

MAKERERE UNIVERSITY

Virtual Portfolio Manager

By

BSE 22-26

BLOCKCHAIN and MOBILE APPLICATION PROJECT

DEPARTMENT OF NETWORKS

SCHOOL OF COMPUTING AND INFORMATICS TECHNOLOGY

A Project Report Submitted to the School of Computing and Informatics Technology

for the Study Leading to a Project in Partial Fulfillment of the

Requirements for the Award of the Degree of Bachelor of

Science in Software Engineering of Makerere University.

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Declaration

We, group BSE 22-26, hereby declare that the work presented is original and has never been submitted for an award to any university or institution of higher learning.

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Approval

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Dedication

We dedicate this report to our supervisors, Dr Nsabagwa Mary and Dr Joab Agaba who have persistently guided and contributed to the success of this project.

Additionally, we dedicate this report to Stanbic Innovation Hub Kampala which allowed the team to carry out the project studies that led to the success of the project.

Finally, we thank our loved ones who have supported us during the duration of this project.

Acknowledgements

We also deeply acknowledge the support of our supervisors Dr. Mary Nsabagwa and Dr. Joab Agaba who have tirelessly and consistently guided us throughout the conception, realization, design, and completion of this project. Your intellectual support has been a great asset to us. They have been very supportive and present to offer all the necessary guidance whenever we needed them.

We thank Stanbic Incubation Hub Kampala that allowed the team to carry out the project studies that led to the success of the project.

We would like to also extend our gratitude to our parents, guardians, friends, and everyone that has supported us in all ways possible to the end of this journey. We are truly grateful for the financial and moral support rendered.

Abstract

At present, the Crowdfunding source of raising funds typically for startups or projects has gained popularity with most startups resorting to the use of Crowdfunding platforms to raise funds in exchange for equity because it is relatively inexpensive and uncomplicated in nature. In the existing model, a Pool of people contribute small amounts of money towards a project or cause and expect some financial returns.

The call for a solution to issues related to security, investor abuse and, illegal transactions that could plague crowdfunding has led us to investigate the implications of blockchain in Crowdfunding. Blockchain technology is a decentralized ledger, a more efficient, safe and tamper-proof system of nodes in connection. Introduction of blockchain in crowdfunding will make it more reliable, transparent, trusted, decentralized, cost-efficient and convenient.

A crowdfunding platform which was acting as an intermediary before will only provide the technology and its own crypto-currency which will act as a medium of transaction and exchange. I highly anticipate that this project will drive the attention of researchers to delve into the applications of blockchain technology in Crowdfunding practicality.

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System Implementation, Testing and Validation Report for the Virtual Portfolio Manager(VPM)

Chapter 1: Introduction

1.1 Background and scope of the project

At present, Crowdfunding source of raising funds typically for startups or projects has gained popularity with most startups resorting to the use of Crowdfunding platforms to raise funds in exchange for equity because it is relatively inexpensive and uncomplicated in nature. In the existing model, a Pool of people contribute small amounts of money towards a project or cause and expect some financial returns. The call for a solution to issues related to security, investor abuse and illegal transactions that could plague crowdfunding has led me to investigate the implications of blockchain in Crowdfunding.

The Virtual Portfolio Manager (VPM) is a combination of a web and a mobile phone App system that integrates start-ups and investors. The VPM automatically links the investor's interested field of business with potential start-ups in the same field. The system helps startups to keep track of their financial progress from their profile and captures all daily and authentic activities of a startup and it can Rank all startups for investors to identify the best startups their issues out annual Certificates.

The VPM shall contain blockchain technology and manage and execute smart contracts between a startup and an investor. The electronic notary shall be used to affix the authorized seal and signatures to certified documents. The notary startup certificate issuing activity shall use cryptography and a secured public key to manage, create, store and distribute the digital certificate. The documents shall be saved on blockchain and any modifications on such documents are detected and easily traced through the timestamps placed on the documents. This technology shall ease investment in startups in a secured and authentic time-saving process.

The VPM system will be programmed in blockchain languages which include Solidity, NodeJs, and Flutter. The objective of the VPM system is to help improve the current state of investment protocols in the Business incubators in Uganda.

1.2 Overview of the document

This document describes the implementation, testing and validation findings for the VPM system. It is divided into the following sections:

- a) Section 1: This section describes the background and scope of the document. It also gives a general overview of the document describing the purpose of the system under

development.

- b) Section 2: This section describes and specifies the system completely and is the basis for the validation process. This section explains the validation activities done during the implementation of the project. It includes information about the tasks performed, methods used, and criteria for acceptance, input and output required for each task during validation and testing.
- c) Section 3: This section describes the implementation (coding and compilation). It describes the development tools used to implement the system, notes on anomalies, module and integration details, all device interfaces and equipment to be supported. It contains information about the modules, mobile phone used for the mobile phone application.
- d) Section 4: This section describes the testing of the VPM, the extent of the testing, the system acceptance test specification, the approach, complexity, risks, and the intended and expected use of the computer system.
- e) Section 5: This section describes the installation and system acceptance test for the system
- f) Section 6: This section describes the performance, servicing, maintenance for the system
- g) The appendix contains other relevant information for the users of the system.

Chapter 2. System Specifications

The section describes and specifies the system completely and is the basis for the validation process.

2.1 Version of requirements and Version Control

The requirements specified in the System Requirements Specification document (Version 1.0) were sufficient and approved. The team considered these requirements throughout the process of design and implementation of the system.

The VPM device has one version which is v1.0. We used Git and GitHub for version control during the mobile application development. The source code is available and can be accessed on GitHub.

2.2 Functionality

The VPM system has the following functionalities:

- The system shall authenticate all users.
- The system shall provide a mobile app interface to register business owners that will capture name, email and center.
- The system shall provide a web app interface to register investors, business owners, auditors and business hub owners that will capture name, email and center.
- The system shall operate the mobile app offline.
- The system shall collect different data about the businesses.
- The system shall display data collected about the businesses.
- The system shall have different permission levels such as auditor, guest, business owner, admin, investor.
- The system shall synchronize the mobile app data when connected to the internet.
- The system shall send alerts to specific events through email and notification popups.
- The system shall provide an interface to analyze business performance for the investor, auditor, business owner and business hub manager.
- The system shall log data collected to the ethereum blockchain.

