



**University of
Zurich^{UZH}**

Design and Development of an Android-based Supply Chain Tracking Application

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Abstract

Supply chain management systems have been developed and used in the last decades and the food life cycle has always been important for the human being. By increasing the demand in the twenty first century, many production process of foods have encountered enormous changes and food health has become an imperative requirement. The supply chain monitoring and tracking system can be a potential means of providing value to producers, who tend to provide healthy food for consumers, and consumers, who may select the final product based on food chain details. With such a tracking system, end users will be able to track a product's life cycle from the first producer via processing stakeholders to the shelf, where the end user had finally purchased the product [1]. In today's highly competitive business environment, getting the correct products to the right place at the right time via the most cost-effective manner is paramount for business' success. It's imperative for businesses to innovate new ways to streamline their supply chain and optimize productivity. To stay ahead of the competition, tech-smart operations, savvy professionals are using logistics and supply chain mobile applications as must-have tools for operational excellence to enhance the visibility within supply chain, and to have more control over the business. In this independent study, such a supply chain tracking system is designed and developed to fulfill the requirements of end users. This system is developed in the form of an Android application to enable a fast and easy tracking, which users and producers can easily use, install on their smart phones.

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Contents

Abstract	i
Acknowledgments	ii
Contents	iii
1 Introduction	1
1.1 Motivation	1
1.2 Description of Work	2
2 Related Work	3
3 Design and Implementation	6
3.1 System Design	6
3.1.1 System Diagram/High Level Overview	6
3.1.2 Use Case Diagram	7
3.1.3 MVC Code Architecture	9
3.1.4 Back-end APIs	9
3.2 Implementation	11
3.3 Producer Mode	11
3.3.1 Logging on to FoodChain App	12
3.3.2 Main Page	14
3.3.3 SCAN QR CODE	15
3.3.4 Generate QR CODE	16

3.3.5	Product Tags	17
3.3.6	Settings	17
3.4	Consumer Mode	21
3.5	Food Chain Database Schema	22
3.5.1	Database Schema	22
3.5.2	Database Schema	22
4	Evaluation	23
5	Summary and Conclusions	25
	Bibliography	27
	Abbreviations	29
	Glossary	30
	List of Figures	31
A	Installation Guidelines	33

Chapter 1

Introduction

1.1 Motivation

Enhancing trust in food is a growing concern in a climate where public confidence in food producers, processes and sellers-even government regulators has been rocked by many high-profile scandals [2]. The ability to track and trace products is fundamental to sound supply chain management. Traceability affects supply chain efficiency, product safety and security, controlling costs, and regulatory compliance. In a typical scenario, materials and products are traced only at certain phases of the supply chain, and data is not communicated effectively between stakeholders. Among the various technologies that are available to assist in tracing materials and products throughout supply chains, the most common ones are alphanumerical codes, bar codes, RFID tags, and GIS. Alphanumerical codes are inexpensive but require human resources for code writing and data input. Bar code systems, the most frequently used tracing technology offer high levels of automation and are economical, but require manual screening that leaves room for error. RFID tags, long hailed as the future of product traceability, track materials in real time with precision and no manual intervention. However, the cost of tags is still prohibitive in many applications. GIS is similar to RFID, but the technology uses radio signals that are collected by satellites or cell phone antennas as opposed to radio tag signals. While many of these tools are in place in certain phases of the supply chain, often information collected at each point is not translated across the chain between actors. Depending on the product and needs of the company, technologies are selected based on the product and production processes, and levels of automation in the supply chain. A technology that could leapfrog many of these issues and transform supply chain traceability is blockchain, the computing system behind Bitcoin. Because the information generated in a blockchain system is crowd-sourced, competing or conflicted actors can cooperate because no one organization has control of the information [3].

Global megatrends are driving change and legislation is making it mandatory. It's not just their customers who are more concerned about food trust issues - new legislation is being enacted by governments committed to protecting their people and improving safety standards [4].

The distributed ledger technology that underpins cryptocurrencies is now poised to disrupt supply chain management, especially in the global shipping industry. Blockchain will be the killer app for supply chain management in the global shipping industry in future. Blockchain testing programs are being evolved from pilot tests to real-world platforms, and supply chain management is among the industries the distributed ledger technology is set to disrupt. In January 2018, Maersk and IBM announced a joint venture to deploy a blockchain-based electronic shipping system that will digitize supply chains and track international cargo in real time. The new platform could save the global shipping industry billions of dollars a year by replacing the current EDI and paper-based system, which can leave containers in receiving yards for weeks. As goods move from one place to another or one part of a company to another, companies are interested in using blockchains to keep track of how goods are moving and where they are. You can go industry by industry and you're seeing concepts proven, pilots now moving into production. Things like supply chain validation, food safety verification, consumer products companies and potentially industrial and even life sciences companies are starting to circle it. The real value for blockchain is when you use distributed electronic ledgers and data to connect with suppliers, customers and intermediaries. Manufacturers want to ensure goods get to where they're supposed to go and those purchasing the merchandise want to make sure it originated from a reputable source. By including both ends of that supply chain, it addresses the threat of counterfeit goods, fraud and theft [5].

1.2 Description of Work

This technical document introduces the functionalities of Food Chain App and guides on how the actors can easily create QR code for a product and customers can scan QR code for tracking the history of product. It describes by listing the step-by-step procedure of how a user can register with food chain application as a producer, register the licenses and actions as producer which enables adding trust to the documented production transport-processing process for all interested stakeholders, how to link up previous QR code of product to their newly generated QR code and as a consumer how to see the whole life cycle of product by scanning a QR code on product. All this is meant to give a good understanding of the Food Chain application in order to make use of it right away.

Chapter 2

Related Work

In recent times food safety has drawn upsurge of academic and commercial concerns. In supply chain area, with the rapid growth of internet technologies, a lot of emerging technologies have been applied in traceability systems. However, to date, nearly all of these systems are centralized which are monopolistic, asymmetric and opaque that could result in the trust problem, such as fraud, corruption, tampering and falsifying information. The blockchain has the potential to take the power of information from Big Food and place it into the hands of the direct customer. Through the use of a simple QR code and a smartphone, customers can scan a package at the Point of Sale and receive a full and complete history of their foods journey.

This is particularly useful in the grey areas of food traceability, such as country of origin labelling. This is an element of food information where it can be difficult to differentiate true claims from false, for instance a product can claim to be Swiss pork when in reality it is for example, French in origin and subsequently processed in the Switzerland.

Companies can no longer rely on generalized terms such as "healthy" or "organic" in order to signal value, the new generation of consumers are savvy enough to seek reassurances of quality past just what is printed on the label. The blockchain provides a method of substantiating these previously unsubstantiated claims, strengthening customer loyalty for those companies who can consistently guarantee quality.

In an increasingly volatile market, the blockchain adds an extra level of security for the food industry. Companies who can utilize the blockchain to instill transparency in their supply chains already have an insurance policy should another scandal hit the industry.

It is already clear that the tide is turning towards traceability. The blockchain provides a method of substantiating these previously unsubstantiated claims, strengthening customer loyalty for those companies who can consistently guarantee quality[6].

The blockchain is a useful tool here as it records each interaction with an item and assigns it a digital certificate, meaning it cannot be changed or adulterated later by a company seeking to hide the true origin and movement of the product through the chain. Consumer

trust in food is already damaged and demand for full traceability is only growing stronger.

In [7], they build a food supply chain traceability system for real-time food tracing based on HACCP (Hazard Analysis and Critical Control Points), blockchain and Internet of things, which could provide an information platform for all the supply chain members with openness, transparency, neutrality, reliability and security. Feng Tian [8] study the utilization and development situation of RFID and blockchain technology first, and then analyze the advantages and disadvantages of using RFID and blockchain technology in building the agri-food supply chain traceability system; finally, he demonstrates the building process of this system.

[9] analyzes a traceability ontology and translate some of its representations to smart contracts that execute a provenance trace and enforce traceability constraints on the Ethereum blockchain platform.

