Elevator System Design Documentation

COMP3004

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If diagrams are illegible, please refer to the following google drive folder for better quality images:
https://drive.google.com/drive/folders/14XFY6Ivh8G8_682I5zHYOJpsyeSxc_pW?usp=sharing
For any issues with any further links, please email me at gabemartell@cmail.carleton.ca *or* message me on discord *skrtskrtgod#0001*

Explanation/Introduction

To accommodate for the GUI interface of this assignment, my design documentation and ideas in Assignment 2 have been changed slightly.

- ➔ Building
- ➔ Floor Control Panel
- ➔ Floor Sensors
- ➔ Elevator Car
- ➔ Elevator Door
- ➔ Elevator Door Sensors
- ➔ Elevator Control Panel (Main Window)
- ➔ Audio System
- ➔ Display System
- ➔ Control System

Instead of 11 classes, the total classes in this implementation ended at 10, ultimately removing the Passenger class. As the user were to be in-charge of the elevator's weight, level, and other components relevant to the car, I found that the passenger did not fit in with this GUI-driven application. As I stated in my documentation in the previous assignment, the Passenger would've been viable if it "...envisioned a simulation where it will be run within some 'main.cpp' application." For this assignment, it's reimagined that the user *is* the passenger.

And, in addition, the elevator car control panel is now present in the "MainWindow", so all of the functions in the Elevator Control Panel class before are transferred and expanded upon in the Main Window class. The Floor Control Panel is also present in the Main Window, however, it has its own functions (IlluminateButton, etc…) and information where it can work as its own class. However, the connection isn't "airtight" as the Floor Control Panel can still be controlled from the Main Window. Yet, the MainWindow is predominantly controlling of the elevator car, so for this design we will associate it with the *Car Control Panel*

As for all previous thoughts on this design, seen in Assignment 2, they stay true. The Control System still acts as the *mediator* for all actions. I was *unable* to achieve asynchronous action in this design, but nonetheless, all calls and signals, no matter the quantity, are still sent and handled at the Control Center. Despite the Main Window also reading the signals, it will always handle everything by calling the Control System.

Allocation Strategies still exist in this design, as seen in the code. MoveCar() is a function heavily used for different types of reasons. MoveCar() can be called from the Car Control Panel, Floor Control Panel, or any emergency where cars are moved to the building's designated safe floor.

The demo video can be found here. (14 minutes)

Use Cases

Use Case 1: Call the Elevator

Primary Actor:

Passenger

Scope:

Elevator System

Level:

User Goal

Stakeholders and Interests:

Passenger/Caller - wants to call the elevator to then go on it
Car - wants to pick up the passenger on their current floor to transport them
Elevator Control System - receives requests to indicate what the elevator should do
Elevator Floor Control Panel - the control panel on each floor, sends requests to the elevator control computer

Pre-Conditions:

The passenger/caller intends to ride the elevator to a desired floor

Minimal Guarantee:

None.

Success Guarantee:

The car is in transit towards the passenger requesting the elevator

Main Success Scenario:

1. Passenger call the car by pressing their desired direction button (Up or Down) on elevator floor control panel
2. Elevator's floor control panel direction button illuminates
3. Elevator's floor control panel sends request to the elevator control system to move cab to caller's floor
4. Elevator control system acknowledges and accepts the request to transport car to specific floor
5. Car transports to designated floor
6. Elevator control system updates its position by updating the display to show its current level
7. Elevator control system detects the requested floor has been reached through it's sensor
8. Car sensor sends a request to the control system to stop

Extension:

1a. The car is already on the caller's floor
    1a1. Elevator control system opens doors and becomes available for use
3a. The elevator is already in use
    3a1. Car intersects with the caller's floor mid-transit
        3a1a. Elevator control system acknowledges this, Elevator is stopped and passenger is picked up
        3a1b. Elevator control system did not process this in time, (The car just passed the caller's floor) skips the caller's floor and delivers current passengers; passenger waits

3a2. Car does not intersect with the caller's floor mid-transit

3a2a. Elevator completes delivery of current passengers, and then goes to next request; passenger waits

Use Case 2: Arrive to Destination

Primary Actor:

Car

Scope:

Elevator System

Level:

User Goal

Stakeholders and Interests:

Car- wants to pick up/unload passengers on the requested floor

Elevator Control System - handles requests to indicate what the elevator should do

Passenger - wants to get off/on the elevator at the requested floor

Pre-Conditions:

A request has been made to the elevator computer indicating the car to stop.

Minimal Guarantee:

None.

Success Guarantee:

The car is stopped at the desired floor, and most importantly, allows passengers to enter or exit the car.

Main Success Scenario:

1. Elevator control system stops at the designated floor
2. Elevator control system rings its bell to indicate arrival
3. Elevator control system opens both landing and cab doors for 10 seconds
4. Car unloads passengers onto current floor
5. Car loads passengers from current floor
6. Elevator control system rings its bell to indicate departure after the 10 seconds (from Step 7)
7. Elevator control system closes both landing and cab doors

Extension:

3a. A passenger holds the "Open Door" button on the cab control panel

3a1. Elevator control system halts all movement requests and car doors remains open until button is released

3b. A passenger holds the "Close Door" button on the cab control panel

3b1. Car forcefully closes doors until button is released

4a. No passengers want to get off at this floor

5a. No passengers want to enter the elevator

7a. A passenger holds the "Open Door" button on the cab control panel

7a1. Elevator control system halts all movement requests and car doors remains open until button is released

7b. A passenger holds the "Close Door" button on the cab control panel

7b1. Car forcefully closes doors until button is released

Use Case 3: Ride the Elevator

Primary Actor:
Passenger
Scope:
Elevator System
Level:
User Goal
Stakeholders and Interests:
Passenger - wants to ride the elevator to their desired floor
Car - wants to bring the passenger to their desired floor
Elevator Control System - recognizes what floor the passenger desires to arrive at
Pre-Conditions:
The passenger has called, and entered, the elevator
Minimal Guarantee:
None.
Success Guarantee:
The elevator travels to and stops at the passenger's requested floor
Main Success Scenario:

1. The passenger presses on their desired floor symbolized by a button on the elevator's cab control panel
2. The button sends a request to the elevator control system
3. Elevator control system acknowledges and accepts the request to transport car to specific floor
4. Car transports to designated floor
5. Elevator control system updates its position by updating the display to show its current level
6. Car detects the requested floor has been reached through its sensor
7. Elevator sensor sends a request to the control system to stop

Extension:
1a. The passenger's desired floor is the one they're currently on
    1a1. The elevator does not move, the passenger gets off
1b. The passenger's desired floor has been already pressed
4a. The elevator intersects with a floor where the elevator has been called
    4a1. The elevator stops, and *Arrive to Destination* for the caller, the elevator then continues
    4a2. The elevator ignores the caller and continues

Use Case 4: Press the Help Button

Primary Actor:
Passenger
Scope:
Elevator Control Panel
Level:
Summary
Stakeholders and Interests:

Passenger - wants to receive help
Elevator Control System - wants to contact help when requested to
Building Safety Service - wants to ensure the passengers are safe
Emergency Services - wants to respond to and ensure safety for the passengers

Pre-Conditions:

The passenger decides that help is required within their elevator.

Minimal Guarantee:

None.

Success Guarantee:

Building Safety Service dispatches help to the elevator passengers that requested it

Main Success Scenario:

1. Passenger presses the button labeled “Help” on the elevator’s cab control panel
2. The control panel sends a “Help” request to the elevator’s control system
3. Elevator control system receives the “Help” alarm
4. Elevator control system creates a voice connection within the cab
5. Elevator control system calls the Building Safety Service
6. Building Safety Service answer the call made by the elevator’s control system within 5 seconds
7. Passenger provides information that indicate help being needed
8. Building Safety Service dispatch help responders to the elevator

Extension:

1a. The passenger has accidentally pressed the “Help” button
    1a1. Passenger tells Building Safety Service of the accident
6a. The Building Safety Service is unable to answer; five seconds have passed
    6a1. Emergency Services (911) are called.
7a. Passenger is unresponsive
    7a1. Emergency Services (911) are called.

Use Case 5: Initiate Fire Safety Features

Primary Actor:

Elevator Control System

Scope:

Elevator Safety Features

Level:

User Goal

Stakeholders and Interests:

Elevator Control System - follow safety features
Car - wants to move to the safest floor level to ensure passenger safety
Passengers - to ensure their safety from the fire

Pre-Conditions:

A fire alarm signal has been sent from the building or elevator to the elevator control system.

Minimal Guarantee:

None.

Success Guarantee:

The elevator control system successfully and efficiently follows fire safety protocol and ensures that all passengers are safe from the elevators.

Main Success Scenario:

1. Elevator control system responds to the fire alarm signal
2. Car transits to a designated safe floor
3. Elevator control system presents audio information to the passengers about emergency situation
4. Elevator control system presents text on the display to inform passengers of emergency
5. Car detects the safest floor has been reached through its sensor
6. Car sensor sends a request to the control system to stop
7. Car stops at respective floor
8. Elevator control system opens the landing and cab doors
9. Elevator control system notify passengers to disembark the elevator to reach safety

Use Case 6: Initiate Fire Safety Features

Primary Actor:

Elevator Control System

Scope:

Elevator Safety Features

Level:

User Goal

Stakeholders and Interests:

Elevator Control System - follow safety protocol to ensure passenger safety
Car - wants to move to the safest floor level to ensure passenger safety
Passengers - to ensure their safety from the fire

Pre-Conditions:

A “Fire” alarm signal has been sent from the building or elevator to the elevator control system.

Minimal Guarantee:

None.

Success Guarantee:

The elevator control system successfully and efficiently follows fire safety protocol and ensures that all passengers are safe from the elevators.

Main Success Scenario:

1. Elevator control system responds to the “Fire” alarm signal
2. Car transits to a designated safe floor
3. Elevator control system presents audio information to the passengers about emergency situation
4. Elevator control system presents text on the display to inform passengers of emergency
5. Car detects the safest floor has been reached through its sensor
6. Car’s sensor sends a request to the control system to stop
7. Car stops at respective floor
8. Elevator control system opens the landing and cab doors
9. Elevator control system notify passengers to disembark the elevator to reach safety

Use Case 7: Initiate Overload Safety Features

Primary Actor:
Elevator Control System
Scope:
Elevator Safety Features
Level:
User Goal
Stakeholders and Interests:
Elevator Control System - follow safety features; wants to lower capacity to ensure passenger safety
Passengers - to lower the capacity weight so that the elevator can be safely used
Pre-Conditions:
The elevator cargo weight has been exceeded, sending an “Overload” alarm signal.
Minimal Guarantee:
None.
Success Guarantee:
The elevator control system follows its safety protocol, having the current weight being reduced to a safer weight
Main Success Scenario:

1. Elevator control system responds to the “Overload” signal
2. Elevator control system halts the affected elevator’s movement
3. Elevator control system keeps the landing and cab doors open
4. Elevator control system presents audio to the passengers about reducing elevator weight
5. Elevator control system presents text on the display to inform passengers elevator weight
6. Passengers disembark until the elevator weight is at a suitable, safe capacity
7. Elevator control system determines that elevator is at suitable weight
8. Elevator control system is back to usual usage

Extension:
7a. Elevator control system determines that elevator is still not at suitable weight
7a1. Movement remains halted and the door remains open until elevator is underneath threshold; “Overload” signal is sent to the control system.

Use Case 8: Initiate Power Outage Safety Features

Primary Actor:
Elevator Control System
Scope:
Elevator Safety Features
Level:
User Goal
Stakeholders and Interests:
Elevator Control System - follow safety protocol to ensure passenger safety
Car - wants to move to the safest floor level to ensure passenger safety
Passengers - to ensure their safety from the fire
Pre-Conditions:

A “Power Out” alarm signal has been sent to the elevator control system; the backup battery is operational and sufficient.

Minimal Guarantee:

None.

Success Guarantee:

The elevator control system successfully and efficiently follows power outage safety protocol and ensures that all passengers are safe from the elevators.

