Elevator Control System

Requirements Definition Document

RDD Version 1.1

Team #1
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CS 460 Software Engineering

TABLE OF CONTENTS

1 Introduction

The introduction gives a brief explanation of what lies ahead in the document. It will go over the purpose of the document, project description, and summary of sections.

1.1 Purpose of the Document

This document provides a detailed description of the requirements of the Elevator Control System (ECS). It is created during the planning phase of the development process. It is intended for the project team, project manager, project sponsor, and client. It explains the objectives and features of the software, the interfaces of the software, what the software will do and the constraints under which it must operate. Team members will use this document as a reference while making the ECS.

1.2 Project Description

The product described in this document is an Elevator Control System which main function is to move people vertically between floors in buildings. There are 4 elevators provided with weight sensors to detect capacity. If the elevator cabin is overweight, it will make a noise and the door will open. Each of the elevator cabins has a panel that has buttons for every floor (1 through 19) and contains two keyholes, one is "EMERGENCY", providing ease of access to emergency personnel, the other one is "EXECUTIVE" and is reserved for executive access to the top (20th) floor suite.

1.3 Summary of Sections

Section 2 contains the definition of terms that are commonly used. Section 3 explains the requirements and objectives of the ECS in detail. Section 4 details the hardware and software components in the system. Section 5 explains the interfaces with which the system will interact. Section 6 talks about what components the ECS has and what they are supposed to do. Section 7 details the limitations under which it must operate.

2 Definition of Terms

It is important to understand the terminology used throughout the rest of the document so as to fully understand what is being communicated.

- ***Car***

  The car references to part of the elevator that carries passengers up and down the shaft to deliver them to a chosen floor. A car consists of a set of doors that open at the center and several sensors meant to enable safe and reliable travel.

- ***Elevator Bay***

  An elevator bay refers to the space in the building in which users request and wait for a car to arrive on the floor.

- ***Elevator Control System (ECS)/Controller***
  The ECS and controller refer to the software combination that manages the behavior of the entire system through controlling the hardware.

- ***Inside Elevator Button***
  Inside elevator button refers to the elevator buttons that are located in the inside of the elevator car. The buttons that mirror the number to the desired floor you want, the emergency button, the maintenance button, and the open/close door button.

- ***Outside Elevator Button***
  Outside Elevator Button refers to the button that is located on each floor, it is used to call the elevator to the floor that the button is located.

3 Objectives

The following summarizes the overarching goals for the ECS project and should be the means by which to quantify the success of the project. These objectives should be the basis for technical decisions and guide the development of the project.

3.1 Reliable Transportation

The elevator should be a form of transport in the building that can be relied upon to always work, barring specific situations such as emergencies.

3.1.1 Consistent behavior

The behavior of the elevator needs to be consistent with the user's expectations, meaning that all standard conventions for elevators should be followed. There should be no special casing of the behavior, to avoid providing an inferior user experience.

3.2 Adhere to Safety Standards

The utmost priority must be given to following safety standards, to ensure that our users are safe and so to minimize liability. All mechanical operations must take into account all relevant laws or regulations as such operations pose the most danger to the end user.