In [10], the authors review the current status of this technology and some of its applications. The potential benefit of such technology in manufacturing supply chain is then discussed in this article and a vision for the future blockchain ready manufacturing supply chain is proposed.

This study [11] illustrates the various mechanisms by which blockchain help achieve the above supply chain objectives. Special emphasis has been placed on the roles of the incorporation of the IoT in blockchain-based solutions and the degree of deployment of blockchain to validate individuals' and assets' identities.

In [12], they design and implement ProvChain, an architecture to collect and verify cloud data provenance, by embedding the provenance data into blockchain transactions. ProvChain operates mainly in three phases:

1. provenance data collection
2. provenance data storage
3. provenance data validation

Results from performance evaluation demonstrate that ProvChain provides security features including tamper-proof provenance, user privacy and reliability with low overhead for the cloud storage applications.

In light of General Data Protection Regulation (GDPR) requirements, [13] proposes the use of a blockchain-based approach to support data accountability and provenance tracking relying on the usage of publicly auditable contracts deployed in a blockchain that increase the transparency with respect to the access and usage of data.

Many theoretical discussions and related proposals have been studied in the past, but the existence of blockchain based applications to solve the real life problems, are still lacking into the industry. In this project, a working prototype has been developed for

foodchain products with a potential to generalize it for other relevant use cases in the future. Pioneering a new standard for trust in food retail. Empowering customers all along the supply chain, this app enables retailers to provide shoppers with trustworthy data.

Chapter 3

Design and Implementation

This section covers the architectural design and implementation details for Food Chain App. A high-level overview of the software architecture is presented, followed by the back-end endpoints.

3.1 System Design

Systems design is the process of defining the architecture, modules, interfaces, and data for a system to satisfy specified requirements. Systems design could be seen as the application of systems theory to product development. There is some overlap with the disciplines of systems analysis, systems architecture and systems engineering. The architectural design of a system emphasizes the design of the system architecture that describes the structure, behavior and more views of that system and analysis. The logical design of a system pertains to an abstract representation of the data flows, inputs and outputs of the system. This is often conducted via modelling, using an over-abstract (and sometimes graphical) model of the actual system. In the context of systems, designs are included. Logical design includes entity-relationship diagrams (ER diagrams). The physical design relates to the actual input and output processes of the system. This is explained in terms of how data is input into a system, how it is verified or authenticated, how it is processed, and how it is displayed [14].

3.1.1 System Diagram/High Level Overview

A system diagram defines the boundary between the system, or part of a system, and its environment, showing the entities that interact with it. This diagram is a high level view of a system. It is a visual model of a system, its components, and their interactions. With supporting documentation, it can capture all the essential information of a system's design. It explains the visual interactions with the system of all actors e.g. producers, consumers, farmers etc. where producers can generate QR-code at different locations, whenever a producer makes some changes in the product. Consequently, it develops a

digital chain which helps the consumers to trace the life cycle of a product using their smartphones.

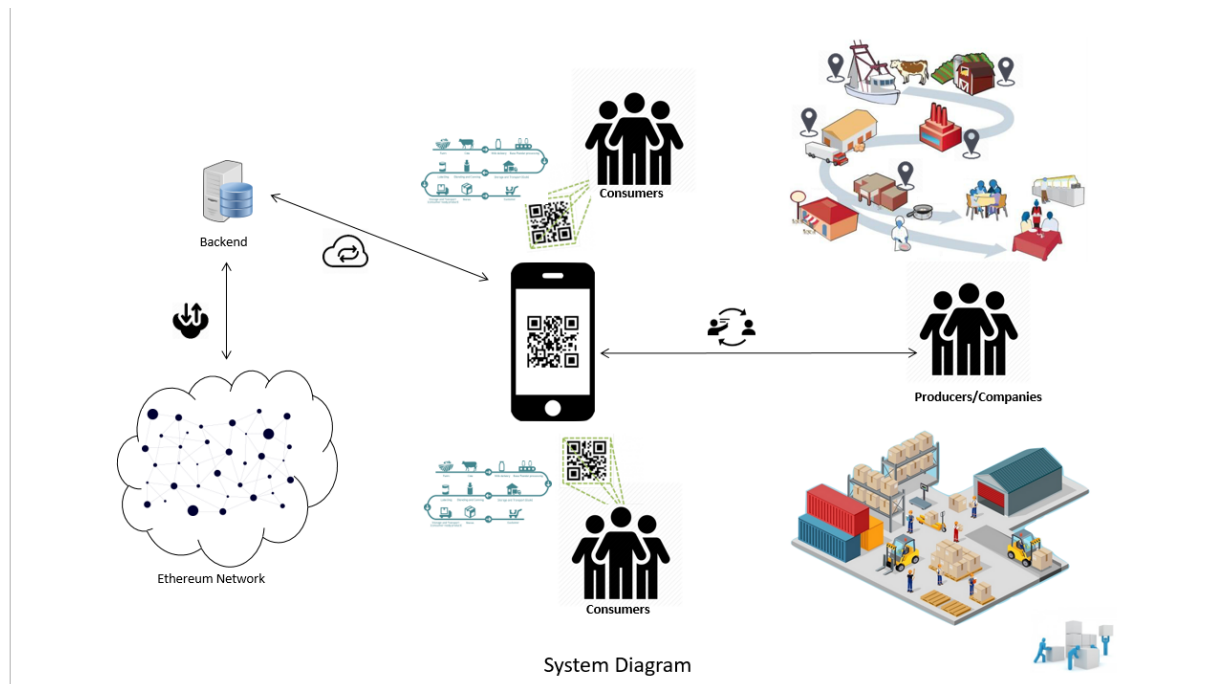


Figure 3.1: System Diagram

3.1.2 Use Case Diagram

A use case diagram is a graphic depiction of the interactions among the elements of a system. The main purpose of a use case diagram is to show who interacts with the system, and the main goals they achieve with it. It is high level diagram and typically won't show a lot of detail but it's a great way to communicate complex ideas in a fairly basic way.

Following use case diagram breakdowns in four elements.

1. **System:**

The system is what we have developed, which is a food chain app for monitoring and tracking product life cycle. Rectangle shows a food chain system. This rectangle shows the scope and context of system. Anything inside this rectangle is the part of food chain application.

2. **Actors:**

Actor is depicted by stick figure. Actor is someone which is using food chain application to achieve a goal. In the system, producer and end users are interacting with the app. Producer interacts with app to create and scan QR codes and end user uses this app to scan QR code of product to verify the provenance of product. These actors are external objects and they are placed outside of our system.

