جامعة الملك سعود
King Saud University

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Introduction

Source: Baseer Team

The Problem

What's happening today?

MWAN مـــوان

المركز الوطني لإدارة النفايات

National Center for Waste Management

Source: Subject Matter Experts + Mwan Offilicial Website

The Problem

What's happening today?

Source: Subject Matter Experts + Mwan Offilicial Website

The Problem

What's happening today?

Quantity Based Contracts

Source: Subject Matter Experts + Mwan Offilicial Website

The Problem

- Saudi Arabia generates 110M+ tons of waste annually; Riyadh produces 21 percent of the national total
- Current system uses static routes, not real-time bin data
- Leading to...

Overflowing Bins

Wasted resources (fuel, time, labor)

Negative impact on city cleanliness and quality of life

The Solution?


بصير
BASEER

What's BASEER?

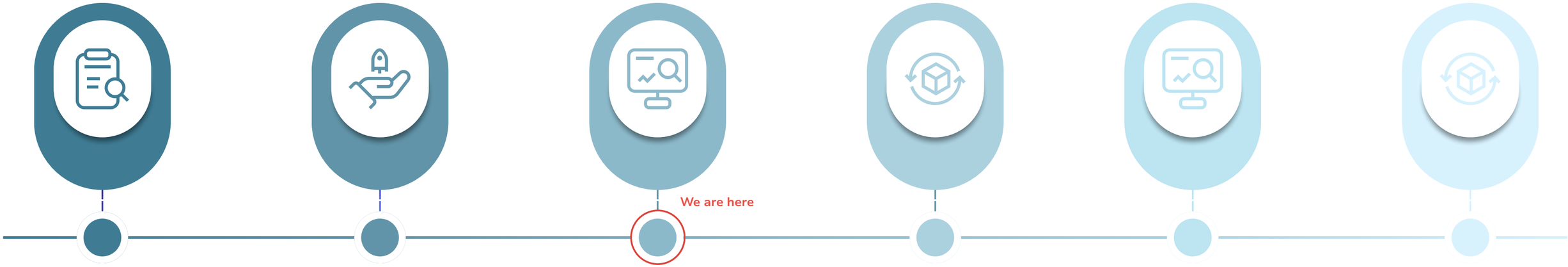
- A smart waste monitoring device using ultrasonic sensors + microcontroller
- Sends real-time fill-level data to Firebase
- Supports optimized routes instead of fixed schedules
- Aligns with Vision 2030, Saudi Green Initiative, and Smart City goals

"تحسين جودة الحياة في المدن السعودية وجعلها أكثر نظافة وكفاءة واستدامة"

– الأمير محمد بن سلمان

Roadmap

to a new Saudi... Via Baseer!



Sprint 0

- Sprint 0 Report Prep.
- Tools & Enviroment Set up
- Jira Setup
- Github Setup

Sprint 1

- Hardware Setup
- Firebase Setup
- Integrate Initial Components
- Initialize Flutter

Sprint 2

- Calibrate fill levels
- Initial App Login
- Finalize Driver Application with Core Features

Sprint 3

- Route Optimization
- Finalize Admin Dashboard

Sprint 4

- Configure Fill Level Notifications for Driver
- Build Multi-language Support

Sprint 5

- Admin Reporting & Insights
- Data storage & Analytics
- Final Testing
- Quality Assurance

Background & Literature Review

Background

Why Current Systems Fail?

- No real-time visibility of bin fill levels
- No dynamic route planning
- High operational costs due to unnecessary trips
- Overflow leads to odor, pests, and dissatisfaction among residents

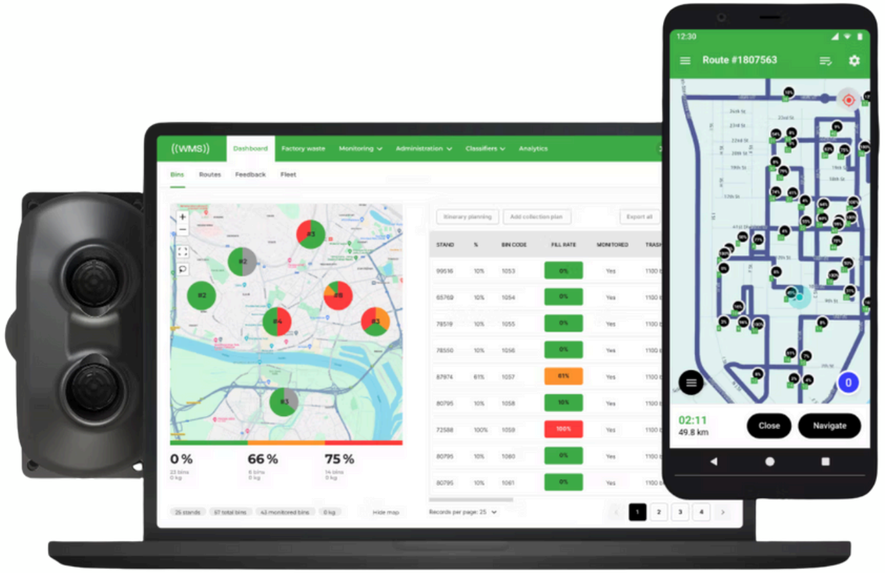
Key Technologies Used:

