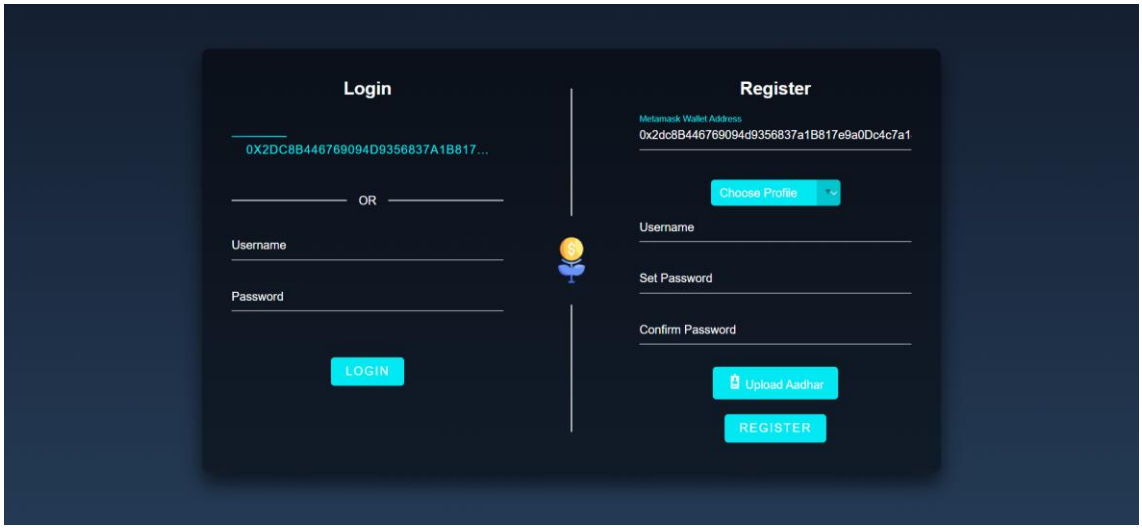


Fig 5.2: User Interface of the Login/Registration Page

5.2.3 Admin Panel

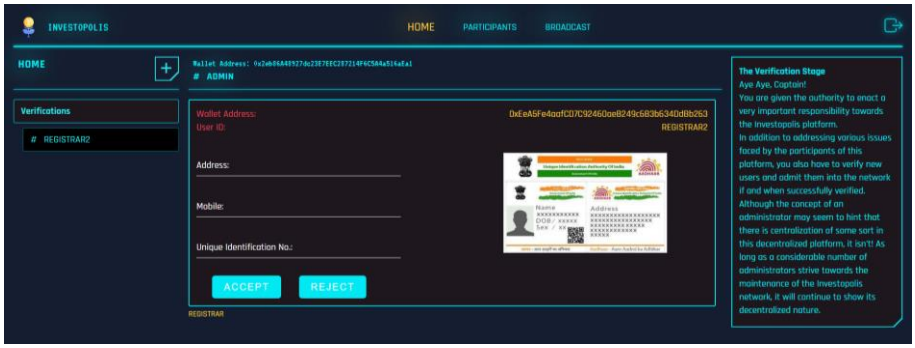


Fig 5.3: User Interface of Admin Panel's Home Page

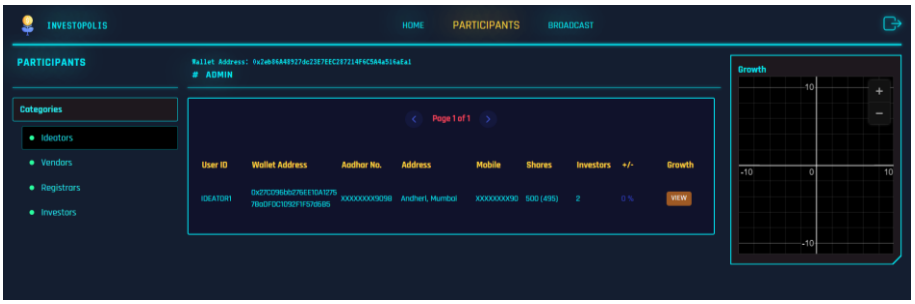


Fig 5.4: User Interface of Admin Panel's Participants Page

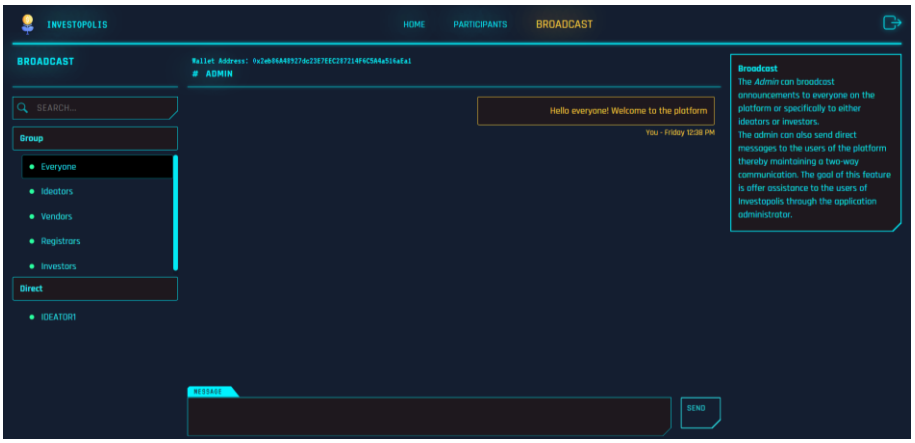


Fig 5.5: User Interface of Admin Panel's Broadcast Page

5.2.4 Ideator Panel