2.3 Limitations and safety

- Due to infrastructure constraints, we shall deploy a localized testing ethereum blockchain to store data. We shall also validate transactions on the blockchain using the in-built test validator since it would be costly to do otherwise.

- The system requires an active internet connection to make transactions on the application.

2.4 Default settings

- The user has to register and login to the mobile application.
- The start ups have to register the business to the mobile application.
- The investor has to buy tokens in order to invest into a business.

2.5 Special requirements

- Our code is closed source.
- All data entered during the register or login session is kept confidential and sensitive data like passwords is encrypted for security.
- All the data the data on the application referring to the transactions of the the start ups is made public for investors to make decision on its basis

2.6 Errors and alarms

In the process of logging in, if the user logs in with wrong credentials, an error message will be displayed on top of the login form “invalid username or password, try again.”

Form validation of different fields is done at the point of user registration, and update such that the user only enters valid format of the respective fields. In the event of wrong user input, error messages are displayed to guide the user on the input.

Chapter 3: Design output

3.1 Implementation (Coding and Compilation)

3.1.1 Development tools

We used Visual studio code (VsCode), a streamlined source code editor with support for software development operations like debugging, task running and version control. VsCode was used for the backend development.

For front-end development, Android studio was used and it provides a unified environment in which applications suitable for android environments are built.

An android phone was used to execute and test the mobile application.

HP laptop and a mac book were used for the system development, calibration and data storage.

Ganache truffle suite was used to run a personal block chain network for testing and deploying our smart contracts in a deterministic environment.

3.2 Documentation

A Software Design Document for the virtual portfolio manager was written as output from the Design process. This document describes the architecture and system design and was intended to the project supervisor, system developers, system testers and caretakers.

Table 3-1 Design Details

Topics	Design output	
Good programming practice	Source code is... Modularized Encapsulated Functionally divided Fail safe <input type="checkbox"/> Strictly Compiled	Source code contains... Comments Meaningful names Readable source code <input type="checkbox"/> Revision notes <input type="checkbox"/> Printable Source code
Dynamic testing	All statements have been executed at least once All functions have been executed at least once All loops have been executed to their boundary <input type="checkbox"/> All case segments have been executed at least once <input type="checkbox"/> Some parts are not subject to dynamic tests	

Chapter 4: Inspection and testing

4.1 Introduction

Table 4-1 Inspection Plan and Performance

<i>Topics</i>	3.3.1 Inspection plan and performance	<i>Date / Initials</i>
Design output <i>Results from the Design Output section inspected...</i>	Program coding structure and source code Evidence of good programming practice Design verification and documented reviews <input type="checkbox"/> Change- control reviews and reports <input type="checkbox"/> Comments: The code structure is simple <input type="checkbox"/> and understandable.	11th/08/2022 B.K.E,B.J,K.L
Documentation <i>Documentation inspected.</i>	System documentation, flow charts, etc. User manuals, Online help, Notes, etc. Contents of user manuals approved <input type="checkbox"/> Test results <input type="checkbox"/> Comments: The user manual and system documentation are complete and available	15th/08/2022 B.K.E, B.J, K.L
Software development environment <i>Environment elements inspected...</i>	Data integrity File storage Access right <input type="checkbox"/> Code protection <input type="checkbox"/> Installation kit, replication and distribution	17th/08/2022 B.K.E, B.J, K.L
Result of inspection <i>Approval of inspection.</i>	Inspection approved	17th/08/2022 B.K.E, B.J, K.L

4.2 Test plan and performance

Create camp, buy equity and get details

- ✓ Create a new camp (260ms)
- ✓ Buy equity (287ms)
- ✓ Get camp details (92ms)

Buying over the target

- ✓ Create a new camp (230ms)
- ✓ Buy equity - 30 (242ms)
- ✓ Buy equity - 20 (298ms)
- ✓ Buy equity - 10 (Should not go through) (151ms)
- ✓ Checking the amount raised (84ms)

Checking the Angels and the numbers of Angels in the AngelList

- ✓ Create a new camp (244ms)
- ✓ Buy equity - 20 (194ms)
- ✓ Buy equity - 20 (252ms)
- ✓ Buy equity - 10 (261ms)
- ✓ Checking the amount raised (74ms)
- ✓ Checking the angel list length (80ms)
- ✓ Checking the angel address in the angel list (82ms)

Checking the funding amount for a angel

- ✓ Create a new camp (194ms)
- ✓ Buy equity - 20 (240ms)
- ✓ Buy equity - 25 (250ms)
- ✓ Checking the amount raised (93ms)
- ✓ Checking the funding amount for a angel (81ms)

Camp Collaboration

- ✓ Create a new camp (179ms)
- ✓ Buy equity - 20 (177ms)
- ✓ Checking the amount raised (105ms)
- ✓ Adding First collaborator with amount (194ms)
- ✓ Adding Second collaborator with amount (222ms)
- ✓ Fetching and checking camp collaborator (127ms)

26 passing (6s)

Figure 4-1 Test Cases

Table 4-2 Test plan and performance

Item to test	How to test	Expected output	Approved
MOBILE APPLICATION	It should be downloaded and installed on an android device	It should be able to install and open successively on an android phone	Yes
GANCHE	It should be download and installed on a server	It should be able to deploy smart contracts from the devices	Yes
NODEJS API	It should be deployed on server and await request from api endpoint	It should be able to respond with request status codes such as 404, 200, 202 etc	Yes

4.2.1 Test objectives

Table 4-3 Test objectives

What was tested	How it was tested	Why it was tested
Create Business	Mocha and Assert allows developers to perform in-depth testing of the smart contracts. We created	To verify that the application can create businesses and deploy them on the blockchain.