- IoT | connecting sensors to cloud
- Ultrasonic sensing | accurate distance measurement
- ESP32 microcontroller | low-cost, Wi-Fi enabled
- Firebase Realtime Database | instant data sync

Literature Review

Global Smart Waste Solutions

((SENSONEO))



IoT sensors + analytics dashboard

Source: Sensoneo Official Website

Literature Review

Global Smart Waste Solutions

Bigbelly

Solar-powered compacting smart bins

Source: Bigbelly Official Website

Key Takeaway?

Smart sensing + data-driven routing significantly reduces costs and improves waste management efficiency

Literature Review

Saudi Arabia Inititatives

WASTECH
SMART ENVIRONMENTAL SOLUTIONS

Source: Baseer Team

Literature Review

Saudi Arabia Inititatives

WASTECH
SMART ENVIRONMENTAL SOLUTIONS

Problems with Wastech:

- Designed mainly for commercial smart bins, not large neighborhood bins
- No clear real-time rerouting for drivers based on live bin changes
- Not tailored to Riyadh's existing waste-collection workflow

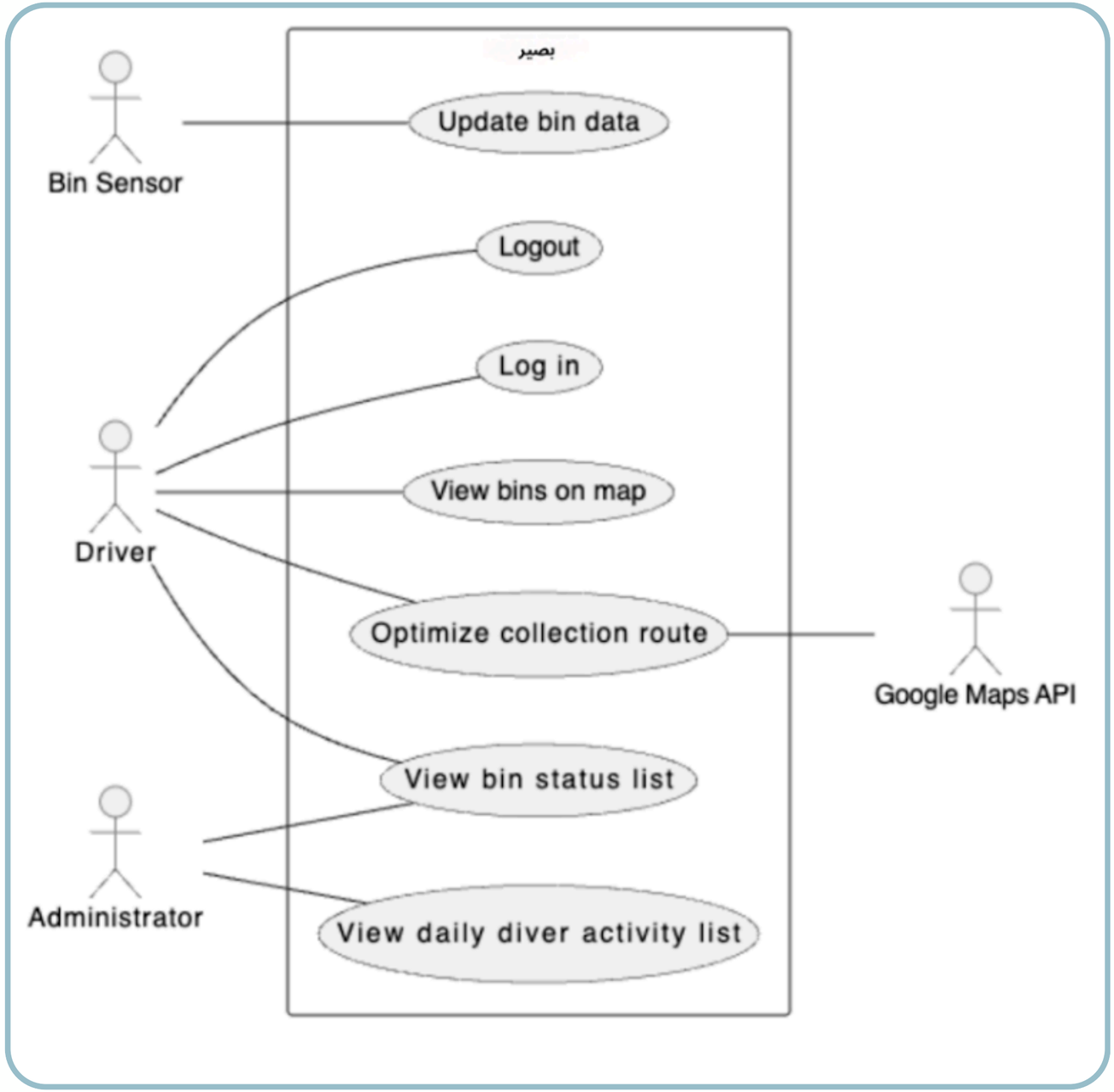
System Requirements

System Users

Driver

Admin

Use Case Diagram



Product Backlog (Release 1)

Functional requirements focused on system setup :

01 As a developer, I want to configure and test hardware connections (ESP32 + wiring) so that the sensor works reliably

02 As a developer, I want to set up Firebase Realtime DB and structure collections so that app data is stored consistently

03 As a developer, I want the ESP32 to transmit sensor data to Firebase so that the system can update the bin status in real time

