B.Tech. CSE (III YEAR – V SEM) (2025-2026)

DEPARTMENT OF COMPUTER ENGINEERING & APPLICATIONS

GLA University

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Project Title

AI-Based Voice Command Home Automation

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Signature: _____

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Project Synopsis: AI-Based Voice Command Home Automation

0. Cover

- **Project title:** AI-Based Voice Command Home Automation.
- **Team name & ID:** Team Sigma (T11)
- **Institute / Course:** GLA University, B.Tech CS (Hons.)
- **Version:** v0.1
- **Date:** 29 Aug 2025

Revision history

Version	Date	Author	Change
v0.1	29 Aug 2025	T11	Initial draft

1. Overview

1.1 Problem statement: Traditional home automation systems require manual control (switches, apps, or remotes) and lack personalization. Existing voice assistants (Alexa, Google Home) depend heavily on cloud, which raises privacy concerns, and they don't adapt well to individual users' habits.

1.2 Goal: The proposed Voice Command Home Automation System provides a smart, hands-free way to control home appliances, lights, and security systems. The system begins by capturing user input through speech-to-text processing, converting spoken words into digital text. Using Natural Language Understanding (NLU), it identifies the intent behind the command—for example, recognizing "Goodnight" as a request to turn off lights, lock doors, and activate the alarm.

1.3 Non-goals: In v1, we will not focus on advanced features like proactive device control based on user mood, or integration with external services like music streaming.

1.4 Value proposition: A secure, local-first voice control system that enables easy, natural language interaction for controlling home appliances, lights, and security.

2. Scope and Control

2.1 In-scope

- Speech-to-text processing for voice commands.
- Natural Language Understanding (NLU) for intent recognition.
- Integration with a minimum of two device types (e.g., smart lights, smart plugs).
- Support for pre-defined routine scheduling (e.g., "Goodnight" routine).
- A simple mobile app for remote control.

2.2 Out-of-scope

- Support for a wide range of devices beyond the initial scope.
- Biometric voice recognition for multiple users.
- Advanced machine learning models for user habit prediction.

2.3 Assumptions

- The system will run on a local network hub (e.g., Raspberry Pi).
- The user's home has a stable Wi-Fi network.
- The integrated smart devices have public or local APIs.

2.4 Constraints

- 10-week timeline.
- Limited budget for hardware.
- Team skills are beginner-level in AI/ML model training.

2.5 Dependencies

- Access to an open-source or commercial speech-to-text API.
- Availability of a Raspberry Pi or similar single-board computer.

2.6 Acceptance criteria and sign-off

- **Acceptance Criteria:**
  - GIVEN a user says a command like "Hey Home, Turn on the living room light" WHEN the system hears the command THEN the light turns on within 3 seconds.
  - GIVEN a user says "Hey Home, Goodnight" WHEN the command is processed THEN all specified lights turn off and the smart lock engages.

- **Signoff:** Mentor approval of the demo and a completed test report. All P1 bugs are closed.

Sign-off table

Stakeholder	Role	Decision area	Signature/Approval	Date
Dr. Yunis Lone Ahmed	Mentor	Scope, final acceptance	Approved	28 Aug 2025
Nitin Kumar	Product Lead	Release readiness	Approved	26 Aug 2025

3. Stakeholders and RACI

Activity	Responsible (R)	Accountable (A)	Consulted (C)	Informed (I)
Requirements	Aditya Pratap Singh	Nitin Kumar	Mentor	Team
Design	Nitin Kumar, Aditya Pachaury	Nitin Kumar	Mentor	Team
Implementation	Aditya Pachaury	Aditya Pachaury	Mentor	Team
Testing	Aditya Pratap Singh	Aditya Pratap Singh	Mentor	Team
Release	Team	Team	Mentor	Dept