Main Success Scenario:

1. Car control system responds to the “Power Out” alarm signal
10. Car transits to a designated safe floor
11. Elevator control system presents audio information to the passengers about power outage
12. Elevator control system presents text on the display to inform passengers of outage
13. Car detects the safest floor has been reached through its sensor
14. Car’s sensor sends a request to the control system to stop
15. Car stops at respective floor
16. Elevator control system opens the landing and cab doors
17. Elevator control system notify passengers to disembark the elevator to reach safety through audio and display system.

Use Case 9 Detect Door Obstacles

Primary Actor:

Elevator Light Sensor

Scope:

Elevator System

Level:

Summary

Stakeholders and Interests:

Elevator Light Sensor - ensure that the landing and cab doors are not blocked

Elevator Control System - ensure the doors remain open until the obstacle is removed

Passenger - ensure that their obstacles and items are not blocking the doors

Pre-Conditions:

The elevator doors are closing and the sensor is activated due to a passenger’s item acting as an obstacle.

Minimal Guarantee:

None.

Success Guarantee:

The elevator door sensors no longer detect any obstacle, therefore the doors are no longer blocked.

Main Success Scenario:

1. Light sensor detects an obstacle in the way of the doors while the door is closing.
2. Light sensor sends command to elevator control system to stop doors from closing
3. Elevator control system receives command from light sensor
4. Elevator control system stops the doors from closing and opens the doors fully.
5. Passenger remove obstacles blocking the doors.
6. Light sensor no longer detects an obstacle in the way

7. Elevator control system releases hold on the doors

Extension:

5a. Passenger does not remove obstacle

5a1. The elevator remains open

5a1a. Obstacles are still not removed

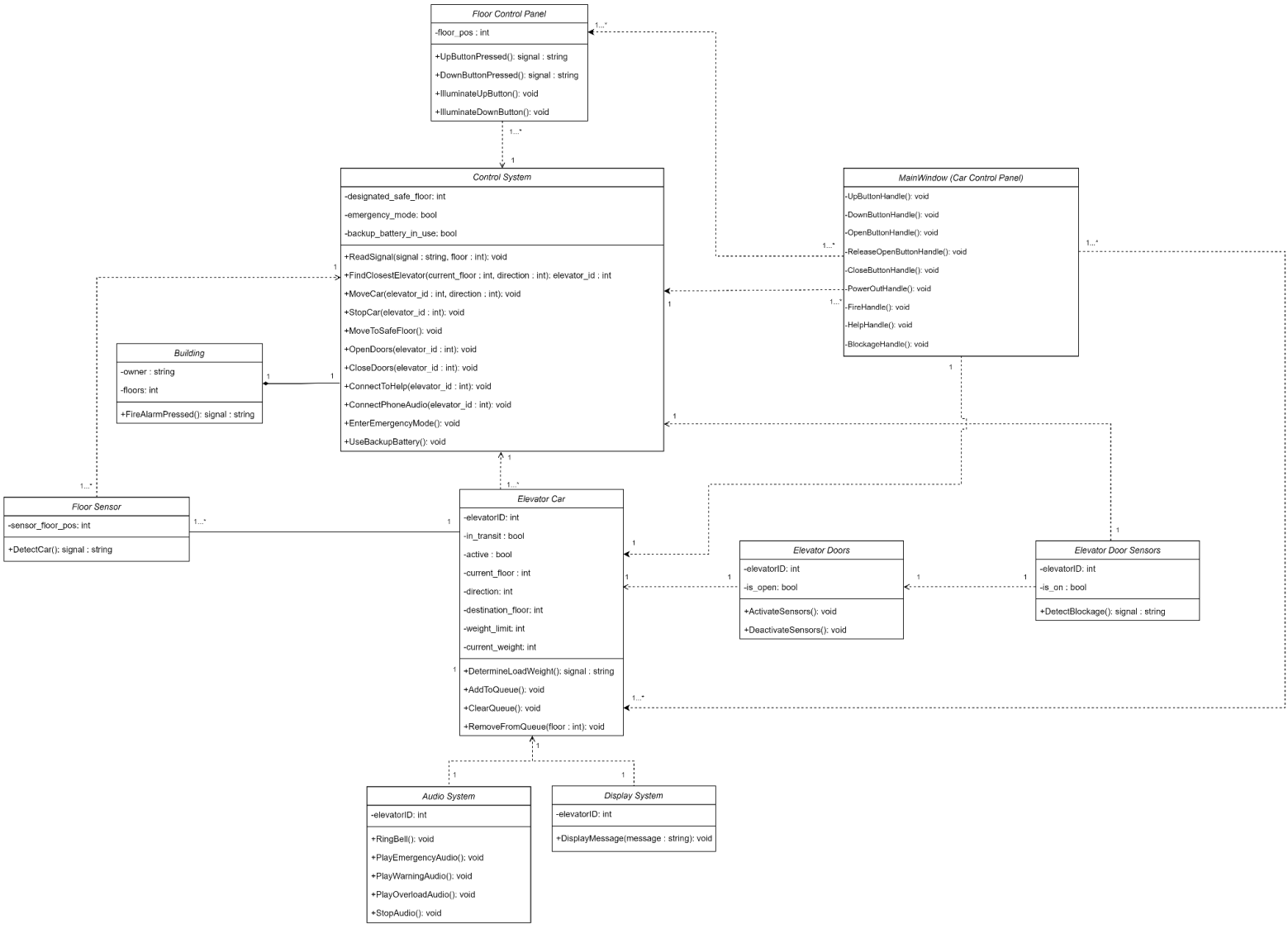
5a1a1. A warning is sounded on the elevator's audio system and text is displayed

5a1b. Door obstacles are removed

5a1b1. Light sensor no longer detects an obstacle, the elevator is no longer on movement hold