	mock data and called the necessary api end points.	
Buy Equity	We simulated buying with mobile money since we never had access to mobile money api	To verify that the application transfer tokens from one smart contract account to another and record it on the blockchain.
Get Business Details	We created mock business and call the necessary end points.	To verify that the application can pick the information from the mongodb database and blockchain.
Buying business over target	We created a mock investor, assigned investor funds and tested him buying over the targeted price required.	To prevent investors from investing beyond the required target requested by business.
Checking angel investors and number of investors	We created mock investors and assigned them business then queried them through the necessary end point api.	To verify that the application can pick the information from the mongodb database and blockchain
Checking funding amount from investor	We created mock investors and assigned them business then queried funding details from investor through the necessary end point api.	To verify that the application can pick the information from the mongodb database and blockchain

Creating Incubator collaborations	We created mock incubation hubs and assigned them business.	To verify that incubation hubs can manage businesses through collaborations.
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4.2.2 Scope and Relevance of tests

The tests included all the functionalities of the system. They were done on individual components to avoid complexity after integration.

Table 4-4 Test Scope

System Requirements	Test Coverage (%)	Test objective met
The system shall provide a mobile app interface for start-ups to register their businesses.	100	To allow start-ups to register their business on to the system
The system shall provide a mobile app interface for investors to register.	100	To give access to potential investor onto the system
The system shall provide an interface for start-ups to log in.	100	To give access to already existing start-ups into the system
The system shall provide an interface for investors to log in.	100	To allow investors already registered into the system

The system shall provide an interface for start-ups to view their wallets which hold all their funds.	100	For the start-ups to view how much funds they have collected from investors
The system shall have an interface where they create the businesses which are to be invested in.	100	Create a business to be viewed by potential investors.
The system shall have an interface for start-ups to view their created business.	100	Display businesses for potential investors to view
The system shall provide an interface for start-ups to manage their personal details	100	Start-ups view and edit personal details
The system shall provide an interface for businesses wishing to invest in the available start-ups to manage their personal details	100	Businesses wishing to invest in the available start-ups able to view and edit personal data
The system shall provide an interface to provide a help center for all its users	100	To provide assistance to the users.
The system shall provide an interface for investors to perform investment activities	100	Perform investments activities on the platform
The system shall provide an interface for the investor to buy tokens	100	Investor are able to buy tokens
The system shall provide an interface for investors to search for businesses.	100	Allow investor find businesses of their preference.
The system shall provide an interface for investors to see other business investors investing into the businesses within the system.	100	Investors view all the other investor investing into the business of interest

4.2.3 Levels of tests

Module test

Each module was tested to ensure that it worked as per its specification.

Integration test

All modules of the system were integrated into one and tested to ensure that the system worked well as a whole.

4.2.4 Types of tests

Input tests:

These were done to check whether the investors wishing into their preferred businesses are able to buy tokens for that business using known currency on the platform.

Functionality test:

This was done to check whether the system modules function as specified in the requirements specification document. It involved checking the performance of every system module and the system as a whole after integration.

Performance test:

This was done to verify that the business receives the funds as the investor buys the token. A certain amount of fund was viewed incrementing on the funds currently in the business wallet displaying the buyers user name which is also associated with his address.

Usability test:

This was done to check whether the system can be used with ease.

4.2.5 Sequence of tests

Input test cases

Check whether the increment of funds in the business wallet is equivalent to the number of tokens bought by the investor.

Check whether the mobile phone application can register , authenticate the logins, display the the registered businesses.

Display test cases

Check whether thebusiness's target investment fund is displayed correctly with accordance to the funds acquired..

Check whether the application displays the businesses registered.

Output test cases

Check whether a notification alerts business owners when funds are sent to his/her wallet.

4.2.6 Configuration and calculation tests

How long it takes for the funds to reflect in the business's wallet when transaction has been made..

4.3 Precautions

4.3.1 Anomalous conditions

Anomalies are events that differ from the standard events defined in the application.

Therefore, anomalous conditions in our application basically refer to the deviations of system from the user's expected behavior. From this application, the following are the possible anomalous conditions that may occur during operation of the application.

- The VPM system may take longer time complete transactions. Since its blockchain technology and it involves a network of node which are also performing other task on the network. It might a transaction between five and ten minutes to fully complete the transaction.

4.3.2 Precautionary steps taken

Ensure that only the owner of the business and maybe a few more who have access to business have the login credentials to prevent access to wallet.

Chapter 5: Installation and system acceptance test

5.1 Input files

The installation will only require a mobile phone running android operating system to install the VPM application APK.

5.2 Supplementary files

User manual will be provided to guide the users on how to use the application.

5.3 Installation qualification

Table 5-1 Checklist of the Installation and system acceptance test

<i>Topics</i>	Installation summary
Installation method <i>Automatic or manual installation...</i>	<input checked="" type="checkbox"/> Automatic - installation kit located on the installation media <input type="checkbox"/> Manual - Copy & Paste from the installation media Comments:
Installation media <i>Media containing the installation files...</i>	<input type="checkbox"/> Diskette(s) <input type="checkbox"/> CD-ROM <input checked="" type="checkbox"/> Source disk folder (PC or network) <input checked="" type="checkbox"/> Download from the Internet
Installed files	<ul style="list-style-type: none">• APK file

Table 5-2 Installation Procedure Check

<i>Topics</i>	Installation procedure	<i>Date / Initials</i>
Authorization	Person responsible: Development team lead	18th/05/2022 K.L
Installation test	<input checked="" type="checkbox"/> Tested and approved in a test environment <input checked="" type="checkbox"/> Tested and approved in actual environment <input type="checkbox"/> Completely tested according to test plan <input type="checkbox"/> Partly tested (known extent of update) Comments: Prototype currently works as expected.	20th/05/2022 K.L, B.J, B.K.E

Chapter 6: Performance, servicing, maintenance, and phase out

6.1 Service and maintenance

As all software systems evolve there are a number of issues that should be taken care of for the software to remain robust and reliable. These needs arise because of a number of factors including the change in the operating environment of the system, upgrades and updates in the technology and programming languages used among other factors. Because of these factors, systems require constant servicing and maintenance.

