# IBM Hack Challenge – Team hackOverflow

### (SmarTangleWMS)

**Problem Statement :** Optimized Warehouse Management of Perishable Goods for a Food Delivery Company.

# *1. Introduction*

## *1.1 Overview*

A food delivery service must deal with a substantial amount of perishable raw materials and the most important factor for such a company, is to accurately forecast daily and weekly demand. Too much inventory in the warehouse means more risk of wastage, and not enough could lead to out-of-stocks - and push customers to seek solutions from your competitors.

As a food warehouse optimizing system, our solution- SmarTangleWMS, would principally work to reduce and hence eliminate this issue. We have come up with the idea of a *SaaS Warehouse Optimization system* for a warehouse that covers tracking of the movement, quality and shelf life of the product and also predicts the requirement of specific products based on daily demands for long term usage so as to prioritize and deliver as per requirements and reduce food insecurity. We plan to implement our solution with the help of *Tangle* , ML and IoT for supply chain demand prediction and visualization, a foolproof food quality and movement tracking as well as to ensure legitimacy and convenience for customers.

## *1.2 Purpose*

The primary aim of our solution is to provide a digital system for the Warehouse to manage and optimize their inventory starting from the procurement phase through its pre-production stages, to finally when its sold to a customer. We also provide the customers with a mobile application that enables them to see the processing and information regarding the raw materials and its production with

more clarity. More importantly, our solution has its paramount interest in integrating all the stakeholders involved in the system so as to *predict the requirement of food and its trends, over a period of time.* This would aid in a situation like the present one, where logistics has hit a wall due to the COVID pandemic while *food insecurity and panic buying is on an all-time peak*

# 2. Literature Survey

## 2.1 Existing Problem

One of the major issues faced by the food industry, that has been accelerated particularly in the wake of a pandemic is food insecurity - ranging from unavailability of food material for the mass from panic buying to food wastage due to rotting in store shelves as well as owing to the former. The problem statement further defines the issues faced by a food delivery system, wherein they are forced to deal with a lot of perishable raw materials. The most important factor for such a company is to accurately forecast daily and weekly demand. Too much inventory in the warehouse means more risk of wastage, and not enough could lead to out-of-stocks - and push customers to seek solutions from your competitors. In such a scenario, the replenishment of majority of raw materials is done on weekly basis and since the raw material is perishable, the procurement planning is of utmost importance.

## 2.2 Proposed Solution

As a food warehouse optimizing system, our solution would principally work to reduce, or if possible eliminate these issues.

Our proposed scheme works on a *Tangle based system* - an upcoming technology that stands as a fierce competitor, if not a probable successor to the blockchain system. Since the quality rating, timestamp of activity, movement and shelf life of each and every raw material and food item is tracked in this immutable structure and made available to the consumers, the legitimacy of the food produced is exponentially clarified to the end users.

We initially evaluate the nature of the same produce by competitive suppliers and the best ones in terms of freshness and shelf life is received based on quality score. Each raw material is then processed per day and batch, is recorded and on packaging, is given a QR code. The QR code has information regarding the suppliers, the movement of the food material (Location, timestamp, vehicle, store info, predicted shelf life) from procurement of the material till checkout. The data regarding the demand of raw materials are collected and collated on a daily basis.

- Apart from this, the end-user application allows the customers to know the cycle of material replenishment/ availability in the nearby stores – which store specifically has the material they require and if not when such material will be made available again. This in-turn contributes a major role towards reducing panic buys from customers as they are made aware of the genuine cycle of the products.

