



University of  
Bedfordshire

**INDIVIDUAL PROJECT**

# **ASSESSMENT 1**

**ELEVATOR CONTROL SYSTEM**

**DESKTOP APPLICATIONS  
DEVELOPMENT AND SOFTWARE  
(CIS116-2)**

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# TABLE OF CONTENTS

1	CHAPTER 1   INTRODUCTION .....	5
1.1	Background .....	5
1.2	Aim.....	5
1.3	Objectives.....	5
1.4	Scopes.....	6
1.5	Significance.....	6
2	CHAPTER 2   PROJECT PLAN AND SCHEDULE .....	7
2.1	Task Description .....	7
2.2	Time Management.....	7
3	CHAPTER 3   REQUIREMENT ANALYSIS.....	8
3.1	Functional Requirements.....	8
3.1.1	Floor Request Buttons.....	8
3.1.2	Door Control .....	8
3.1.3	Direction Buttons .....	8
3.1.4	Event Logging.....	9
3.2	Non-Functional Requirements .....	9
3.3	Usability Requirements .....	10
3.3.1	User-Friendly Interface.....	10
3.3.2	Display Readability.....	10
3.3.3	Responsive Controls .....	10
3.3.4	Accessible Design.....	10
3.3.5	Emergency Assistance .....	10
3.4	Assumptions .....	11

4	CHAPTER 4   DESIGN ANALYSIS.....	12
4.1	Design Overview.....	12
4.2	Use Case Diagram.....	13
4.3	Data Flow Diagram.....	15
4.3.1	Actors.....	15
4.3.2	Processes.....	16
4.3.3	Data Store.....	16
4.4	Class Diagram.....	17
4.4.1	DBContext.....	18
4.4.2	Elevator.....	18
4.4.3	IElevatorState (Interface).....	19
4.4.4	IdleState.....	19
4.4.5	MovingUpState.....	19
4.4.6	MovingDownState.....	19
4.4.7	MainForm.....	19
4.4.8	Relationships.....	20
4.5	Entity Relationship Diagram.....	21
4.5.1	Attributes.....	21
4.6	User Interface Design.....	22
4.6.1	UI Components.....	22
4.6.2	Features and Functionalities.....	23
4.7	Database Design.....	24
4.7.1	Data table: Log.....	24
4.7.2	Purpose.....	25
5	CHAPTER 5   IMPLEMENTATION.....	26

5.1	Implementation Overview .....	26
5.2	Front-End Implementation .....	26
5.2.1	Prototyping.....	26
5.2.2	UI Design .....	26
5.2.3	Interactive Elements.....	27
5.3	Back-End Implementation.....	27
5.3.1	State Design Pattern .....	27
5.3.2	Database Integration .....	27
5.3.3	Timers for Movement .....	27
5.3.4	Event Logging.....	27
5.4	Development Tools and Environment.....	28
5.5	Challenges and Solutions .....	28
5.5.1	Synchronizing Door and Elevator Movements.....	28
5.5.2	Database Connectivity .....	28
5.6	Methodology .....	28
5.7	Coding Approach .....	29
5.7.1	Object-Oriented Principles.....	29
5.7.2	State Design Pattern.....	29
5.8	Unique Concept.....	29
5.9	Database Development.....	30
5.9.1	Database Design.....	30
5.9.2	Database Connection .....	30
6	CHAPTER 6   TESTING PHASE.....	32
6.1	Unit Testing.....	32
6.2	Integration Testing .....	32

6.3	System Testing .....	32
6.4	Test Cases and Results .....	33
6.5	Test Summary .....	38
7	CHAPTER 7   PROJECT EVALUATION .....	40
7.1	Self-Assessment Report .....	40
8	CHAPTER 8   REFLECTION AND CONCLUSION .....	41
8.1	Reflection .....	41
8.2	Conclusion.....	41
9	REFERENCES .....	42
10	APPENDIX.....	43

# CHAPTER 1 | INTRODUCTION

## 1.1 Background

The elevator is an integral part of any modern multi-story building, and people consider elevators an easy means of transport vertically through the building. In corporate buildings, the elevator system should work smoothly to maintain efficiency in work processes and provide maximum safety. This project deals with the designing and implementation of an elevator control system that provides an intuitive, user-friendly interface to the occupants of a building. It provides continuous travel between floors, with door security systems, and offers each user a way, from any floor, to summon the elevator ride.

The C# language is modern, object-oriented, and will be used in building the elevator control system. C# allows the realization of a responsive and expandable system that can fulfill both functional and operational needs. SQLite is used as the database for logging and tracking elevator activity; this assures that the system will operate independently without dependence on server resources, making it applicable to embedded applications.

## 1.2 Aim

The project implies the design of the elevator control system intended for service in a two-story office building, emphasizing user interaction, operational safety, and ease of use. This project follows object-oriented principles by modeling a real-world transportation challenge in building management and gives insight into software design and architecture of such a control system.

## 1.3 Objectives

- To design an elevator controller that will facilitate simple navigation of users through floors.
- To ensure safety by having automatic door control and secured user interaction.
- To login using SQLite for activity monitoring and maintenance.

## 1.4 Scopes

This project is primarily designed for a two-story building setup. This includes scenarios such as:

**Small Office Buildings:** It fits corporate settings with two floors well, allowing employees and visitors easy access from one floor to the other quickly and safely.

**Residential Duplexes or Small Apartments:** Ideal for low-level residential buildings, such as two-floor houses, apartments, or tiny buildings with two levels.

**Medical Clinics or Small Healthcare Facilities:** Can be used on two-story clinics as a comfortable way of moving around for both the patients and the personnel.

**Retail Stores or Boutiques:** Applicable on smaller commercial areas, like boutiques or two-story retail stores where access to the floors allows customers to experience a better shopping environment.

## 1.5 Significance

Elevator control ensures smooth, effective, and safe operation. Some of the following are its significances:

- It aids in smooth traveling between floors for easy access.
- It reduces waiting time by automating quick responses to controls.
- It ensures security in the operation with management and logging of doors.
- It is easily extendable for any additional floors and types of buildings.
- It provides the possibility of planned maintenance by storing activity logs.

## CHAPTER 2 | PROJECT PLAN AND SCHEDULE

### 2.1 Task Description

The busy corporate building, an effective elevator control system, therefore offering operational efficiency, has been installed. Imagine a 2-storied office building in which employees and guests have to walk up-and-down the stairs, to go to staff meetings, meetings with clients, and other collaborative sessions. An automated elevator system, which responds to floor requests with secure door management, would get them to their destinations with speed and safety. Such a system would log all events related to elevator use to provide maintenance teams with the usage patterns that could, in turn, possibly enable them to fix problems before they became issues. A system such as this will only smooth out day-to-day operations but also enhance user experience, safety, and accessibility. A project like this is exemplary of how technology can make what's simple-a basic elevator-an important building block in seamless building management through scalable and data-driven means. (Gaiceanu, 2016)

### 2.2 Time Management

Each phase was scheduled to ensure timely completion.

Tasks/Week	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Initial GUI Design & Requirement Analysis						
Prototype Development						
Backend Implementation & Database Integration						
Logging System & Advanced Features						
Testing & Bug Fixing						
Documentation & Project Submission						



## CHAPTER 3 | REQUIREMENT ANALYSIS

### 3.1 Functional Requirements

The functional requirements of the elevator control system will guarantee that the software is effective and all the required functionality is provided for users' safety and access:

#### 3.1.1 Floor Request Buttons

There should also be request buttons on every floor and inside an elevator cabin. The system responds to the pressing of a button by the movement of an elevator to a floor it is called from.

#### 3.1.2 Door Control

- Open Door Button: Pressing an open button should make the elevator open its doors.
- Close Door Button: On pressing a close request button, the doors should close, except if another request occurs.
- Automatic Door Operation: The doors should open automatically whenever the floor is reached.

#### 3.1.3 Direction Buttons

Button/Panel	Location	Function
Up and Down Buttons	On each floor	Allows users to call the elevator in a specific direction (up or down).
Emergency Button	Inside cabin	Alerts building staff or personnel in case of emergency, potentially triggering an alarm.
Display Panel	Inside cabin and each floor	Shows the current position of the elevator, direction (up/down), and arrival at the requested floor.

### 3.1.4 Event Logging

- Log Movement Events: Each floor request and arrival of an elevator should be tracked by the system.
- Log Door Events: The opening and closing of doors should also be recorded.
- Log Emergency Events: The action of the emergency button should be recorded for safety and maintenance checks.
- These functional requirements indicate the primary roles or operations concerned with smooth movement, safety, and operational transparency of an elevator system.

## 3.2 Non-Functional Requirements

The non-functional requirements have made the elevator system reliable, easy to use, secure, and satisfactory to meet the need.

Non-Functional Requirement	Description
Reliability	System operates consistently with minimal downtime.
Performance	Quick response to requests and efficient door operations.
Usability	Intuitive interface and clear status displays for easy use.
Scalability	Easily expandable to accommodate additional floors or features.
Maintainability	Modular design allows for easy updates and troubleshooting.

### **3.3 Usability Requirements**

Usability requirements include simplicity, responsiveness and ease of use by all users for ease of use and safety.

#### **3.3.1 User-Friendly Interface**

The control panel should be provided with buttons associated with up, down, open, close and emergency, and intuitive and intuitive pictograms to prevent confusion.

#### **3.3.2 Display Readability**

It should be an easily understandable floor indication signage device, which can show the current floor level, and the movement direction of the elevator.

#### **3.3.3 Responsive Controls**

Proactively provide visual or auditory feedback to confirm that the user's request has been received.

#### **3.3.4 Accessible Design**

Controls must increasingly be made available to grasp by all end-users, such as children and disabled individuals, as a way of complying with accessibility mandates.

#### **3.3.5 Emergency Assistance**

The emergency keycap should have a good accessibility and be clearly marked so that the people can press it in case of an emergency.

### **3.4 Assumptions**

Assumptions establish the foundational conditions for the elevator system's design and operation.