4. Team and Roles

Member	Role	Responsibilities	Key skills	Availability	Contact
Nitin Kumar	Product Lead & IoT Specialist	System design, project planning, API contracts, documentation, coordination	Product design, REST APIs, IoT basics	8 hrs/wk	email
Aditya Pratap Singh	Frontend (Android - Java),IOT	Android app (Java), UI/UX design, API integration, device control & status screens	Android (Java), Android Studio, MQTT, XML layouts	10 hrs/wk	email
Aditya Pachaury	Backend, IOT	IoT architecture, device communication (ESP32), API development, database, security	Node/Express, Python Flask, SQL, MQTT, ESP32	10 hrs/wk	email

5. Week-wise Plan and Assignments

Week	Dates	Nitin Kumar	Aditya Pratap Singh	Aditya Pachaury	Deliverables	Status
1	1–7 Sep	Finalize project scope, gather requirements, check feasibility (voice + IoT + app).	Prepare wireframes for mobile app (ON/OFF, status screen).	Research APIs (Whisper API, HuggingFace LLMs, ESP32 libraries).	Draft SRS (Software Requirement Specification).	Planned
2	8–14 Sep	Prepare system architecture & workflow diagram.	Define API contracts (Laptop/Whisper → ESP32 → Relay).	Define API contracts (Laptop/Whisper → ESP32 → Relay).	Architecture Diagram + ERD + API Spec v1.	Planned
3	15–21 Sep	Setup Whisper API in laptop	Authentication screen for app (login/signup if needed).	Build module: Speech → Text → Intent ("Turn ON/OFF light").	Working voice-to-text prototype.	Planned
4	22–28 Sep	Setup ESP32 with WiFi + Relay. Test manual ON/OFF via code.	Build app shell (basic navigation: Home, Devices).	Create API to send command from laptop → ESP32.	Laptop/App can control relay via ESP32.	Planned
5	29 Sep–5 Oct	Integrate speech recognition + IoT.	Add device control screen (ON/OFF switch UI).	Implement full flow: Speech → Intent → Command → ESP32.	Demo: Speak → Light turns ON/OFF.	Planned
6	6–19 Oct	Add multi-device	Add status indicator (Light	Add HTTP/REST support for stable	Feature B Demo (multi-device control).	Planned

		support (fan, bulb).	ON/OFF shown in app).	communication.		
7	20–31 Oct	Identify risks (network failure, API delays).	Polish UI, add error messages.	Optimize code for faster response.	Tested stable prototype.	Planned
8	1-15 Nov	Prepare project documentation & presentation.	Final UI polish + animations.	Final API cleanup + code comments.	Final Project Demo + Report Submission.	Planned

6. Users and UX

6.1 Personas

- **New Seller Sam:** Wants to use voice commands to control her home without lifting a finger. Values speed and reliability.
- **Bargain Buyer Bella:** Values secure, local processing and wants to use voice commands for doors and alarms.

6.2 Top user journeys

- **Lights:** User says "Turn on the lights" -> System processes command -> Lights turn on.
- **Routine:** User says "Goodnight" -> System processes routine -> Lights off, doors lock.

6.3 User stories

- As a user, I want to control my lights with a voice command so I don't have to get up to use a switch.
- As a user, I want to set up a "Goodnight" routine so I can turn off multiple devices with a single command.

7. Market and Competitors

7.1 Competitor table

Competitor	Product	Target users	Key features	Pricing	Strength	Weakness	Our differentiator
Google Home / Alexa	C2C marketplace	General households	Voice control, device integration, routines	Device cost + free app	Wide ecosystem, strong AI	Privacy concerns, limited offline use	More secure, offline-first features
Apple HomeKit	C2C marketplace	General households	Multi-category	Device cost + free app	Strong privacy, seamless UX	Limited device support, costly devices	Affordable + broader device support
Samsung SmartThings	Social C2C	Smart home platform	Device hub, automation, IoT integrations	Device cost	Strong privacy, seamless UX	Complex setup for beginners	Simple setup for non-tech users

7.2 Positioning

- **Unique angle:** A voice assistant focused on local control and privacy, designed specifically for home automation tasks.
- **Measurable delta:** Our system processes commands locally, reducing latency and minimizing reliance on an internet connection, ensuring faster and more reliable responses.