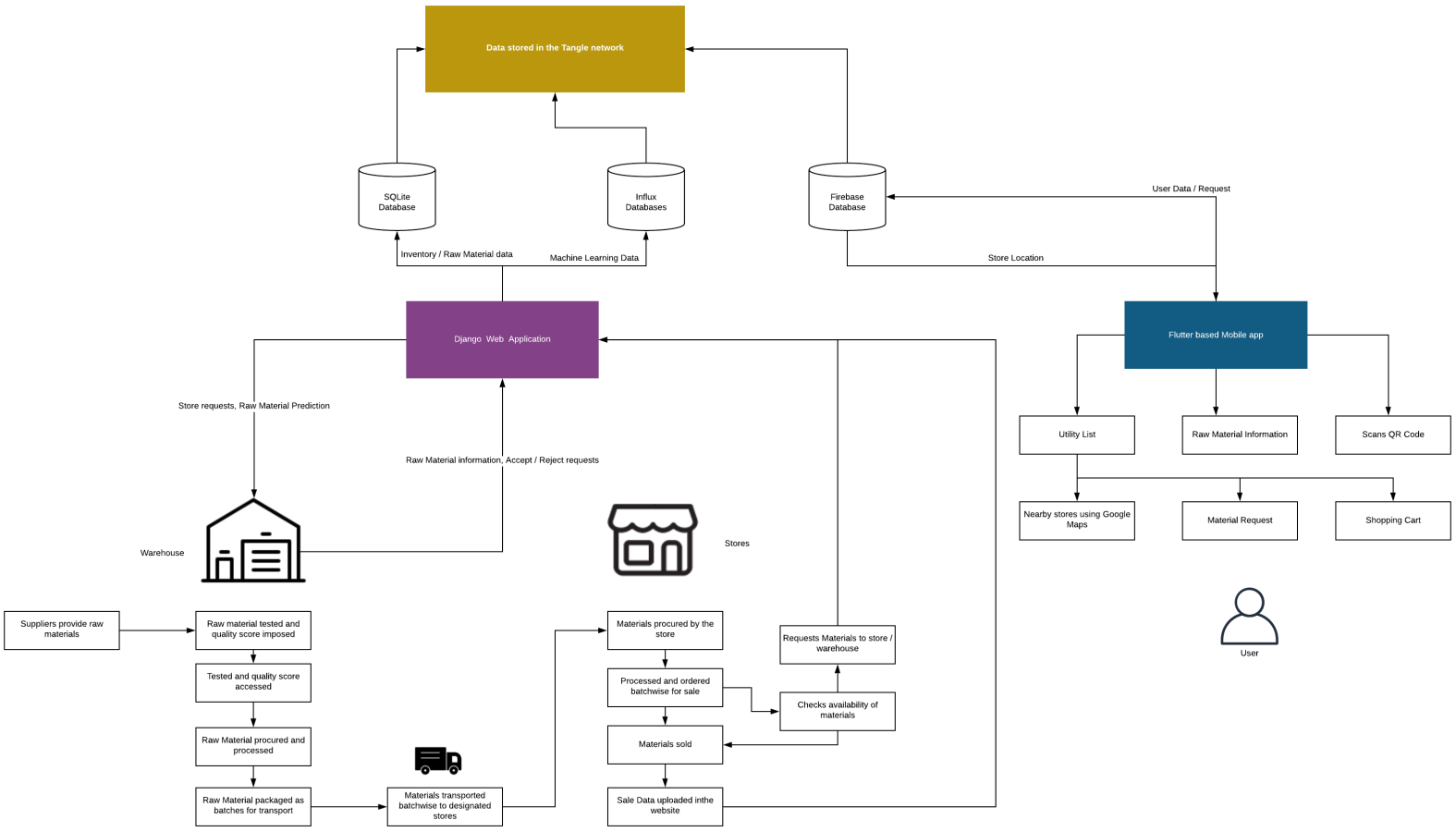
- *The major functionality of our solution involves a time-series based machine learning model (FB Prophet) that is used to predict and visualize the demand of goods for a longer period* based on daily acquired data from the stores so as to reduce the supply-demand gap region wise. Using this, it becomes easier to understand the requirement of resources over the span of stores in various regions and this, in turn, helps to prioritize resources. This pressures the warehouse to only opt for material as per requirement, avoid overproducing materials less required while utilizing that resource to for a material more in demand and pushes for fresher materials that could be consumed in a higher pace, hence resulting in less food wastage.

- Amongst other uses of the data we collect for training our prediction model, we also aim to obtain a clear view of the *rush hours in each and every store.