- **Fixed Layout:** Designed for a two-story building, changes require system adjustments.
- **Single Elevator:** Designed for one elevator unit, additional units need separate configurations.
- **Basic User Knowledge:** Users understand basic elevator controls and operations.
- **Limited Emergency Response:** Alerts only produces sound, not external services.

## CHAPTER 4 | DESIGN ANALYSIS

### 4.1 Design Overview

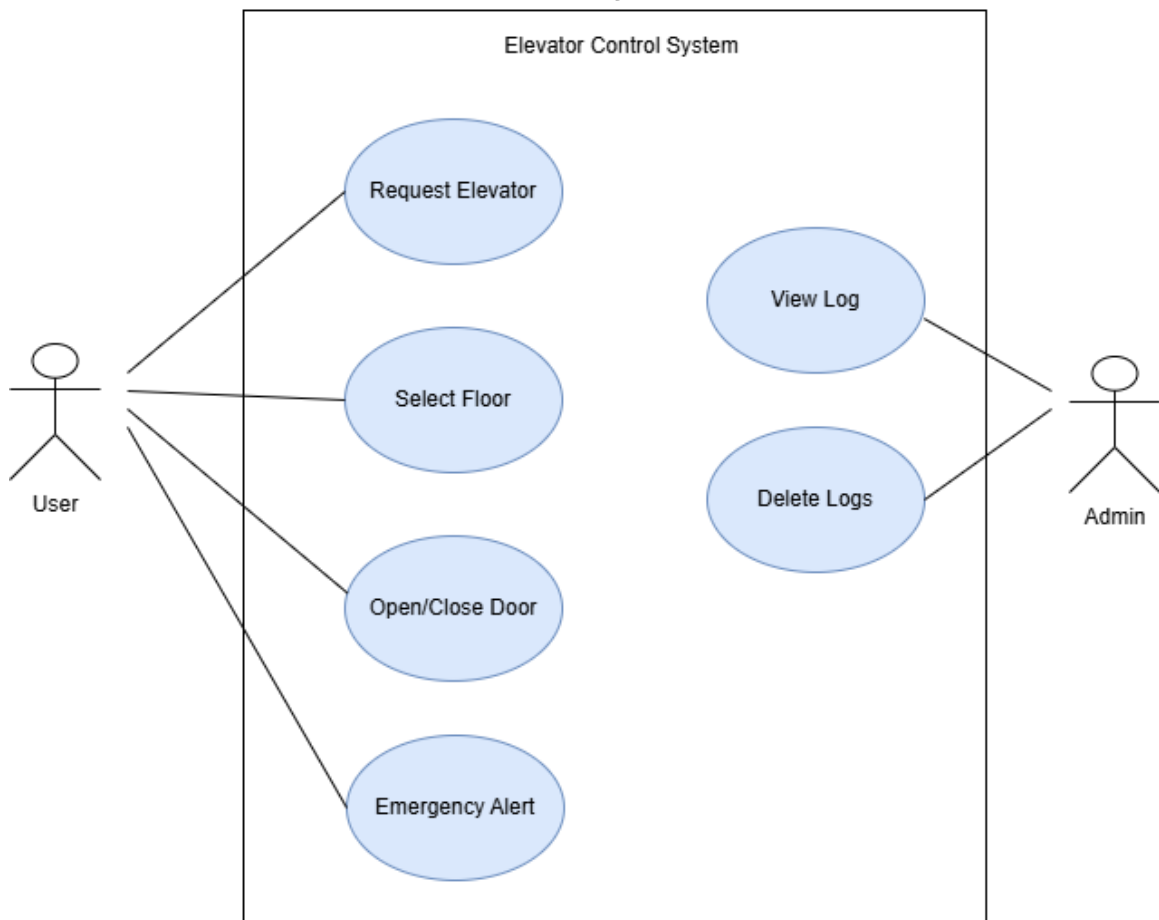
The control of the elevator has been designed to provide ease of operation with a great degree of safety and flexibility in a multi-floor environment. This would involve an operating control panel that is easy to use, with distinct buttons for floor requests, door operations, and cases of emergency; this is supported by real-time status displayed on a digital panel. The doors of this system are automatic when it reaches the floors and manually if there is such a need. This, in theory, should be very straightforward to extend upward to add more floors, or modify its purpose as needed. The present design balances efficiency and accessibility such that the experience will be both safe and intuitive. (E. Irmak, 2011)

- **Control Panel:** Clear buttons for floor requests, door control, and emergencies.
- **Display Panel:** Real-time updates on the current floor and elevator movement.
- **Automated Doors:** Open and close automatically, with manual controls for safety.
- **Event Logging:** SQLite database records all actions for monitoring and maintenance.
- **Alert Mechanisms:** Emergency button alerts produces beeping sound.
- **Modular Structure:** Easily scalable to add more floors or features as needed.

This design caters for a reliable, safe, and flexible elevator control system that can grow with future demands.

## 4.2 Use Case Diagram

This use case diagram shows the interaction between users and the elevator system. The use case is a description of how the users interact with a system to achieve certain goals. It defines what functionalities the system will provide to the user in terms of actions and responses, respectively, but with an emphasis on usability and user needs. A use case includes major actors involved, primarily users and admins, and the things they can do.



The Elevator Control System Use Case described affirms that the system shall support the following major interactions:

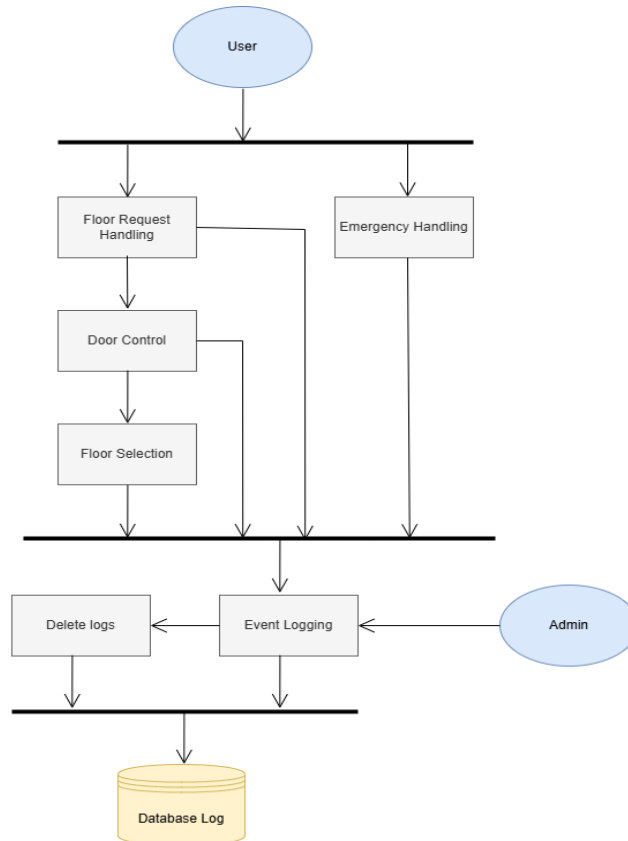
- **Request Elevator:** Users can call the elevator to their floor.
- **Select Floor:** Users select the floor they want to go to once inside the elevator.

- **Open/Close Door:** Doors automatically open upon reaching a floor, with options for users to manually control door operations if needed.
- **Emergency Alert:** Users can press an emergency button to alert building staff in case of critical situations.
- **View Log:** Admin can access logs to monitor elevator usage, door operations, and emergency alerts.
- **Delete Logs:** Admin can delete outdated logs, ensuring effective data management.

The use case lists the basic features to be supported by the elevator system in order for operations to be safely, efficiently, and easily maintained. Each use case describes how the system should respond to some particular action by a user.

## 4.3 Data Flow Diagram

The next section illustrates the data flow diagram of the requests being made from the control panels to the elevator and logging system. Data Flow Diagram (DFD) describes the flow of data within an Elevator Control System. It is basically a representation of the various interactions among the entities: user, admin, processes, and data storage Database Log.



### 4.3.1 Actors

- **User:** Represent the building or maintenance personnel who are responsible for the system's logs. The admin is granted privileges to read and delete logs stored in the system.
- **Admin:** Processes the user's call for the elevator. When a user calls the elevator, this process initiates the movement of the elevator toward the called floor.



### 4.3.2 Processes

- **Floor Request Handling:** Processes the user's call for the elevator. Once a user requests the elevator, this process starts the elevator moving to the requested floor.
- **Door Control:** allowing a person to choose the destination floor after getting into the elevator. This causes the elevator to travel to your chosen floor.
- **Floor Selection:** Responds to emergencies when the user presses the emergency button by notifying the appropriate personnel or triggering an alert.
- **Emergency Handling:** Responds to emergencies when the user presses the emergency button, notifying the appropriate personnel or triggering an alert.
- **Event Logging:** Log all the system's activities, which includes floor requests, door operations, floor selections, and emergency alerts.
- **Delete Logs:** Allows the Admin to remove old or useless logs from the Database Log for effective data management.