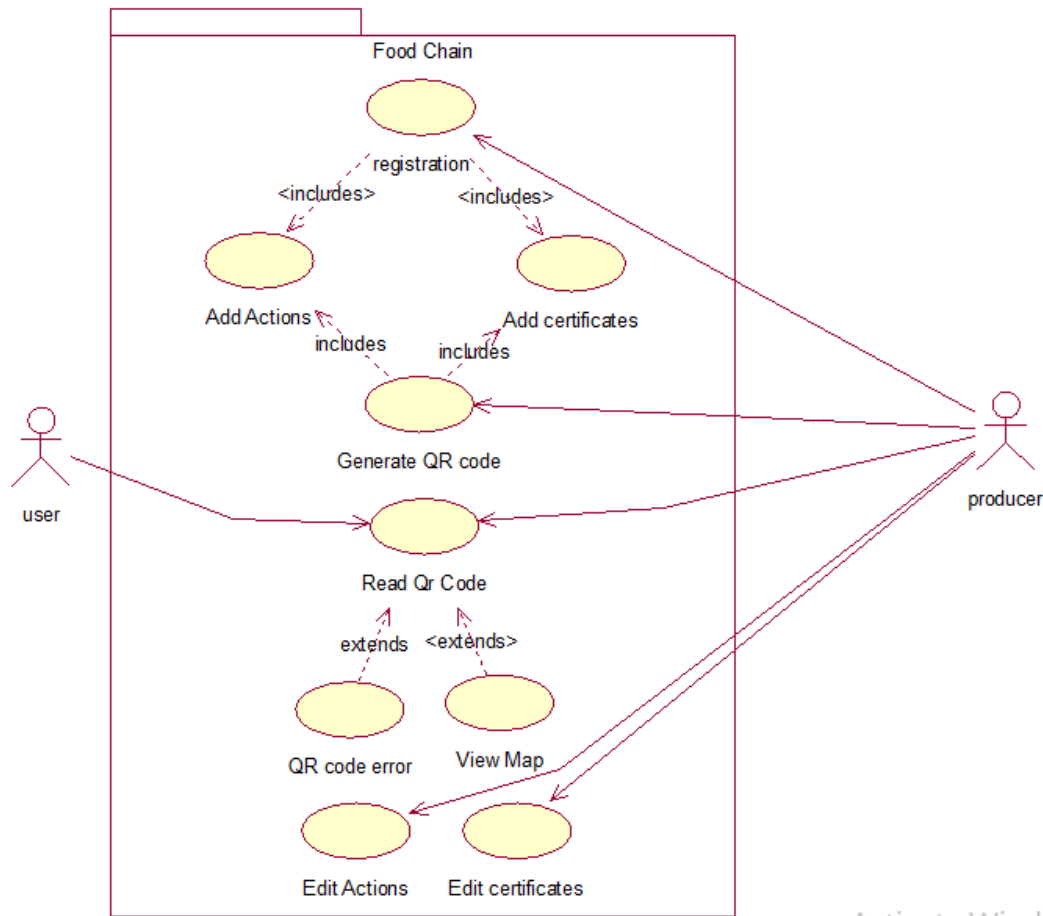


Figure 3.2: Food Chain Usecase

3. Use cases:

Use case is depicted by oval shape and it represents an action that accomplishes some sort of task inside system. Food chain application allows producers to register and then login into system, create QR codes, read QR codes and view them on map, add actions, add certificates, edit actions and edit certificates. And it allows end users to scan QR codes and see the product lifecycle.

4. Relationships:

- **Association:** Solid arrows show the association relationship which depicts the actions, that a particular actor can perform using food chain application. Consumer is associated to read QR code only because there is no need for end user to register or login into system or perform other actions.
- **Include:** This relationship shown by dotted arrow with the head pointing to use cases which we want include. It shows we require add certificate, add action use case in order to complete registration and to generate QR code.
- **Extend:** This relationship describes the use case that meets certain conditions and it is depicted by dotted arrow and its head pointing to use case from which we want to extend. For instance, if hash query is successful, a map view is shown to producer or end users which shows the lifecycle of product and if

the hash query is unsuccessful then it shows an error message that product information is not available.

3.1.3 MVC Code Architecture

Standard Android (Model-View-Controller) - This is the "default" approach with layout files, Activities or Fragments acting as the controller and Models used for data and persistence. With this approach, Activities are in charge of processing the data and updating the views. Activities act like a controller in MVC but with some extra responsibilities that should be part of the view [15].

In a world where the user interface logic tends to change more often than the business logic, the desktop and Web developers needed a way of separating user interface functionality. The MVC pattern is their solution.

- **Model.** the data layer is responsible for managing the business logic and handling network or database API
- **View.** the UI layer is a visualization of the data from the Model
- **Controller.** the logic layer, gets notified of the user's behavior and updates the Model as needed.

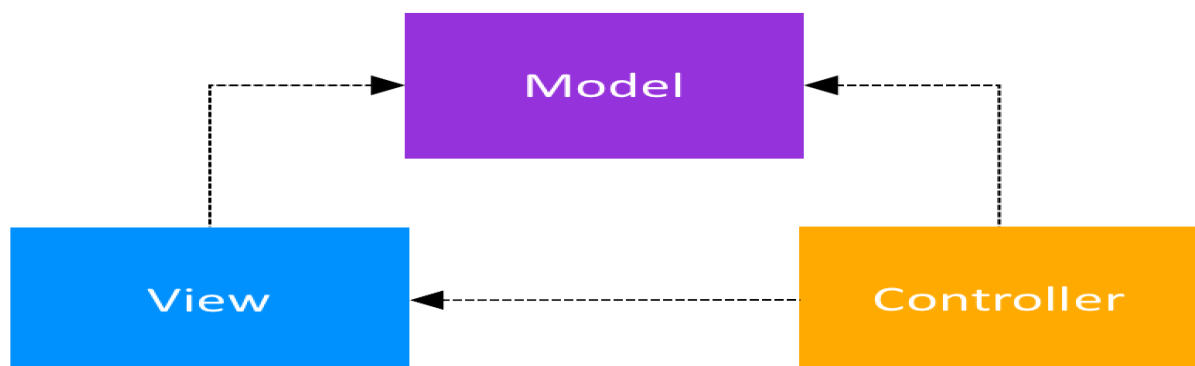


Figure 3.3: Model-View-Controller Class Structure

this means that both the Controller and the View depend on the Model: the Controller to update the data, the View to get the data. But, most important for the desktop and Web devs at that time: the Model was separated and could be tested independently of the UI. Several variants of MVC appeared. The best-known ones are related to whether the Model is passive or is actively notifying that it has changed [16].

3.1.4 Back-end APIs

REST or RESTful API design (Representational State Transfer) is designed to take advantage of existing protocols. While REST can be used over nearly any protocol, it usually

takes advantage of HTTP when used for Web APIs. This means that developers do not need to install libraries or additional software in order to take advantage of a REST API design.

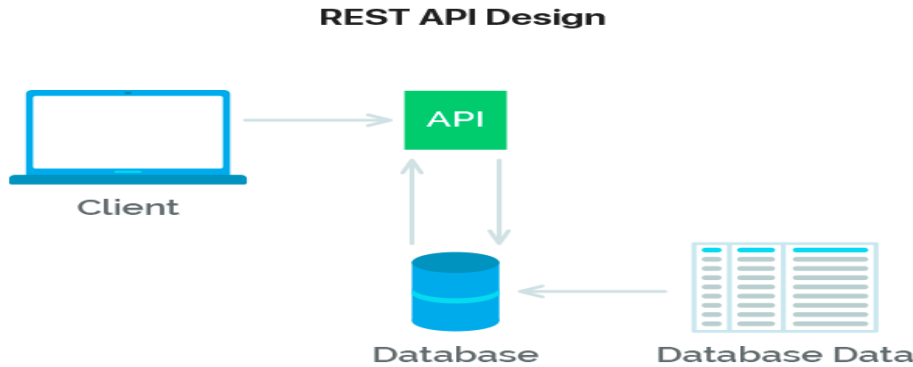


Figure 3.4: Rest APIs

Client-Server The client-server constraint works on the concept that the client and the server should be separate from each other and allowed to evolve individually and independently. In other words, it should allow to make changes to mobile application without impacting either the data structure or the database design on the server. At the same time, it should allow to modify the database or make changes to the server application without impacting the mobile client.

Stateless REST APIs are stateless, meaning that calls can be made independently of one another, and each call contains all of the data necessary to complete itself successfully. A REST API should not rely on data being stored on the server or sessions to determine what to do with a call, but rather solely rely on the data that is provided in that call itself. Identifying information is not being stored on the server when making calls. Instead, each call has the necessary data in itself, such as the API key, access token, user ID etc. This also helps increase the API's reliability by having all of the data necessary to make the call, instead of relying on a series of calls with server state to create an object, which may result in partial fails. Instead, in order to reduce memory requirements and keep your application as scalable as possible, a RESTful API requires that any state is stored on the client-not on the server [17].

This freedom and flexibility inherent in REST API design allows to build an API that meets your needs while also meeting the needs of very diverse customers. Unlike SOAP, REST is not constrained to XML, but instead can return XML, JSON, YAML or any other format depending on what the client requests [18]. Foodchain App is using following APIs from backend. The details of these APIs are out of the scope of this IS report.