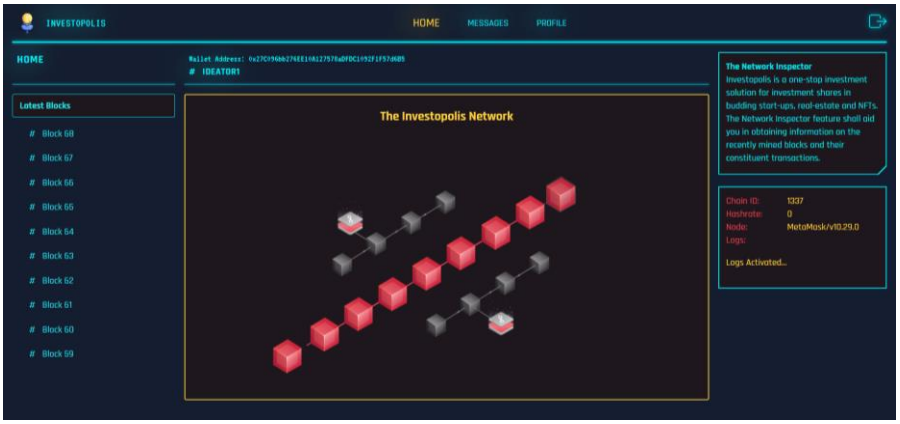


Fig 5.6: User Interface of Ideator Panel's Home Page

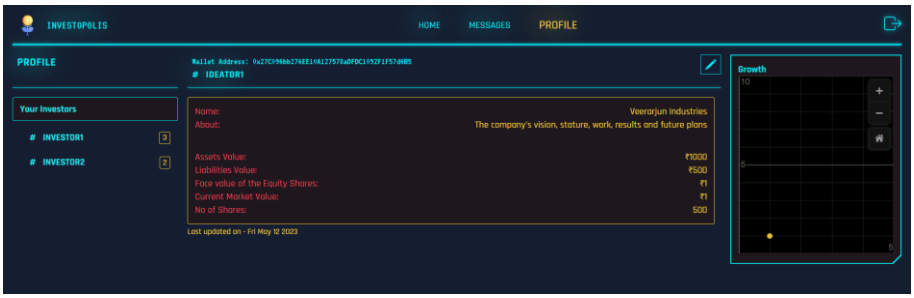


Fig 5.7: User Interface of Ideator Panel's Profile Page

The "Messages" page is similar in look to the Broadcast Page of Admin Panel.

5.2.5 Vendor Panel

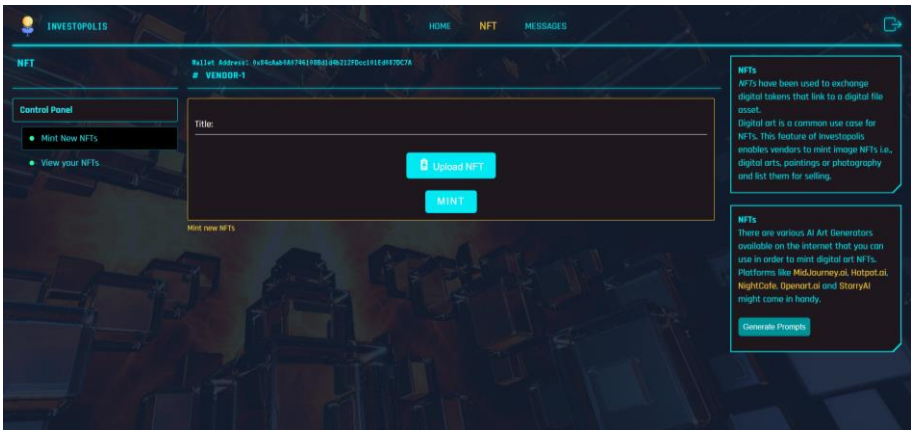


Fig 5.8: User Interface of Vendor Panel's NFT Page

The "Home" and "Messages" pages are similar in look to the that of Admin Panel.