04 As a developer, I want to initialize the Flutter project and secure the connection to Realtime Database so that the mobile app is ready to reliably exchange all data

Product Backlog (Release 1)

Functional requirements focused on driver features:

05 As a driver, I want to know what bins are full so that I can optimize my route

06 As driver, I want to log in to a mobile app so that I can securely access bin information

07 As a driver, I want to see a list of bins with their fill levels so that I know which bins need collection

08 As a driver, I want to see bin locations and their fill levels on a map so that I can easily visualize which bins need servicing

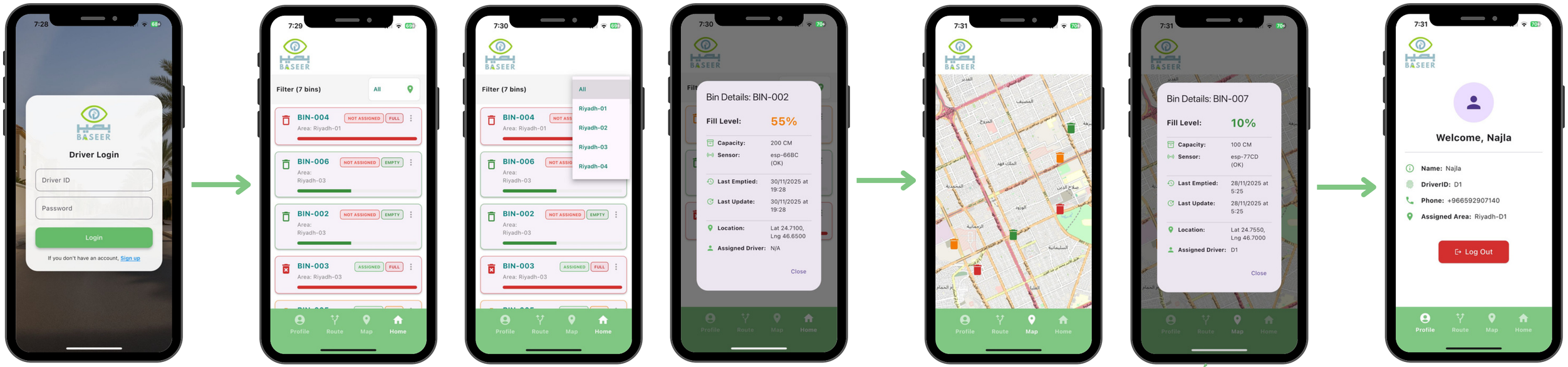
09 As a driver, I want to view my profile details and be able to log out so that I can verify my identity and secure the application

Product Backlog (Release 1)

Non-functional requirements:

10	As a driver, I want bin fill-level data in the app to refresh within 5–10 seconds of the sensor update so that I can rely on accurate information during collection
11	As a driver, I want the mobile application to remain available 99% of the time during operational hours so that I can depend on it for navigation and bin status
12	As a developer, I want the app and system codebase to be modular, documented, and include unit tests so that future features or bug fixes can be added without disrupting existing functionality.