- <http://192.41.136.233:8080/actions>
- <http://192.41.136.233:8080/producers>

- <http://192.41.136.233:8080/producers/register>
- <http://192.41.136.233:8080/productTags>
- <http://192.41.136.233:8080/actions>
- <http://192.41.136.233:8080/certificates>
- <http://192.41.136.233:8080/actions>
- <http://192.41.136.233:8080/producers/login>
- <http://192.41.136.233:8080/productTags/hash/afedb543c7308eabd72442963a4e497d4f9a48b455c79df73904e1bdac3a77f9>
- <http://192.41.136.233:8080/productTags/producer/>

3.2 Implementation

Food Chain (supply chain monitoring and tracking system) is a potential means of providing value to producers, who tend to provide healthy food for consumers, and consumers, who may select the final product based on food chain details. With such a tracking system, end users are able to track a product's life cycle from the first producer via processing stakeholders to the point of sale, where the end user has finally purchased the product. In this application, such a supply chain tracking system is designed and developed to fulfill the requirements of end users regarding the location and date of the production. Also, producers' license(s) and certificate(s) are collected as additional information, which enables adding trust to the documented production-transport-processing process for all interested stakeholders. This system is developed in the form of an Android application to enable a fast and easy tracking, which users and producers can use easily, install on their smart phones, and will apply to persist all relevant, necessary, may legally require data and information.

Food Chain android-based application consists of following core components:

- Producer Mode
- Consumer/End User Mode
- Backend

3.3 Producer Mode

In supply chain monitoring and tracking system, a producer needs to register with the system to leverage the functionality of android app. Producers can enter licenses, actions and certificates to their profile during registration. Subsequently, they can select a list of

available actions in the system to generate QR tags for their products. QR-code contains a hash key which will be added in the backend system, this hash key serves as a primary key to register all details (e.g. time, location, actions, previous information) of the product with the system. Android app allows to print the QR-code for tagging it on the product. These QR tags on products can be scanned by producers or consumers anytime to see the whole product life cycle. A step-by-step guide to walk through the android app is given below, a user can log on to Foodchain app as a producer for creating and scanning QR codes.

3.3.1 Logging on to FoodChain App

If you click on the Foodchain application icon, a startup screen with following two options will appears as shown in Figure 3.5

1. Producer
2. Consumer

By clicking producer button, the Login window appears, as shown in Figure 3.6 .The purpose of this screen is to secure the application from unauthorized access. You need to provide your authorized application username and password in order to log on to the system successfully.

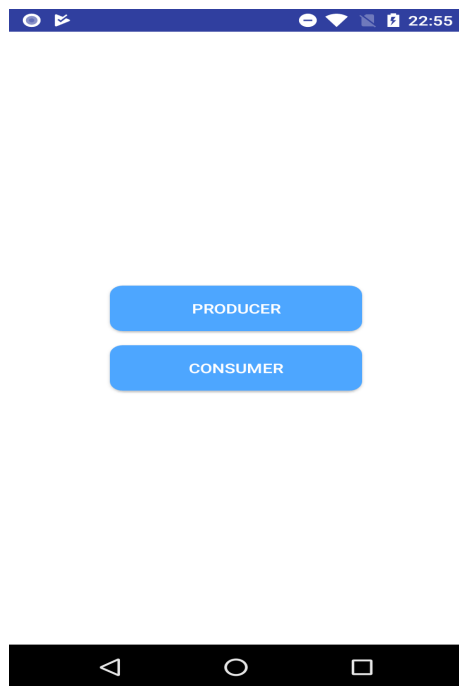


Figure 3.5: Startup Screen

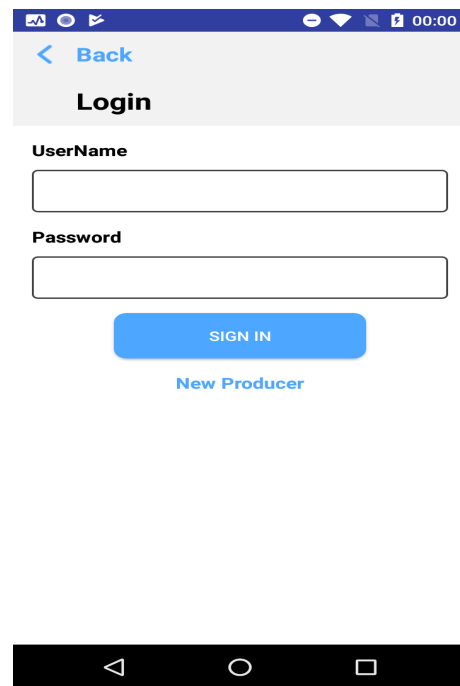


Figure 3.6: Login Screen

If you do not have credentials to access the Application, click on "New Producer" and the screen will appear for registration as shown in Figure 3.7.

1. Enter the name in the **Producer Name** field.
2. Enter Producer Certificate in the **Producer Certificate** field.
3. Enter username in the **Producer Username** field.
4. Enter password in the **Password** field.
5. Enter Ethereum Account information in **Ethereum Account** field.
6. Enter website address in the **Website** field.
7. Producer can select the licenses from registration screen, if available in the system, by clicking on "Enter list" under "Licenses". Producer can select the licenses from the available list as shown in the Figure 3.8

Figure 3.7: Registration

Figure 3.8: Select Licenses

8. If a license is not present, then click on "Create Licenses" to create a new license on the fly. A new screen appears with one edit box, after clicking on Create Licenses. By clicking "+" button on edit box, you can create more than one license at a time as showing in Figure 3.9. Enter your license name (s) and click on "create" button to create it. And then select the license(s) from list.
9. To add list of actions that you can click on "Enter list" under "Processes and Actions". After clicking following screen [fig 3.10] appears for entering adding action. Now you select action from list.

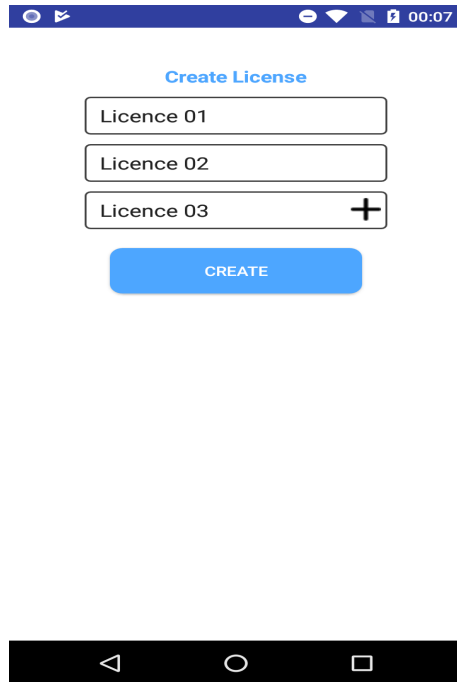


Figure 3.9: Create New Licenses

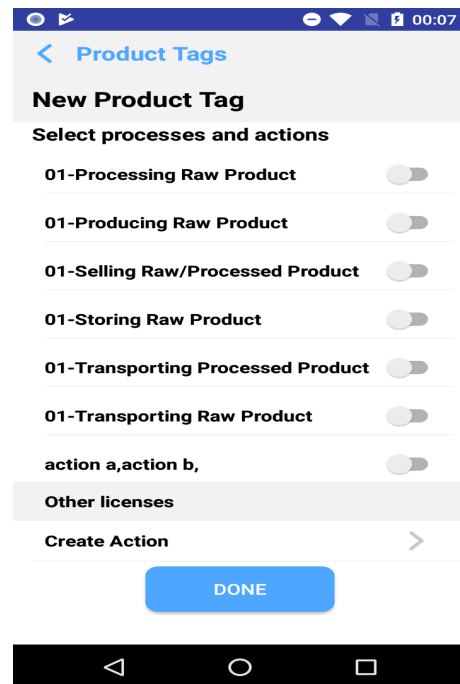


Figure 3.10: Select Actions

10. If an Action is not present, then click on "Create Action" to create a new Action on the fly. A new screen appears with one edit box, after clicking on Create Actions. By clicking "+" button on edit box, you can create more than one action at a time as showing in Figure 3.11. Enter your action name (s) and click on "create" button to create it. And then select the action(s) from list.
11. Click on "Register" button to register with the system.

If you already have user credentials, please provide the login details.