3.3 Provide Secure and Express usage for Penthouse Users

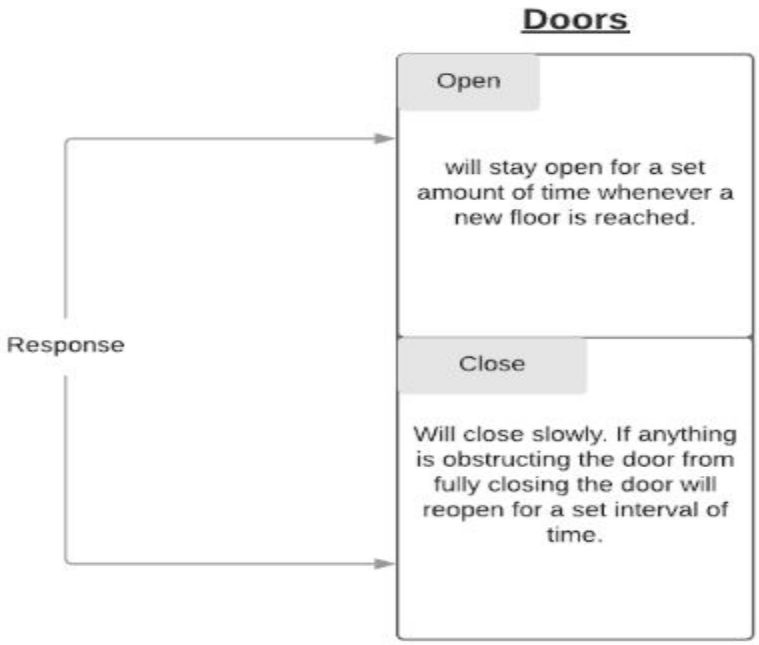
As we require a key for the elevator to access the penthouse floor, we need to ensure that the experience for the individuals living in the penthouse is expedited in a comfortable fashion

4 Overall System Organization

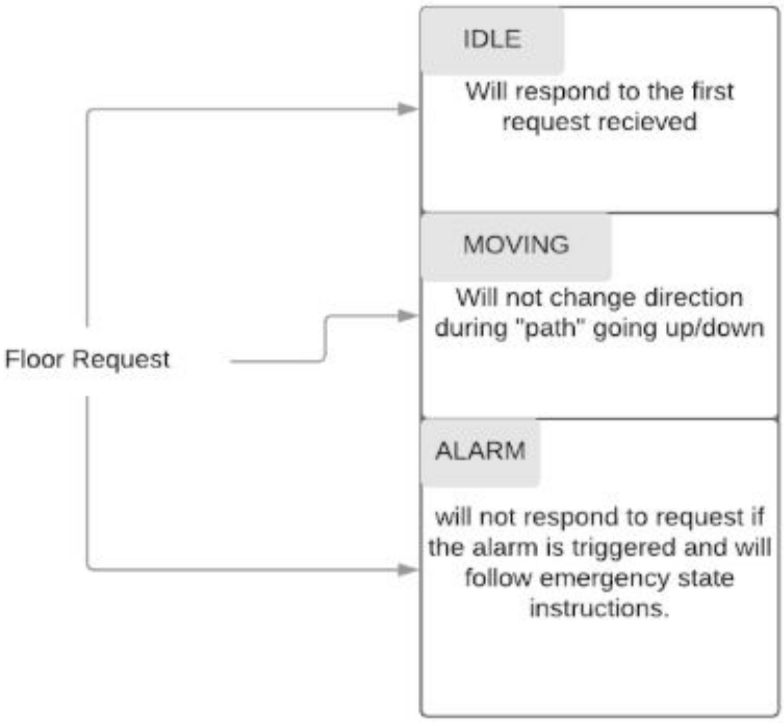
In order to have concise and effective dialog about making an elevator, there needs to be an organized system of hardware and software components in place. This is what this section will try to introduce as clearly as possible.

