BEACONHOUSE NATIONAL UNIVERSITY

Project Title

PRJ-F23/xxx [project ID]

PROJECT PROPOSAL REPORT

INTERNAL SUPERVISORS

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Problem Statement

In the current landscape of the food industry, a factor significantly contributing to inefficiencies, wastage, and inadequate demand forecasting are traditional manual processes for inventory management which underscore the need for digitalization and automation within the food industry. Businesses presently have not streamlined their processes up to their potential, be able to predict demand precisely, or optimise resource allocation. This implores a more agile and responsive supply chain and in the era where data-driven decision-making has become paramount, digitalization and automation empower businesses to make informed choices swiftly, fostering a resilient and future-ready food ecosystem. Furthermore, a seamless integration of technologies is needed to improve communication between vendors and grocery store retailers to allow a collaborative and synchronised network that could prove to be essential for the industry’s growth and sustainability.

Existing System

In Pakistan, products move from suppliers to stores in an outdated manner, relying heavily on paperwork. Unfortunately, this system faces significant challenges due to its outdated nature and dependence on manual processes. This traditional approach makes the supply chain vulnerable to disruptions, worsened by limited visibility caused by infrastructure and technological constraints. Communication is also a hurdle, as less developed infrastructure leads to delays and potential misunderstandings. Retailers struggle with stock outs because they can't predict when supplies will arrive, and the slow replenishment process hampers their operations. The conventional procurement structure demands a significant time investment, with retailers spending an average of 25 hours per week navigating wholesale markets and dealing with distributors. This not only affects operational efficiency but also imposes working capital restrictions. Consequently, retailers are forced to invest more capital in their stores, resulting in a limited range of product categories due to constraints in expanding their offerings range. Wholesalers and distributors face challenges as well, including a small customer base, limited reach, and information gaps, relying heavily on manual efforts, which makes order generation a labour-intensive process. Given these challenges, there's an urgent need for the supply chain in Pakistan to transition towards more modern and technology-driven practices. This shift is particularly crucial in the current business landscape, where rapid changes are the norm. Embracing modern solutions can enhance efficiency, reduce delays, and create a more resilient supply chain ecosystem.

Literature Survey

Addressing challenges in the food industry, recent studies offer innovative solutions. One study, utilising low-cost sensors and Arduino UNO supported by a machine learning algorithm, achieves a remarkable 92.65% accuracy in predicting and preventing food wastage [1]. Another explores global food supply chains, emphasising efficiency and behaviour change to combat waste, particularly in affluent economies [2]. Amid the pandemic, a research framework proposes AI and robotics to fight food loss, focusing on sensory enhancement and collaborative automation [3]. Examining the supply chain, the debate between traditional and machine learning forecasting emerges, with a support vector machine showing promise in handling multiple demand series [4]. Shifting focus to supermarkets in Western Kenya, a study underscores the effectiveness of high-tech inventory management, attributing 56.7% of supermarket performance to automation [5].

Expanding insights, a study on e-grocery highlights its role as an alternative to traditional retailing, emphasising in-stock availability in customer decisions [6]. Addressing demand distribution tails, another exploration recommends Generalised Additive Models for Location, Scale, and Shape (GAMLSS) in e-grocery [7]. Transitioning to vendor-managed inventory (VMI) in the grocery supply chain, a simulation model dissects benefits and drawbacks, revealing manufacturers reap more significant benefits from VMI adoption [8]. Furthering knowledge, a study on the chocolate industry employs machine learning for refined predictions based on regular and promotional sales data [9]. In the grocery sector, a study explores the delicate balance between customer satisfaction and overstock, unveiling strategies for proactive food waste reduction [10]. Analysing retail firms as economic indicators, a study on Walmart, Costco, and Kroger employs statistical regression and machine learning, exposing operational inefficiencies [11]. In predictive analytics, 'Corporacion Favorita,' a major grocery chain in Ecuador, is studied to optimise predictions and avoid stock-out and over-stocking issues [12].

In the area of demand forecasting, recent advancements in deep learning [13] mark a transformative shift. A multi-modal sales forecasting network, integrating real-life events with historical data, achieves a 7.37% improvement in SMAPE on a supermarket dataset [13]. Another exploration showcases the prowess of deep learning models, particularly LSTM, in forecasting food demand with superior accuracy [14]. Focusing on the grocery sector, the utilisation of LGBM in time series analysis yields a model with notable accuracy [15]. Despite progress, challenges such as training set size, overfitting, and model complexity persist, urging further exploration. These collective studies significantly contribute to the evolving landscape of demand forecasting and inventory management, fostering a responsive and sustainable food system.

Additional Research

The additional research included conducting interviews with different grocery store owners in order to understand the on ground issues that are being faced by them. The findings of these interviews included discovering the fact that they do not have a proper mechanism to contact their vendors, there is no formal way of checking if the vendor is authentic or a ‘mobiler’ (a person who acts as a real vendor and sells fake goods). They also mentioned that they have to manually check how much of the items are left for them to order more and when asked about how they decide which new item to place they mentioned that their only source to new products is only through vendors. Furthermore, we looked into platforms like Shelf Engine and Gauc who also perform demand forecasting for perishable items in the US. Both of these platforms help reduce food wastage by using machine learning models. Shelf Engine also acts as a middle man between the vendors and the grocery stores by automatically placing orders for the retail shops however through Guac the grocery stores would have to place orders themselves and it recommends the quantity that they should order based on their previous data. Similarly, a platform with the name of Tajir is working in Pakistan to help mom and pop stores manage their inventory by being their vendors and help with purchasing inventory.