5.2.6 Registrar Panel

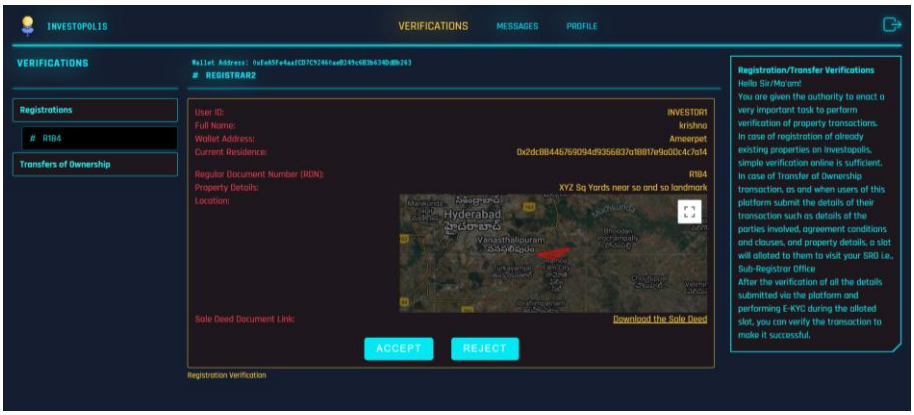


Fig 5.9: User Interface of Registrar Panel's Verifications Page

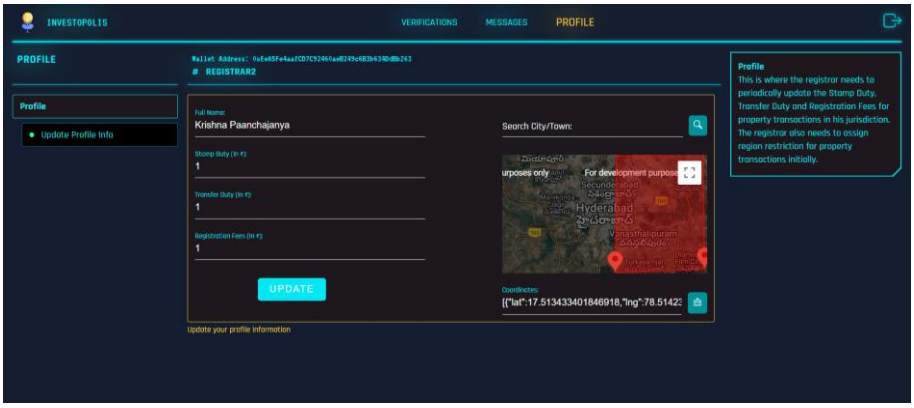


Fig 5.10: User Interface of Registrar Panel's Profile Page

The "Messages" page is similar in look to the Broadcast Page of Admin Panel.