The team responsible for the development of this particular system is always available to work with the stakeholders on any anomalies that may arise while using the system. For this reason, the current system is the first of the many versions that are yet to come. This will be influenced by the different concerns from the users.

6.2 Performance and Maintenance

Many factors will inform the need for maintenance, these include too much delay in the synchronization of data to the online database for example beyond one minute. The other factor is where software component upgrades are required for example migrating to newer version of the programming language or the need to adapt a new technology on the market.

The team will be able to provide the following support where need be.

Training of users on how to use the system. There will be training sessions on the site of the users to enable users learn how to use the new system.

Installation, integration and configuration of the system. The time will do the installation and any necessary integrations.

Data migration from the old system. There will be a phased cleaning and migration of the data in the old system to the new system.

Software upgrades. Software upgrades will be informed by new user requirement and bugs discovered. The software development lifecycle will be followed from start to end and all the necessary artifacts will be produced during upgrades.

Debugging in case of any bugs discovered. Bugs that require immediate attention and rectifying will be documented post implementation.

Table 6-1 Performance and maintenance details

<i>Topics</i>	Performance and maintenance	<i>Date / Initials</i>
Problem / solution	Problem: Crashing of application Solution: A debug report will be sent to developers immediately since analytics software plugins have been integrated and an update will be made.	B.K.E,B.J,K.L
Functional maintenance	The project documentation shall be updated when new user requirements arise.	B.K.E, B.J, K.L
Functional expansion and performance improvement	Maintain a stable internet connection	B.K.E, B.J, K.L

Chapter 7: Conclusion and Recommendations

The possible application of Blockchain technology in different fields is still under study and this is an indication of the possibility of blockchain technology resolving most of the problems related to humans in terms of the trust. The call for investor protection and security in Crowdfunding contracts could be answered by the introduction of the blockchain technology which functions on a trust-free system where individuals have little to do to make it work.

There are challenges with Crowdfunding in relation to abuse, trust and confidentiality and the adoption of blockchain technology in Crowdfunding contracts could provide the much-needed solution. Blockchain technology provides cheaper, easy, and secure and a convenient means for the exchange of information and transfer of funds. The technology is programmable and can be extended to cater for any other requirement in the Crowdfunding contract where necessary. Although currently the technology can be used to modify the role of the platforms (intermediaries), in future the technology could be used to execute Crowdfunding contracts without the need for the institutional platforms.

7.1 Further Research / Improvements

Migrating to a micro-service based architecture

- Currently the back-end architecture of the platform follows a MVC architecture for modularity.
- A micro-service base architecture using RabbitMQ can truly bring granular control to the platform and will improve upon the modularity of the existing MVC pattern.

Moving all the business images/media to IPFS or AWS S3 bucket.

- The current system uses the hard disk storage of the AWS EC2 instance to store images and servers them with the help of express static server.
- While the current system being completely acceptable the cost of storing media files on the EC2 will grow exponentially as the platform grows and new users upload more and more media.
- This issue can be addressed by implementing a dedicated AWS S3 bucket in the system design which might also help to improve the media loading speeds.
- In-order to improve upon the current decentralized nature of the platform the media files can be stored on IPFS.

Hedera hashgraph integration

- Blockchain is a technology that has potential to change how the world handles their data, but it doesn't come without its flaws. Scalability, Gas fees, Transaction speeds are few of the issues that plague the technology at this moment and might just be the hurdle for the mass adoption.
- Hedera hashgraph is a 3rd generation DLT (Distributed ledger technology) which uses direct acyclic graphs to store data and improve transaction speeds and reduce the transaction costs.
- HTS (Hedera token service) is a service provided by Hedera which enables engineers to create smart contractless fungible tokens like VPM and vastly improve their security by abstracting the underlying complexities. Hedera smart contract service 2.0 can also bring improvements to the platform by decreasing the transaction fees and improving the transaction speeds.

Chapter 8: Appendices

Appendix A: User Manual

A step-by-step manual that will guide you on how to use the VPM Mobile Application

How to get the application and Installation

The application only runs on android phones

- You will be provided with an APK to install on the mobile phone.
- When you attempt to install the application, you'll receive a prompt that you're installing an application from an unknown source.
- Head to settings and in security, enable installation from unknown sources.
- The application will then be installed successfully

Main Features:

The VPM MOBILE consists of the following main sections;

Register Screen : The user can create a new account by entering their email, username and password. Every time a user create an account on collective the platform automatically creates a new Ethereum account for the user.

Login Screen : The user can use their email or username along with their password to login to the platform.