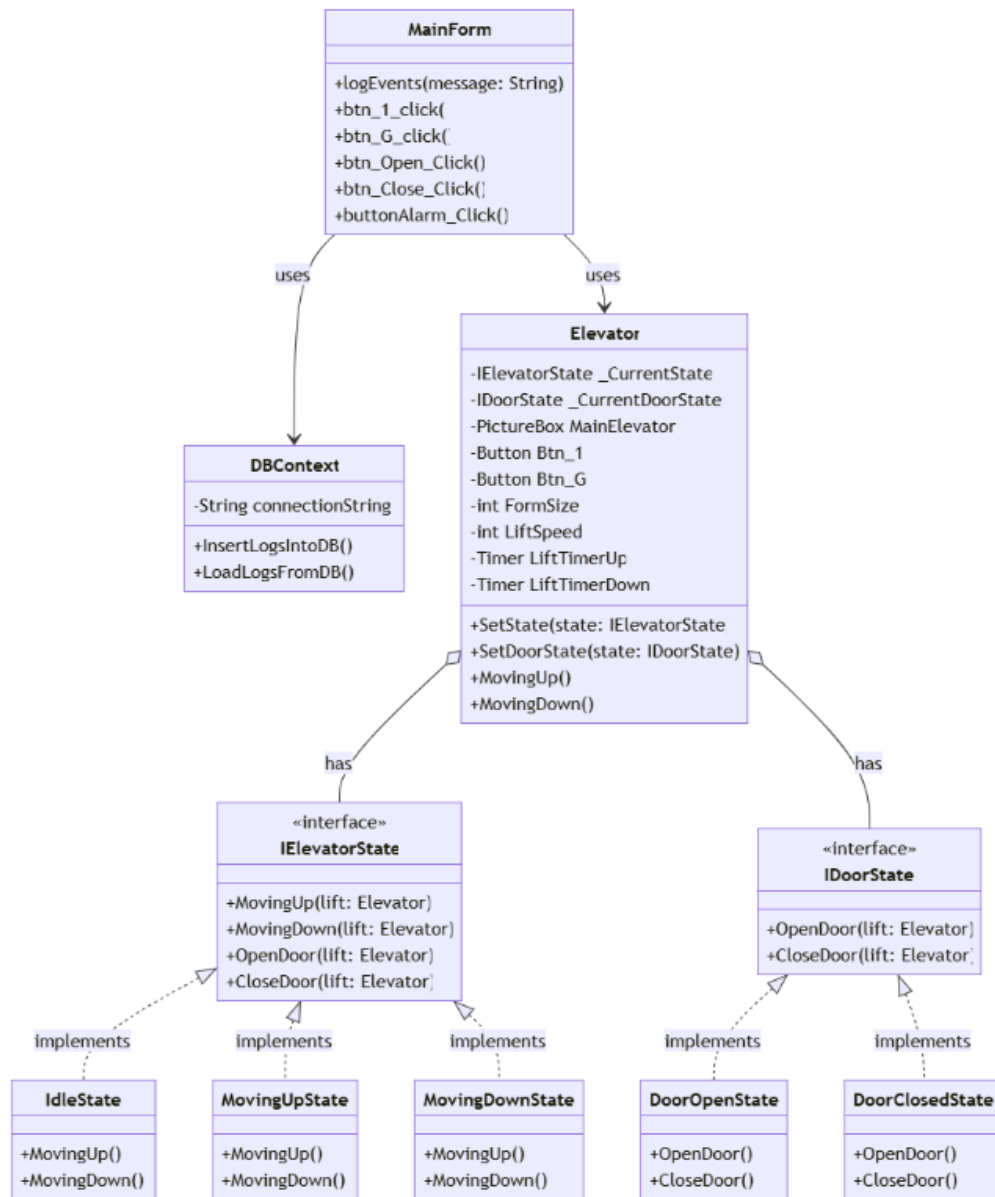
### 4.3.3 Data Store

- **Database Log:** A storage system that keeps the record of all activities and events of the elevators. It helps the system to function properly by holding a record of events that can be reviewed or deleted by the admin when needed.

This DFD is a clear representation of data flow through the Elevator Control System, showing responsibility for every process and depicting interaction among users, admins, and system components. It underlines how responsive the system is to user action, logging of events, and permission for administrative maintenancen all features that make it very instrumental in understanding system operations and maintenance.

## 4.4 Class Diagram

This class diagram gives a structured view of the Elevator Project with regard to its modular design supporting state transition, database logging, and user interface interactions. Application of the State Design Pattern guarantees clear responsibilities, improving maintainability and scalability of the code. This class diagram shows the principal classes, methods, and attributes involved in the elevator system.



## **4.4.1 DBContext**

### **4.4.1.1 Attributes:**

- `connectionString`: Represents the database connection string used for establishing communication with the SQL database.

### **4.4.1.2 Methods:**

- `InsertLogsIntoDB()`: Inserts event logs into the database.
- `LoadLogsFromDB()`: Loads event logs from the database and displays them on the UI.

## **4.4.2 Elevator**

### **4.4.2.1 Attributes:**

- `_CurrentState`: `IElevatorState`  
Represents the current operational state of the elevator.
- `MainElevator`: `PictureBox`  
The visual representation of the elevator in the UI.
- `Btn_1`: `Button`, `Btn_G`: `Button`  
Buttons for selecting floors (1st floor and Ground floor).
- `FormSize`: `int`  
The size of the form used to set the boundaries for the elevator.
- `LiftSpeed`: `int`  
The speed at which the elevator moves between floors.
- `LiftTimerUp`: `Timer`, `LiftTimerDown`: `Timer`  
Timers for managing the elevator's movement in upward and downward directions.

### **4.4.2.2 Methods:**

- `SetState(state: IElevatorState)`: Sets the current operational state of the elevator.
- `MovingUp()`: Moves the elevator upward.
- `MovingDown()`: Moves the elevator downward.

### **4.4.3 IElevatorState (Interface)**

#### **4.4.3.1 Methods:**

- MovingUp(lift: Elevator): Defines behavior when the elevator moves up.
- MovingDown(lift: Elevator): Defines behavior when the elevator moves down.
- OpenDoor(lift: Elevator): Handles opening the elevator door.
- CloseDoor(lift: Elevator): Handles closing the elevator door.

### **4.4.4 IdleState**

- Implements **IElevatorState**.

#### **4.4.4.1 Methods:**

- MovingUp(): Does nothing, as the elevator is idle.
- MovingDown(): Does nothing, as the elevator is idle.

### **4.4.5 MovingUpState**

- Implements **IElevatorState**.

#### **4.4.5.1 Methods:**

- MovingUp(): Handles elevator movement upward.
- MovingDown(): Not applicable in this state.

### **4.4.6 MovingDownState**

- Implements **IElevatorState**.

#### **4.4.6.1 Methods:**

- MovingUp(): Not applicable in this state.
- MovingDown(): Handles elevator movement downward.

### **4.4.7 MainForm**

#### **4.4.7.1 Methods:**

- logEvents(message: String): Logs events such as button presses and movements.

- `btn_1_Click()`: Handles the button click to move the elevator to the 1st floor.
- `btn_G_Click()`: Handles the button click to move the elevator to the ground floor.
- `btn_Open_Click()`: Opens the elevator door.
- `btn_Close_Click()`: Closes the elevator door.
- `buttonAlarm_Click()`: Activates the elevator's alarm system.

#### 4.4.8 Relationships

- **Elevator** implements the **IElevatorState** interface, allowing it to transition between different operational states.
- **IdleState**, **MovingUpState**, and **MovingDownState** implement **IElevatorState**, defining specific behaviors for each state.
- **MainForm** interacts with both **Elevator** and **DBContext** to manage user inputs and log data.

## 4.5 Entity Relationship Diagram

The ER Diagram represents a pictorial view of designing the structure of a database. This diagrammatic representation shows the relationships between entities (tables) in a system and defines the attributes (fields) associated with each entity, respectively. The primary goal of an ER Diagram is to design a well-structured database by outlining:

- **Entities:** Represent objects or concepts in the system (e.g., Log).
- **Attributes:** Define properties or details about each entity (e.g., LogTime, EventDescription).
- **Relationships:** Show how entities are related to each other.

Log	
PK	<u>LogID</u>
	LogTime
	EventDescription

This entity represents the **Log** table in the database, which stores all the event logs related to elevator operations.

### 4.5.1 Attributes

#### 4.5.1.1 LogID (Primary Key):

- Type: int, not null
- A unique identifier for each log entry.

#### 4.5.1.2 LogTime:

- Type: datetime
- Represents the timestamp when the event occurred.

#### 4.5.1.3 EventDescription:

- Type: nvarchar

- Provides a detailed description of the logged event (e.g., "Elevator moved to Floor 1", "Door opened").

The Log table serves as a central repository for recording all events related to elevator operations. Every activity performed by the elevator system, such as changing levels or handling emergency situations, is logged with a timestamp and a descriptive note. This structure allows for efficient event tracking and auditing.

## 4.6 User Interface Design

A simple design of the UI containing the buttons for the floors and a display panel was made, ensuring intuitiveness in its use. Elevator Prototype UI: An interface that provides a functional and user-friendly setting to manipulate the operation of the elevator. Below is a detailed description of its components and features:

### 4.6.1 UI Components

#### 4.6.1.1 Elevator Display Panel:

- Displays a graphical representation of the elevator, showing its current position (e.g., ground or 1st floor).
- Includes **up** and **down** arrows to indicate the direction of movement.

#### 4.6.1.2 Control Panel:

##### Floor Selection Buttons:

**Button "1"**: Moves the elevator to the 1st floor.

**Button "G"**: Moves the elevator to the ground floor.

##### Door Controls:

**Open Door Button** ( $\leftarrow \rightarrow$ ): Opens the elevator door.

**Close Door Button** ( $\rightarrow \leftarrow$ ): Closes the elevator door.

**Emergency Alarm Button:**

**Red Alarm Button:** Activates the alarm system in case of emergencies.

**Delete Log Button:**

Clears logged events from the event log to maintain a clutter-free log view.

**4.6.1.3 Event Log Display:****Time Column:**

Displays the exact timestamp of logged events.

**Events Column:**

Describes elevator activities such as "Elevator Moving Up," "Door Closed," "Alarm Activated," etc. This log provides a real-time update of all events for auditing and monitoring purposes.

**4.6.2 Features and Functionalities**

- **Real-Time Log Tracking:**

- Every elevator action is recorded with a timestamp and description.
- The logs are displayed in a tabular format for easy reference.

- **Interactive Buttons:**

- Floor selection and control buttons ensure seamless user interaction with the elevator.

- **Emergency Handling:**

- The alarm system ensures quick user response in emergencies.