4.1 *Elevator Overall System Design*

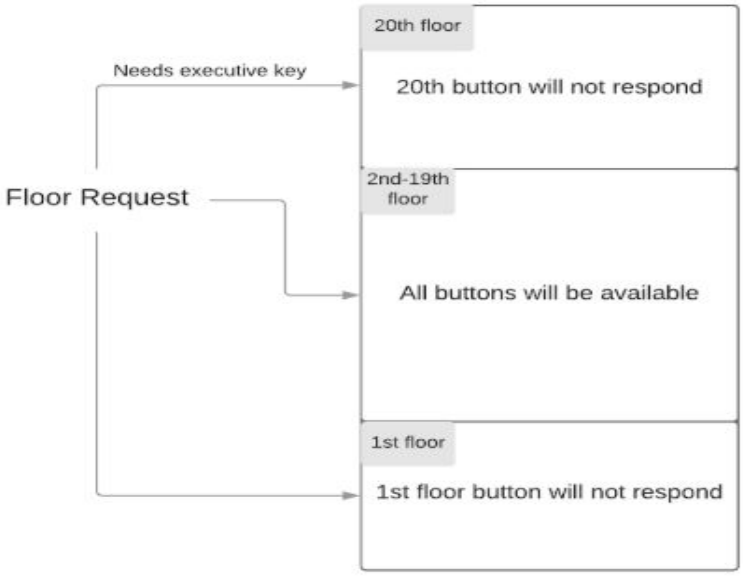
- This section will detail the overall system design approach (State, IO Mapping) that the software and hardware will follow.