5.2.7 Investor Panel

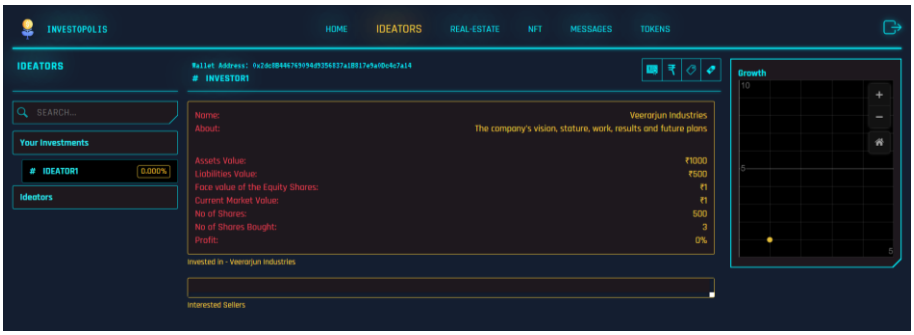


Fig 5.11: User Interface of Investor Panel's Ideators Page

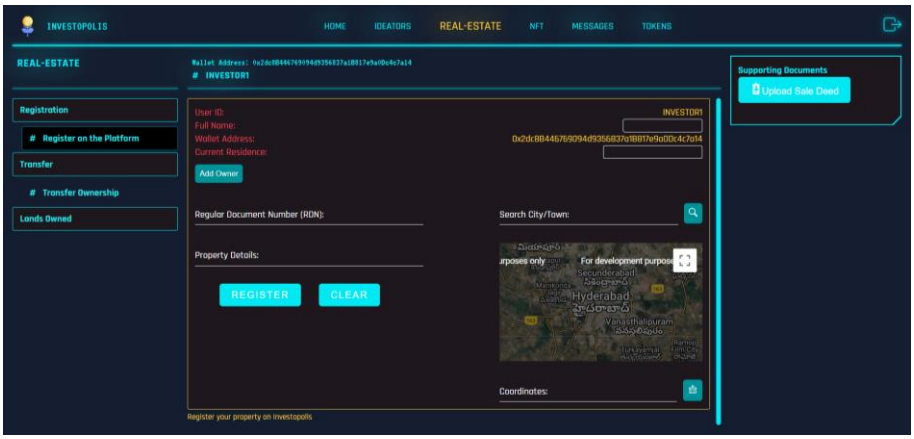


Fig 5.12: User Interface of Investor Panel's Real-Estate Page

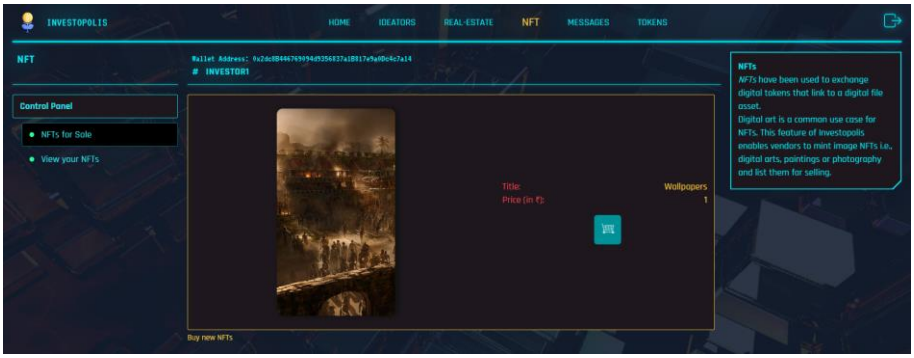


Fig 5.13: User Interface of Investor Panel's NFT page

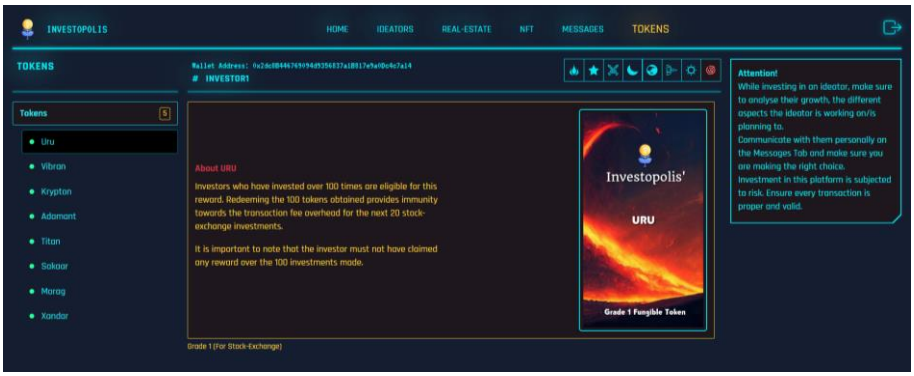


Fig 5.14: User Interface of Investor Panel's Tokens Page

The "Messages" page is similar in look to the Broadcast Page of Admin Panel.

5.3 Smart Contracts

There have been several smart contracts written to initiate and execute Blockchain Transactions and store the business logic of Investopolis. They are classified as follows:

- context.sol: Provides context to any transaction i.e., details of the user who initiated the transaction
- users.sol: Implements user management in the platform
- messages:sol: Implements messaging feature for various user roles in the platform
- shares.sol: Implements the investment scenario of unlisted shares
- lands.sol: Implements the investment scenario of Real-Estate
- nfts.sol: Implements the investment scenario of NFTs. Employs ERC-720
- tokens.sol: Implements Customer Loyalty Program through tokenization in Investopolis. Employs ERC-20

5.4 Deployment Strategy

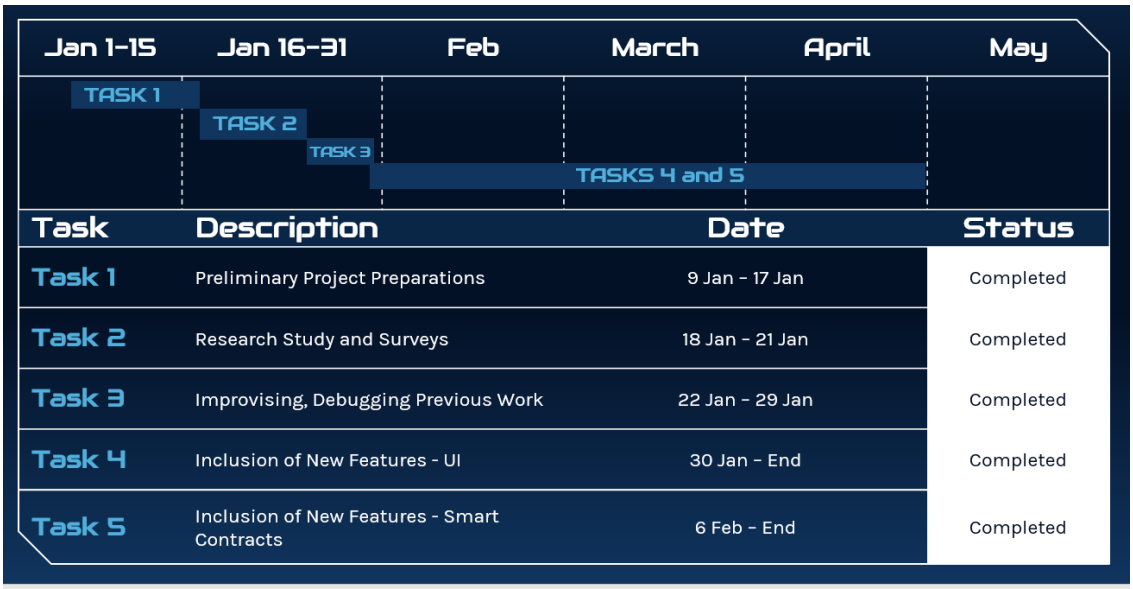
The User Interface is placed on a virtual machine powered by Amazon Web Services' (AWS) EC2 service. We have employed XAMPP's Apache to serve the requested wb pages. The Smart Contracts are currently deployed on the Goerli Test Network for the sake of simplicity and price optimization. The actual deployment Strategy that should be implemented to establish Investopolis on a private permissionless blockchain network involves setting up GETH (Go Ethereum) client and creating nodes on multiple EC2 instances in order to mimic the architecture of a decentralized Ethereum blockchain network. These nodes will be synced in order to store multiple copies of the immutable blockchain network and perform Proof of Authority Consensus Mechanism every time blocks or its constituent transactions are attempted to be mined into the network.