- **Planned Log Deletion:**

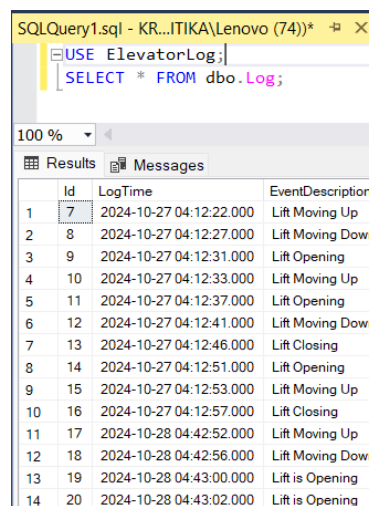


- Once applied, the Delete Log Button will allow users or administrators to clear logs so that only the most relevant data is available.

This is a design intended to make sure the interface remains simple and effective through clear, real-time controls of the elevators and tracking of their status. All this is planned to be further enhanced in terms of usability by adding in a Delete Log Button that will enable users or administrators to handle the logs correctly to maintain the clarity of the system.

## 4.7 Database Design

The Elevator Project Database Design provides a very efficient way of storing and retrieving system events or activities within the system. In turn, this proposes a reliable tracking mechanism for the operations of the elevators and how users interact with them.



	Id	LogTime	EventDescription
1	7	2024-10-27 04:12:22.000	Lift Moving Up
2	8	2024-10-27 04:12:27.000	Lift Moving Down
3	9	2024-10-27 04:12:31.000	Lift Opening
4	10	2024-10-27 04:12:33.000	Lift Moving Up
5	11	2024-10-27 04:12:37.000	Lift Opening
6	12	2024-10-27 04:12:41.000	Lift Moving Down
7	13	2024-10-27 04:12:46.000	Lift Closing
8	14	2024-10-27 04:12:51.000	Lift Opening
9	15	2024-10-27 04:12:53.000	Lift Moving Up
10	16	2024-10-27 04:12:57.000	Lift Closing
11	17	2024-10-28 04:42:52.000	Lift Moving Up
12	18	2024-10-28 04:42:56.000	Lift Moving Down
13	19	2024-10-28 04:43:00.000	Lift is Opening
14	20	2024-10-28 04:43:02.000	Lift is Opening

### 4.7.1 Data table: Log

#### 4.7.1.1 Id (Primary Key)

**Data Type:** int, not null

**Description:** A unique identifier for each log entry, ensuring every record is distinct.

**Purpose:** To uniquely identify each event log for easy reference and retrieval.

#### 4.7.1.2 LogTime

**Data Type:** datetime

**Description:** Captures the exact timestamp when an event occurs.

**Purpose:** To maintain a chronological record of events for tracking and analysis.

#### **4.7.1.3 EventDescription**

**Data Type:** nvarchar(255)

**Description:** Provides a detailed description of the logged event (e.g., "Elevator moved to Floor 1," "Door opened").

**Purpose:** To store the event details for monitoring elevator activities and troubleshooting issues.

#### **4.7.2 Purpose**

- To monitor elevator performance.
- To audit historical data for compliance and safety.
- To quickly diagnose and resolve operational issues.

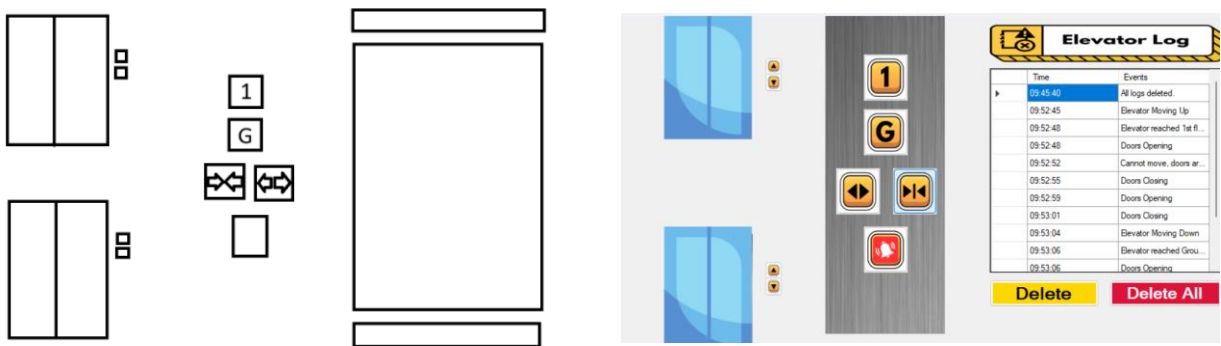
This design has achieved a balance between simplicity and functionality in order to meet current needs while allowing for future scalability.

# CHAPTER 5 | IMPLEMENTATION

## 5.1 Implementation Overview

It was implemented with C# by structuring the program in an object-oriented way to efficiently control and handle data. The Implementation phase for the Elevator Project involves front-end interface development and back-end logic, eventually ensuring smooth and operational elevator control. It was implemented using C# with a focus on object-oriented principles and thus gave many real-world advantages of scalability and maintainability.

## 5.2 Front-End Implementation



### 5.2.1 Prototyping

During the start of this project, a rough prototype was made for the placements of elements.

### 5.2.2 UI Design

- The interface for the elevator control system was developed in Windows Forms.

- The UI includes interactive buttons for floor selection, door control, and emergency handling, along with a real-time event log display.
- The design ensures user-friendly interactions and provides visual feedback for all elevator operations.

### 5.2.3 Interactive Elements

- **Floor Buttons:** The user can select floors using the available buttons (1 for the first floor, G for the ground floor).
- **Door Control Buttons:** Separate buttons for opening and closing elevator doors.
- **Alarm Button:** Allows users to activate the alarm during emergencies.
- **Delete Log Button:** Planned for future implementation to clear event logs.

## 5.3 Back-End Implementation

### 5.3.1 State Design Pattern

- The elevator's behavior was implemented using the **State Design Pattern**.
- Different states such as IdleState, MovingUpState, and MovingDownState manage the elevator's operations dynamically.

### 5.3.2 Database Integration

- Logs are stored in a **SQL Server** database via the **DBContext** class.
- Key operations include inserting new logs and retrieving them for display in the event log panel.

### 5.3.3 Timers for Movement

- Timers (LiftTimerUp and LiftTimerDown) control the elevator's movement speed between floors.
- Timers ensure smooth and realistic transitions when the elevator is moving.

### 5.3.4 Event Logging

- Every action (e.g., floor selection, door operation) is logged with a timestamp and description.

- Logs are displayed in real time and stored in the database for auditing purposes.

## **5.4 Development Tools and Environment**

- **Language:** C# (Windows Forms)
- **Database:** Microsoft SQL Server
- **IDE:** Microsoft Visual Studio
- **Sound Player:** It is applicable to handle alarm sounds in emergencies.

## **5.5 Challenges and Solutions**

### **5.5.1 Synchronizing Door and Elevator Movements**

Implemented timers and state checks to ensure operations like door closing and elevator movement don't overlap improperly.

### **5.5.2 Database Connectivity**

The data access layer to handle log storage and retrieval efficiently.

It succeeds in developing a fully functional elevator control system during the implementation phase. Real-time control, efficient logging, and a friendly interface can be realized with the help of C# and SQL Server in this system. The system also features a modular design and allows the facility for scalability, hence enhancements like safety features or the logging facility.

## **5.6 Methodology**

The Elevator Project followed the Agile Methodology, which in development includes iteration-an adaptive software approach. Agile means continuous collaboration with stakeholders, adaptive planning, and incremental delivery of functional units. This made sure the project was developed effectively by embedding changes to requirements into every stage of the cycle of development.

## 5.7 Coding Approach

The **Elevator Project** utilizes an **Object-Oriented Programming (OOP)** approach combined with the **State Design Pattern** to ensure modular, scalable, and maintainable code.

### 5.7.1 Object-Oriented Principles

- **Encapsulation:** Classes like Elevator, DBContext, and MainForm encapsulate their attributes and operations, ensuring clean code organization.
- **Abstraction:** The IElevatorState interface defines methods for elevator operations, allowing different states to implement their behavior.
- **Inheritance:** Concrete state classes like IdleState, MovingUpState, and MovingDownState inherit from the IElevatorState interface.
- **Polymorphism:** The elevator dynamically switches behavior by transitioning between different states.

### 5.7.2 State Design Pattern

- The elevator's behavior changes dynamically based on its state (IdleState, MovingUpState, MovingDownState).
- This approach reduces complexity and avoids hardcoding conditional logic, improving modularity and flexibility.

## 5.8 Unique Concept

The project's unique concept lies in its use of the **State Design Pattern** to manage elevator behavior dynamically and **real-time event logging** for monitoring operations. Key features include:

**Dynamic State Transitions:** Seamless switching between Idle, MovingUp, and MovingDown states, enhancing flexibility.

**Real-Time Logging:** Every action is logged with timestamps and displayed on the GUI, ensuring transparency.

**Efficient Multi-Tasking:** Background operations for smooth performance without freezing the interface.

**Scalability:** Designed for easy expansion using OCP (Open Closed Principle) to accommodate more floors or new features.

## 5.9 Database Development

SQLite The **database development** for the Elevator Project focuses on creating a reliable and efficient system to log and retrieve elevator operations. It ensures real-time storage and display of events while maintaining data integrity and accessibility.

### 5.9.1 Database Design

- The database consists of a single table named **Log** with the following structure:
  - **Id:** Primary Key (int), ensures unique identification of each log entry.
  - **LogTime:** (datetime), records the exact timestamp of each event.
  - **EventDescription:** (nvarchar(255)), stores a detailed description of the event (e.g., "Elevator moved to Floor 1").

### 5.9.2 Database Connection

- A connection to the **SQL Server** database is established using a **connection string**.
- The DBContext class manages all database operations, including inserting and retrieving data.

#### 5.9.2.1 Inserting Logs

- **InsertLogsIntoDB** method:
  - This method uses SqlDataAdapter to insert event logs into the database.
  - It accepts a DataTable containing the current log data and updates the database efficiently.