UML Class Diagram

Elevator System Class Diagram



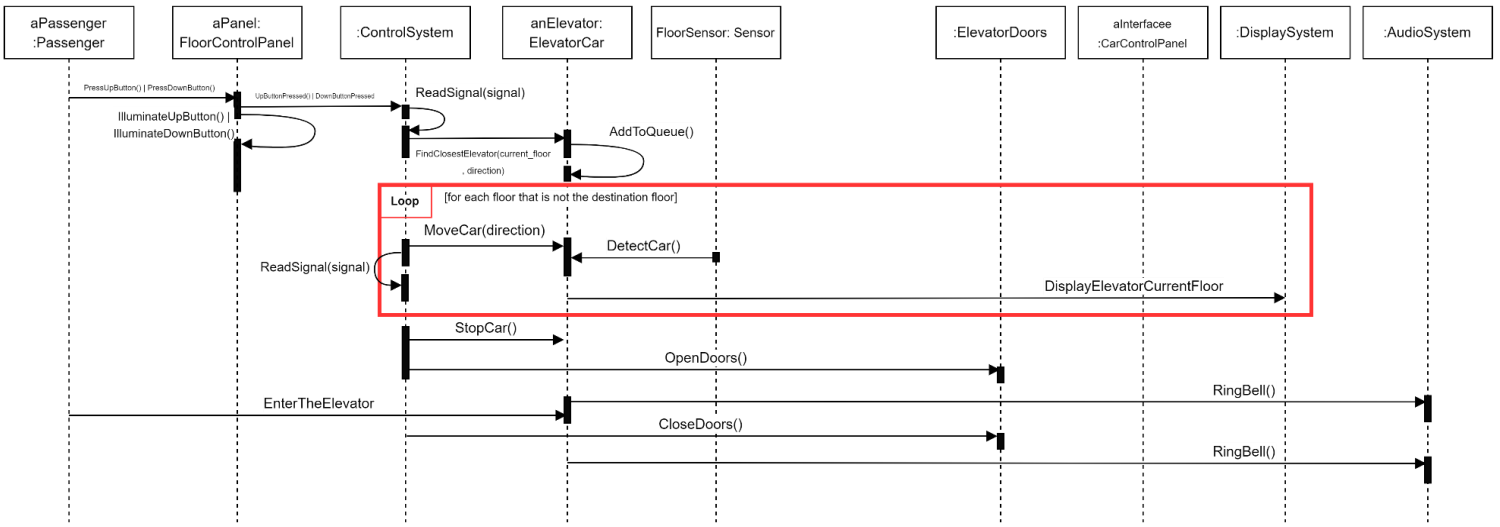
How I envisioned this design is based on the following:

The building contains a control system, if the building goes, so does the control system.
The control system is depended on by the Elevator Car, Sensors and Control Panels.
The elevator car is depended on by the Elevator Doors, Display and Audio System, and Car Control Panel.

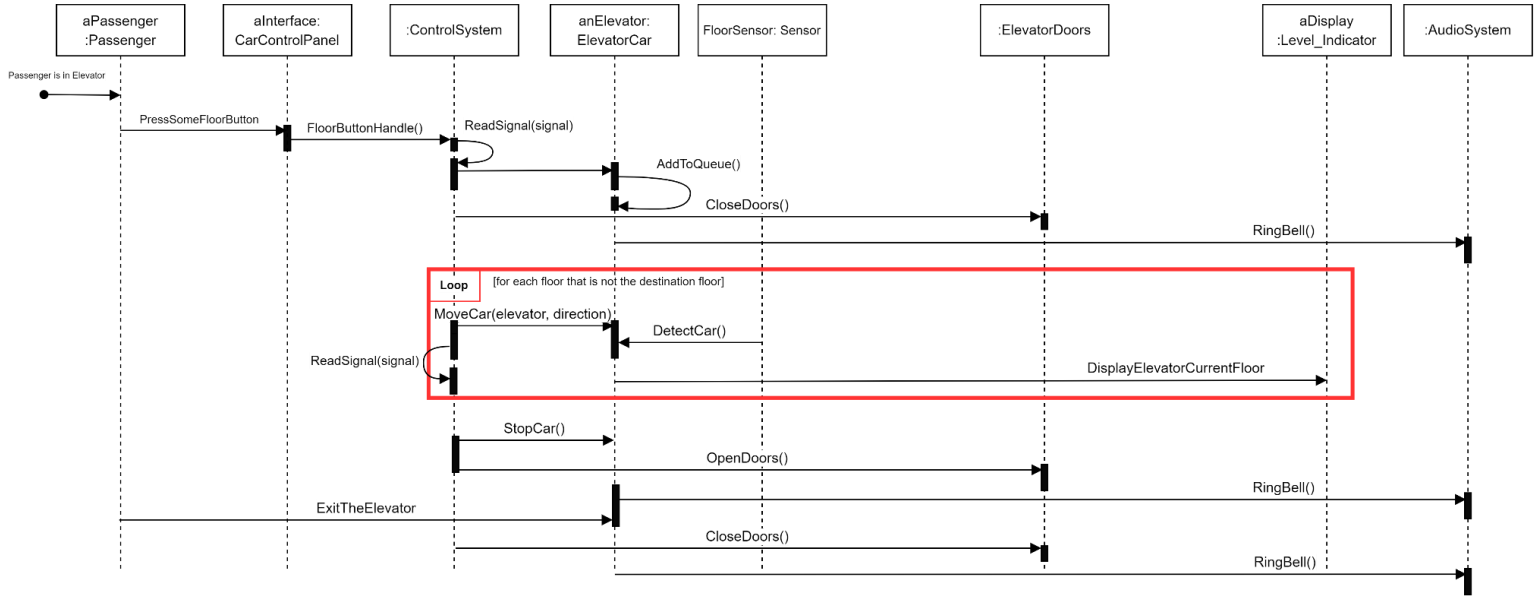
The elevator door sensors are dependent on the elevator doors.
The floor control panel is depended on by the MainWindow, as some aspects of the UI interact closely with the floor control panel, despite the MainWindow being solely for the car control panel.