6.

Gannt Chart

The following figure illustrates the outline of several tasks that were to be accomplished in order to complete the development of the decentralized investment platform for Stock Exchange, Real-Estate, and NFTs i.e., “Investopolis”.

The tasks span from literature review and research survey to UI Design, development of smart contracts, testing and deployment.



Task	Description	Date	Status
Task 1	Preliminary Project Preparations	9 Jan - 17 Jan	Completed
Task 2	Research Study and Surveys	18 Jan - 21 Jan	Completed
Task 3	Improvising, Debugging Previous Work	22 Jan - 29 Jan	Completed
Task 4	Inclusion of New Features - UI	30 Jan - End	Completed
Task 5	Inclusion of New Features - Smart Contracts	6 Feb - End	Completed

Fig 6.1: Minimized Gannt Chart

In case you need to view an in-detail list of tasks, the dates in which they were completed and other associated data, please refer to the appendices.

7.

Challenges Faced

Our team had less expertise in developing decentralized applications on a private permissionless blockchain network prior to last year. But, we gained proficiency in it after learning the underlying concepts and practising initializing such networks in GETH Client. We also gained profound amount of knowledge on deployment strategies for decentralized applications built on private permissionless blockchain networks i.e., consortium blockchain networks.

Another significant speed breaker that we came across was the Contract code size warnings that were raised during the development of Smart Contracts. Ethereum Smart contracts' byte code size had a maximum limit introduced in the Spurious Dragon iteration. Some of our contracts had functionalities that were extending beyond the maximum limit laid. We had to create separate contracts and perform other workarounds in JavaScript in order to counter the difficulty.

As far as challenges are concerned, these were the only speed-breakers our team has come across.

8.

Results and Discussions

As far as the outcome of this project is concerned, after the ideation and implementation of an ensemble of features to attain the objectives that we sketched out initially to tackle the problem statement, we obtained a decentralized web application that has the ability to invest upon shares of budding startups that are currently unlisted in the Stock-Exchange, manage property transactions such as registration and transfer of ownership in a smooth and efficient manner, and collect and trade photographs, digital arts generated by either Artificial Intelligence powered generators or paint tools, etc.

After performing the deployment of Investopolis, the User Interface now lies on an EC2 server which can now serve the application at the URL https://ec2-44-203-182-197.compute-1.amazonaws.com/dashboard/. It is to be noted that this URL only serves the codebase for the User Interface. In order to access a full-fledged application, one has to deploy the Smart Contracts in a blockchain network of choice. The entire codebase is committed to a GitHub Repository located here. Only collaborators who are given prior permission to view the repository can access it.

Although the current iteration of the platform is sufficient to roll out in the market, it still has some additional features that could be added in order to become a full-fledged investment platform. The additional features include an Artificially Intelligent System that helps investor get an idea on the forecasted growth of an ideator's company, showcases relevant NFTs for sale in accordance to user's prior NFT trade.

From the technical standpoint, some other additions include employing the Twilio SMS Service in order to notify users about any activity that has taken place relevant to them while they were offline, upscaling in terms of Smart Contracts for Load Handling, and CSS Responsiveness in some dimensions.

9.

Summary and Conclusions

Thus, an investment platform – Investopolis – has been ideated and implemented that performs tokenization of customer loyalty programs on Ethereum Blockchain Network. The platform establishes high standards of security due to the nature of its network being private and permissionless and the technologies used like Smart Contracts and IPFS in various aspects like Storage and access control.

As security concerns inherent to any application such as encryptions for Brute Force Attacks, withstanding Fraudulent Resource Consumption, invalid authorization and avoiding race conditions in Smart contracts have been considered during the development, the Investopolis Platform is completely secure and stable in its current state.

10.