1. Enter your Username in the UserName field.
2. Enter your password in the Password field.
3. Click Sign In.

3.3.2 Main Page

On successful login, home page for producer mode is displayed. From here, producer can utilize the supply chain monitoring and tracking system to create or scan QR codes.



Figure 3.11: Create New Actions

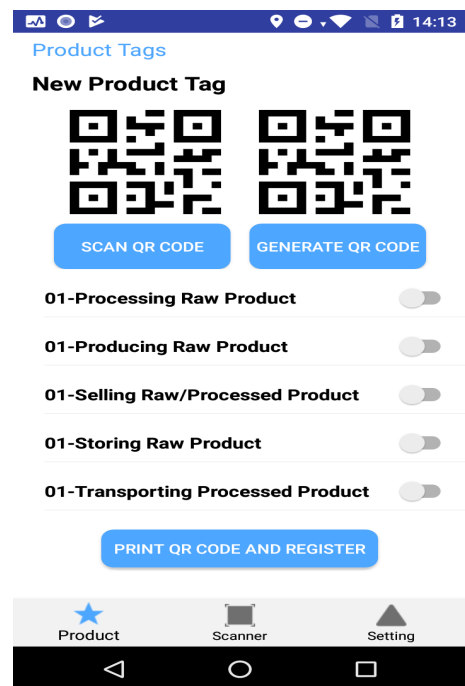


Figure 3.12: Main Page

3.3.3 SCAN QR CODE

By clicking on Scan QR Code, a camera view will open, adjust the QR code inside the viewfinder rectangle to properly scan it as shown in Figure 3.13.

If a product already exists in the system and it has QR code/tag associated with it,



Figure 3.13: Product Scanning

then by scanning QR code you can get the previous information of product e.g. previous location, date of modification, list of actions etc.

If a scanned product is valid, a message will be displayed on the screen "Product Data is valid" as shown in Figure 3.14. If the hash key of scanned product is invalid or QR code information does not exist in database, a message will be displayed that product is invalid.

User can click on the product to visualize the traceability or tracking of product in the map view with location markers, at which product was modified as shown in the Figure 3.15.



Figure 3.14: Scanned Product

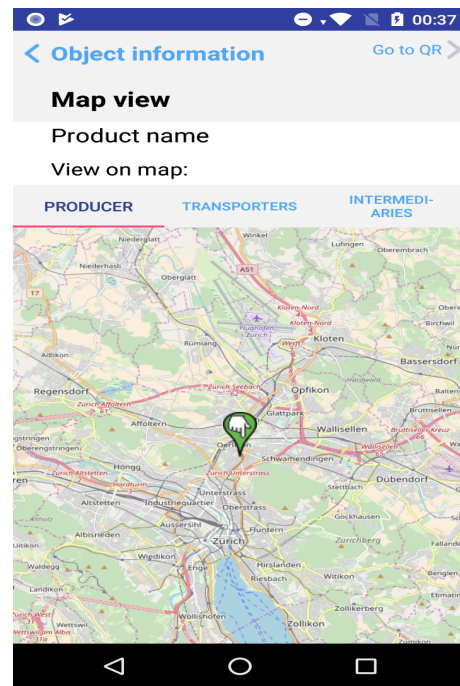


Figure 3.15: Map View

3.3.4 Generate QR CODE

If a user is registering a product into the system for the first time, select actions from the available list before generating QR code. If the QR Code has successfully been generated, information about the product will be registered on the backend, and a message will be displayed on the screen as shown in the Figure 3.16. You click on "Print QR Code and Register" to print the QR code or send it to an E-mail address. If the product has already a tag printed on it, you scan QR code at first to find out the previous history of product and then select your actions, create a new QR code based on previous QR code and click on "Print QR Code and Register" to register and print the QR code.

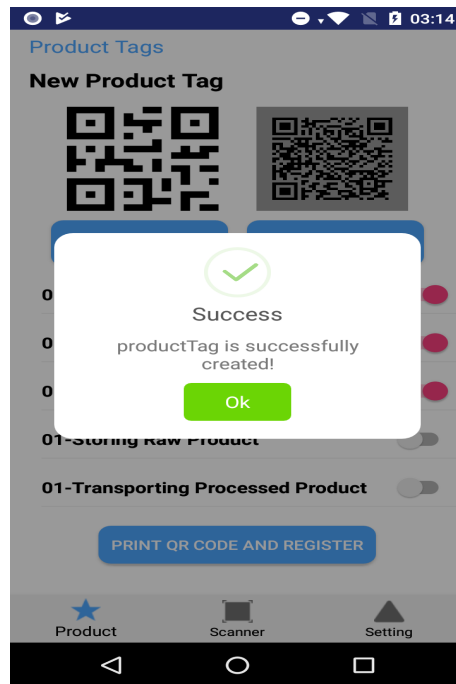


Figure 3.16: Product Tag Created Successfully

3.3.5 Product Tags

On the Home screen you can see Product Tags link. A new screen will open by clicking on the Product Tags as shown in the Figure 3.17. It contains a bottom navigation with following options:

1. Product Tags
2. Scanner
3. Settings

3.3.6 Settings

By clicking on setting following screen appears as shown in Figure 3.18.

- **All Actions:** By clicking on "All actions" screen appears which has all actions that anyone can perform on a product as Shown in Figure 3.19. By clicking on action producer can delete and update that action as shown in Figure 3.20.
 - **Delete:** by clicking on this button will delete the action if the action has not been registered with some product in the past as shown in Figure 3.21. Otherwise, producer will not be able to delete action from the system.

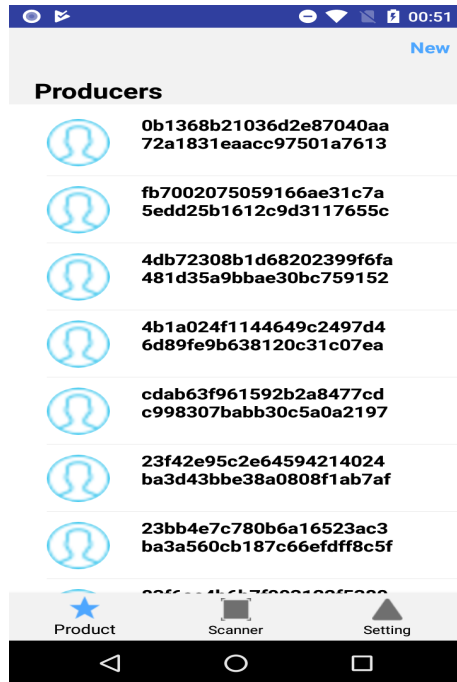


Figure 3.17: Products Tag

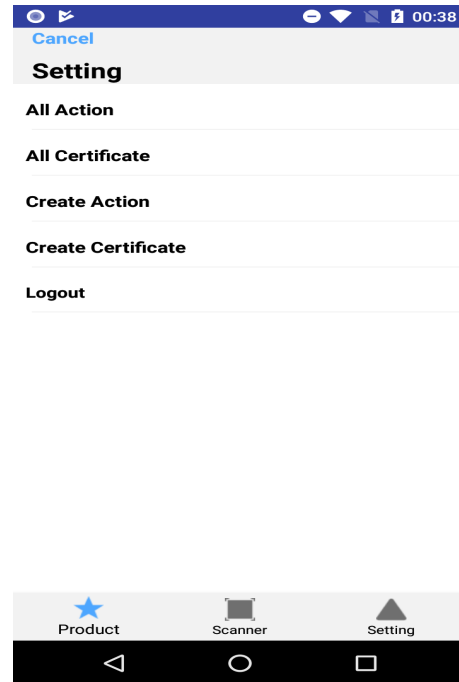


Figure 3.18: Settings

- **Update:** By clicking on this button, "updating action" window appears, you can update the name of action and then click on "update" button and this will update the action as shown in Figure 3.22. Action name will be updated even if it's registered with some product in the system.
- **All Certificates:** By clicking on this option, a screen appears which have all certificates that producers have as shown in Figure 3.23.
- By clicking on certificate you can delete and update that certificate as shown in figure 3.24.
 - **Delete:** by clicking on this button you can delete the certificate, if the action has not been registered with some product in the past as shown in Figure 3.25. Otherwise, you will not be able to delete action from the system.
 - **Update:** By clicking on this button "updating certificate" window appears, you can add new name of certificate and then click on "update" button and this will update the certificate as shown in Figure 3.26. Certificate name will be updated even if it's registered with some product in the system.
- **Create Action:** By clicking on this button, "creating a new action" window appears. Now write action name in "Action name" field, and then click on "create" button for creating the action as shown in Figure 3.27.