### 5.9.2.2 Retrieving Logs

- **LoadLogsFromDB** method:
  - Retrieves log data from the database using a SELECT query.
  - Displays logs in a DataGridView on the GUI for real-time monitoring.
- Supports sorting by time (ORDER BY LogTime DESC) to show the latest events first.

### 5.9.2.3 Log Deletion:

- Clears old logs from both the database and the GUI, ensuring efficient database management.



## CHAPTER 6 | TESTING PHASE

Functional and non-functional testing of the elevator project confirms that this application fulfills all the requirements. Unit testing, integration testing, and system testing were carried out to assure the correctness, efficiency, and robustness of the application.

### 6.1 Unit Testing

- Focused on individual components, such as button click events and database operations.
- Verified that each method, including `InsertLogsIntoDB` and `LoadLogsFromDB`, performed as expected.

### 6.2 Integration Testing

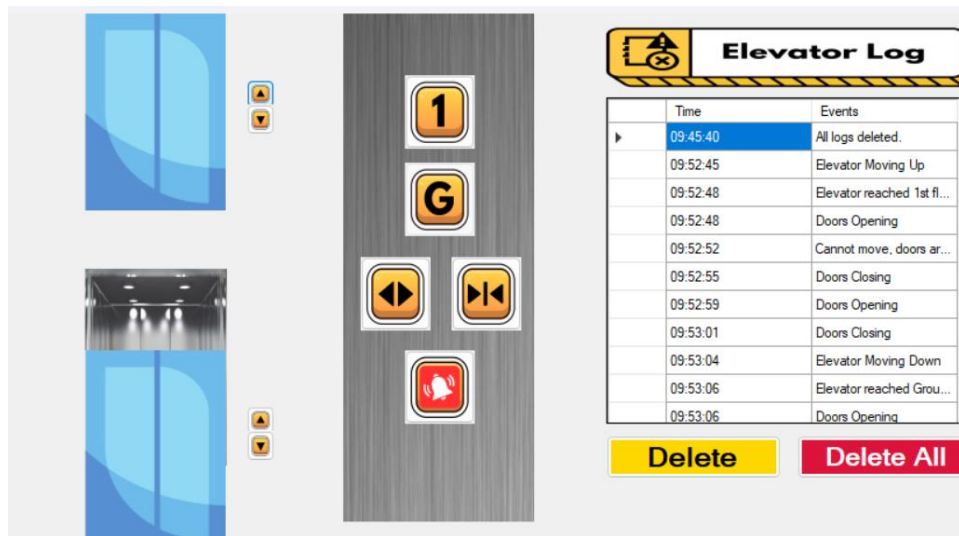
- Tested interactions between different components, such as the **GUI**, **Elevator State System**, and **Database**.
- Ensured smooth transitions between states (`Idle`, `MovingUp`, `MovingDown`) and accurate logging of events.

### 6.3 System Testing

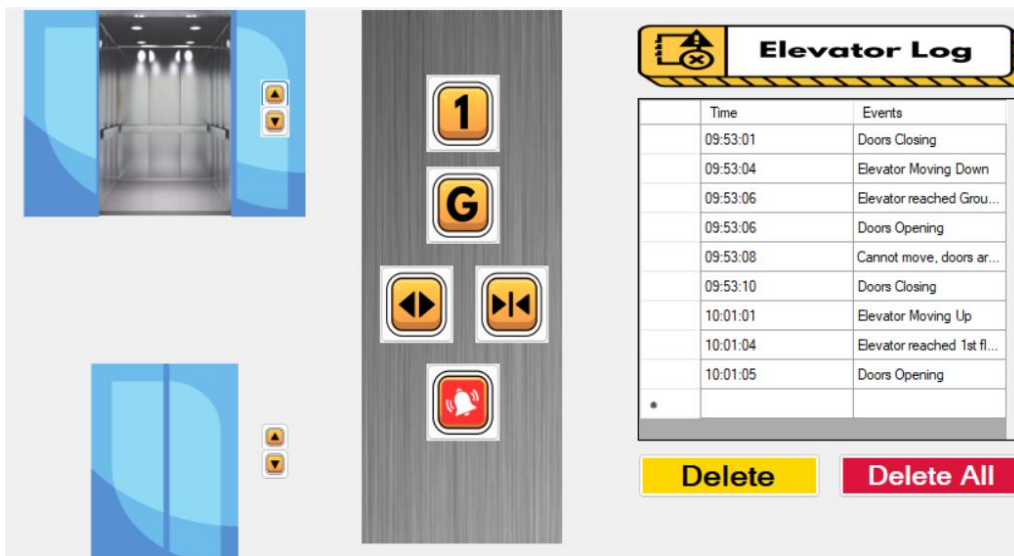
- Validated the entire elevator control system.
- Tested real-time event logging, elevator movements, door operations, and alarm activation.

## 6.4 Test Cases and Results

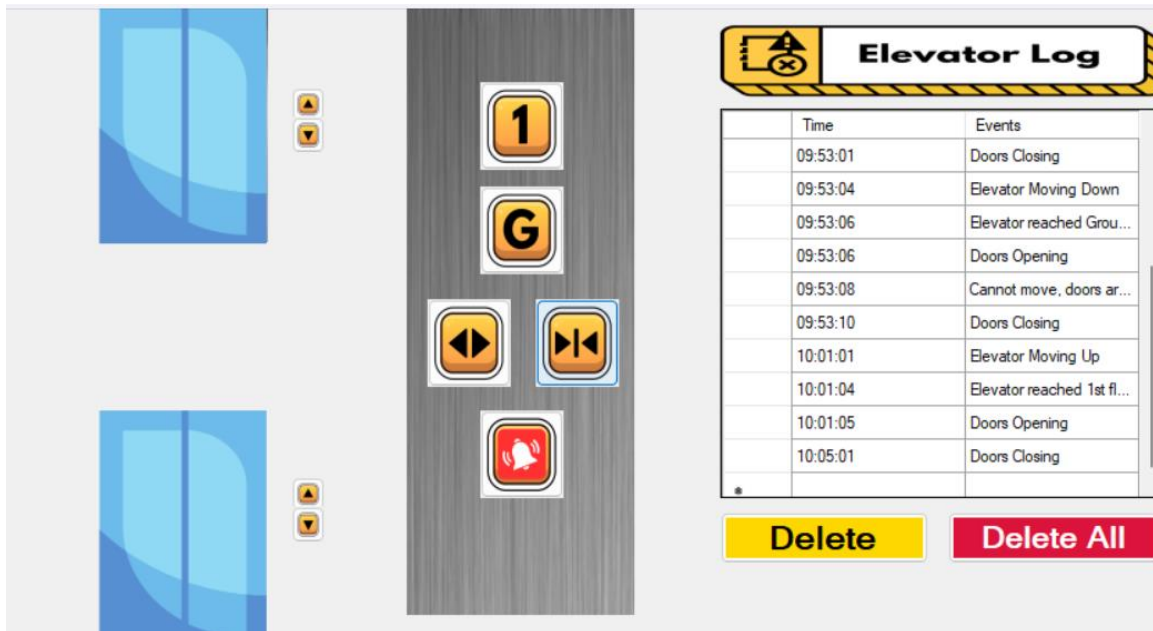
1. **Press floor request button:** Elevator moves to the requested floor and displays the floor number.



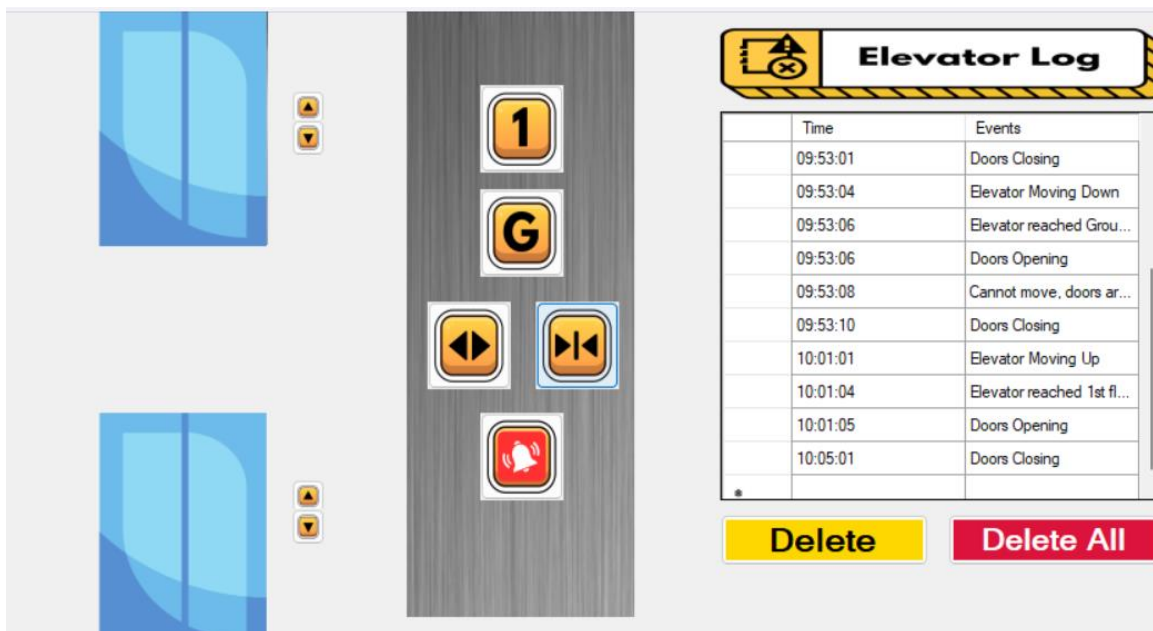
2. **Press open door button:** Elevator doors open successfully.



3. **Press close door button:** Elevator doors close successfully.



4. **Press log button:** Event logs are displayed correctly.



5. **Database log insertion and retrieval:** Logs are accurately inserted and retrieved from the database.