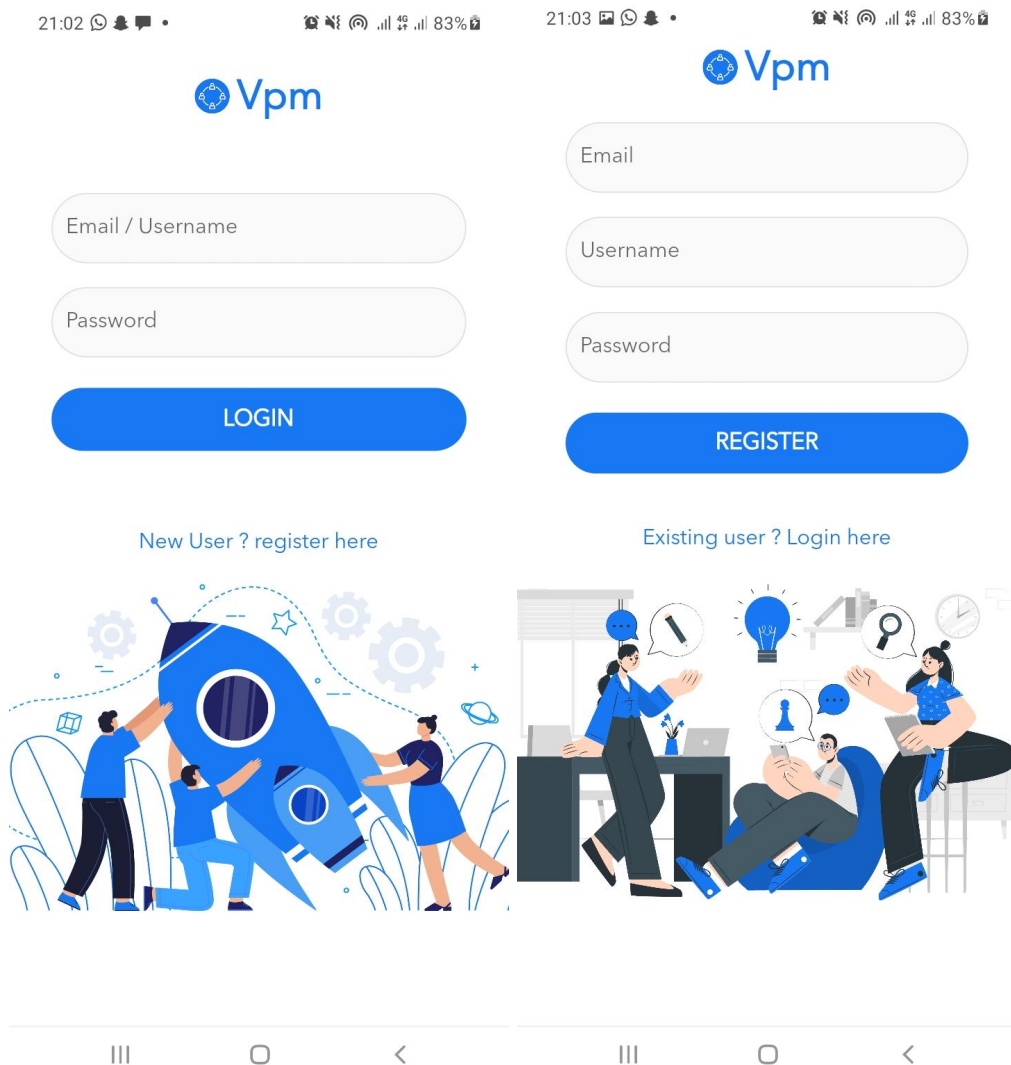


Figure 8-0-1 Register Screen and Login Screen

Home Screen : The home screen displays all the businesses that the users/angels can invest into along with tab view to switch between screens.

Buy tokens screen : The users can buy token (VPM) by making payments using Mobile Money on the buy screen.

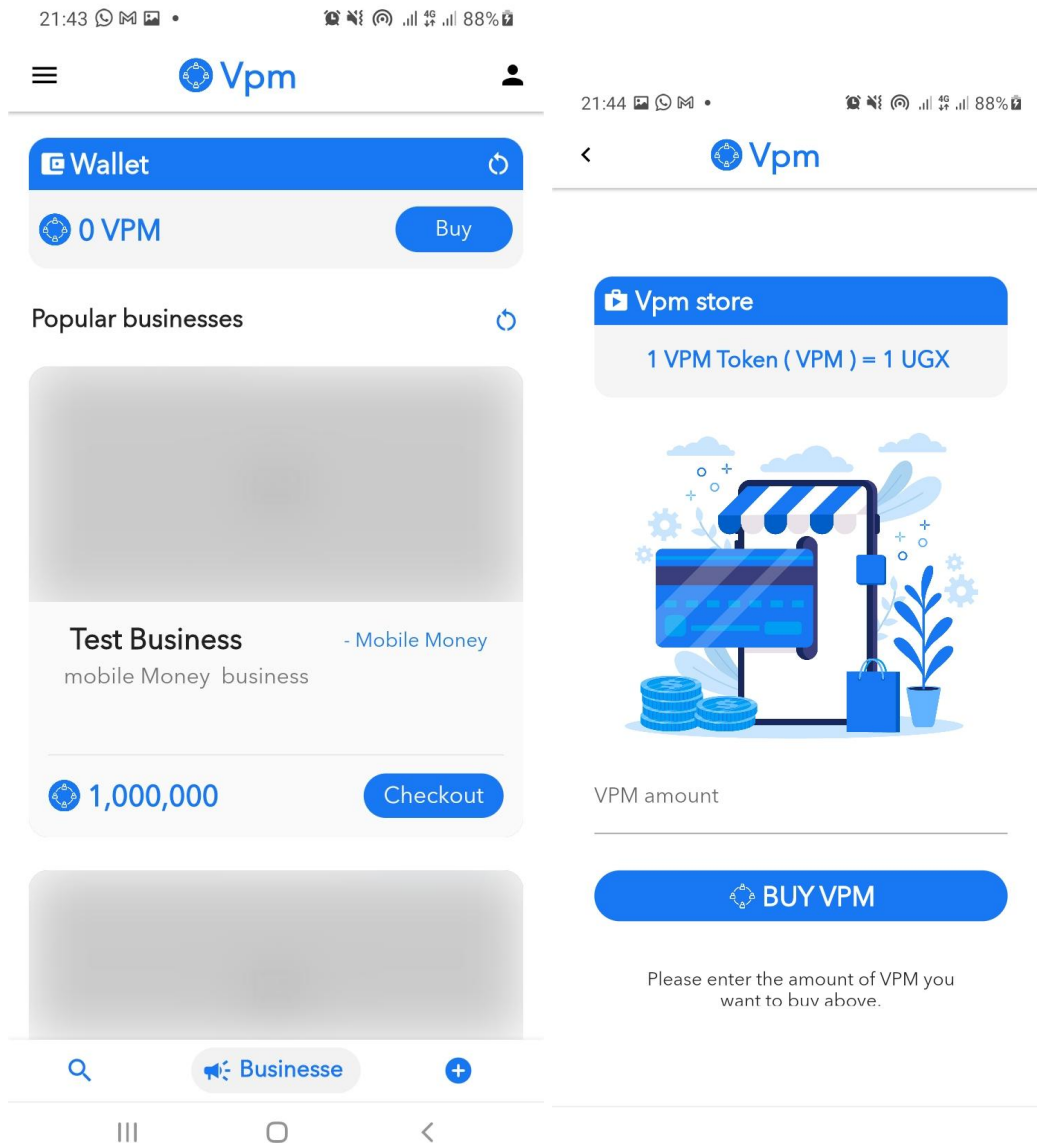


Figure 8-0-2 Home Screen and Buy tokens screen

Create new business screen : The create a new business screen allows the users to create new business by entering various details and also gives an option for uploading business cover option. Every business on the platform actually is a Ethereum account.