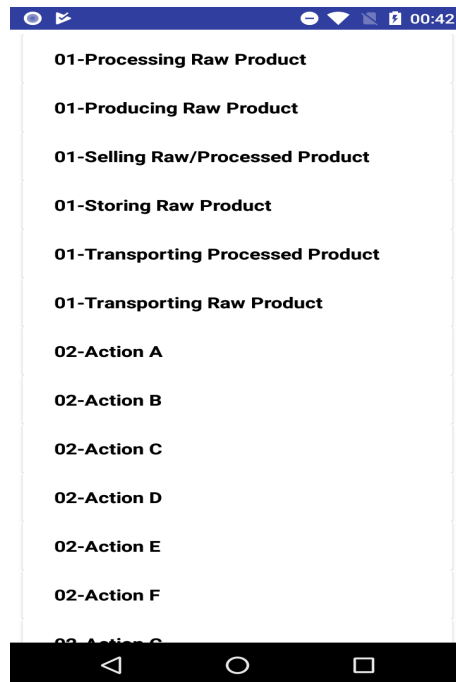


Figure 3.19: All Actions

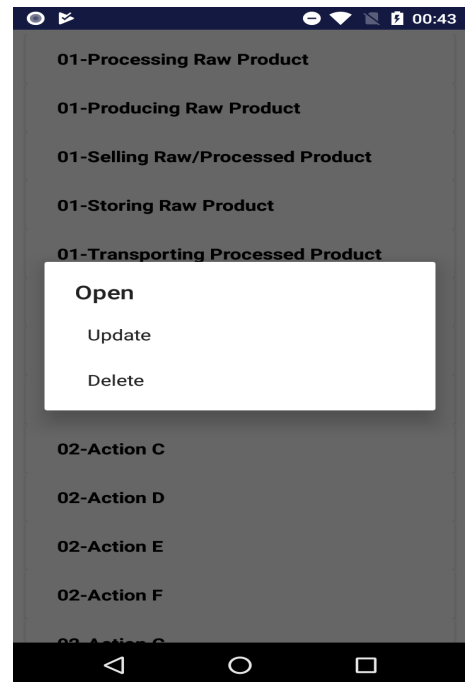


Figure 3.20: Update or Delete Selected Actions

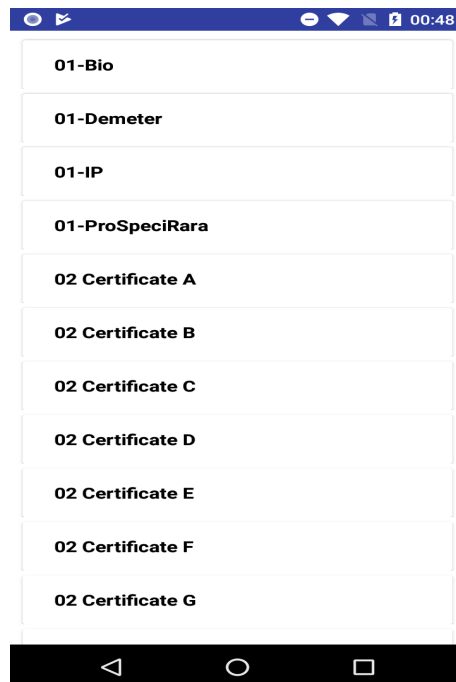


Figure 3.21: All Certificate

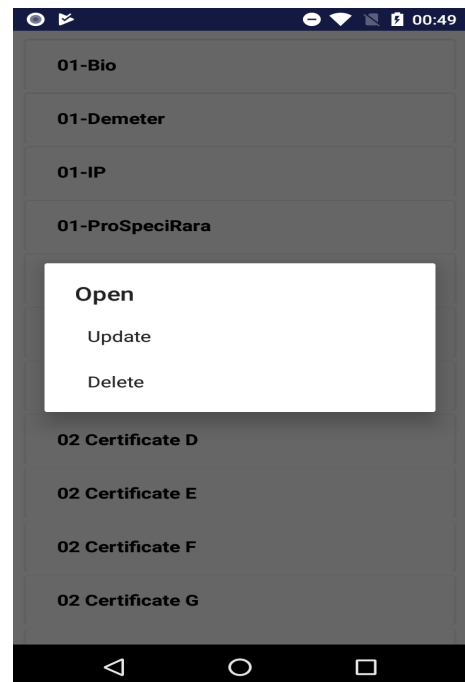


Figure 3.22: Update or Delete Selected Certificate

- **Create Certificate:** By clicking on this button, "creating a new certificate" window appears. Now write certificate name in "Certificate name" field, and then click on "Create" button for creating the certificate as shown in Figure 3.28.
- **Logout:** Click on this button to logout from the application.