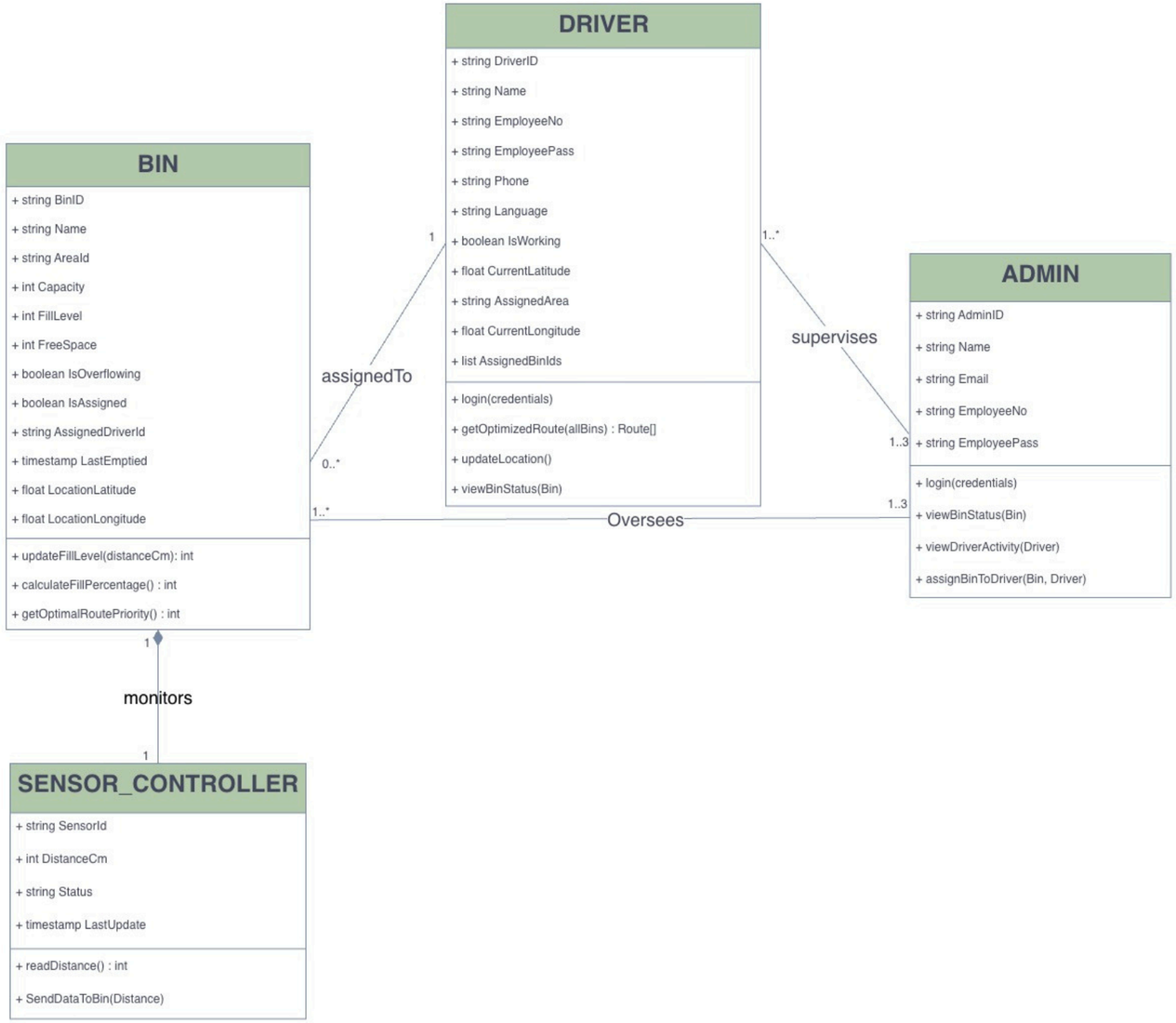
Driver Operational Workflow



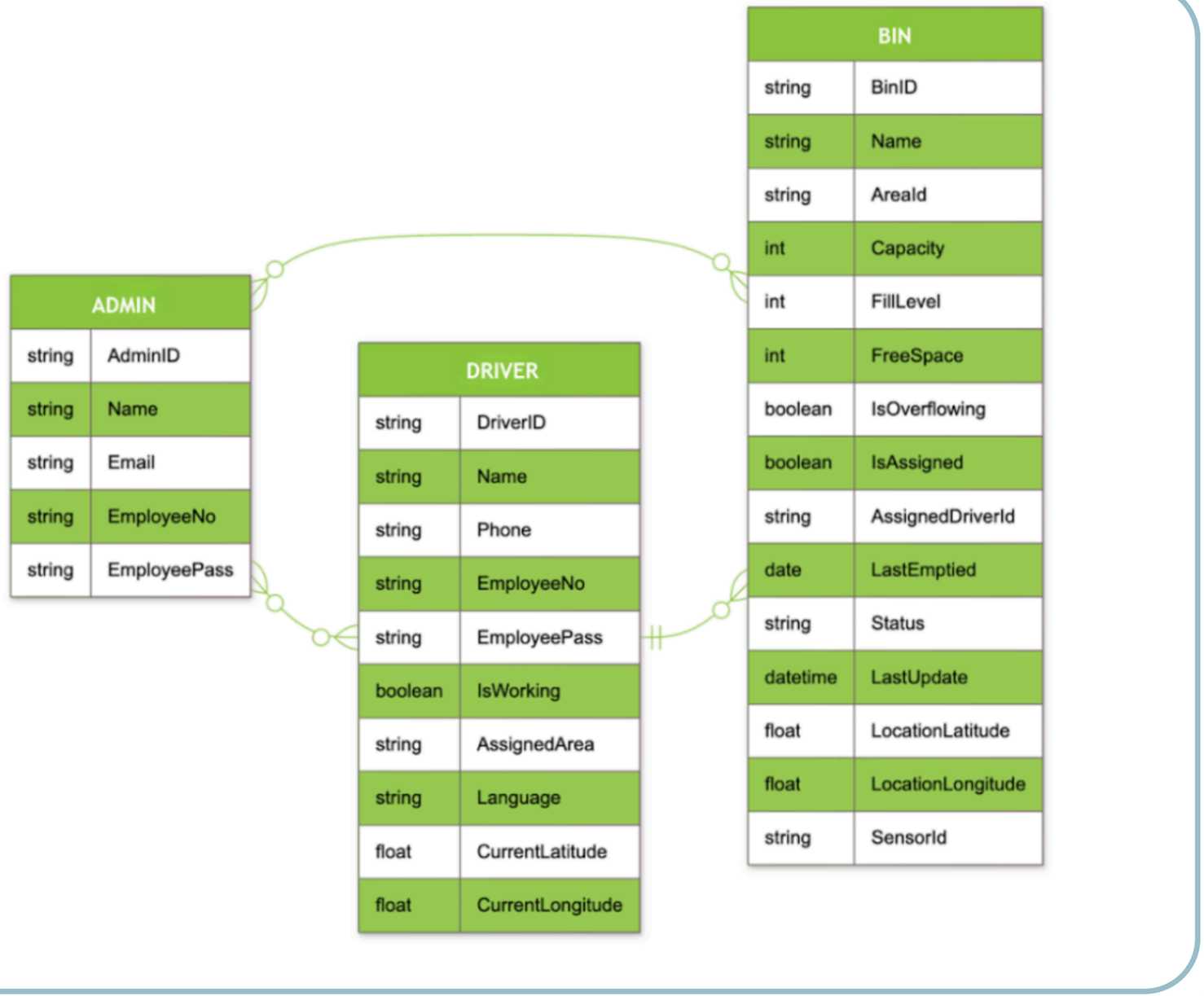
Route Optimization Page: Pressing 'Start Route' will automatically choose a fixed number of urgent bins in the driver's area and launch the route using the Google Maps API (it is planned for release 2)