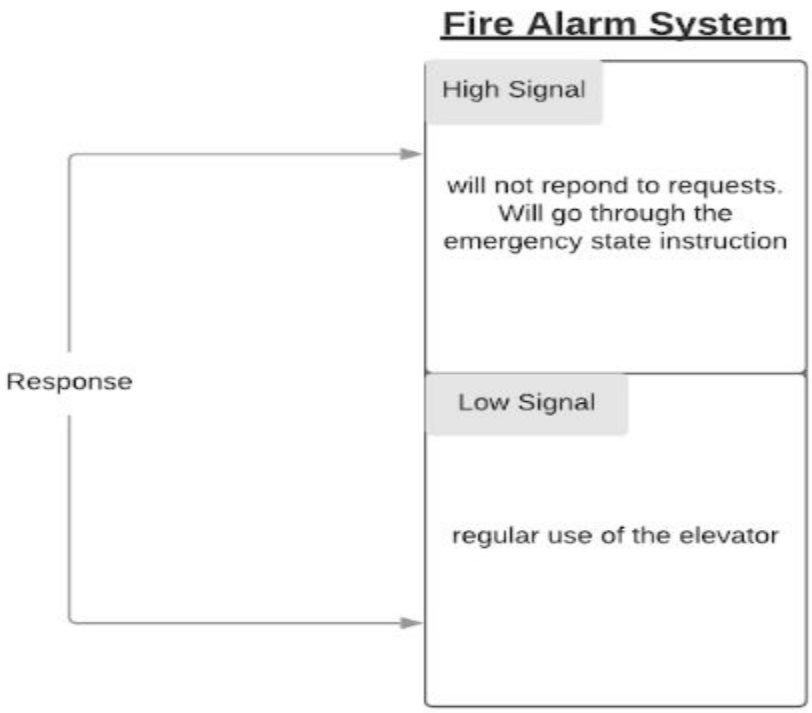
Floor request

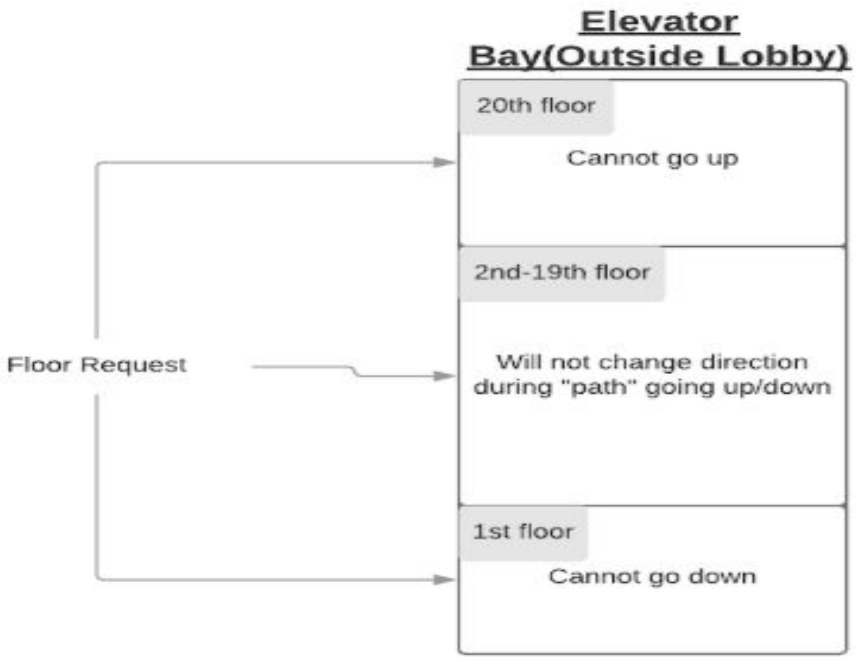


Inside Cab



Note: if weight sensor triggers. Alarm will sound and doors will stay open


Fire Alarm System
High Signal
will not repond to requests. Will go through the emergency state instruction
Response
Low Signal
regular use of the elevator


Elevator Bay(Outside Lobby)
20th floor
Cannot go up
2nd-19th floor
Floor Request
Will not change direction during "path" going up/down
1st floor
Cannot go down

5 Interfaces

The interfaces of the elevator control system can be categorized by the interactions had by users and the interaction of the software interacting with the hardware.

5.1 User Interfaces

User interfaces are means by which users can interact with the elevator system to receive service. These are interfaces that are common to most, if not all, elevators.

5.1.1 Internal car interfaces

- Buttons for floor selection
    - There will be 20 buttons, though the software should be able to handle arbitrary numbers of floors to avoid needing to rewrite the software in other buildings
    - Buttons will need both iconographic numerals and braille symbols
- Button to contact emergency services
    - Should provide communication with emergency services through speaker next to button.
- Keyhole for Penthouse
    - Needs to be labeled “EXECUTIVE”, should be in braille as well as text
- Keyhole for emergency services
    - Needs to be labeled “EMERGENCY”, should be in braille as well as text
    - Will allow for regular behavior during an emergency. Key should only be held by public safety department employees.
- Keyhole for maintenance
    - Allow maintenance staff to insert key and override regular behavior. Key to only to be held by members of the maintenance staff.

5.1.2 External interfaces

- Buttons outside of elevator bays
    - First floor will only have a single button, an up button
    - Top floor will only have a single button, a down button
    - All other floors will have both an up and down button
    - There will be N-1 sets of buttons, but they should act in unison.
        - If a button is selected, should be selected on all button panels on that floor.

5.2 Hardware-Software Interfaces

As the elevator has a number of embedded devices that provide crucial information to the control system, considerations of how the software handles events from the hardware is fundamental to the project’s success.

5.2.1 Car Inputs

- Floor sensors
    - There are sensors on the car that provides the controller with feedback with when the car is level with a floor and is capable of opening the door and allowing users to enter and exit the car.
- Weight sensor
    - Sensor that provides feedback on how much weight is currently in the car. This will provide the information to the controller necessary to prevent the car moving when it is over limit. Which should be approximately 4500 pounds.
- Door sensor
    - Provides notification that there is something preventing the doors from closing, which should cause the doors to reopen.
- Microphone
    - Be used in the scenario that a user in the car uses the emergency call button, will record their voice and be sent to the individuals on the other end of the line.

5.2.2 Outputs

- Car Motor
    - When a car goes from idle to moving, the controller will send a constant signal to the car's motor to allow movement to another car. This will need to be modulated to ensure a comfortable and consistent speed.
- Doors
    - Once a car has arrived at the correct floor, the controller should trigger the doors on the car to open by signaling the car's door mechanism.
- Speaker
    - Used to notify users that the car is overweight by emitting a tone. Will also be used as a means to communicate through the emergency call button.

5.2.3 Emergency signals

The controller is hooked into the building's alarm system and will receive signals from it.

- Fire alarm
    - Provides a HIGH digital signal if there is an emergency which will trigger the emergency protocol of sending all cars to the first floor and open the doors.