8. Objectives and Success Metrics

- **O1 Latency:** Command-to-action latency of less than 3 seconds.
- **O2 Accuracy:** Intent recognition accuracy of 95% for core commands.
- **O3 Reliability:** System uptime of 99.0%.

9. Key Features

Feature	Description	Priority	Dependencies	Acceptance criteria
Local Voice Control	Control lights, fans, and devices via voice locally	Must	Speech-to-text, Device APIs	GIVEN command WHEN spoken THEN device responds in ≤ 1 s without internet
Device Management	Add, remove, group devices for easy control	Must	Auth, Local DB	GIVEN device WHEN added THEN visible in dashboard and controllable
Automation Rules	Set schedules and triggers (e.g., lights on at 7 PM)	Should	Device Management	GIVEN rule WHEN condition met THEN automation executes within 2 s
Privacy Settings	Manage permissions and data storage locally	Must	Auth	GIVEN settings WHEN updated THEN data remains local and permissions apply instantly
Mobile Dashboard	App dashboard to monitor and control devices	Should	Local Network	GIVEN dashboard WHEN opened THEN status of devices is updated in real time
Alerts & Reports	Send local notifications on unusual activity	Could	Device Management	GIVEN event WHEN unusual activity occurs THEN notification shown in ≤ 3 s

10. Architecture

10.1 High level

- **Clients:** React SPA (Single Page Application) providing the user interface for students to access the marketplace.
- **Services:** Auth service for registration, login, and verification; Listing service to handle CRUD operations on items; Search API to support keyword, category, and price-based queries.
- **Data stores:** MySQL as the main relational database for structured data; Object storage for images and other static assets.
- **Integrations:** SMTP for sending email verifications and notifications; optional campus SSO for seamless login with institutional credentials.

10.2 API spec snapshot

Endpoint	Method	Auth	Purpose	Request schema	Response schema	Codes
Google Speech Recognition API	POST	—	audio to text	------	200	201, 400

10.3 Config and secrets

10.3.1 Configuration (Config):

- Non-sensitive settings that vary between environments (dev, test, prod).
- Example: APP_PORT=8080, LOG_LEVEL=debug.

10.3.2 Secrets:

- Sensitive data that must not be hardcoded in code or shared publicly.
- Example: DB_PASSWORD=xyz123, API_KEY=abcd-efgh.

11. Data Design

11.1 Data dictionary

Entity	Field	Type	Null?	Allowed values	Source	Notes
User	id	UUID	No	—	System	PK
User	email	String	No	RFC 5322 (email)	User	Unique
Listing	id	UUID	No	—	System	PK
Listing	title	String(120)	No	—	Seller	Indexed
Listing	price	Decimal(10,2)	No	≥ 0	Seller	—