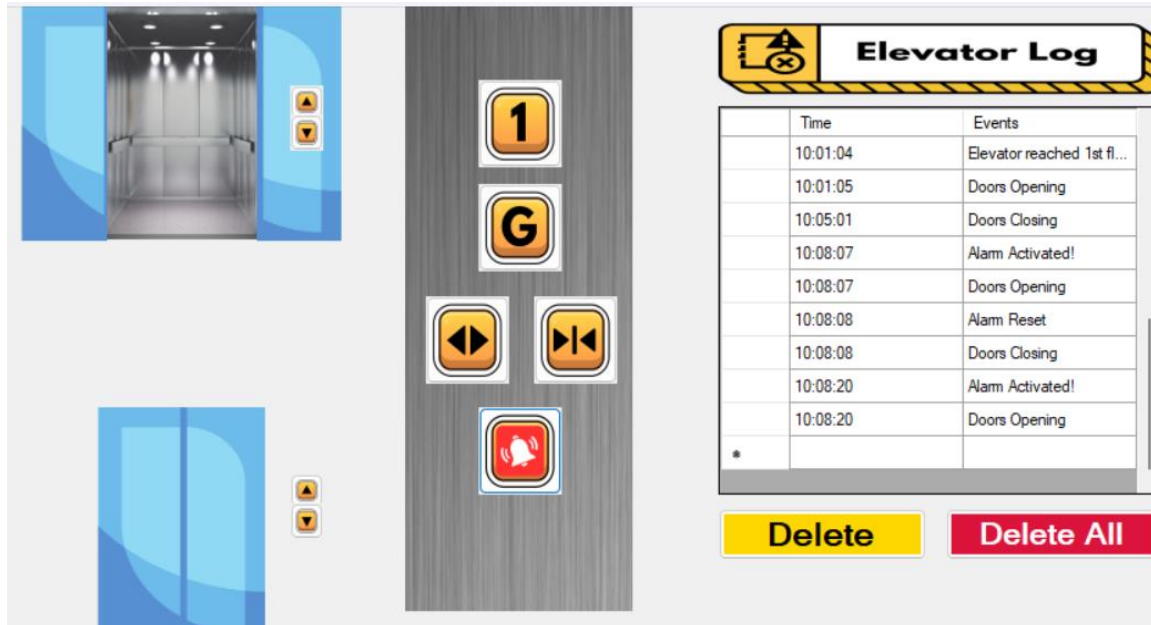
Use ElevatorLog;  
Select \* from dbo.Log;

100 %

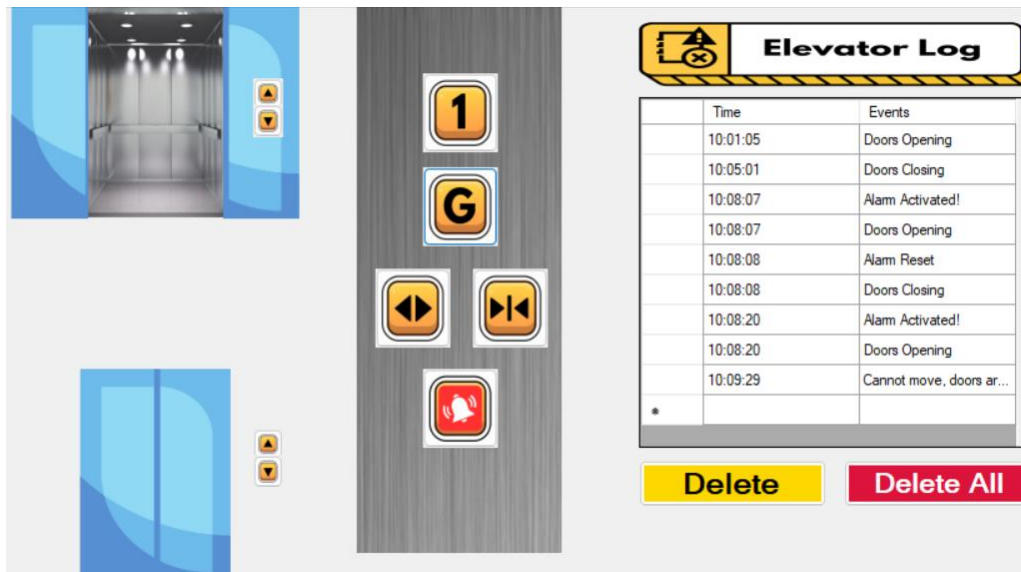
Results Messages

	Id	LogTime	EventDescription
1	1124	2024-11-11 09:45:40.000	All logs deleted.
2	1125	2024-11-11 09:52:45.000	Elevator Moving Up
3	1126	2024-11-11 09:52:48.000	Elevator reached 1st floor.
4	1127	2024-11-11 09:52:48.000	Doors Opening
5	1128	2024-11-11 09:52:52.000	Cannot move, doors are open.
6	1129	2024-11-11 09:52:55.000	Doors Closing
7	1130	2024-11-11 09:52:59.000	Doors Opening
8	1131	2024-11-11 09:53:01.000	Doors Closing
9	1132	2024-11-11 09:53:04.000	Elevator Moving Down
10	1133	2024-11-11 09:53:06.000	Elevator reached Ground floor.
11	1134	2024-11-11 09:53:06.000	Doors Opening
12	1135	2024-11-11 09:53:08.000	Cannot move, doors are open.
13	1136	2024-11-11 09:53:10.000	Doors Closing
14	1137	2024-11-11 10:01:01.000	Elevator Moving Up
15	1138	2024-11-11 10:01:04.000	Elevator reached 1st floor.
16	1139	2024-11-11 10:01:05.000	Doors Opening
17	1140	2024-11-11 10:05:01.000	Doors Closing

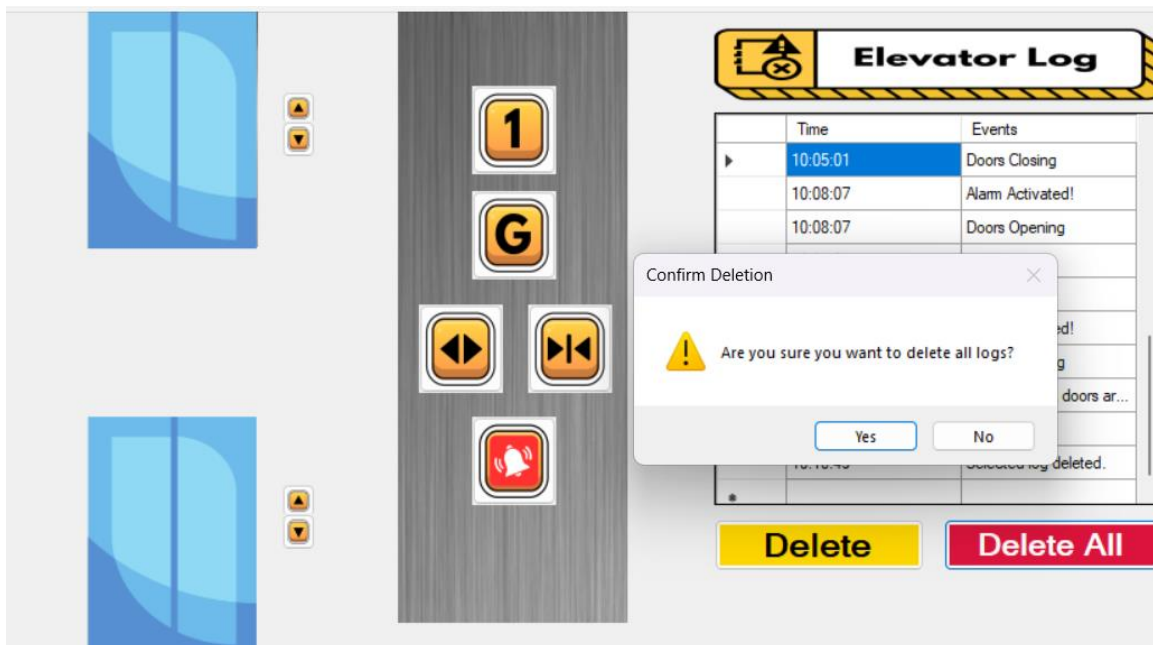
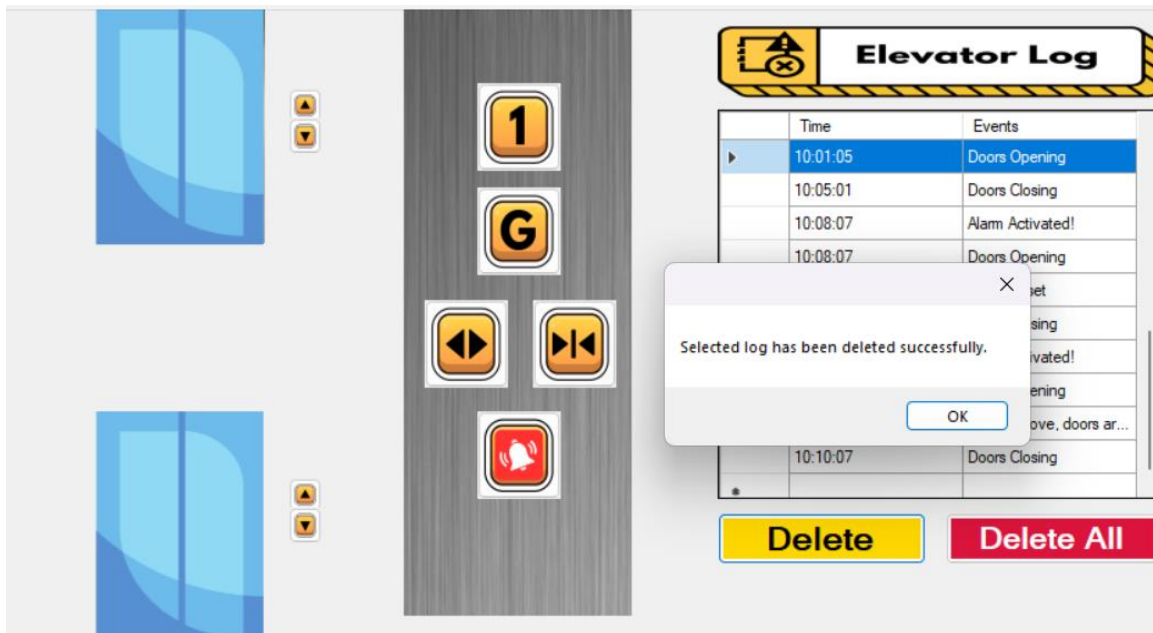
6. **Alarm activation:** Alarm sound plays, and elevator controls are disabled successfully.