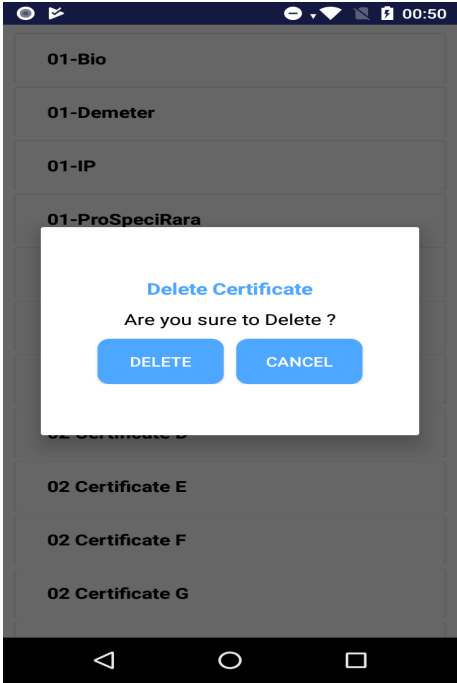


Figure 3.23: Delete Selected Certificate

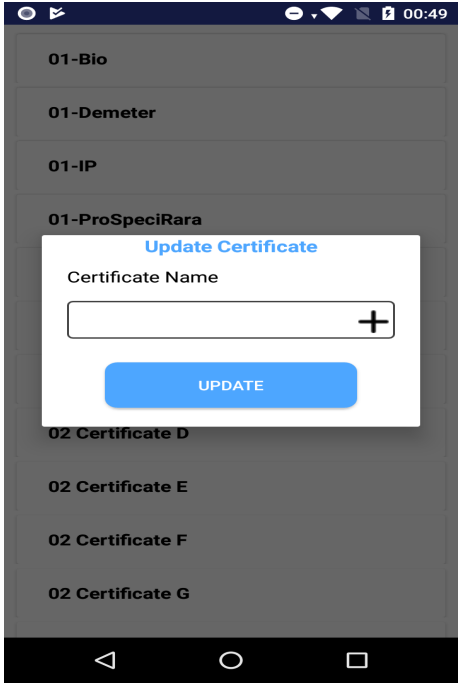


Figure 3.24: Update Selected Certificate

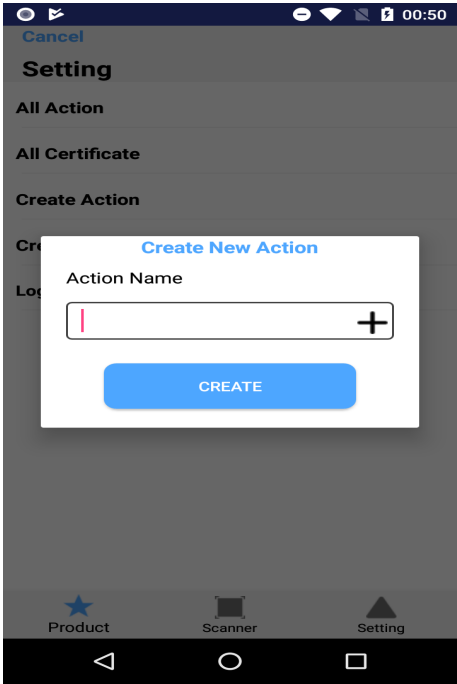


Figure 3.25: Create New Action

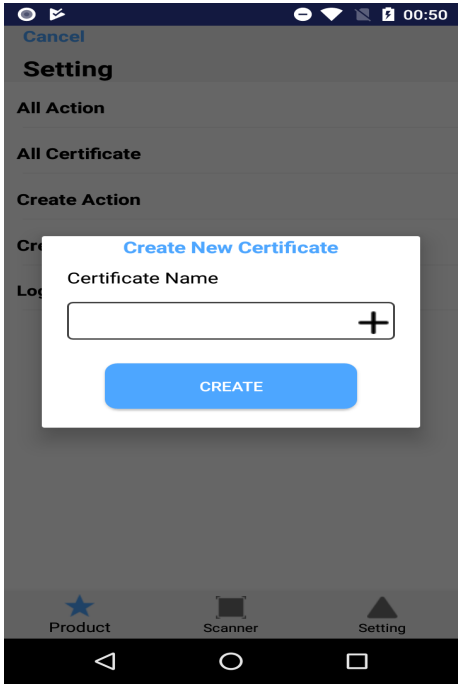


Figure 3.26: Create New Certificate

3.4 Consumer Mode

If you click on the food chain application icon a startup screen appears with following two options

1. Producer
2. Consumer

Consumer view of app allows the end users to scan QR codes for provenance and traceability of the product. Customers are able to track a product's life cycle from the first producer via processing stakeholders to the shelf, where the end user finally purchase the product. By scanning QR codes they can see the locations on map at which the products were produced or actions were performed by the producer.

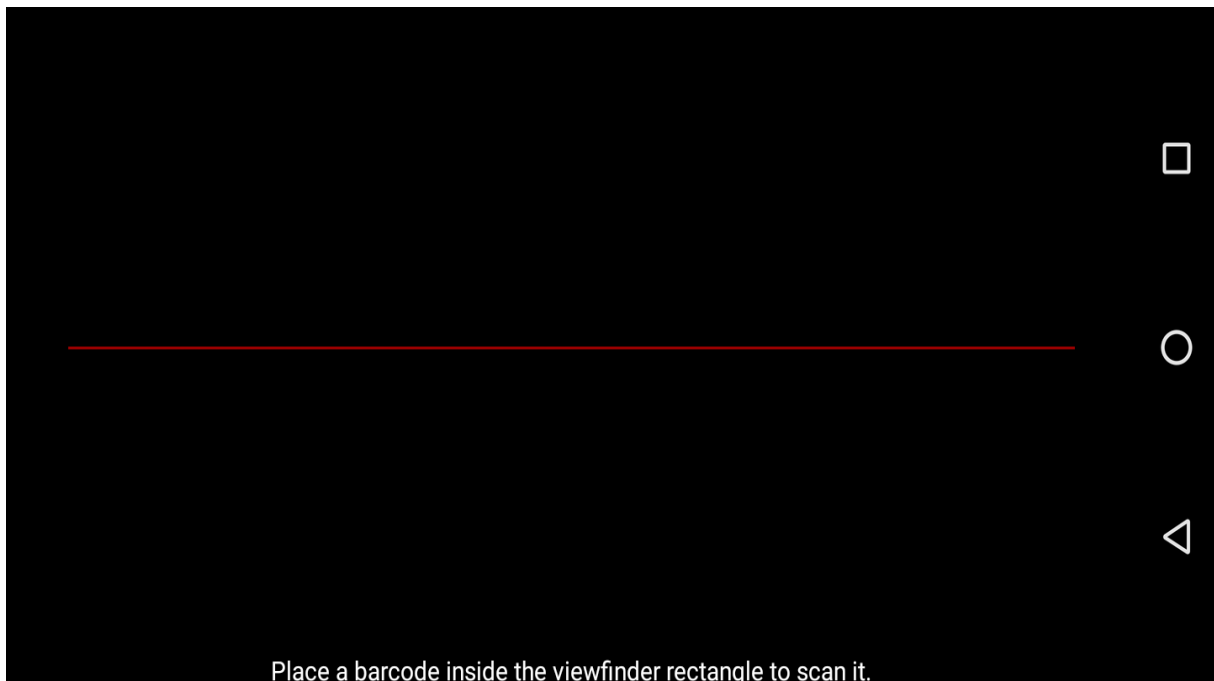


Figure 3.27: QR Code Reader

For consumer mode there is no need to register and login to system, they just need to click on the consumer button and camera gets ready to scan QR codes as shown in Figure 3.29. [If product exists in the system and has QR code(s) associated with it then by scanning QR code consumer will get the information regarding product, location from which it came and modified, date of modification of product. If the hash key of scanned product is invalid or QR code information does not exist in database, a popup window will be shown with a cross mark, saying that the "product info was not available" with a link "product tagging page". If a scanned product is valid, a message will be displayed on the screen "Product Data is valid". User can click on the product to visualize the traceability or tracking of product in the map view with location markers, at which product

was modified. It is required to place the place camera inside the viewfinder rectangle to properly scan QR code .

3.5 Food Chain Database Schema

3.5.1 Database Schema

A database schema is the skeleton structure that represents the logical view of the entire database. It defines how the data is organized and how the relations among them are associated. It formulates all the constraints that are to be applied on the data.

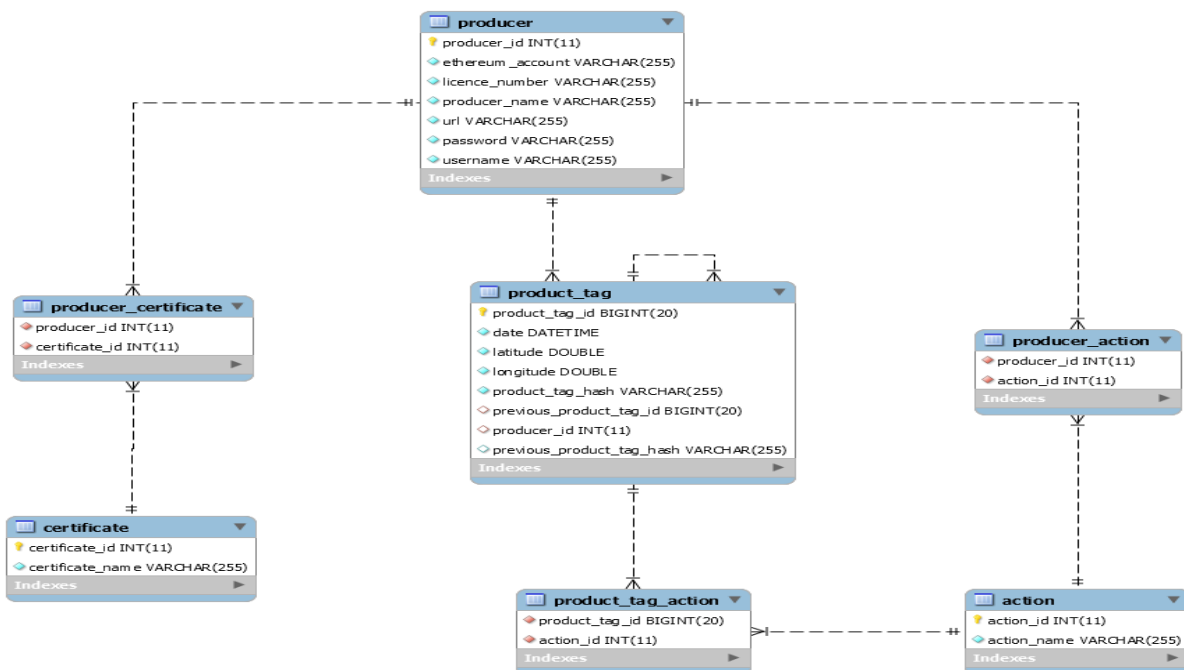


Figure 3.28: EER Diagram

EER Diagram is database schema of Food-Chain Application. It shows seven tables, their columns along with their data types, relationships between the tables, as well as their primary keys and foreign keys. Above Diagram