Appendices

10.1 Appendix I: Research Survey Responses

Table 10.1 Responses from the Research Survey

Q1	Q2	Q3	Q5	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q16	Q17	Q19	Q20	Q21	Q22
No	No	No	Maybe	Quarterly	3	Maybe	Somewhat important	2	Yes	Somewhat important	No	Moderate Understanding	3	No	Maybe	Maybe	Maybe
Yes	Yes	Yes	Maybe	Every time you purchase	3	Maybe	Somewhat important	1	Yes	Very important	Yes	Moderate Understanding	3	Maybe	Maybe	Yes	Maybe
Yes	Yes	No	No	Quarterly	3	Maybe	Somewhat important	4	Maybe	Somewhat important	No	Moderate Understanding	3	No	Yes	No	Yes
Yes	Yes	Yes	Maybe	Every time you purchase	5	No	Somewhat important	5	Yes	Very important	No	Moderate Understanding	3	Maybe	No	No	Maybe
Yes	Yes	No	Yes	Monthly	2	Maybe	Somewhat important	3	Yes	Very important	No	Limited Understanding	5	Yes	Yes	Yes	No
Yes	Yes	Yes	Yes	Annually	5	Maybe	Very Important	5	Maybe	Very important	No	Moderate Understanding	5	Maybe	Maybe	Maybe	Maybe
No	Yes	No	Maybe	Every time you purchase	3	Maybe	Somewhat important	3	Maybe	Somewhat important	No	Limited Understanding	3	Maybe	Yes	Yes	Maybe
No	Yes	Yes	Yes	Monthly	4	Yes	Very Important	4	Yes	Very important	No	Limited Understanding	5	No	No	No	No
Yes	Yes	Yes	Yes	Every time you purchase	4	Maybe	Somewhat important	2	Yes	Very important	No	Strong Understanding	4	No	Maybe	No	Yes
No	Yes	Yes	Maybe	Monthly	2	No	Somewhat important	1	Yes	Very important	No	Limited Understanding	3	Maybe	Maybe	No	Maybe
Yes	Yes	Yes	Yes	Every time you purchase	5	Yes	Very Important	1	Yes	Very important	No	Limited Understanding	4	No	Maybe	Maybe	Yes
Yes	Yes	No	No	Monthly	3	No	Somewhat important	1	No	Very important	Yes	Limited Understanding	4	Yes	Yes	Yes	No
No	No	No	Yes	Every time you purchase	5	No	Very Important	2	Yes	Very important	No	Strong Understanding	5	Yes	Yes	Yes	Yes
No	Yes	No	Maybe	Every time you purchase	3	No	Not important	4	No	Very important	Yes	Moderate Understanding	2	No	Maybe	Maybe	Yes
Yes	Yes	Yes	Maybe	Every time you purchase	3	Maybe	Somewhat important	1	Yes	Somewhat important	No	Strong Understanding	3	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Maybe	Every time you purchase	4	Maybe	Somewhat important	3	Yes	Very important	No	Strong Understanding	5	Yes	Yes	Maybe	Maybe
Yes	Yes	Yes	Maybe	Every time you purchase	4	No	Somewhat important	3	Maybe	Very important	Yes	Limited Understanding	4	Maybe	Yes	Maybe	No
Yes	Yes	Yes	Maybe	Every time you purchase	2	No	Very Important	1	Yes	Very important	Yes	Limited Understanding	1	Yes	No	No	No
Yes	Yes	Yes	No	Every time you purchase	2	Maybe	Somewhat important	2	Maybe	Somewhat important	No	Moderate Understanding	2	Maybe	Maybe	Maybe	Maybe
Yes	Yes	No	Yes	Quarterly	3	No	Somewhat important	3	Maybe	Somewhat important	Yes	Strong Understanding	5	Maybe	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Every time you purchase	4	No	Somewhat important	2	Yes	Very important	No	Strong Understanding	3	No	No	No	Maybe
Yes	Yes	Yes	No	Every time you purchase	3	No	Not important	2	Maybe	Somewhat important	No	Moderate Understanding	4	Maybe	Maybe	No	Yes
Yes	Yes	No	Yes	Monthly	5	No	Somewhat important	2	Maybe	Very important	No	Limited Understanding	4	Yes	Yes	Yes	No
Yes	No	No	No	Every time you purchase	1	No	Somewhat important	5	Maybe	Very important	No	Moderate Understanding	1	No	Maybe	Maybe	Maybe
Yes	Yes	Yes	Yes	Every time you purchase	2	Maybe	Very Important	2	Yes	Somewhat important	Yes	Moderate Understanding	5	No	Yes	No	Yes
Yes	Yes	Yes	Yes	Every time you purchase	3	No	Somewhat important	1	Maybe	Not important	Yes	Limited Understanding	5	No	Yes	Yes	No