* Such information can be used by the food company to know the approximate time of the day or days of the week when the rate of buying is high and furthermore use it to manipulate (increase) the prices for those time periods. *This yet again works towards reducing panic buys of materials* as well as immensely utilizes such a scenario to generate more revenue to the company and impact its business as well.

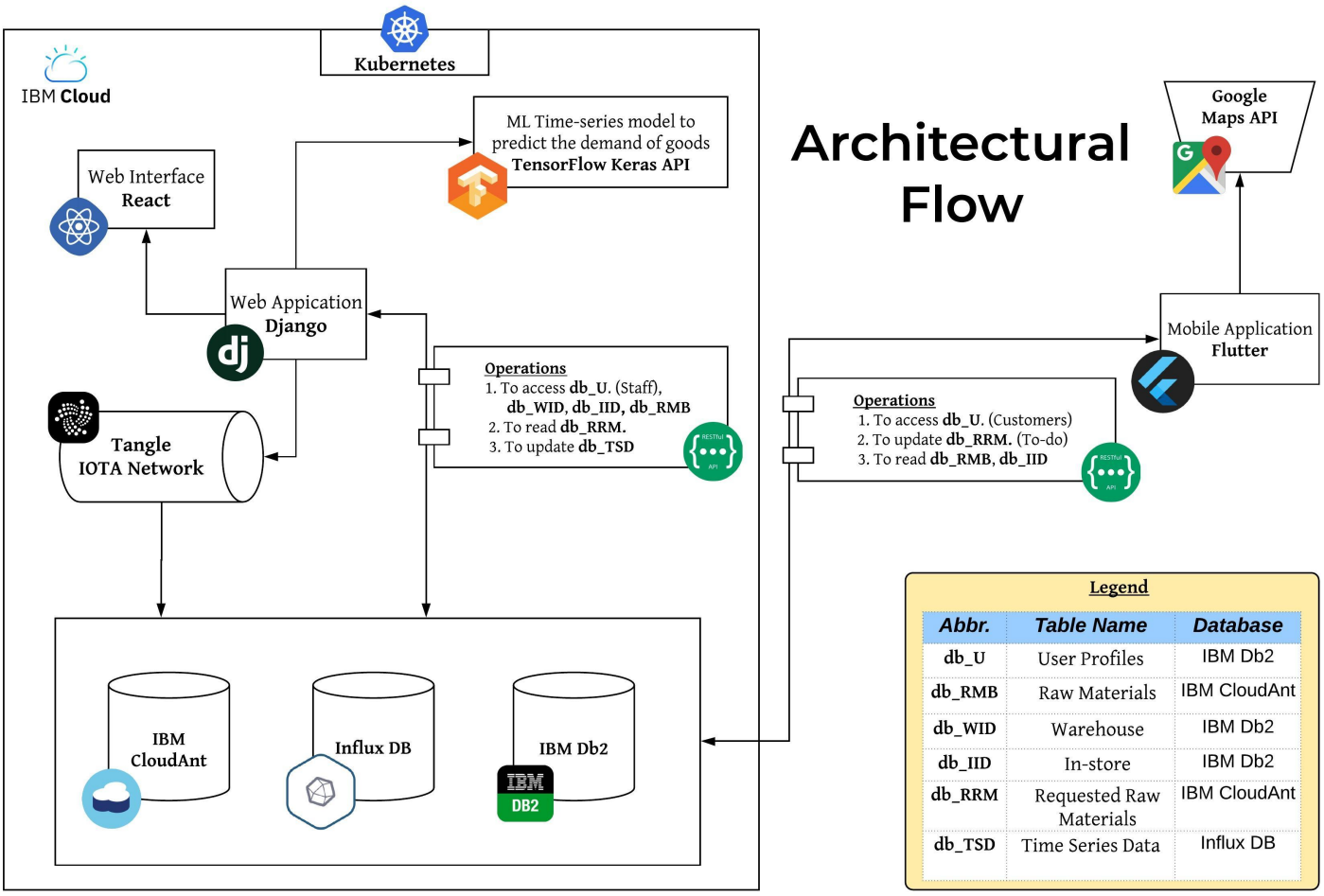
- In addition, the utilities present in the consumer end application such as the ability to request for specific material from an area, view livestock and availability further enhances the ease of shopping, contributes to reducing bulk purchasing and acts as a supplementary method of getting data regarding the requirement of material in an area to aid accuracy in prediction of the supply-demand gap. Hence our system works to improve brand loyalty while providing the legitimacy of food tracking, freshness, quality insurance and movement monitoring.