6 Capabilities

The capabilities explain what the elevator control system will be able to do, which is safe and efficient travel with four simultaneous controlled elevator cars. The elevator control system will be able to connect with multiple interfaces to allow easy information gathering.

6.1 Outline of Solution

The Elevator control system is designed to provide safe and reliable mode of transportation between floors of a building. The need for a mechanism that controls the speed and acceleration of a multi-ton box (2.1 -- Car) arises when multiple layers of the system are interacting and interfacing with each other at every moment. The elevator control system will be maintaining the button calls, sensors, and logic, and speeds that are required to traverse floors.

6.1.1 Traversing Floors

- Elevator on current floor
    - A person hits the inside elevator button and the elevator will take them to the floor in an acceptable amount of time and the doors will open when they arrive.

- Elevator on different floor
    - A person hits the outside elevator button and the elevator will close the doors and start going up or down depending on the floor the person hit the button on. When the elevator arrives it will open the doors and await the press of the inside elevator button.

6.1.1.1 Queueing

- The ECS uses a FIFO(First in First Out) queueing system. FIFO is mainly used for the efficiency aspect and garners the ability to efficiently handle multiple call requests coming from Outside button calls *(5.1.2)*. When in transition from one floor to another, it travels to the location signaled from the Inside button call (5.1.1) before listening to the signal from the Outside button call.

6.2 Modes

- Normal Mode
    - When in Normal mode, the user is able to go to floors 1st through 19th and are able to queue the floor order from the Outside elevator buttons or the Inside elevator Buttons
- Emergency Mode
    - When Emergency mode is activated, all buttons are disabled (Inside and Outside), the queue is cleared, and the elevator starts descending towards the first floor. This mode is activated in case of a fault detected.
- Maintenance Mode

    - When in Maintenance mode, all Outside elevator buttons are disabled for the elevator. It requires a specialized maintenance key to activate this mode.
- Penthouse Mode
    - When in Penthouse mode, the user of the elevator is able to go to the 20th floor of the building. This mode requires a specialized key to become active.

7 Design Constraints

This design is constrained to and must meet legal safety requirements (eg. ASME A17.1 Safety Code for Elevators and Escalators) as well as design requirements and constraints to satisfy software objectives (Section 3).

7.1 Design Restrictions

This design must meet the following design requirements to meet system objectives (Section 3).

- Number of Concurrent Elevators
    - The ECS will control 4 concurrent elevators on the system.
- Floor Constraints
    - The ECS is constrained to floors 1 through 20 (but can handle an arbitrary amount of floors).
- Restrict Executive Penthouse Access
    - Restricted access to the 20th floor unless authorized with designated executive key.

7.2 ASME A17.1 Safety Compliance Restrictions

Safety is the number one priority; the software is in compliance with ASME A17.1 Safety Code for Elevators and Escalators.

https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/guide-to-the-ada-standards/chapter-4-elevators-and-platform-lifts

- Maximum Acceleration and Deceleration
    - Acceleration and deceleration rates will not exceed $1.5 m/s^2$.
- Weight Capacity
    - Weight capacity of approximately 4500 pounds.
- System Overrides
    - The system must allow for emergency and maintenance override procedures.
- Status Indicators
    - Must have lights on every exterior of elevator on every floor, signalling if the elevator is in use, and if so what direction.

- Door Timing
    - Doors must remain open for at least 20 seconds in compliance with the Americans with Disabilities Act (ADA).
- Safety Constraints
    - Compliance with ASME A17.1 Safety Code for Elevators and Escalators.
- Security Constraints
    - Must have security protocols in place to prevent unauthorized access to system data.

8 Additional Documentation

[1] https://symmetryelevators.com/elevator-operation/

[2] http://www.accesscontrolindia.in/elevator-control-system-works/

[3]https://www.researchgate.net/publication/318058765_Design_Control_of_an_Elevator_Control_System_using_PLC