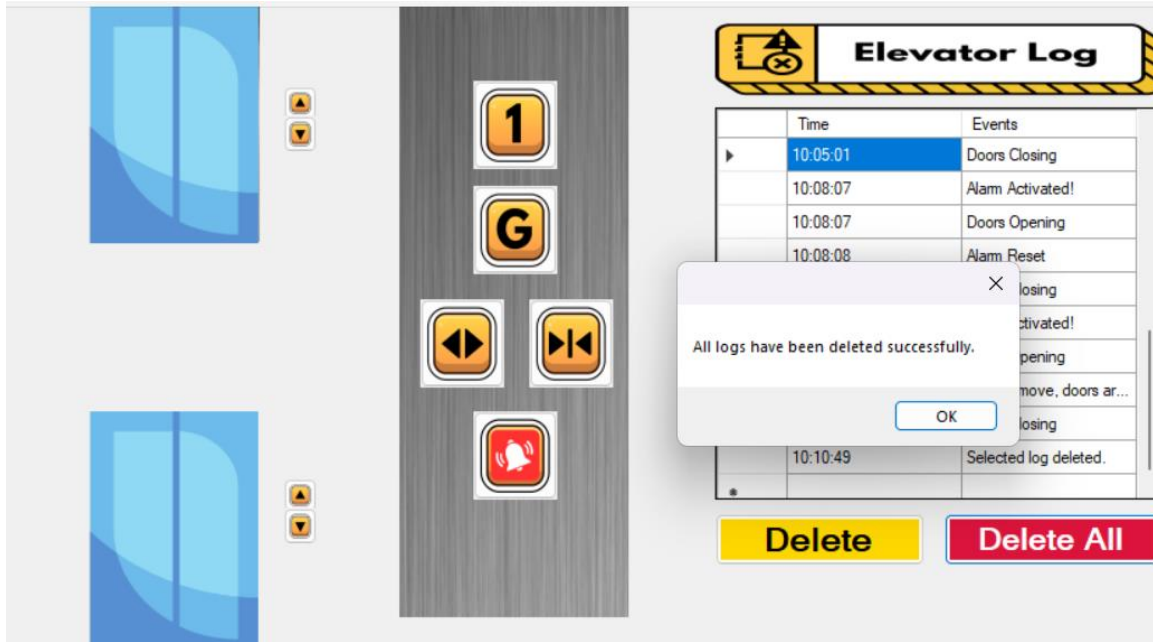


7. **Exception handling during database operation:** Application handles errors gracefully without crashing.
8. **Concurrent operations with BackgroundWorker:** GUI remain responsive during database operations.
9. **Elevator moves while doors open:** Movement is prevented, and a log is recorded.



10. **Delete log functionality:** Logs are removed from both the GUI and database successfully.





## 6.5 Test Summary

Test Case	Test Description	Expected Outcome	Actual Outcome	Result
1	Press floor request button	Elevator moves to the requested floor; displays floor number	Elevator moved correctly; displayed floor number	Pass
2	Press open door button	Elevator doors open	Doors opened successfully	Pass
3	Press close door button	Elevator doors close	Doors closed successfully	Pass
4	Press log button	Event logs displayed	Logs displayed correctly	Pass

Test Case	Test Description	Expected Outcome	Actual Outcome	Result
5	Database log insertion and retrieval	Logs inserted and retrieved accurately	Logs were correctly inserted and retrieved	Pass
6	Alarm activation	Alarm sound plays, elevator controls disabled	Alarm activated successfully	Pass
7	Exception handling during database operation	Application handles errors gracefully	Errors handled properly without crashing	Pass
8	Concurrent operations with BackgroundWorker	GUI remains responsive during database operations	GUI operated smoothly without freezing	Pass
9	Elevator moves while doors open	Prevent elevator movement	Movement prevented; log recorded	Pass
10	Delete log functionality	Logs removed from GUI and database	Logs deleted successfully	Pass

The testing phase validated all functionalities for a robust and reliable system of elevator control. The system has passed all test cases, which confirms it meets project requirements and provides an optimal user experience.



## CHAPTER 7 | PROJECT EVALUATION

### 7.1 Self-Assessment Report

Task	Possible Marks	Self-assessment Completed	Reference to Testing Report	Mark Awarded
Complete GUI	10	Yes	Test Case 1-3	10
Functional Handlers	10	Yes	Test Case 1-3	10
Database Operations	15	Yes	Test Case 4-5	15
Log Functionality	5	Yes	Test Case 5, 10	5
Animation & Timer	10	Yes	Test Case 1-2	10
Error Handling	5	Yes	Test Case 7	5
Efficiency via Tasks	5	Yes	Test Case 8	5
State Pattern	10	Yes	Test Case 1-2	10
Testing Report	10	Yes	Included	10
<b>Total</b>	<b>100</b>			<b>100</b>

## **CHAPTER 8 | REFLECTION AND CONCLUSION**

In the development of the Elevator Project, my understanding of Object-Oriented Programming principles and the State Design Pattern was broad. This project underlined the importance of designing systems that are modular, maintainable, and scalable in real-world applications.

### **8.1 Reflection**

Key reflections include:

- Enhanced Understanding of OOP and Design Patterns:
- Importance of Database Integration:
- Problem-Solving and Resilience:
- Continuous Feedback and Improvement

### **8.2 Conclusion**

In this way, the Elevator Project returned a very robust and functional control system in relation to the set aims. Generally, this project showed that every robust design must be supported by an appropriate implementation technique. This is a great point from which one can start trying to solve more complex tasks of software engineering using the principles of constant learning and improvement.

## REFERENCES

- E. Irmak, I. C. (2011). Development of a real time monitoring and control system for PLC based elevator. *Proceedings of the 2011 14th European Conference on Power Electronics and Applications*, (pp. 1-8). Birmingham, UK.
- Gaiceanu, M. (2016). *Experimental Portotype of an Electric Elevvator*. IOP Publishing Ltd.

# APPENDIX

## IDoorState.cs

```
namespace ElevatorProject
{
    4 references
    public interface IDoorState
    {
        6 references
        void OpenDoor(MainForm form);
        4 references
        void CloseDoor(MainForm form);
        4 references
        bool IsDoorOpen();
    }
}
```

## IElevatorState.cs

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace ElevatorProject
{
    5 references
    internal interface IElevatorState
    {
        4 references
        void MovingUp(Elevator lift);
        4 references
        void MovingDown(Elevator lift);
    }
}
```

## Elevator.cs

```
namespace ElevatorProject
{
    11 references
    internal class Elevator
    {
        public IElevatorState _currentState;

        public PictureBox MainElevator;
        public Button Btn_U;
        public Button Btn_D;
        public int FloorSize;
        public int LiftSpeed;
        public Timer LiftTimerUp;
        public Timer LiftTimerDown;

        1 reference
        public Elevator(PictureBox mainElevator, Button btn_U, Button btn_D, int floorSize, int liftSpeed, Timer liftTimerUp, Timer liftTimerDown)
        {
            MainElevator = mainElevator;
            Btn_U = btn_U;
            Btn_D = btn_D;
            FloorSize = floorSize;
            LiftSpeed = liftSpeed;
            LiftTimerUp = liftTimerUp;
            LiftTimerDown = liftTimerDown;
            _currentState = new IdleState();
        }

        2 references
        public string CurrentFloor { get; private set; } // Add this property

        2 references
        public void UpdateFloor(string floor)
        {
            CurrentFloor = floor; // Update the current floor
        }

        4 references
        public void SetState(IElevatorState state)
        {
            _currentState = state;
        }

        1 reference
        public void MovingUp()
        {
            _currentState.MovingUp(this);
        }

        1 reference
        public void MovingDown()
        {
            _currentState.MovingDown(this);
        }
    }
}
```

## DBContext.cs

```
using System;
using System.Collections.Generic;
using System.Data.SqlClient;
using System.Data;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
using System.Windows.Forms;

namespace ElevatorProject
{
    2 references
    internal class DBContext
    {
        string connectionString = @"Server = KRITIKA; Database = ElevatorLog; Trusted_Connection = True;";

        1 reference
        public void InsertLogsIntoDB(DataTable dt)
        {
            try
            {
                using (SqlConnection conn = new SqlConnection(connectionString))
                {
                    string query = @"Insert into Log (LogTime, EventDescription) values (@Time, @Log)";

                    using (SqlDataAdapter adapter = new SqlDataAdapter())
                    {
                        adapter.InsertCommand = new SqlCommand(query, conn);
                        adapter.InsertCommand.Parameters.Add("@Time", SqlDbType.DateTime, 0, "LogTime");
                        adapter.InsertCommand.Parameters.Add("@Log", SqlDbType.NVarChar, 255, "EventDescription");

                        conn.Open();

                        adapter.Update(dt);
                    }
                }
            }
            catch (Exception ex)
            {
                MessageBox.Show("Error saving logs to DB: " + ex.Message);
            }
        }
    }
}
```

```
1 reference
public void LoadLogsFromDB(DataTable dt, DataGridView dataGridViewLogs)
{
    try
    {
        using (SqlConnection conn = new SqlConnection(connectionString))
        {
            string query = @"Select LogTime, EventDescription from Log order by LogTime desc";

            using (SqlDataAdapter adapter = new SqlDataAdapter(query, conn))
            {
                dt.Rows.Clear();

                adapter.Fill(dt);

                dataGridViewLogs.Rows.Clear();

                foreach (DataRow row in dt.Rows)
                {
                    string currentTime = Convert.ToDateTime(row["LogTime"]).ToString("hh:mm:ss");
                    string events = row["EventDescription"].ToString();

                    dataGridViewLogs.Rows.Add(currentTime, events);
                }
            }
        }
    }
    catch (Exception ex)
    {
        MessageBox.Show("Error loading logs from DB: " + ex.Message);
    }
}
}
```

## DoorOpenState.cs