Sequence Diagrams

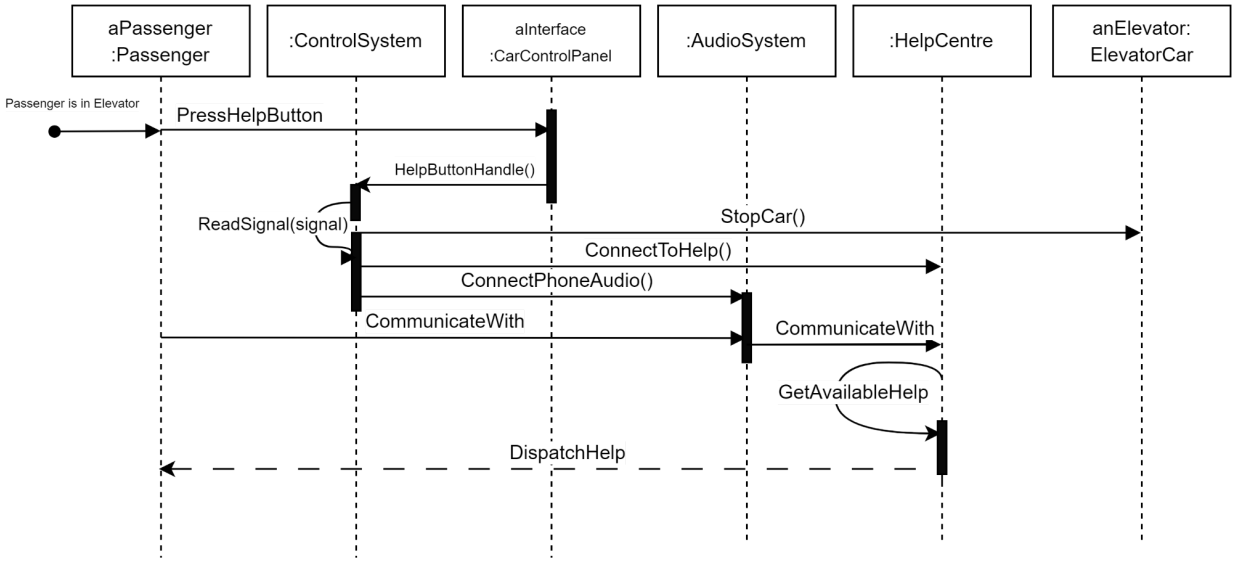
Scenario: Passenger Calls Elevator | **Elevator Moves** (Floor Control Panel)



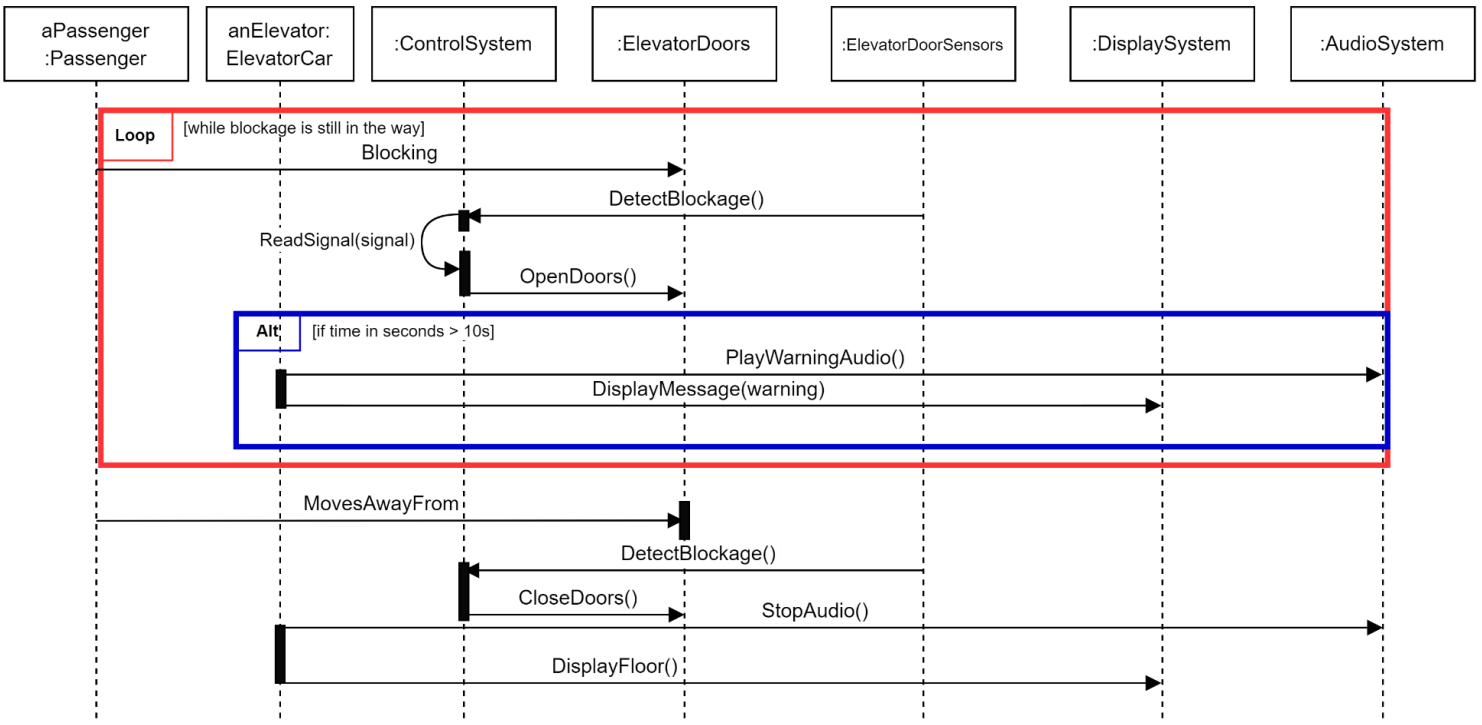
Scenario: Passenger Goes To Another Floor | **Elevator Moves** (Car Control Panel [QT Interface])