12. Technical Workflow Diagram

12.1 State Transition Diagram

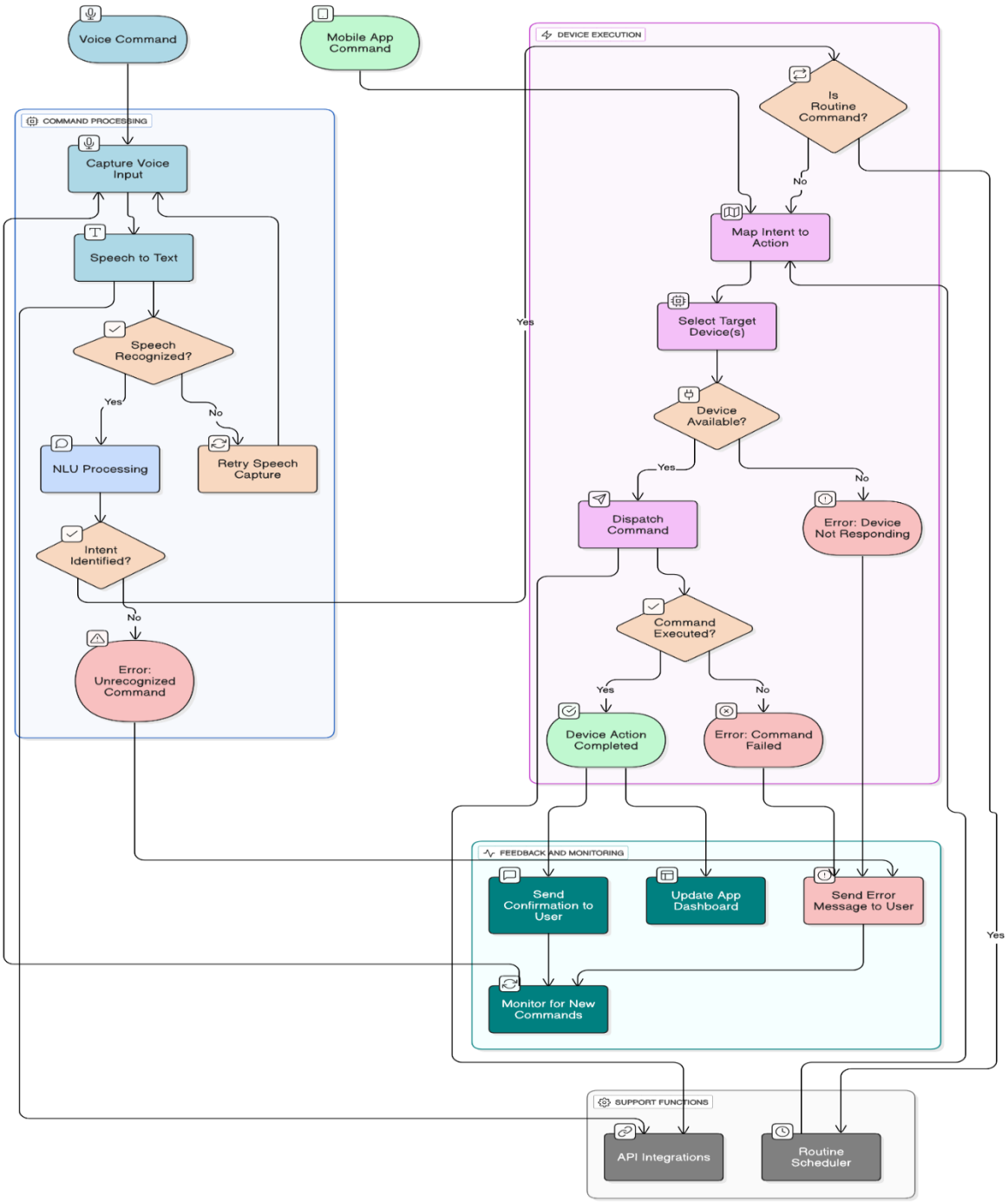

Figure 12.1

12.2 Sequence Diagram

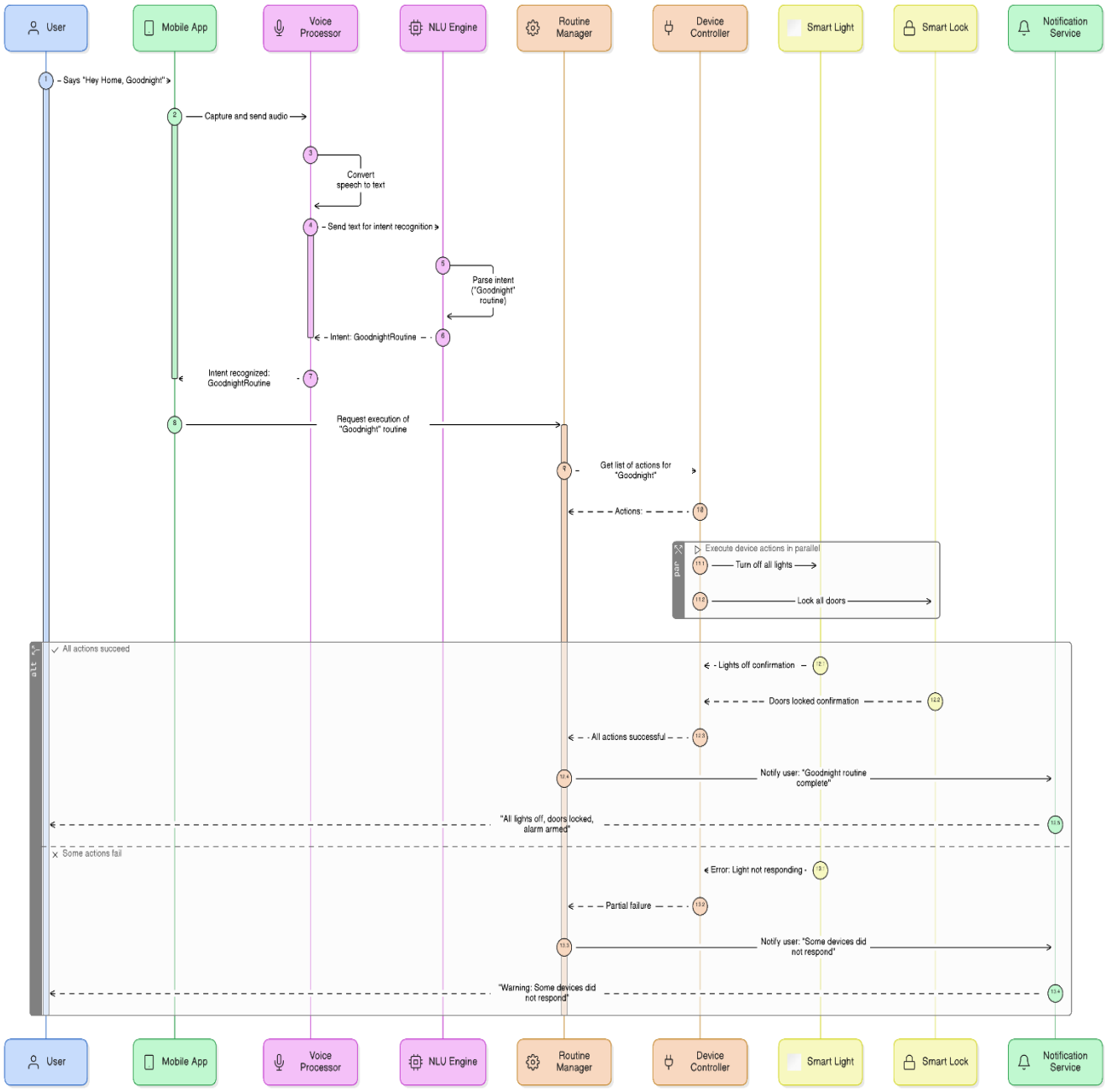

Figure 12.2

12.3 Use Case Diiagram

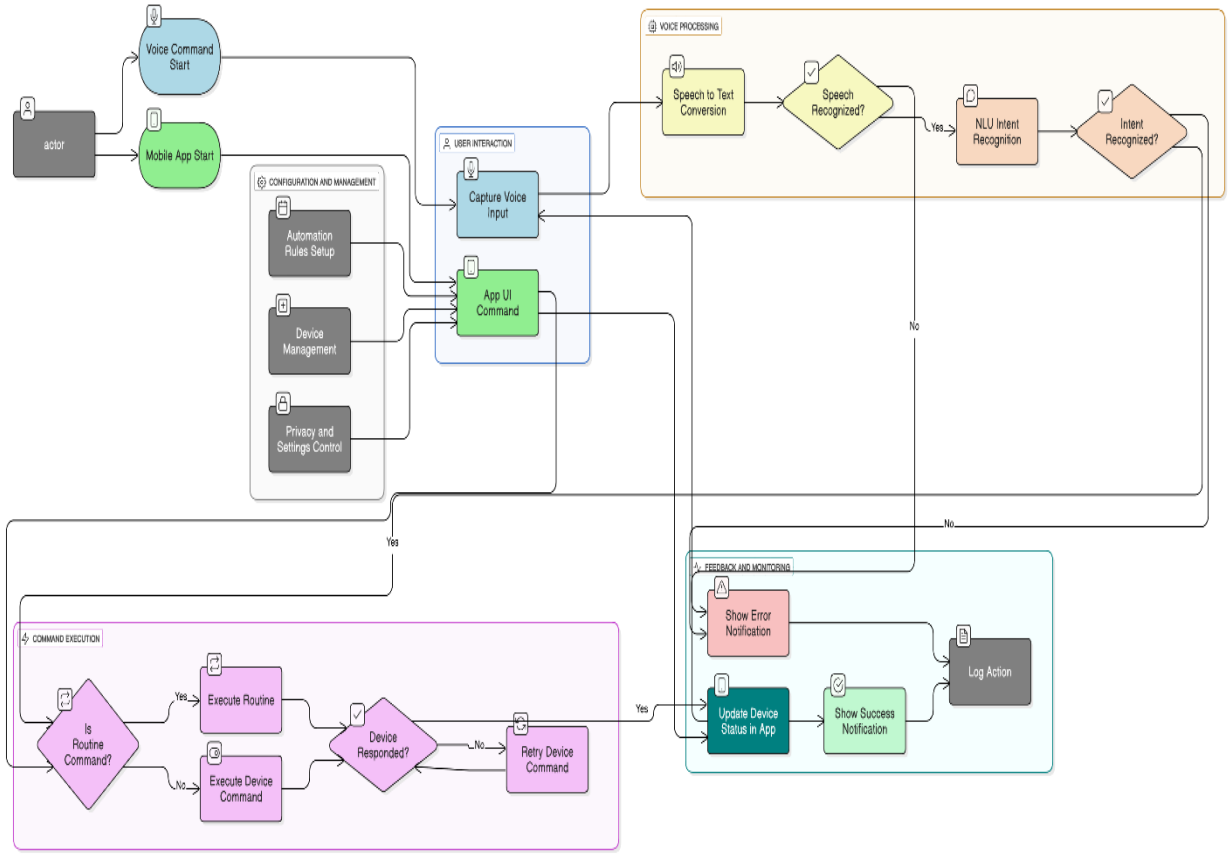

Figure 12.3

12.4 Data Flow Diagram

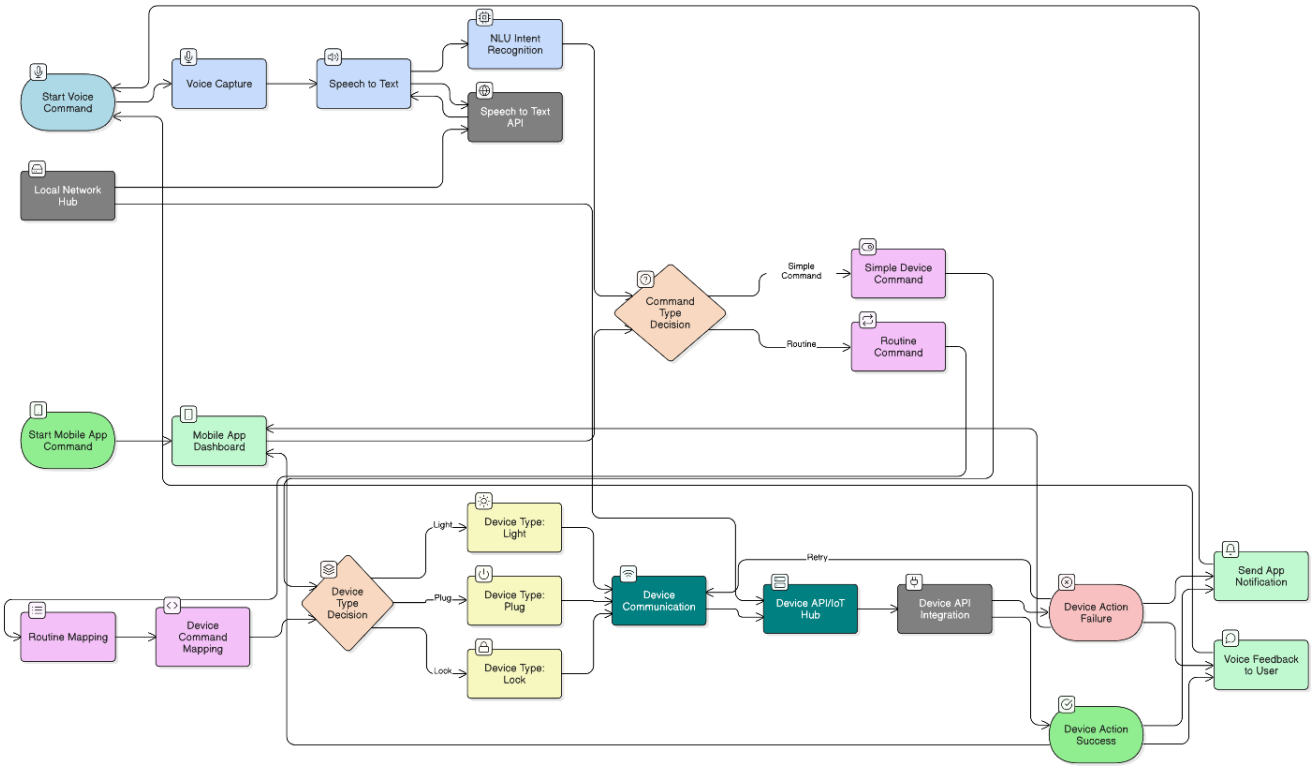

Figure 12.4

12.5 ER Diagram

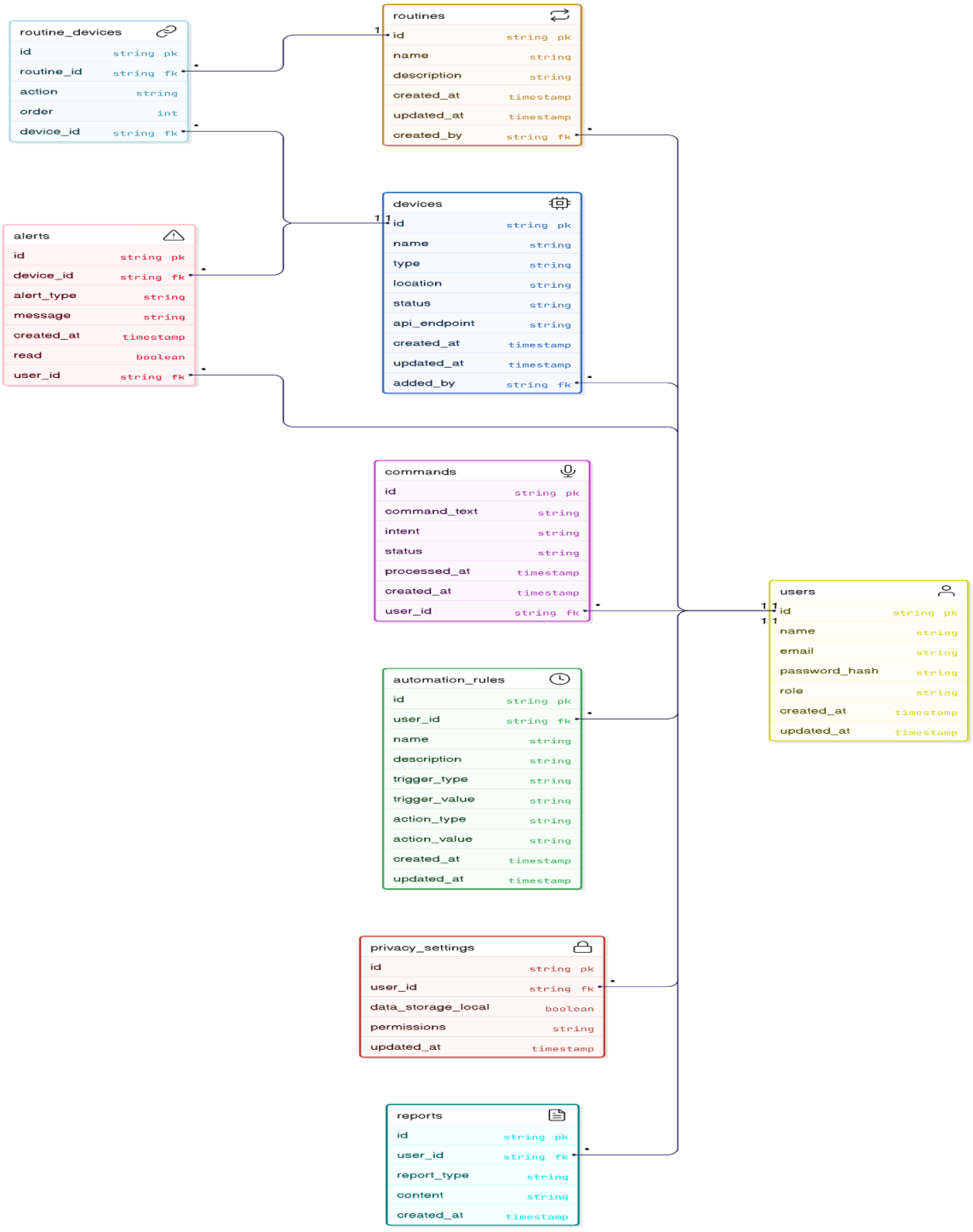

Figure 12.5

13. Security and Compliance

13.1 Threat model (STRIDE)

Asset	Threat	Impact	Mitigation	Owner
Raspberry Pi Hub	Unauthorized physical/network access	High	Strong password for OS, secure local network config, physical security	Nitin Kumar