Yes	Yes	Yes	Yes	Monthly	3	Maybe	Somewhat important	1	Yes	Not important	No	Limited Understanding	5	No	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Every time you purchase	2	Yes	Somewhat important	1	Yes	Not important	No	Limited Understanding	5	Maybe	Yes	No	No
No	No	No	Yes	Quarterly	3	Yes	Very Important	1	Yes	Not important	No	Limited Understanding	5	No	Yes	Maybe	Yes
Yes	Yes	Yes	No	Every time you purchase	4	No	Somewhat important	3	No	Very important	No	Limited Understanding	5	No	Yes	No	Yes
Yes	Yes	Yes	Maybe	Every time you purchase	2	Yes	Somewhat important	3	Yes	Somewhat important	No	Moderate Understanding	4	Yes	Yes	Maybe	Maybe
No	Yes	No	Maybe	Every time you purchase	1	No	Somewhat important	3	Maybe	Very important	No	Limited Understanding	5	No	Yes	Maybe	Maybe
Yes	Yes	No	Yes	Every time you purchase	5	Maybe	Somewhat important	1	Yes	Very important	Yes	Limited Understanding	5	No	Maybe	Maybe	Maybe
Yes	Yes	Yes	Maybe	Every time you purchase	5	Maybe	Not important	3	Yes	Not important	No	Moderate Understanding	4	Yes	Maybe	Maybe	Maybe
Yes	Yes	Yes	Yes	Monthly	3	Yes	Very Important	2	Yes	Very important	No	Moderate Understanding	5	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Monthly	5	Yes	Very Important	1	Yes	Very important	No	Strong Understanding	5	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Monthly	2	No	Not important	2	Yes	Very important	No	Strong Understanding	5	No	Maybe	No	No
Yes	Yes	Yes	Yes	Monthly	3	No	Very Important	3	Yes	Very important	No	Strong Understanding	4	No	Yes	Yes	Yes
Yes	No		Maybe	Quarterly	1	No	Very Important	1	Yes	Very important	No	Moderate Understanding	1	No	No	Yes	No
Yes	Yes	Yes	Yes	Monthly	3	No	Very Important	2	Yes	Very important	No	Moderate Understanding	4	Yes	Yes	Maybe	No
No	No		No	Monthly	3	Maybe	Somewhat important	2	Yes	Very important	No	Moderate Understanding	5	No	Yes	Yes	No
Yes	No		No	Monthly	3	Yes	Somewhat important	3	No	Somewhat important	Yes	Moderate Understanding	3	No	No	No	No
Yes	Yes	Yes	Yes	Every time you purchase	4	Maybe	Somewhat important	1	Yes	Very important	No	Strong Understanding	4	No	Maybe	Maybe	Maybe
Yes	Yes	Yes	Yes	Every time you purchase	1	No	Very Important	4	Yes	Very important	No	Moderate Understanding	4	No	No	No	No
Yes	Yes	No	Maybe	Every time you purchase	2	No	Not important	3	Yes	Very important	No	Moderate Understanding	4	Maybe	Maybe	Maybe	Maybe
Yes	No		Yes	Monthly	3	Maybe	Very Important	3	Yes	Very important	No	Moderate Understanding	5	Maybe	Yes	Yes	Yes
Yes	Yes	No	Yes	Every time you purchase	1	Maybe	Very Important	1	Yes	Somewhat important	No	Strong Understanding	5	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Every time you purchase	2	Maybe	Somewhat important	4	Yes	Very important	No	Strong Understanding	5	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Monthly	4	Maybe	Somewhat important	2	Yes	Very important	No	Strong Understanding	5	Yes	Maybe	Yes	Yes
Yes	Yes	Yes	Yes	Every time you purchase	4	Maybe	Somewhat important	2	Yes	Somewhat important	No	Limited Understanding	4	Yes	Yes	Maybe	No
Yes	Yes	Yes	Maybe	Annually	3	Yes	Somewhat important	4	Yes	Somewhat important	No	Limited Understanding	4	No	Yes	No	Yes
Yes	Yes	Yes	Maybe	Every time you purchase	2	No	Somewhat important	3	Maybe	Very important	No	Limited Understanding	1	No	Yes	Yes	Yes
Yes	No		Maybe	Every time you purchase	2	Maybe	Somewhat important	3	Yes	Somewhat important	No	Moderate Understanding	3	Maybe	Maybe	Maybe	Yes
Yes	Yes	Yes	Maybe	Every time you purchase	1	No	Very Important	3	Yes	Very important	Yes	Moderate Understanding	4	No	Yes	Maybe	Maybe