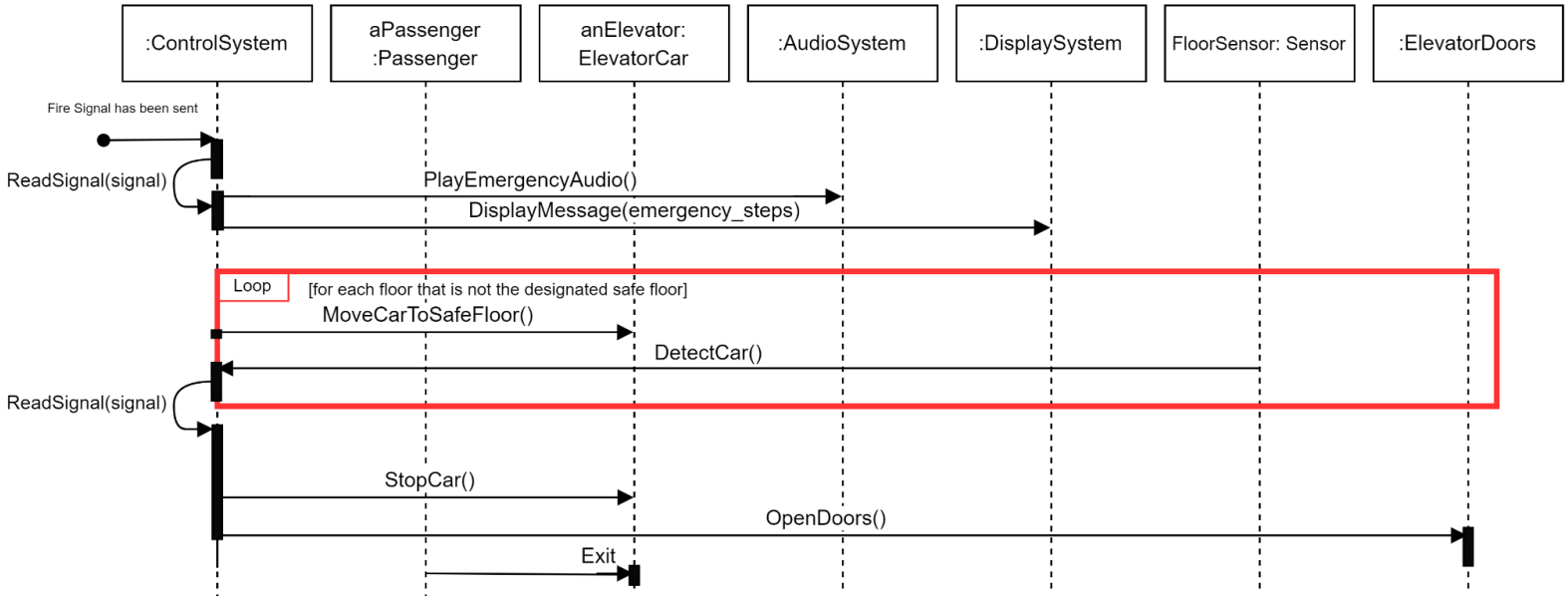
Scenario: Passenger Presses Help Button



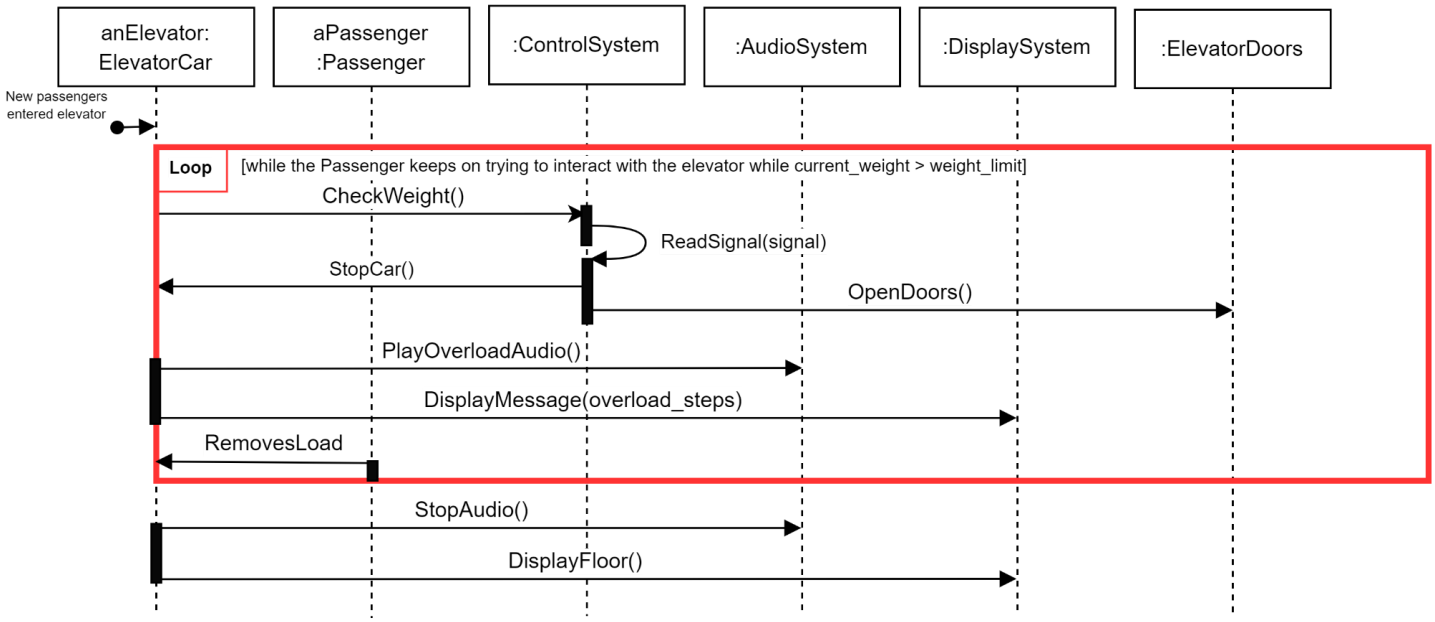
Scenario: Passenger Blocking Elevator Doors