- For the purposes of creating a visual overview of the database, each table becomes a box in the diagram. The title of each box indicates what the data in that table describes, while attributes are listed in box.
- Attributes selected as Primary key or Foreign key are depicted as Golden key and diamond respectively.
- Tables are connected through various relationship

3.5.2 Database Schema

Chapter 4

Evaluation

This chapter presents the results of the experimental evaluation of the implemented Food Chain version as presented in above chapters. The main focus of this independent study is to Design and Development of an Android-based Supply Chain Tracking Application. The working prototype with tested in a group meeting with client. A working demonstration was presented in a group meeting with client including both frond-end and back-end of Food Chain App within the scope of this Independent Study Module. This meeting provided a satisfactory response on the development and implementation of required functionalists. However, many suggestions, some change requests and improvements were discussed in the meeting for next version of app.

Some of the relevant suggestion are discussed in following points.

- Graphical User Interface Improvements
- Designing a cross-platform app (Iphone, Android) to get a large customer base in Switzerland
- A digital transformation of food chain records using blockchain

when it comes to food supply chain, technology advancement has led to a heightened customer expectation. At the basic level, a client would expect that orders placed, would be fulfilled quickly, delivered on-time and with no compromise on quality. Therefore, a true customer-centric supply chain initiative will need to go beyond the norm. It refers to all customer experience improvement initiatives embedded in the process of moving finished products from suppliers to customers. The key ingredient for establishing a true customer-centric supply chain comes with embedding, or integrating, real-time market signals and customer information into all supply chain activities and processes.

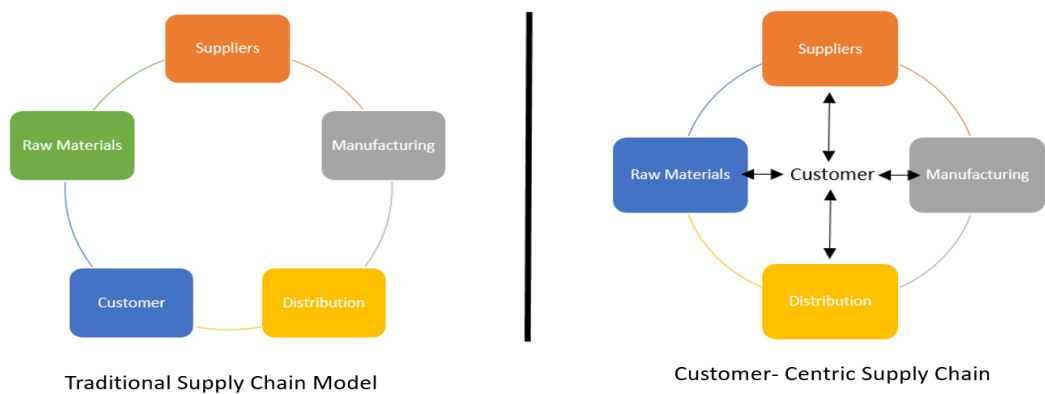


Figure 4.1: High-Level-View of a Supply Chain Process

Chapter 5

Summary and Conclusions

FoodChain App allows businesses to make themselves, their products and supply chains more transparent and traceable. It adds transparency and trust in consumers. FoodChain App is designed and developed to fulfill the requirements of end users in food chain industry. A functional prototype is developed in this Independent Study Module. The system is developed in the form of an Android application to enable a fast and easy tracking, which users and producers can easily use, install on their smart phones. It allows the producers to create new QR code after performing actions on the product, whereas the consumers can scan the QR code to track a product's life cycle. Through the use of a simple QR code and a smartphone, customers can scan a package at the Point of Sale and receive a full and complete history of their foods journey. It empowers the customers to verify the traceability of products at certain phases of the supply chain and data is communicated effectively between stakeholders. FoodChain App offers a personalized customer experience that can only be achieved by having dynamic access to customer data throughout the entire supply chain process.

FoodChain App is capable to make a digital transformation using blockchain in food supply chain industry. The first version of the app is a proof of concept, which will be enhanced in the future by adding more cutting-edge features and business use cases in supply chain industry.

The blockchain is evolving to be used beyond financial industry. Blockchain, through the use of smart contracts, is able to track food throughout the supply chain. Using smart contracts, all products can be coded in such a manner that each product can be tracked from the farmer who produced it. Food supply chain is one of the main industries that could be revolutionized by the blockchain. It would also be interesting to add peer-to-peer payment system in the future release of FoodChain App. Some of the food products are shipped halfway across the world and therefore rely on different currencies which cause changes and difficulties in determining the true value of a product. With cryptocurrencies, it is possible to have one unified cryptocurrency to use for the specific product all through different stages. This would solve complicated and uneven FX differences. Final consumers have leeway to decide whether they want to buy the product with crypto or fiat currency [19].

Following list improvements will be added in the next version of app.

- Interactive Map for Visualizing Traceability
- Security Enhancements
- P2P Payment System
- Smart Contract Integration
- Enhance User Friendliness
- Generalize the App for other use-cases

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Abbreviations

EDI	Electronic Data Interchange
HACCP	Hazard Analysis and Critical Control Points
RFID	Radio-frequency identification
GIS	Geographic Information System
GDPR	General Data Protection Regulation
EER	Enhanced entity-relationship
REST	Representational State Transfer

Glossary

Authorization Authorization is the decision whether an entity is allowed to perform a particular action or not, e.g. whether a user is allowed to attach to a network or not.

List of Figures

3.1	System Diagram	7
3.2	Food Chain Usecase	8
3.3	Model-View-Controller Class Structure	9
3.4	Rest APIs	10
3.5	Startup Screen	12
3.6	Login Screen	12
3.7	Registration	13
3.8	Select Licenses	13
3.9	Create New Licenses	14
3.10	Select Actions	14
3.11	Create New Actions	15
3.12	Main Page	15
3.13	Product Scanning	15
3.14	Scanned Product	16
3.15	Map View	16
3.16	Product Tag Created Successfully	17
3.17	Products Tag	18
3.18	Settings	18
3.19	All Actions	19
3.20	Update or Delete Selected Actions	19
3.21	All Certificate	19

3.22 Update or Delete Selected Certificate	19
3.23 Delete Selected Certificate	20
3.24 Update Selected Certificate	20
3.25 Create New Action	20
3.26 Create New Certificate	20
3.27 QR Code Reader	21
3.28 EER Diagram	22
4.1 High-Level-View of a Supply Chain Process	24

Appendix A

Installation Guidelines

Specifications for app installation:

API level (Platform version): There have been many major changes between API's in android. Food Chain Android App currently supports minimum API level 19 (android version=4.4) and highest API level 27 (android version=8.1) for device compatibility.

Device capabilities: Your android device should have following capabilities: GPS, Integrated Camera, Internet Connection.

Device Permissions: Food Chain app requires following permissions before installation: Internet, location, media storage.

Installation:

Please install 'Food Chain' android application from a shared location. By default, Android devices cannot install apps from sources other than the Google Play Store. To install apps manually, you'll need to allow your device to install apps from other sources. You may need following steps to enable manual installation of android APK.

- Please open the Settings on your android device.
- Tap "Security". it will open the Security menu.
- Scroll down and check the "Unknown sources" box. Tap "OK" to confirm that you want to enable this.
- Download Food Chain APK directly to your device from shared location.
- Navigate to the location of downloaded APK file installation.
- Tap the APK. This will immediately open the installer for the app. You can review the permissions before the app is installed, you will see a list of the
- services that it will have access to.
- Tap "Install" to install the app. The app will automatically install, and an icon for it will be added to your Home screen. You can tap the "Open" button in the installer to open it immediately.