# *3. Theoretical Analysis*

## *3.1 Block Diagram*



## 3.2 Hardware/Software Design




The technological stack that has been used for the component-wise design and implementation of this software project as a reference to the working architecture mentioned above are as follows :

- **Machine Learning Model:**
  - TensorFlow Keras API
  - FbProphet Model by Facebook *(Time Series Model)*
  - TPOT Regressor *(Quality Score Prediction)*
- **Tangle Network**
  - IOTA Devnet (public) Tangle Network

- **Warehouse-End Web Application :**
    - Django Framework *(Back-End)*
    - HTML, CSS, JS, Bootstrap *(Front-End)*
    - Docker & Kubernetes *(Containerization)*
    - IBM Cloud / Amazon AWS *(Deployment)*
- **Customer-End Mobile Application :**
    - Flutter *(Android Development SDK using Dart)*
    - Google Maps SDK *(Maps and Location details)*
- **Prototyping:**
    - Adobe XD
- **Databases:**
    - Influx DB from IBM Cloud Catalog *(Processing of ML data)*
    - Firebase *(NoSQL : User data & Requests from the mobile application)*
    - SQLite *(SQL : Store Inventory & Raw Material information)*

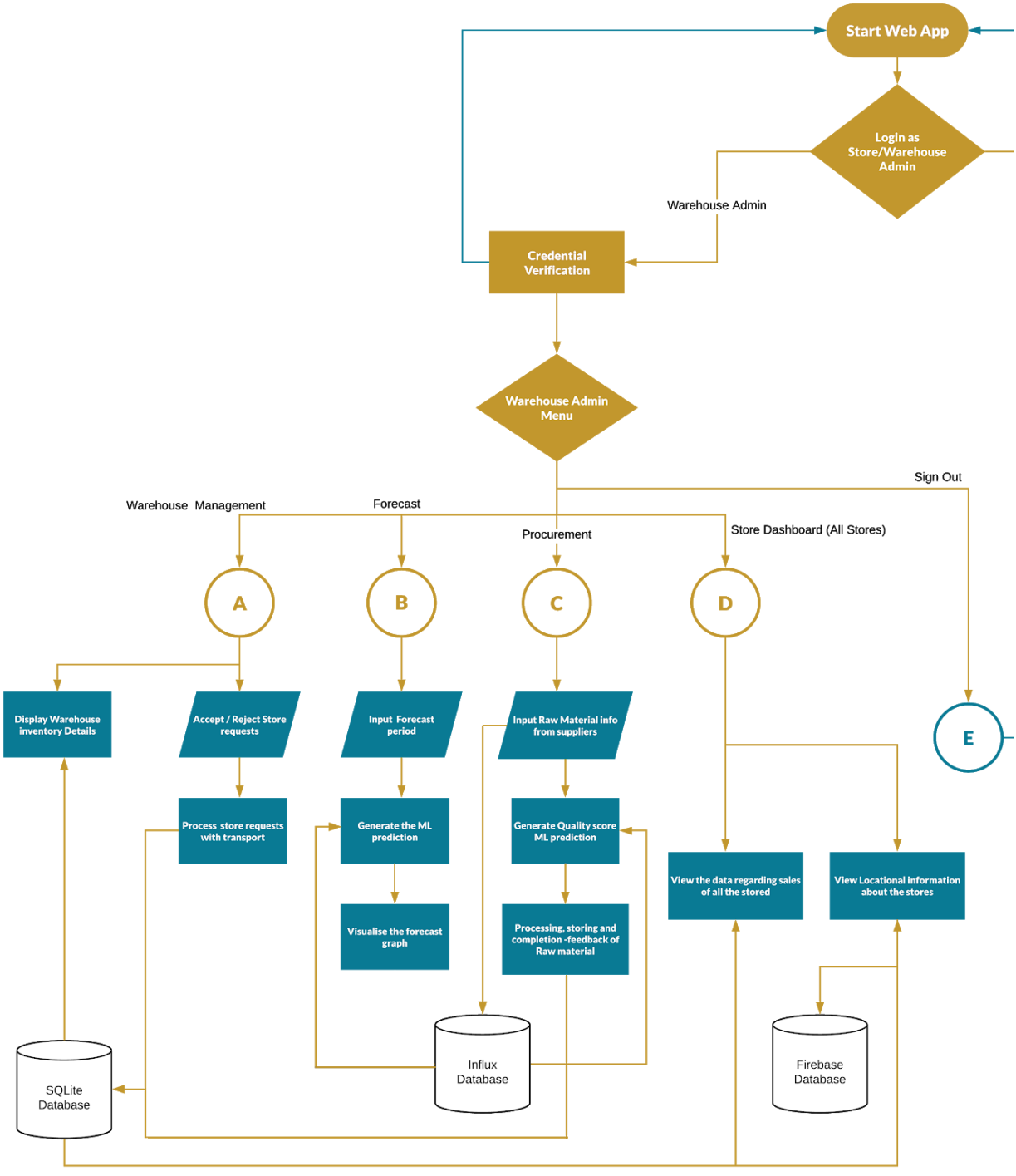
