Green University of Bangladesh

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AgriBridge

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Lab Project Status

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Chapter 1

Introduction

1.1 Overview

AgriBridge is a smart digital marketplace designed to connect farmers directly with buyers, such as supermarkets, wholesalers, or individuals, eliminating third-party middlemen. This platform aims to ensure fair pricing, traceability, and efficient agricultural transactions. It integrates Artificial Intelligence (AI) for product filtering and recommendation, making the buying experience smooth and personalized. AgriBridge brings innovation into the traditional agricultural supply chain and promotes a more equitable market system.

1.2 Motivation

In many developing regions, farmers often face challenges in getting fair prices due to their dependence on intermediaries. These middlemen reduce the profit margins of farmers and increase the cost to consumers. Furthermore, farmers with limited digital literacy lack the tools to access modern marketplaces. This project is driven by a desire to empower these farmers by providing a simple, efficient, and smart platform for direct product listing and selling. By doing so, AgriBridge not only increases farmer earnings but also enhances transparency, digital access, and socio-economic empowerment in rural areas. [**?**].

1.3 Problem Definition

1.3.1 Problem Statement

The existing agricultural market system is dominated by intermediaries, which leads to reduced profits for farmers, increased costs for consumers, and limited transparency. There is no inclusive platform that allows farmers to directly connect with buyers using intelligent filtering or recommendation systems. Additionally, most farmers are digitally underserved and lack tools for direct market access

1.3.2 Complex Engineering Problem

Designing AgriBridge involves several complex engineering challenges:

- **Human-Centric Design**: Creating an interface that is intuitive for low-literacy users while maintaining feature-rich functionality for buyers.
- **AI Integration**: Developing a recommendation engine that filters products based on buyer preferences, seasonality, and supply trends.
- **Real-Time Systems**: Implementing real-time order tracking, messaging, and listing updates with reliability.
- **Security & Privacy**: Ensuring secure transactions, data protection, and user authentication.
- **Scalability**: Building an architecture that can handle thousands of concurrent users, both in urban and rural areas, with variable internet speeds.

1.4 Design Goals/Objectives

- To develop a user-friendly digital marketplace for agricultural products.
- To eliminate third-party interference in the agri-supply chain.
- To integrate AI-powered recommendation and product filtering features.
- To implement secure authentication and real-time communication between farmers and buyers.
- To promote digital literacy among farmers through simplified UI/UX.
- To support local economic growth by connecting producers with end consumers directly.

1.4.1 Applicability

AgriBridge has broad applicability in both rural and urban contexts:

- **For Farmers**: A tool for listing, managing, and selling their products directly.
- **For Retailers & Supermarkets**: A source of fresh agricultural goods directly from producers, with transparency in pricing and origin.
- **For NGOs & Government Programs**: A platform to promote fair trade, provide subsidies, or connect with verified farmer networks.
- **For Researchers & Agri-Tech Firms**: A dataset-rich environment to analyze supply chains and farming trends.

Chapter 2

Design/Development/Implementation of the Project

2.1 Introduction

The development of AgriBridge using Flutter focuses on cross-platform accessibility, smooth UI/UX, and efficient integration of AI-driven features. Flutter's flexibility allows rapid development and beautiful interface design for both Android and iOS users. This chapter outlines the technical details, development steps, and implementation structure using Flutter and complementary backend technologies.

2.1.1 Project Details

Component	Technology
Project Title	AgriBridge – Smart Agricultural Marketplace
Development Framework Flutter (Dart)	
Backend	Node.js with Express
Database	Firebase Firestore / MongoDB
AI Recommendation	SQL Lite
Authentication & Hosting	Firebase Auth, Firebase Hosting/Vercel/Heroku
Architecture Pattern	Getx or Provider

2.1.2 Subsection_name

User Interface Design (Flutter)

- Built using Flutter widgets with responsive layouts
- Custom UI using Material Design and Tailwind-inspired styling
- Separate screens for:
  - Farmer Dashboard