Search screen : The search page allows users to search for business on the platform by using the business name as the keyword.

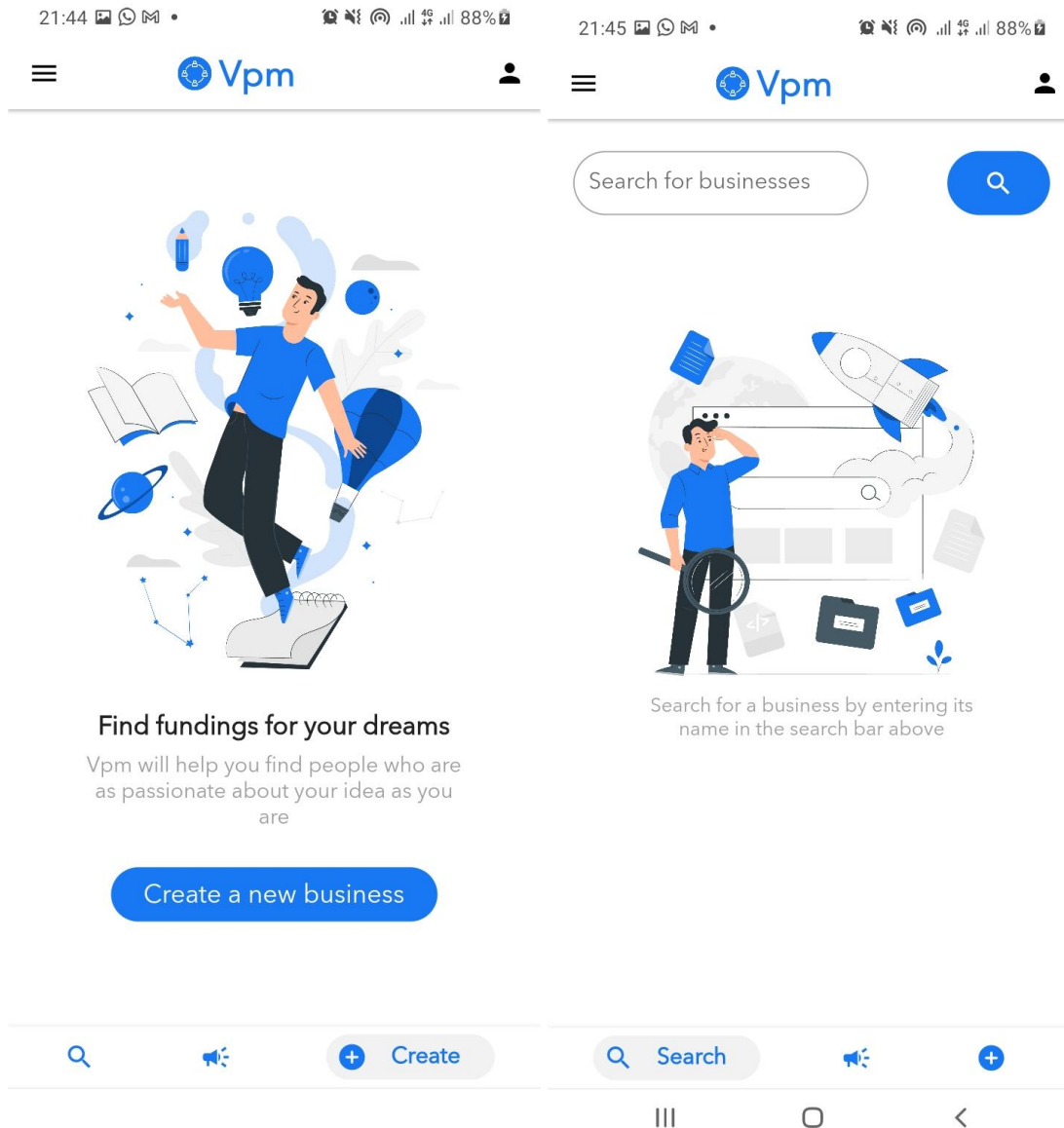


Figure 8-0-3 Create new business screen and Search screen

Business screen : The business screen displays a lot of vital information including the business image, description, target, amount raised, valuation, etc.

Business investment screen : The business investment screen allows the users to invest in the business using the platform exclusive VPM token.