# *4. Experimental Investigations*

Delving deep into the current global scenario, it has been proclaimed by experts that Warehousing and Industrial space demand were set to be one of the most adversely affected sectors in the wake of the COVID-19 pandemic – with special regards to the food industry. Panic buying has been a major bane affecting both the suppliers, the warehouse as well as the customers. The difficulty in availing quality food materials and the lack of planning towards its acquisition and inventory storage adds on to the damage the pandemic has done to the industry. The global food prices have surged and we require a method for lockdowns have led to a collapse in demand for durable goods and discretionary services, the opposite is true of food. In cities around the world, reports of panic buying and food hoarding have proliferated since the pandemic began. On the supply side, global grain stockpiles are healthy but could quickly be depleted as the virus disrupts food production and distribution. And shortages of animal feed, fertilizers, and pesticides have increased both the costs of farming and the risk of bad harvests.
In such a scenario, the requirement of a secure food oriented system is more than just required – it's a necessity. The importance of forecasting the needs

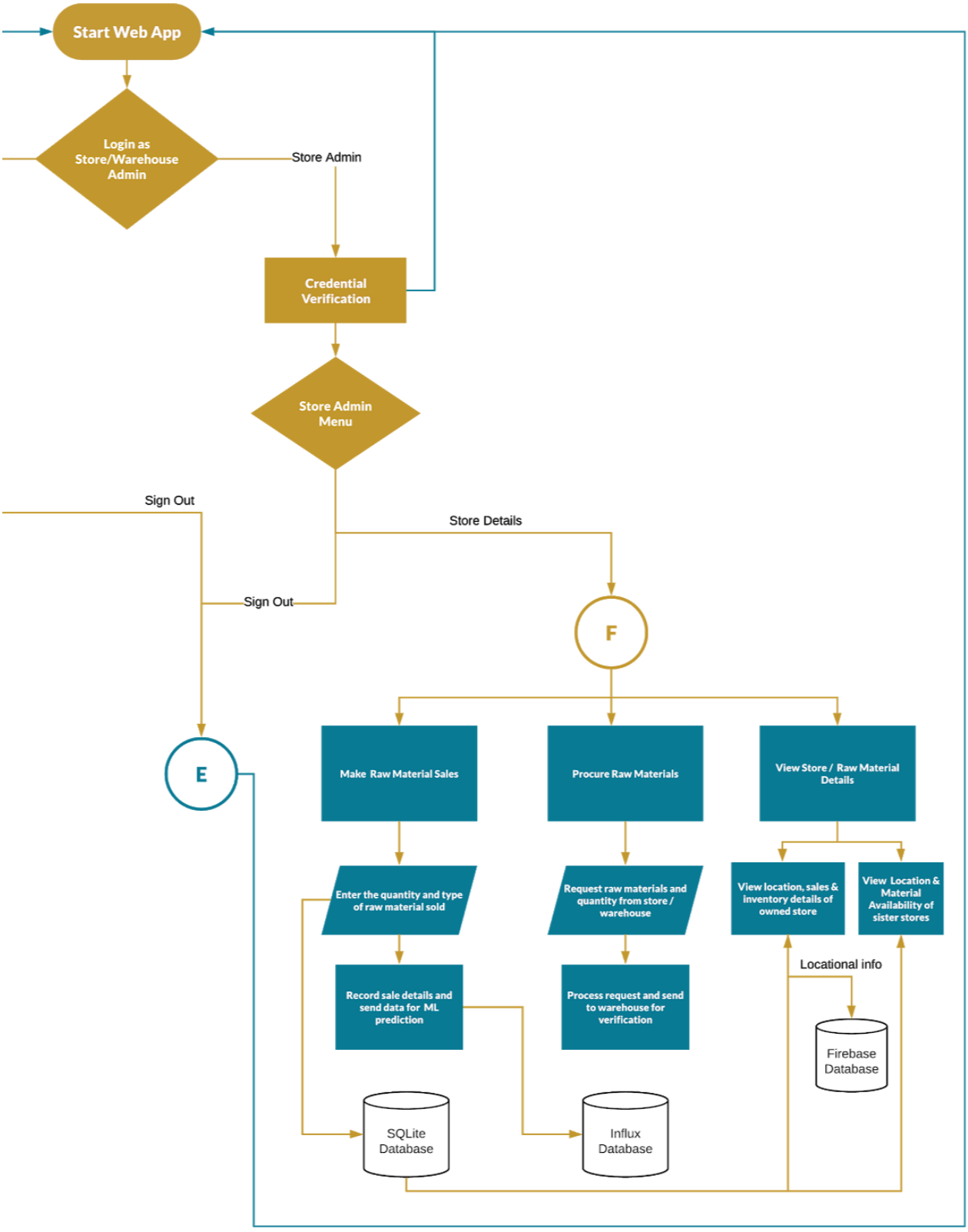
of subsidiary stores alleviates the issue of procurement planning and helps to stock up quality material based on the supply-demand gap in different stores.