Voice Command Text (NLU input)	Command text intercepted on local network	High	No voice recordings stored, text processed locally (not transmitted externally)	Aditya

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13.2 Authentication & Authorization (AuthN/AuthZ)

- **AuthN:** Involves a strong password during Raspberry Pi hub setup and a one-time secure pairing for the mobile app. No email/password or cloud-based authentication is used for daily operation.
- **AuthZ:** The single user acts as an administrator with full control. Future versions might add basic roles (e.g., Admin, Guest) with access checks at the local API layer.

13.3 Audit & Logging

The system logs critical events locally on the Raspberry Pi hub for stability and debugging.

- **Logged Events:** Includes system startup, command execution, routine runs, device status changes, app connections, and errors.
- **Privacy:** No raw voice data or other sensitive PII is logged.
- **Retention:** Logs are kept for a maximum of 30 days locally with rotation.

13.4 Compliance

- **Data Privacy:** A core principle is local data processing and storage. No third-party data sharing occurs, minimizing external compliance concerns by keeping all data within the user's home network.

14. Risks and Mitigations

14.1 Risk heatmap

Risk	Probability	Impact	Score	Mitigation	Owner	Status
Schedule slip	Medium	High	12	Scope freeze, weekly demos, agile sprints	Nitin Kumar	Open
DB performance	Medium	High	11	Focus on core commands first, expand training data incrementally	Aditya Pratap Singh	Open
Image storage costs	Medium	Medium	11	Optimize queries, appropriate indexing, monitor Raspberry Pi load	Aditya Pachaury	Open

15. Research and Evaluation

15.1 Research: Analyze existing voice assistants and smart home hubs.

15.2 Evaluation: Track success metrics (latency, accuracy, reliability) and gather user feedback.

16. Appendices

16.1 Glossary: NLU, STT, IoT.

16.2 References:

What is Natural Language Understanding (NLU) from Replicant. URL: *https://www.replicant.com/glossary/what-is-natural-language-understanding*

How to integrate Google Smart Home API with your IoT devices?" from BriteHome. URL: *https://britehome.tech/integrate-google-smart-home-api-with-iot-devices/*

Speech Recognition In IoT Devices from Meegle. URL: *https://www.meegle.com/en_us/topics/speech-recognition/speech-recognition-in-iot-devices*