Each row in the above table indicates responses of a subject. Responses to Questions 4, 6, 15, and 18 are not mentioned here as they are subjective. You can refer to them in the Excel Sheet consisting of all the Form Responses. You can find the form here.

10.2 The Full-Fledged Gannt Chart

Table 10.2 Complete Gannt Chart

TASK	PROGRESS	START	END
Phase 1: Preliminary Project Preparations			
Ideating various features to be added	100%	09-Jan-23	10-Jan-23
Ideation of Real-Estate Investment Feature studying property registrati	100%	19-Feb-23	22-Feb-23
Preparation of Work Synopsis	100%	13-Jan-23	13-Jan-23
Sketching out the TechStack that shall be used for the Project	100%	14-Jan-23	14-Jan-23
Development of a Wireframe for the Web Application	100%	15-Jan-23	16-Jan-23
Exploratory Analysis of suitable solution for IPFS	100%	13-Mar-23	15-Mar-23
Listing out Security Loopholes and ideation of counter strategies	100%	01-Mar-23	04-Mar-23
Understanding the Procedure for Deployment on AWS	100%	17-Jan-23	17-Jan-23
Phase 2: Research Study and Surveys			
Gathering Research Papers relevant to Reward Systems on Blockchain	100%	18-Jan-23	18-Jan-23
Preparing Literature Review papers gathered	100%	19-Jan-23	21-Jan-23
Research Survey on Loyalty programs from Investment Perspective	100%	21-Jan-23	21-Jan-23
Phase 3: Improvising and Debugging Previous Work			
IPFS and Asynchronous Call bugs and glitches clearance	100%	22-Jan-23	22-Jan-23
Improvising Message Architecture and Styling	100%	23-Jan-23	24-Jan-23
Password Hashing	100%	25-Jan-23	25-Jan-23
Restriction of access to public functions in smart contracts	100%	25-Jan-23	25-Jan-23
Making the Platform responsive for Mobile-access	100%	26-Jan-23	29-Jan-23
Phase 4: Inclusion of New Features - UI			
Creation of a Welcome Page and 404 Page	100%	30-Jan-23	31-Jan-23
Adding new roles and making necessary changes to login UI	100%	05-Feb-23	05-Feb-23
"Add Admin" and "Verified By" features	100%	07-Feb-23	07-Feb-23
Participants feature UI in Admin Panel	100%	09-Feb-23	09-Feb-23
Investor Judgement Score functionality UI in Participants Page	100%	09-Feb-23	09-Feb-23
Vendor and Registrar Broadcast UI in Admin Panel	100%	11-Feb-23	11-Feb-23
UI and JS for Transaction Logs functionality in Network Inspectors	100%	13-Feb-23	13-Feb-23
Share Document Auto-Generation feature	100%	14-Feb-23	16-Feb-23
Resale of Shares	100%	16-Feb-23	05-Mar-23
Inclusion of Real-Estate and NFTs pages in Investor Panel	100%	17-Feb-23	17-Feb-23
Skeleton UI Development of Vendor Panel	100%	18-Feb-23	18-Feb-23
Skeleton UI Development of Registrar Panel	100%	19-Feb-23	19-Feb-23
Implementing Google Maps in Registrar and Investor UI	100%	10-Mar-23	12-Mar-23
Implementing File Storage using IPFS with the help of web3storage	100%	16-Mar-23	18-Mar-23
NFTs UI in Vendor Panel	100%	19-Mar-23	25-Mar-23
Profile and Verifications Page in Registrar Panel	100%	25-Mar-23	31-Mar-23
Completion of Real-Estate and NFTs UI in Investor Panel	100%	01-Apr-23	05-Apr-23
Phase 5: Inclusion of New Features - Smart Contracts			
Adding new roles by modifying users.sol	100%	06-Feb-23	06-Feb-23
"Add Admin" and "Verified By" features	100%	07-Feb-23	07-Feb-23
Participants feature in Admin Panel smart contract functions	100%	10-Feb-23	10-Feb-23
Investor Judgement Score functionality in Participants Page	100%	11-Feb-23	11-Feb-23
Vendor and Registrar Broadcast Smart Contract functions	100%	12-Feb-23	12-Feb-23
Verification ID generation and Verifying functionality in Solidity	100%	16-Feb-23	16-Feb-23
Real-Estate Investment Smart Contract Functionalities	100%	06-Apr-23	15-Apr-23
NFTs Smart Contract Functionalities	100%	15-Apr-23	25-Apr-23

11.
References

[1] Rosa M. Garcia-Teruel (2020) Legal challenges and opportunities of blockchain technology in the real estate sector. *Journal of Property, Planning and Environmental Law Vol. 12 No. 2*

[2] Iftikhar Ahmad, Mohammed A. Alqarni, Abdulwahab Ali Almazroi and Laiba Alam (2021) Real Estate Management via a Decentralized Blockchain Platform. *Computers, Materials & Continua, Vol. 66 No. 2*

[3] Schär, Fabian (2021) Decentralized finance: On blockchain-and smart contract-based financial markets. *FRB of St. Louis Review*.

[4] John, Kose, Leonid Kogan, and Fahad Saleh (2022) Smart Contracts and Decentralized Finance. *Available at SSRN* (2022).

[5] Qin, Kaihua (2021) CeFi vs. DeFi--Comparing Centralized to Decentralized Finance. *arXiv preprint arXiv:2106.08157*.

[6] DuPont, Quinn (2017) Experiments in algorithmic governance: A history and ethnography of "The DAO", a failed decentralized autonomous organization. *Bitcoin and beyond*: *157-177.*

[7] Üslü, Semih (2019) Pricing and liquidity in decentralized asset markets. *Econometrica 87.6: 2079-2140.*

[8] Udegbe, S. (2017) Impact of blockchain technology in enhancing customer loyalty programs in airline business. *Int J Innov Res Adv Stud, 4(6), pp.257-263.*

[9] Madhani, P.M. (2022) Blockchain Implementation in Marketing: Enhancing Effectiveness of Marketing Mix Strategy. *Marketing Mastermind, 19(2), pp.29-40.*

[10] Sun, Q., Dong, M. and Tan, A. (2022) An order allocation methodology based on customer repurchase motivation drivers using blockchain technology. *Electronic Commerce Research and Applications, 56, p.101218.*

12.

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