## 5. Flowchart

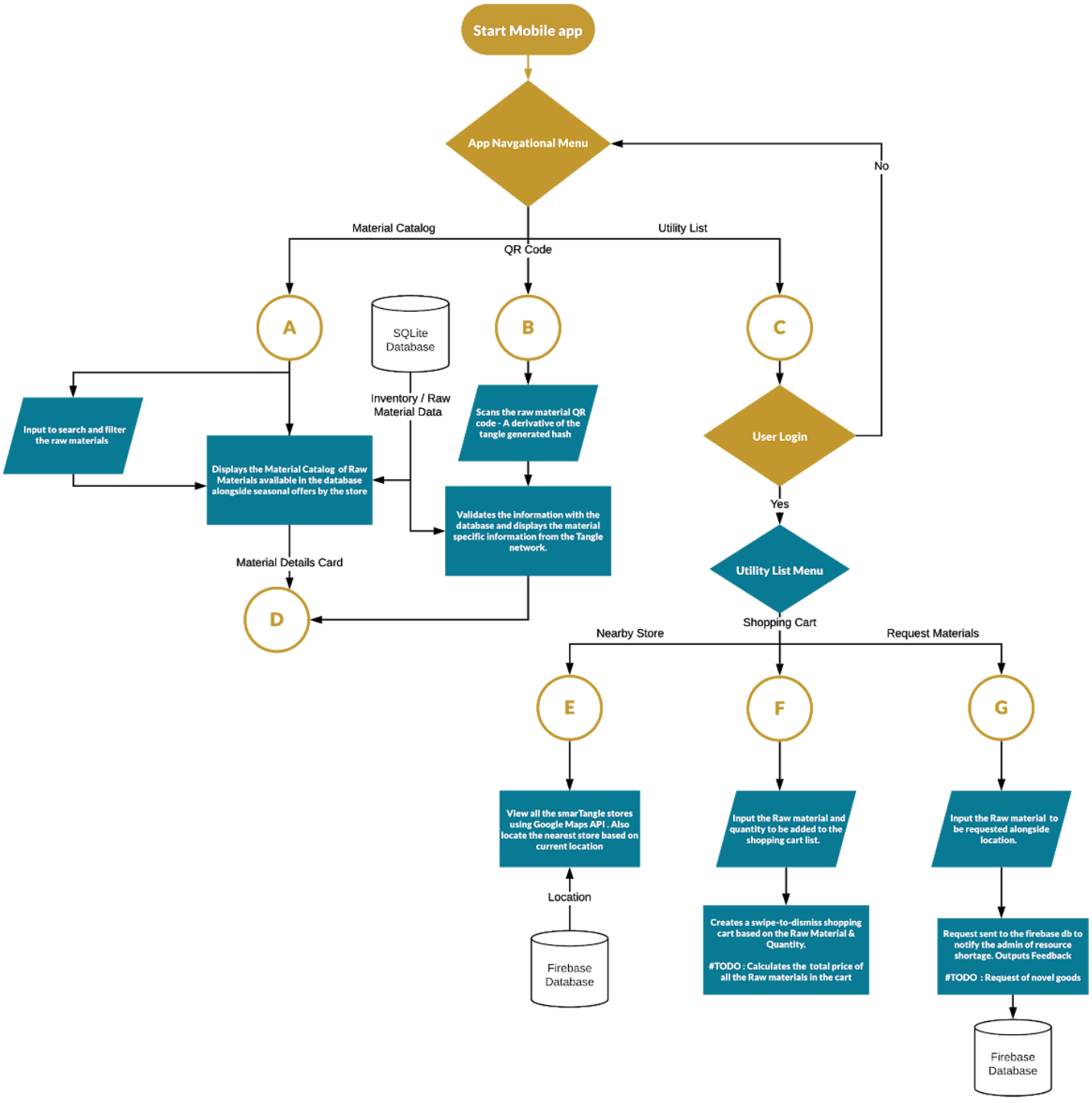
### *Warehouse - end Web app ( part 1 )*