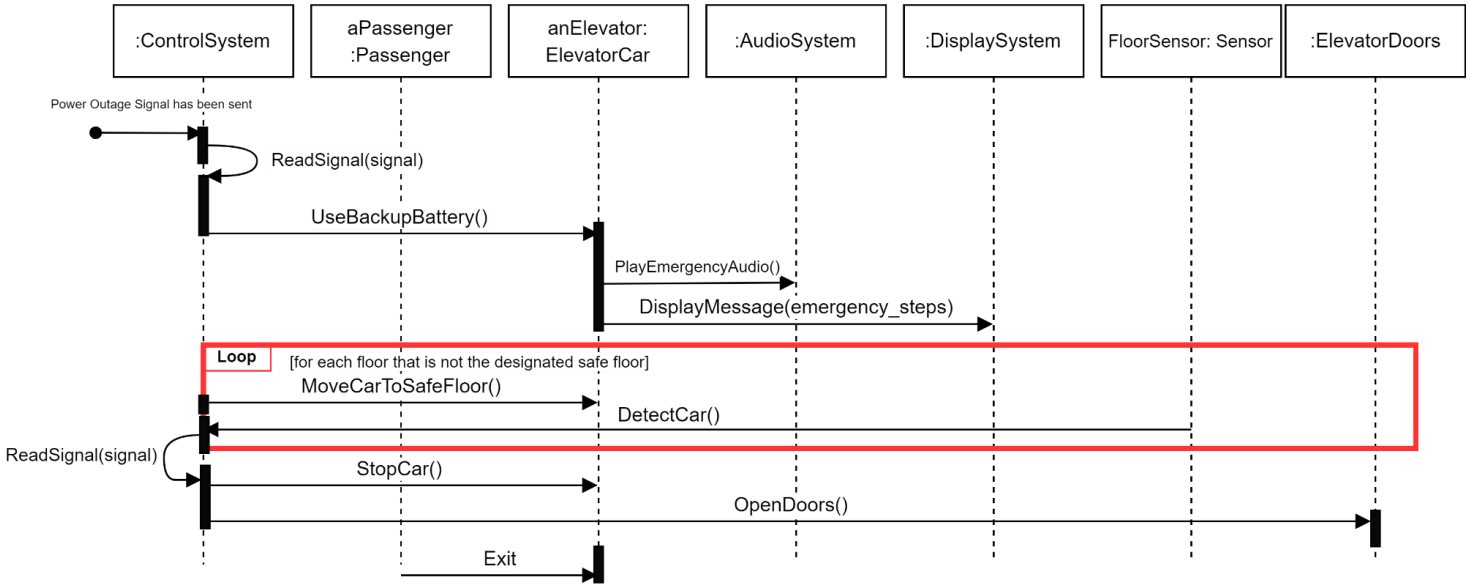
Scenario: Fire Signal has Been Acknowledged



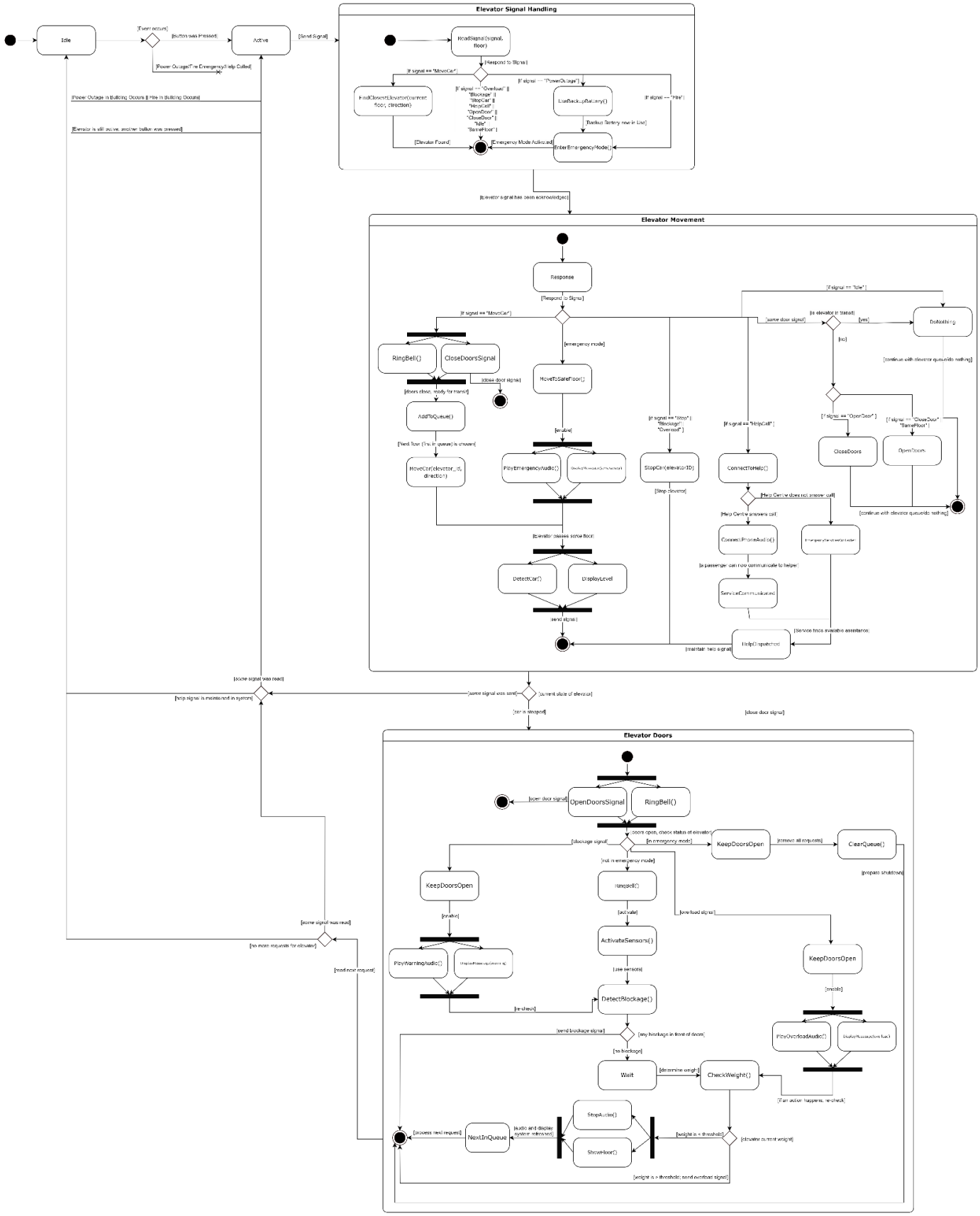
Scenario: Elevator is over Weight Capacity