System Design

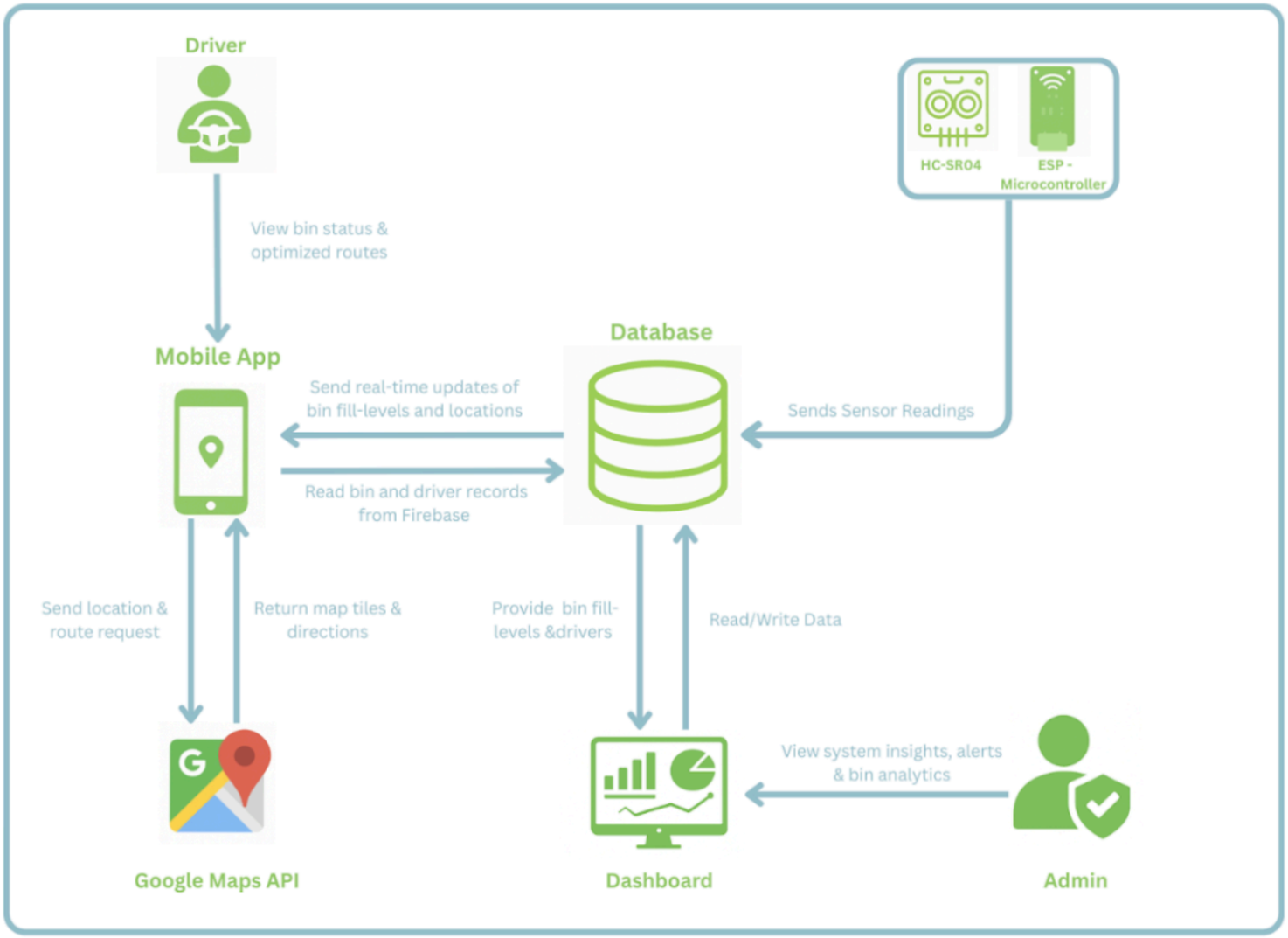
Class Diagram



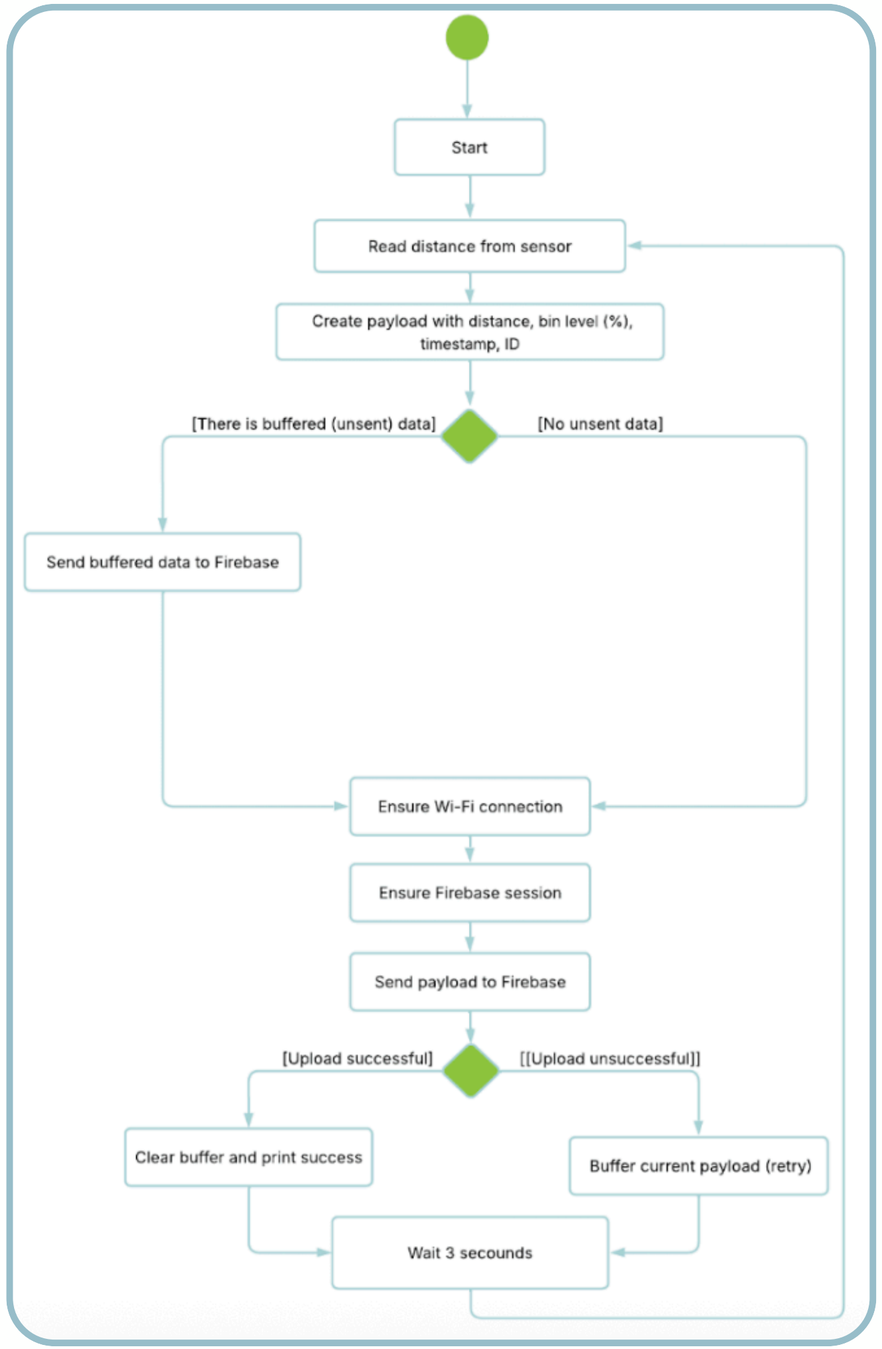
ER Diagram


ADMIN
string AdminID
string Name
string Email
string EmployeeNo
string EmployeePass
DRIVER
string DriverID
string Name
string Phone
string EmployeeNo
string EmployeePass
boolean IsWorking
string AssignedArea
string Language
float CurrentLatitude
float CurrentLongitude
BIN
string BinID
string Name
string AreaId
int Capacity
int FillLevel
int FreeSpace
boolean IsOverflowing
boolean IsAssigned
string AssignedDriverId
date LastEmptied
string Status
datetime LastUpdate
float LocationLatitude
float LocationLongitude
string SensorId