# *Warehouse - end Web app ( part 2 )*

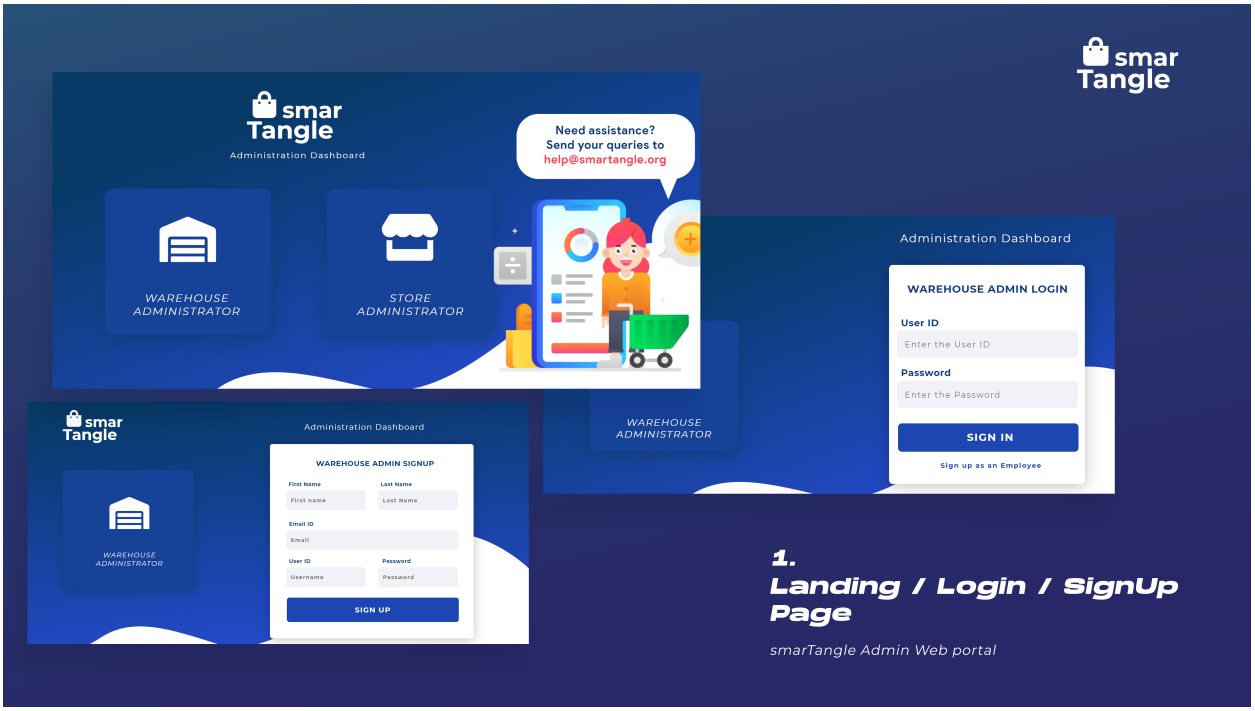


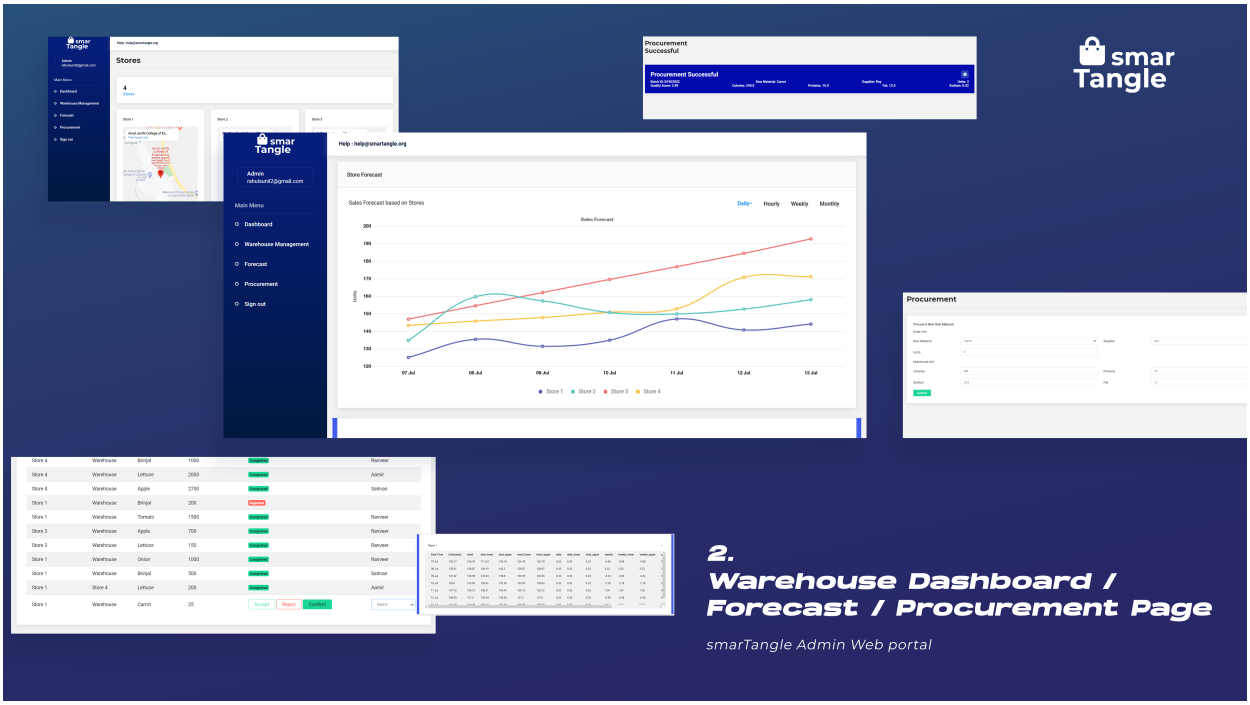
# *Customer - end Mobile app*

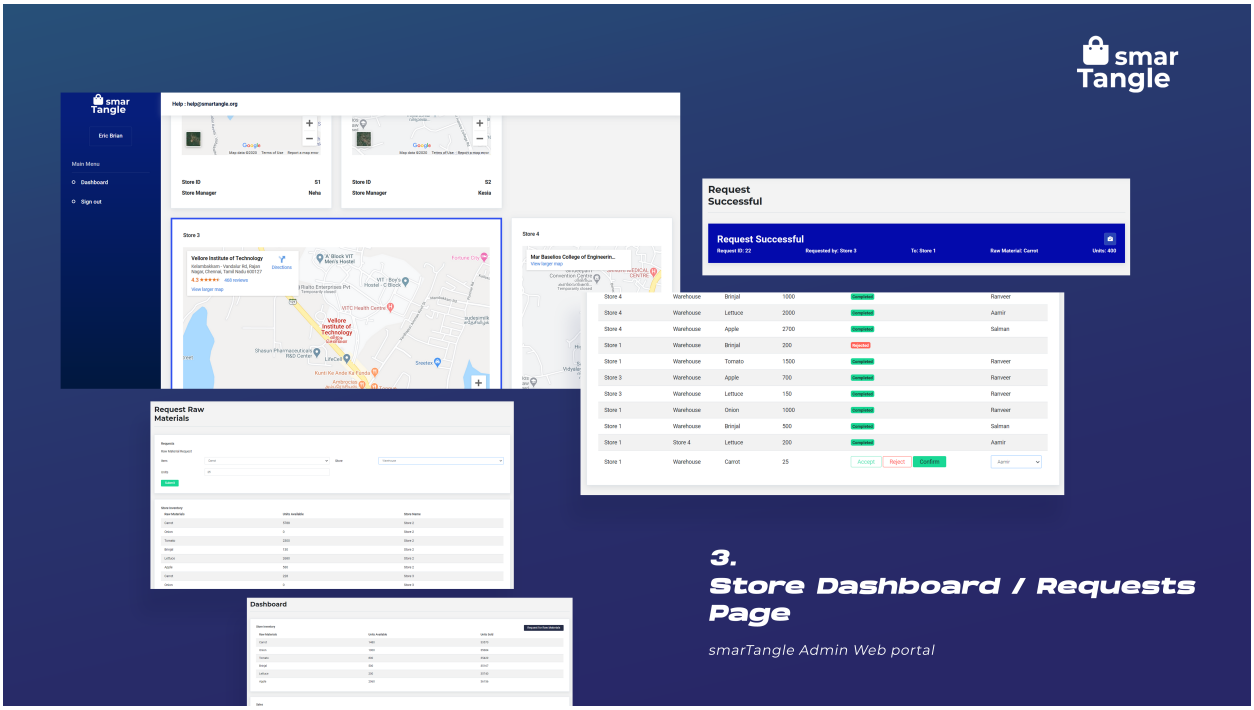


# *6. Result*

The smarTangle WMS system has been developed to comprise of two main components - a **Django-based Web application** and a **Flutter-based mobile application**. The end results of the project at this stage is as follows :