  - Buyer Marketplace
  - Product Details
  - Order Management

State Management

- Implemented using Flutter BLoC for scalable and maintainable architecture
- Separate blocs for:
  - Authentication
  - Product listing
  - Cart
  - Orders
  - Chat

Product Management

- Farmers can upload products with:
  - Image
  - Price
  - Category
  - Description
- Real-time syncing with Firebase Firestore
- Support for image picker and upload to Firebase Storage

AI Recommendation System

- Basic model trained and integrated using:
  - TensorFlow Lite for on-device filtering
  - OR REST API to a Python backend model for heavier tasks
- Recommendations based on:
  - Buyer behavior
  - Product metadata

Communication Module

- Chat feature using Firebase Firestore's real-time updates
- Supports buyer-farmer direct messaging

Order & Tracking

- Buyers can place and track orders
- Farmers receive push notifications (Firebase Cloud Messaging)
- Status updates shown in-app with proper timestamps

Admin Interface

- Separate admin panel with:
  - Approval system
  - User control
  - Listing moderation
- Optionally built as:
  - Web Flutter app
  - Firebase console extension

2.1.3 Development Phases

Phase 1: Planning & UI Wireframes

- Designed UI with tools like Figma
- Created screens for:
  - User onboarding
  - Product browsing
  - Farmer dashboard

Phase 2: Flutter App Development

- Created Flutter project structure with:
  - Routing setup
  - Theme configuration
- Built reusable components:
  - Custom buttons
  - Product cards
  - List tiles

Phase 3: Backend & Firebase Integration

- Set up Firebase project with:
  - Firestore database
  - Authentication service
- Created Node.js API for:
  - AI integration
  - Complex backend logic

Phase 4: AI Recommendation Logic

- Exported TensorFlow model for product suggestions
- Integration approaches:
  - TFLite for on-device inference
  - HTTP requests to backend API

Phase 5: Real-Time Features

- Implemented chat using:
  - Firebase Firestore snapshots
  - Real-time updates
- Configured push notifications:
  - Using Firebase Cloud Messaging (FCM)
  - Device token management

Phase 6: Testing & Deployment

- Testing performed on:
  - Android emulator
  - Real devices (iOS/Android)
- Deployment options:
  - Firebase Hosting (web)
  - Google Play Console (Android)
  - App Store Connect (iOS)

Chapter 3

Performance Evaluation

3.1 Simulation Environment/ Simulation Procedure

To evaluate the performance of the AgriBridge Flutter application, we simulated realistic use-case scenarios focusing on UI responsiveness, backend communication, real-time data handling, and AI response latency. Testing was conducted using both Android emulators and real physical devices under different network conditions.

3.1.1 Testing Methodology

Testing Environment Setup

- **Development Framework**: Flutter , Dart
- **State Management**: Peovider , Getx, BLoC pattern
- **Testing Tools**:
  - Flutter Test (unit testing)
  - Integration Test
  - Firebase Test Lab
- **Devices Used**:
  - Android Emulator (Pixel 5, Android 13)
  - Real Device (Xiaomi Redmi Note 11, Android 12)
- **Network Simulation**: 4G, 3G, and Wi-Fi conditions
- **Backend Services**:
  - Firebase Firestore
  - Firebase Storage
  - Firebase Authentication

- **AI Integration**:
  - REST API to Flask backend
  - Lightweight TensorFlow model (2.5MB)

Test Cases and Scenarios

- App launch time and splash screen performance
- User registration and login flow (Firebase Auth)
- Product upload with image (Firebase Storage + Firestore)
- Product browsing and filtering operations
- AI recommendation response time
- Order placement and tracking workflow
- Chat functionality real-time sync (Firestore snapshots)
- Push notification delivery (Firebase Cloud Messaging)

3.1.2 Results Analysis

Performance Metrics

Table 3.1: Performance Benchmark Results

Metric	Performance
Initial Launch Time	1.8s (average)
Screen Navigation	< 500ms
Firebase Authentication	1.1s (average)
Google Sign-in	1.4s (including selection)
Product Upload	2.0s (with image processing)
Real-Time Data Sync	< 300ms
Search/Filter Response	400-700ms
AI Recommendation	900ms (API + rendering)
Message Delivery	< 200ms (real-time)
FCM Notifications	1.2s (all networks)

Key Findings

- **App Responsiveness**:
  - Achieved sub-second response for 85% of user interactions
  - Lazy loading improved product list performance by 40%

- **AI Integration**:
  - Model inference time averaged 650ms
  - Network latency contributed 250ms to total response
- **Real-Time Features**:
  - Firestore snapshots provided consistent sub-300ms updates
  - FCM showed reliable delivery across network conditions

Discussion about your various results should be included in this chapter in detail.