Scenario: Fire Signal has Been Acknowledged



State Diagram



Traceability Matrix

ID	Requirement	Implemented By	Tested By	Description
1	The interface contains all necessary buttons that control a variety of aspects of the elevators.	MainWindow.ui	Start the simulation, observe if the Output Log, Floor Control Panel, Car Control Panel, Info Panel and External Signals Panel are visible.	This GUI-driven application allows the user to manipulate the movement and other aspects of a series of elevators - the presence of these buttons helps with the accomplishment of that.
2	All buttons on the interface can be interacted with	MainWindow.ui	Press, in some order, all buttons on the interface. Observe if the Output Log responds with text containing information.	For the user to use this application, and experience the simulation, all buttons must work so that the interaction portion of this simulation exists.
3	The control system can read *some* signal	Control System	Send *some* signal (press a button), observe respective response	The control system is the mediator of this design. All events and actions rely on the control system reading its intent, and responding with the desired outcome.
4	The control system determines the closest elevator	Control System, Car(s)	Consider elevators on different floors. Call the elevator from *some* floor control panel. Observe that the elevator that was called was the closest.	The elevator system works fluently, efficiently and quickly with all calls. The control system is able to the closest elevator for some passengers reinforces that envisionment.
5	The floor control panel buttons illuminate when pressed	Floor Control Panel	Press either the up or down button on a floor control panel	The floor control panel should illuminate the chosen direction’s button
6	The elevator car can add a requested floor to its queue	Car	Produce different calls from different floors. Observe if the car reaches each floor.	The car is able to internally keep a floor queue, therefore able to reach each floor within the list.

7	The elevator is able to transit to a given floor	Control System, MainWindow	Press the direction button on a floor control panel AND Press the floor button on the car control panel. Observe if the elevator moves.	The control system is able to process the signal given from *some* control panel, and elevate accordingly to the desired floor from the caller.
8	The floor sensor can detect a car	Floor Sensor	Make a call to go to some floor. Observe the sensor's call to the control system.	The floor sensor will send a "Throw" or "StopCar" signal if the desired floor was reached or not.
9	The elevator can stop	Control System, MainWindow	Make a call to go to some floor. AND Press the Help button.	The control system is able to process the "Stop" signal, therefore stopping the elevator car.
10	The elevator doors can open	Control System, Elevator Doors, MainWindow	Let the elevator arrive at some floor. AND The door open button was held on the car control panel.	The control system is able to process an open door signal and open the door
11	The elevator can ring it's bell	Car, Audio System	Observe the elevator arriving or departing to/from some floor	The elevator is able to ring a bell when the doors open or close
12	The elevator can display the floor num.	Car, Display System	Observe the display while the elevator in transit	The elevator is able to accurately display the level the passenger is at
13	The elevator door sensors remain open when blockage is detected	Elevator Door Sensors, Doors, Control System	Put some large object in between the landing and elevator doors.	The elevator door sensors can detect blockage and stop all motor function and keep the doors open until said blockage is removed.
14	Warning audio and messages are displayed when blockage is	Elevator Door Sensors, Audio System, Display System,	Continue (ID.9) testing and wait for some time.	If blockage is still detected, warning audio and messages are presented to the passengers.

	repeatedly detected from the elevator door sensors			
15	The elevator can respond if passenger weight is unsafe	Elevator Car, Control System, MainWindow	Fill the elevator with weight accumulating to the noted max capacity.	The elevator can send signals to the control system to stop all motor functions and keep doors open if the current capacity is exceeding the threshold capacity.
16	The elevator doors can close	Control System, Elevator Doors, MainWindow	Observe a state where the elevator is ready for transit (a floor signal was sent) AND The door close button was pressed on the car control panel.	The control system is able to process an close door signal and close the door
17	The “Help” button is functional	Control System, MainWindow	Press the “Help” button on the car control panel. Observe the control system’s response to the signal.	The control system, when given a “Help” signal, will contact the building safety service, or emergency services when the building safety service cannot be reached.
18	The building safety service is connected to the car’s audio system	Control System, Audio System	Continue (ID.15) and observe if the building safety service phone call is connected to the audio system.	The control system will connect the call with the building safety service (or emergency services) to the audio system in the elevator.
19	The control system brings the car to the designated safe floor efficiently.	Control System, Elevator Car	Send a “Fire” or “PowerOut” signal to the control system. Observe elevator transit.	The control system will read the “Fire” or “PowerOut” signal, and respond in escorting ALL elevators to a listed designated safe floor in the building.
20	The control system utilizes the backup battery during	Control System	Send a “PowerOut” signal to the control system. Observe the backup battery.	The control system, during a power outage, will activate the backup battery - compensating for

	a power outage.			all safety procedures further on (refer to ID.17)
21	The elevator car plays emergency audio and displays text within a “Fire” or “PowerOutage” event	Elevator Car, Audio System, Display System	Send a “Fire” or “PowerOut” signal to the control system. Observe the audio and display during the event.	The control system will play emergency audio and present emergency text which guides passengers about the situation and how to proceed safely.
22	The elevator becomes “Out of Order” or Unavailable after a “Help” signal	Control System, MainWindow	Press the “Help” button, observe the Elevator status after.	If an elevator is currently getting help, it cannot be used by passengers trying to access it from the Floor Control Panels.
23	All elevators become “Out of Order” or Unavailable after a “Fire” or “PowerOutage” event.	Control System, MainWindow	Send a “Fire” or “PowerOut” signal to the control system. Observe Elevators status after.	If there is a “Fire” or “PowerOutage” within the building, all elevators (after moving to a safe floor), should all be shutdown until deemed safe later on by mechanics.