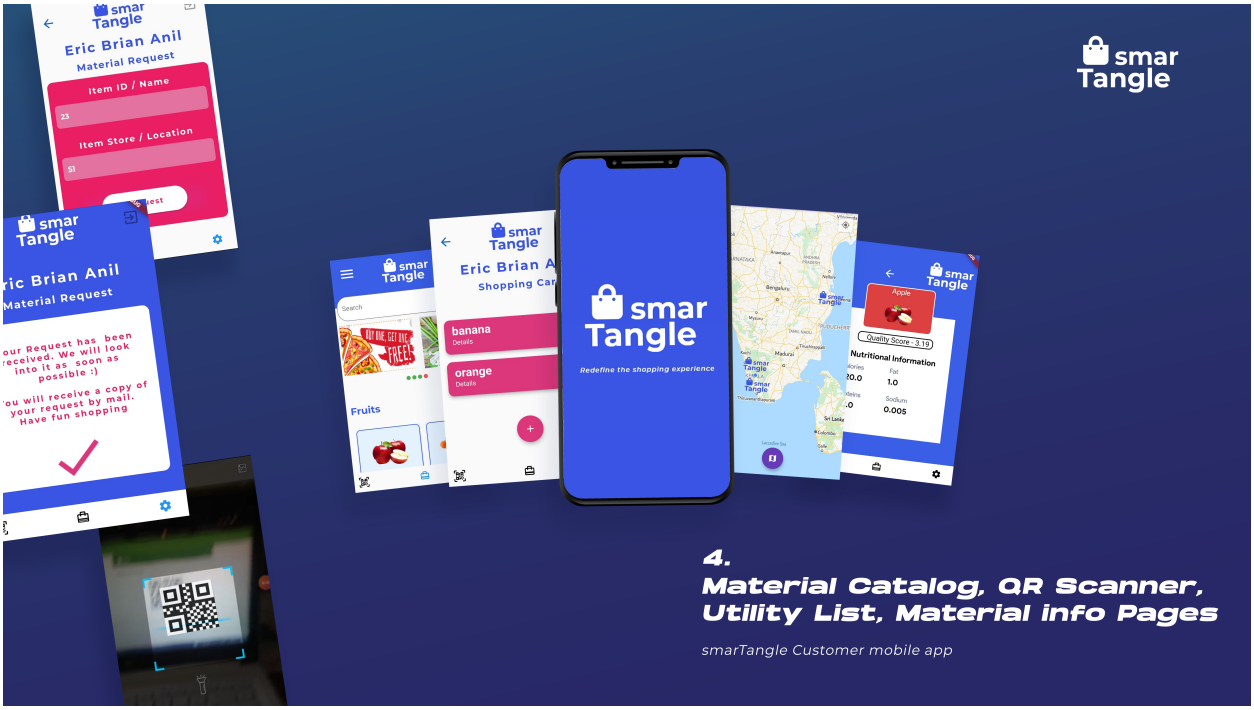





## 3.
## Store Dashboard / Requests Page

*smarTangle Admin Web portal*




## 4.
## Material Catalog, QR Scanner, Utility List, Material info Pages

*smarTangle Customer mobile app*

## *7. Advantages and Disadvantages*

The major **advantages** in the current application can be listed out as :

- The *time-series based material forecast* over a period of 10 weeks that has been implemented could be considered very functional and appropriate for the current supply chain usage as it provides various trends for prediction with very minimal MSE and RMSE values.
- The usage of a node based *Tangle network* works to increase the security in food transactions from the procurement stage. This in turn increases the legitimacy and clarity of each step of the food production for the customers.
- The *prediction of rush hours* in a store aid the warehouse in taking crucial decisions regarding the pricing and supply.
- The *utilities provided by the mobile applicaton* ( such as material availability, material replenishment details, material request, etc. ) aid towards reducing the impact of panic buying in customers as it provides customers clarity regarding the functioning of the warehouse and lets them be a part of this structure.
- The *quality score prediction metric* ensures that there is competition among suppliers to provide the best available produce of each raw material. This in turn enhances the shelf-life of the raw materials.

A few factors **that could be improved** are :

- The current time series prediction of the raw materials is uni variate specifically due to the unavailability of reliable , real-time data and could be scaled up as a multivariate model to predict the demand supply gap more efficiently *based on the geographic location of the stores, holiday seasonality, etc.*
- The addition of a user profile customisation, scope to request for introducing new materials into a store and the display of the next date of replenishment in each store for a specific raw material is still under development in the mobile. The general UI/UX needs to be more streamlined.

## *8. Application*

*The current system consisting of the Web app and the Mobile app bundle is intended to be used as an SaaS for the Warehouse Optimization and Management of a warehouse that supplies raw materials relating to food items. Nevertheless, this could be adapted to a general use-case software solution in the field of warehouse optimisation as it provides a novelty in maintaining material transactions way beyond the specificity of food items.*

## *9. Conclusion*

In a nutshell, our solution proposal - **smarTangle** is a novel system which integrates the use of the IOTA based Tangle network to set its base as a Warehouse Optimization and Management system for a food warehouse that produces raw materials. It consists of a Django based web application for the usage of the warehouse alongside a Flutter based mobile application for the customers. The web app extensively works to forecast the raw material requirements of its subsidiary stores in a span of over 10 weeks , which helps prioritize the warehouse inventory of raw materials to prevent food wastage and reduce food insecurity. On the other hand the mobile app wraps this system by providing crucial information regarding the raw materials and its journey securely till it has reached the customer so as to increase the authenticity of the food network while working to reduce the effects of panic buying.

## *10. Future Scope*

Certain degrees in which the current system is intended be scaled up in the future are :

- *The prediction of shelf life of materials*. The shelf life of raw food materials are very complex and require mandatory physical testing of components with each batch. With the provision of being fed real-time data regarding the batches, the data regarding the conditions in which the raw material was produced and the factors affecting its shelf life, the system could be improved to regressively train the provided data to predict the shelf life of procured raw materials in the future. *This would give an additional insight on selection of*

*suppliers and raw materials.*

- *Adding more seasonality to the Time-Series forecast.* The current time series prediction of the raw materials is uni variate specifically due to the unavailability of reliable data and could be scaled up as a multivariate model to predict the demand supply gap more efficiently based on the geographic location of the stores, holiday seasonality, etc. *This would give an additional insight on the trends in which raw materials get sold and would help prioritize the supply of raw materials to stores more efficiently.*

  *The materials could also be converted as meal groups that are store specific which again adds on to the efficiency of the model to provide more categorized predictions.*
- *Adding a portal for the suppliers.* The procurement stage could be made more efficient with the active monitoring and involvement of the suppliers, especially if the procurement is outsourced to generate a competition for quality materials. Hence addition of a portal for the suppliers to keep monitoring the raw materials they provide, the conditions in which the material is produced etc. would help impose a rating on each supplier and their produce. Apart from this, integration of the additional supplier details with the tangle network further ensures more trust in the chain.
- *Management of staffing and automated machinery.* The admin dashboard provided to the Warehouse admins in the web application could be extended to control staffing information such as staff details, department, punch in, etc. so as to provide ease in managing the staff network digitally.

  In addition to this, if the warehouse does possess automated machinery manageable in a network, *the dashboard could be further used to communicate with and conduct remote diagnosis of the machinery via usage of Node-red. Tangle networks are in fact known for their compatibility with IoT integration.*

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