Chapter 4

Conclusion

4.1 Discussion

The AgriBridge project successfully demonstrates how technology, particularly Flutter and Firebase, can be used to revolutionize the agricultural supply chain in Bangladesh and beyond. By eliminating third-party intermediaries and providing a direct communication bridge between farmers and buyers, the app empowers rural producers, ensures fairer prices, and enhances transparency.

Using Flutter allowed for rapid cross-platform development with a smooth and modern UI, while Firebase's real-time database, authentication, and cloud messaging made implementation of core features efficient. AI-based recommendation, even in its initial phase, adds significant value to user experience by guiding buyers to suitable products.

From the design of the app's architecture to the final testing phase, the project maintained a focus on usability, real-time interaction, and scalability. This positions AgriBridge not only as a functional platform but also as a scalable digital initiative for agricultural innovation.

4.1.1 Limitations

Despite its successful implementation, AgriBridge has several limitations that warrant consideration:

- **AI Recommendation System**:
  - Currently depends on lightweight cloud-based models
  - Real-time accuracy varies due to:
    - Limited training dataset
    - Cold-start problem for new users/products
- **Offline Functionality**:
  - Heavy reliance on internet connectivity
  - Core features unavailable without network access

    - No implemented offline caching or synchronization

- **Scalability Constraints**:
    - Current Firebase infrastructure limitations:
        - Document read/write quotas
        - Concurrent connection limits
    - Potential need for migration to:
        - Custom backend infrastructure
        - Distributed database systems

- **Language Localization**:
    - Initial version English-only interface
    - Critical need for Bengali localization:
        - Rural user accessibility
        - Farmer adoption rates

- **Security & Moderation**:
    - Limited automated content moderation:
        - Spam product listings
        - Chat abuse detection
    - Manual reporting system only
    - No AI-powered fraud detection

4.1.2 Future Enhancements

AgriBridge can evolve into a more robust platform through these planned improvements:

- **On-Device AI**:
    - TensorFlow Lite integration for faster recommendations
    - Improved privacy by processing data locally
    - Reduced cloud dependency

- **Multilingual Support**:
    - Bengali interface for rural users
    - Dynamic language switching
    - Localized agricultural terminology

- **Logistics Integration**:
    - Delivery tracking with third-party APIs

  - Integrated payment gateways (bKash, Nagad)
  - Automated invoice generation

- **Offline Functionality**:
  - Local caching of product listings
  - Draft mode for post creation
  - Automatic sync when reconnected

- **Enhanced Security**:
  - ML-based content moderation
  - Fraud detection algorithms
  - Automated report handling

- **Admin Dashboard**:
  - Flutter web-based control panel
  - Comprehensive user management
  - Dispute resolution tools

- **Smart Farming Tools**:
  - Crop rotation suggestions
  - Hyperlocal weather alerts
  - Real-time market price insights

- **Community Features**:
  - Farmer-to-farmer Q&A forum
  - Best practice sharing
  - Expert consultation system

4.1.3 Related Platforms and Technologies

The following existing platforms and technologies relate to AgriBridge's development:

- **KrishiHub** [?]: A digital agriculture marketplace in Nepal (https://krishihub.com/)
- **AgroStar** [?]: Indian e-commerce platform for farmers (https://agrostar.in/shop?language=mr&state=maharashtra)
- **AgRevolution** [?]: Agricultural technology solutions provider (https://agrevolution.in/)
- **TensorFlow** [?]: Machine learning framework used for recommendations (https://www.tensorflow.org/)