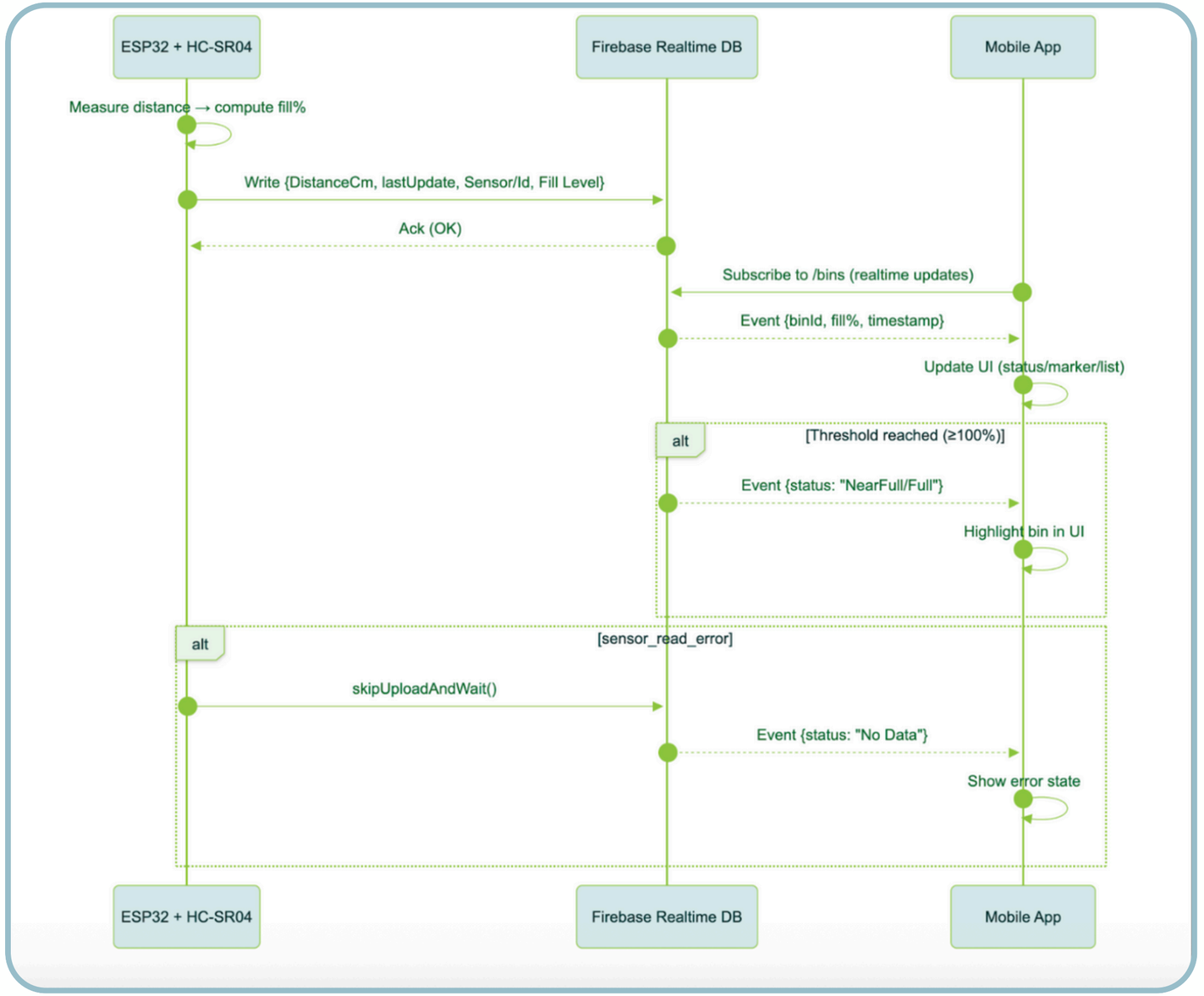
System Architecture



Activity Diagram: Data Collection by the Microcontroller



Sequence Diagram: System Data Flow



System Testing

System Testing Overview

What We Tested:

- Validated both hardware (sensor + ESP32) and software (Firebase + app).
- Tested the real-time communication pipeline from bin → ESP32 → Firebase → Driver App.

Purpose of Testing:

- To confirm the accuracy of the sensor readings.
- To ensure that data reaches Firebase quickly and reliably.
- To evaluate user experience and usability through UAT with real drivers.

Experimental Results

Key Findings:

TEST CASE	RESULT
SENSOR ACCURACY	CORRECTLY DISPLAYED ACCURATE FILL LEVEL → PASSED
FIREBASE UPDATE TIME	AVG. 1.25S (EXPECTED ⩽ 3S) → PASSED
RETRY LOGIC	BUFFERED & RESENT AFTER RECONNECTION → PASSED
MOBILE SYNC	UPDATED IN <1S → PASSED

All core system components functioned reliably under simulated real-world conditions.

User Acceptance Testing

Participants:

5 actual waste-collection drivers representing our real users.

Tasks They Tested:

- Account creation & login
- Viewing bin list + understanding color codes
- Filtering bins by area
- Navigating the map view
- Overall app usability & satisfaction

Key Results:

- Easy to Use: Drivers completed all tasks without help.
- Homepage Clarity: Bin list + progress bars were intuitive.
- Map View: Very clear for locating bins and understanding urgency.
- Color Codes: Immediately understood (green = empty, red = full).
- Overall Satisfaction: Majority rated the app experience as “easy/very easy.”

Conclusion & Future Work

Conclusion and Future Work

Conclusion:

- Baseer successfully demonstrates a working IoT smart waste monitoring system
- Real-time sensor data, Firebase integration, and the driver mobile app all performed reliably
- The system improves efficiency, reduces unnecessary pickups, and supports cleaner urban environments
- The prototype aligns with Saudi Vision 2030 by promoting sustainability and smarter city operations

Future Work:

- Add push notifications for full bins
- Implement route optimization for drivers
- Enhance multilingual support
- Develop a full admin analytics dashboard

Baseer.... Pilot!

Live Demo

Thank You!