Proposed Solution

In the domain of grocery retail, a persistent challenge has been food wastage which demands an approach beginning with the seamless integration of grocery store owners with vendors. The process would be initiated by a registration system for grocery store owners and vendors, followed by rigorous user authentication for safety against unauthorised personnel e.g. mobiliers. Additionally, the legitimacy of grocery store owners would be verified meticulously in order to foster a secure collaborative environment. Collaborators connected through the platform will be facilitated by an intuitive navigation system for product sales and purchase. The platform will not only help reduce the number of physical visits to the grocery stores by the vendors but also provide a tracking feature for grocery store owners, enhancing operational efficiency. Novice grocery store owners would be aided through the platform's assistance in vendor search for specific products.

In this collaborative platform, the integration of a demand-forecasting system will be supported by machine learning (ML), implying the necessity for embracing modernization and automation. To achieve this, a sophisticated system which harnesses advanced data analytics and machine learning, becomes imperative for accurately predicting customer demand for grocery products. The platform will serve as a hub for managing orders, streamlining all aforementioned processes up until

distribution. Automating this process ensures efficiency and accuracy in the inventory management and the precision, owed to ML, will empower stores to order optimal quantities, mitigating the risks of overstocking or understocking. Furthermore, the development of pricing algorithms, factoring in demand trends, and other pertinent variables such as weather and traffic can maximise sales of grocery items before they approach their expiration dates.

This holistic approach strives to redefine the landscape of forecasting, effectively curb waste, and optimise the operational efficiency of grocery stores and vendors, ultimately resulting in an augmentation of overall profitability.

Deliverables

- App
- Website
- ML Model
- REST API
- Database

Technologies

Programming Languages:

- Python
- Java
- JavaScript
- Dart

Data Storage:

- MySQL
- MongoDB

Machine Learning:

- TensorFlow
- PyTorch
- Scikit-Learn

Cloud Services:

- Amazon Web Services

Web Development:

- Front-End
    - HTML
    - CSS
    - React
    - Bootstrap
- Back-End
    - Spring Boot

Mobile Development:

- Flutter

REST API:

- Spring Boot

Analytics and Visualisation:

- Tableau
- Custom Dashboard

Version Control:

- GitHub

Project Management:

- Jira

Collaboration:

- Slack

Business Model (Advertising and Promotion Revenue Stream)

Product Promotion:

- Description:
    - Allow vendors to showcase their products prominently on your platform.
    - Feature products in dedicated sections, banners, or listings to grab the attention of users.
    - Offer vendors the opportunity to have sponsored product listings.
    - Provide banner spaces on the platform for increased visibility.
- Monetization:

    - Charge vendors for premium product placements and visibility.
    - Charge vendors based on a pay-per-click (PPC) or pay-per-impression (PPI) model for sponsored listings and banners.

Performance Analytics:

- Description:
    - Provide vendors with detailed analytics on the performance of their promotions.
    - Include metrics such as click-through rates, conversion rates, and customer engagement.
- Monetization:
    - Charge vendors for access to advanced analytics and insights.

Project Methodology

The project will follow an iterative approach, with planned iterations every six weeks. Feedback from end-users, monitoring tools, and emerging trends will drive continuous improvements in features, performance, and user experience.

Project Initiation (Week 1-3)

- Define the project scope, objectives, and requirements.
- Create a project team with assigned roles and responsibilities.
- Set up project communication channels and tools.
- Conduct an initial market research to understand the grocery industry in Pakistan.

Requirement Gathering (Week 4-6)

- Conduct interviews and surveys with potential users (grocery store owners, vendors, and customers) to gather detailed requirements.
- Identify key features and functionalities for the mobile app, website, API, and ML model.
- Create a comprehensive requirements document.

System Design (Week 7-9)

- Design the architecture for the mobile app, website, and backend system.
- Create wireframes and prototypes for the user interfaces.
- Define the database schema for customer and vendor data.
- Plan the integration of the ML model for demand forecasting.

Development (Week 10-33)

- Database (Week 10-12)
    - Design and create the MySQL database schema
- Machine Learning (Week 10-27)
    - Data Acquisition
    - Data Cleaning
    - Integration of additional factors
    - Feature Engineering
    - Development of ML Models
    - Accuracy Improvement through various techniques
- Application (Week 13-30)
    - Build user interface in Flutter
    - Add Functionality
    - Database and ML Model Integration
- REST API (Week 13-30)
    - REST API design and database integration with Spring Boot.
    - Build the API endpoints for data retrieval
    - Develop APIs frontend and backend communication, including ML model integration
- Website (Week 27-33)
    - Learning JavaScript and React
    - User Interface
    - Admin Portal features
    - User authentication and admin functionalities

Testing and Quality Assurance (Week 13-33)

- Conduct unit testing and integration testing testing for all components.
- Identify and resolve any bugs or issues
- Ensure data security and privacy compliance
- Optimise the ML model's accuracy

Deployment (Week 34-36)

- Deploy the mobile app to app stores
- Host the website on a web server
- Deploy the backend API on a cloud or dedicated server
- Populate the initial data in the database
- Ensure scalability and performance of the system

Maintenance (Ongoing)

- Provide ongoing maintenance, updates, and support to ensure the platform's stability and functionality.
- Continuously improve the ML model's accuracy based on real-world data.

Timeline

Week	1 - 3	4 - 6	7 - 9	10 - 12	13 - 15	16 - 18	19 - 21	22 - 24	25 - 27	28 - 30	31 - 33	34 - 36	Ongoing
Project Initiation													
Requirement Gathering													
System Design													
Development													
Testing and Quality Assurance													
Deployment													
Maintenance													

Expertise

Machine Learning

- Ms. Huda Sarfraz
- Dr. Adnan Rashid

Data Storage

- Ms. Amna Humayun
- Dr. Natash Ali

Web Development

- Mr. Nauman Ali

App Development

- Mr. Asim Irshad

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