```
namespace ElevatorProject
{
    1 reference
    internal class DoorOpenState : IDoorState
    {
        5 references
        public void OpenDoor(MainForm form)
        {
            // Already open, do nothing
        }

        3 references
        public void CloseDoor(MainForm form)
        {
            form.SetDoorState(new DoorClosedState());
            form.StartClosingDoors();
            form.LogEvents("Doors Closing");
        }

        3 references
        public bool IsDoorOpen()
        {
            return true; // Doors are open
        }
    }
}
```

## DoorClosedState.cs

```
namespace ElevatorProject
{
    2 references
    internal class DoorClosedState : IDoorState
    {
        5 references
        public void OpenDoor(MainForm form)
        {
            form.SetDoorState(new DoorOpenState());
            form.StartOpeningDoors();
            form.LogEvents("Doors Opening");
        }

        3 references
        public void CloseDoor(MainForm form)
        {
            // Already closed, do nothing
        }

        3 references
        public bool IsDoorOpen()
        {
            return false; // Doors are closed
        }
    }
}
```

## MovingDownState.cs

```
using System;
using System.Collections.Generic;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace ElevatorProject
{
    1 reference
    internal class MovingDownState : IElevatorState
    {
        2 references
        public void MovingDown(Elevator lift)
        {
            if (lift.MainElevator.Top == 0 || lift.MainElevator.Bottom < lift.FormSize)
            {
                lift.MainElevator.Top += lift.LiftSpeed + 10;
            }
            else
            {
                // Once it reaches the bottom, transition to StoppedState
                lift.SetState(new IdleState());
                lift.MainElevator.Top = lift.FormSize - lift.MainElevator.Height;
                lift.Btn_1.BackColor = Color.White;
                lift.LiftTimerDown.Stop(); // Stop the timer when it reaches the bottom
                lift.Btn_1.Enabled = true; // Re-enable the 1st floor button
                lift.Btn_G.Enabled = true; // Enable other controls
            }
        }

        2 references
        public void MovingUp(Elevator lift)
        {
            /* Do Nothing */
        }
    }
}
```

## MovingUpState.cs

```
using System;
using System.Collections.Generic;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace ElevatorProject
{
    1 reference
    internal class MovingUpState : IElevatorState
    {
        2 references
        public void MovingDown(Elevator lift)
        {
            /* Do Nothing */
        }

        2 references
        public void MovingUp(Elevator lift)
        {
            if (lift.MainElevator.Top > 0)
            {
                lift.MainElevator.Top -= lift.LiftSpeed;
            }
            else
            {
                // Once it reaches the top, transition to StoppedState
                lift.SetState(new IdleState());
                lift.MainElevator.Top = 0;
                lift.Btn_G.BackColor = Color.White;
                lift.LiftTimerUp.Stop(); // Stop the timer when it reaches the top
                lift.Btn_G.Enabled = true; // Re-enable the G button
                lift.Btn_1.Enabled = true; // Enable other controls
            }
        }
    }
}
```

## MainForm.cs

```
using System;
using System.Data;
using System.Drawing;
using System.Media;
using System.Windows.Forms;

namespace ElevatorProject
{
    10 references
    public partial class MainForm : Form
    {
        private bool isOpening = false;
        private bool isClosing = false;

        private int doorMaxOpenWidth;
        private int doorSpeed = 5;
        private int liftSpeed = 5;

        private IDoorState _currentDoorState;
        private SoundPlayer alarmSound;
        private bool isAlarmActive = false;

        private Elevator lift;
        private DataTable dt = new DataTable();
        private DbContext dbContext = new DbContext();

        1 reference
        public MainForm()
        {
            InitializeComponent();

            _currentDoorState = new DoorClosedState();
            lift = new Elevator(mainElevator, btn_1, btn_G, this.ClientSize.Height, liftSpeed, liftTimerUp, liftTimerDown);

            alarmSound = new SoundPlayer("C:\\Users\\Lenovo\\Downloads\\alarmsound.wav");

            doorMaxOpenWidth = mainElevator.Width / 2 - 30;

            dataGridViewLogs.ColumnCount = 2;
            dataGridViewLogs.Columns[0].Name = "Time";
            dataGridViewLogs.Columns[1].Name = "Events";

            dt.Columns.Add("LogTime");
            dt.Columns.Add("EventDescription");
        }
    }
}
```

```
10 references
public void LogEvents(string message)
{
    string currentTime = DateTime.Now.ToString("hh:mm:ss");

    dt.Rows.Add(currentTime, message);
    dataGridViewLogs.Rows.Add(currentTime, message);
    dbContext.InsertLogsIntoDB(dt);
}

1 reference
private void Form1_Load(object sender, EventArgs e)
{
    dbContext.LoadLogsFromDB(dt, dataGridViewLogs);
}

3 references
public void btn_1_click(object sender, EventArgs e)
{
    if (!_currentDoorState.IsDoorOpen())
    {
        lift.SetState(new MovingUpState());
        lift.LiftTimerUp.Start();
        btn_G.Enabled = false;
        LogEvents("Elevator Moving Up");
    }
    else
    {
        LogEvents("Cannot move, doors are open.");
        //btn_G.Enabled = true;
    }
}

2 references
public void btn_G_click(object sender, EventArgs e)
{
    if (!_currentDoorState.IsDoorOpen())
    {
        lift.SetState(new MovingDownState());
        lift.LiftTimerDown.Start();
        btn_1.Enabled = false;
        LogEvents("Elevator Moving Down");
    }
    else
    {
        LogEvents("Cannot move, doors are open.");
        //btn_1.Enabled = true;
    }
}
}
```



```

1 reference
public void liftTimerUp_Tick(object sender, EventArgs e)
{
    lift.MovingUp();
    if (lift.MainElevator.Top <= 0)
    {
        lift.LiftTimerUp.Stop();
        logEvents("Elevator reached 1st floor.");
        lift.UpdateFloor("1st");
        _currentDoorState.OpenDoor(this); // Automatically open 1st floor doors
    }
}

1 reference
public void liftTimerDown_Tick(object sender, EventArgs e)
{
    lift.MovingDown();
    if (lift.MainElevator.Top >= lift.FormSize - lift.MainElevator.Height)
    {
        lift.LiftTimerDown.Stop();
        logEvents("Elevator reached Ground floor.");
        lift.UpdateFloor("Ground");
        _currentDoorState.OpenDoor(this); // Automatically open Ground floor doors
    }
}

2 references
public void SetDoorState(IDoorState state)
{
    _currentDoorState = state;
}

1 reference
public void StartOpeningDoors()
{
    isOpening = true;
    isClosing = false;
    doorTimer.Start();
    btn_Close.Enabled = false;
}

1 reference
public void StartClosingDoors()
{
    isOpening = false;
    isClosing = true;
    doorTimer.Start();
}

```

```

1 reference
private void btn_Open_Click(object sender, EventArgs e)
{
    _currentDoorState.OpenDoor(this);
}

1 reference
private void btn_Close_Click(object sender, EventArgs e)
{
    _currentDoorState.CloseDoor(this);
}

1 reference
private void door_Timer_Tick(object sender, EventArgs e)
{
    if (lift.CurrentFloor == "1st")
    {
        ManageDoorMovement(doorLeft_1, doorRight_1); // 1st floor doors
    }
    else if (lift.CurrentFloor == "Ground")
    {
        ManageDoorMovement(doorLeft_G, doorRight_G); // Ground floor doors
    }
}

2 references
private void ManageDoorMovement(Control doorLeft, Control doorRight)
{
    if (isOpening)
    {
        if (doorLeft.Left > doorMaxOpenWidth / 2)
        {
            doorLeft.Left -= doorSpeed;
            doorRight.Left += doorSpeed;
        }
        else
        {
            doorTimer.Stop();
            btn_Close.Enabled = true;
            btn_G.Enabled = true;
            btn_1.Enabled = true;
        }
    }
}

```

```

        if (isClosing)
        {
            if (doorLeft.Right < mainElevator.Width + doorMaxOpenWidth / 2 - 5)
            {
                doorLeft.Left += doorSpeed;
                doorRight.Left -= doorSpeed;
            }
            else
            {
                doorTimer.Stop();
                btn_0.Enabled = true;
                btn_1.Enabled = true;
            }
        }
    }

1 reference
private void buttonAlarm_Click(object sender, EventArgs e)
{
    if (isAlarmActive)
    {
        ResetAlarm();
    }
    else
    {
        logEvents("Alarm Activated!");
        lift.LiftTimerUp.Stop();
        lift.LiftTimerDown.Stop();
        doorTimer.Stop();
        _currentDoorState.OpenDoor(this);
        alarmSound.PlayLooping();
        buttonAlarm.BackColor = Color.Red;
        buttonAlarm.Text = "Alarm Activated";
        isAlarmActive = true;
    }
}

```

```

private void ResetAlarm()
{
    logEvents("Alarm Reset");
    alarmSound.Stop();
    _currentDoorState.CloseDoor(this);
    buttonAlarm.BackColor = SystemColors.Control;
    buttonAlarm.Text = "Alarm";
    isAlarmActive = false;
}

1 reference
private void DeleteButton_Click(object sender, EventArgs e)
{
}

```

## IdleState.cs

```

using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace ElevatorProject
{
    3 references
    internal class IdleState : IElevatorState
    {
        2 references
        public void MovingDown(Elevator lift)
        {
            /* Do Nothing */
        }

        2 references
        public void MovingUp(Elevator lift)
        {
            /* Do Nothing */
        }
    }
}

```