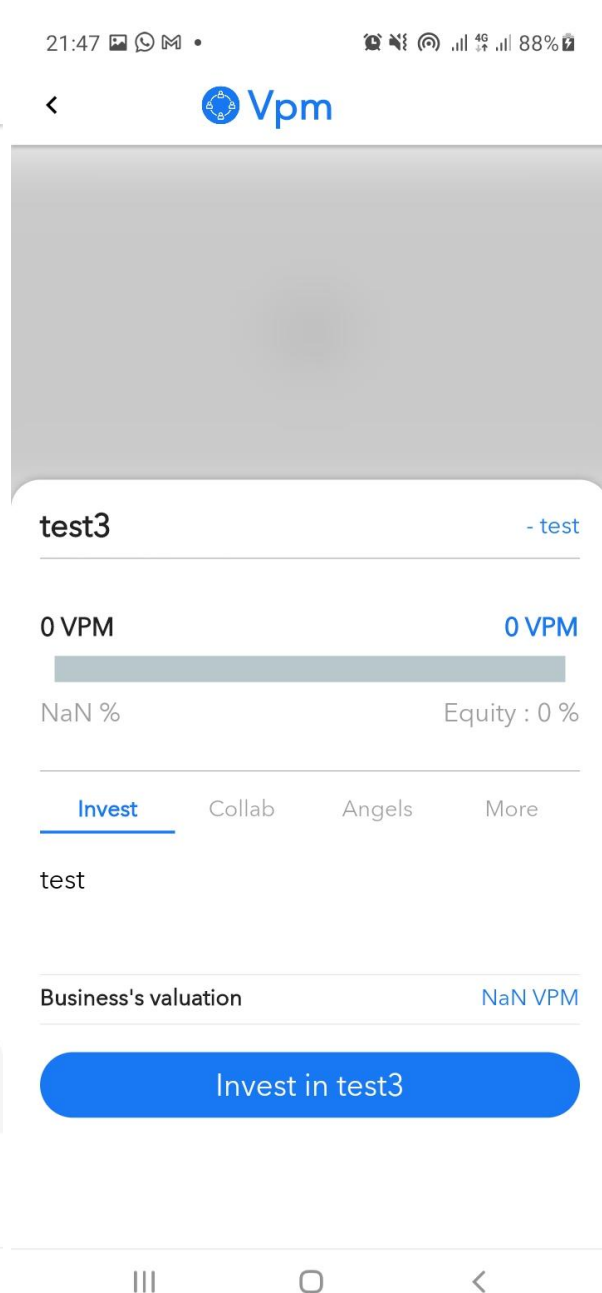
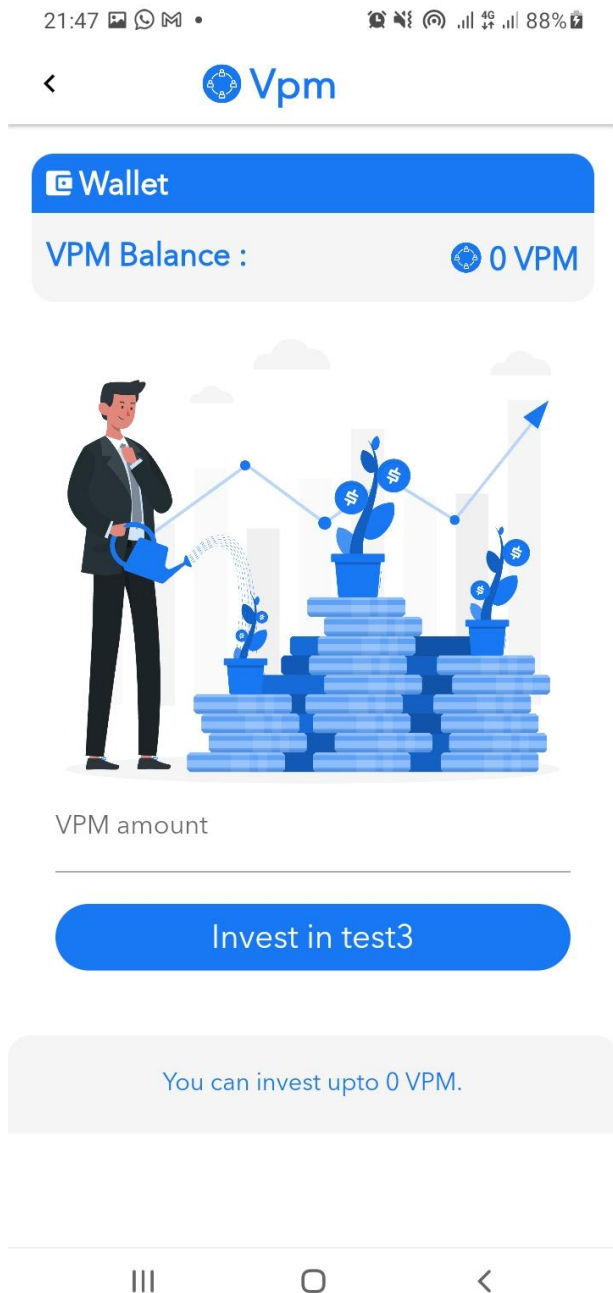


Figure 8-0-4 Business screen and Business investment screen

Business angels tab : The business angels tab show all the angels/investors who have invested in the business and also shows the equity they own in the business after clicking the check investment button.

Business more tab : The business more tab display the owner of the business, the time and date the business was created and also the current status of the business.

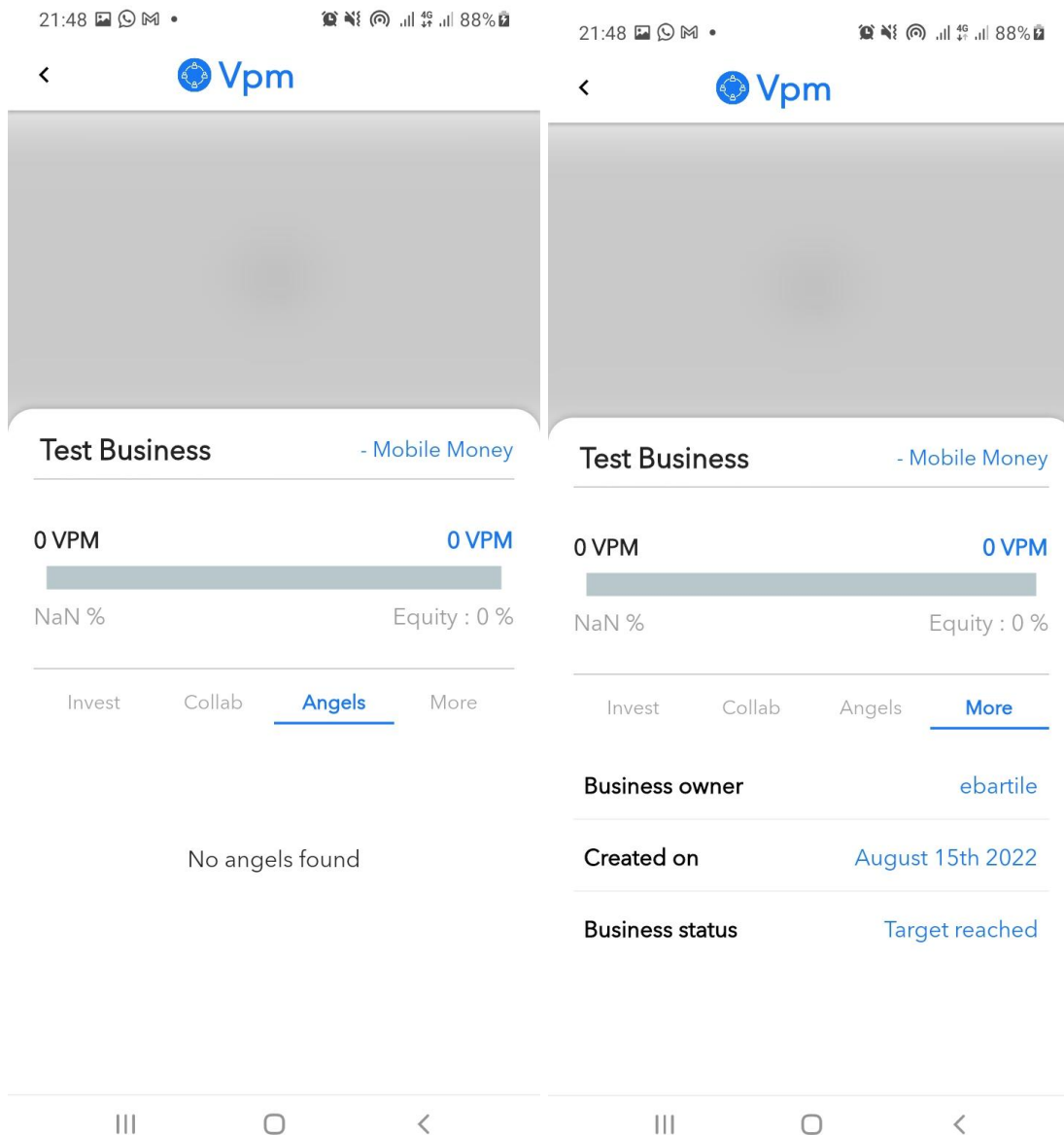


Figure 8-0-5 Business angels tab and Business more tab

Side menu : The side menu allows the users to quickly navigate between various screens.

Support email screen : The support email screen allows the users to send emails to the development team in-order to get tech-support.

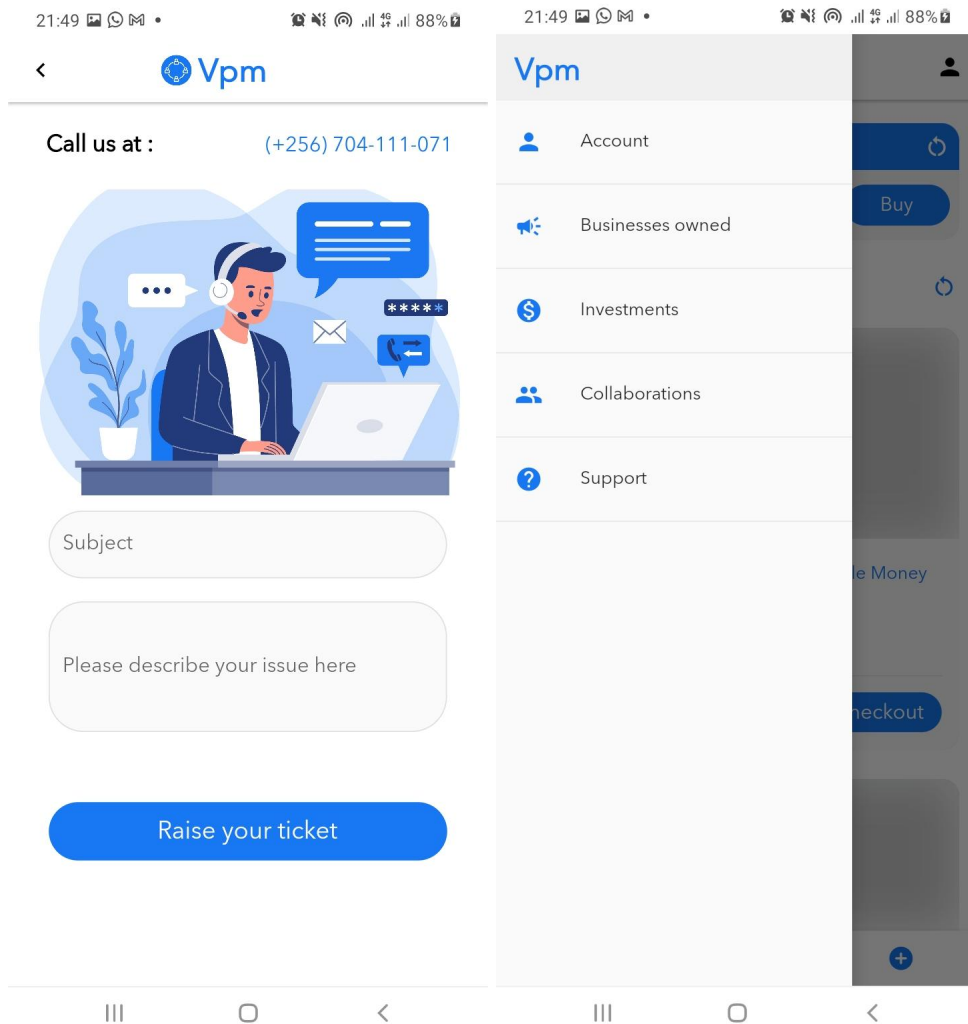


Figure 8-0-6 Side menu and Support email screen

User details screen : This screen displays the users VPM balance, username, email id, businesses owned, investments, collaborations.

Users business investment : This screen displays all the business that the user has invested in the past using VPM token.

Final approval for use	
Identification:	
Responsible for validation:	
Remarks:	
Date:	Signature: