

Assignment 2: Analysis and Design of an Elevator System Controller

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Grace period of 48hrs at -10% penalty for lateness

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Raven Elevators Inc. (REI), a manufacturer of elevators, has hired you to build them an extensible and well-documented software architecture for their line of elevator control systems. You happily accept the task, eager to impress your new employer with your development skills. REI asked you to implement it in Qt C++ but before doing the implementation REI requested that you first deliver use cases, design documentation, traceability matrix, and C++ class interfaces.

Learning objectives:

- Designing and expressing your design in UML
- Verifying consistency between use cases and design
- Building a requirements traceability matrix
- Designing for variability in elevator allocation strategy

Deliverables:

- Use cases (can borrow from A1 & grading feedback)
- Design documentation – structure and behavior:
 - UML Class diagram
 - Sequence diagrams for these scenarios: 1 Basic use cases and 5 safety features
 - Activity or state diagram (where relevant)
 - Textual explanation of your design decisions including use of design patterns, if any.
- C++ header files (interfaces and significant variables)
- Traceability matrix

Your design should include passenger and sensor actors driving the elevator controller responses that are displayed through a simple GUI.

Your design should accommodate for variability in allocation strategy (handle 2 or more allocation strategies).

Use CASE: Using an Elevator

Primary Actor: Passenger

Scope: The building

Level: Summary

Stakeholders and Interests:

Passenger – wants to move to destined floor

Building Safety – helps in case of emergency

911 – helps in case building safety does not respond

Precondition: elevator working

Minimal guarantees:

Success guarantees: passengers move to destined floor safely

Trigger: passenger takes the elevator

Main success scenario:

1. Elevator button gets pressed
2. Elevator arrives and passengers board
3. Passengers select destination floor(s)
4. Display shows the current floor, and the light is illuminated for destination floors
5. Doors close
6. Elevator takes off
7. Elevator arrives and notifies at the destined floor, rings the bell

Extensions:

2a. Passengers overload

2a1. An audio and text messages are presented to passengers asking for the load to be reduced before attempting to move again

2a2. Elevator load needs to be reduced

3a. Fire alarm goes off

3a1. An audio and text message are presented to passengers informing them of an emergency and asking them to disembark once the safe floor is reached

3a2. Elevator moves to safe floor

3b. Power goes out

3b1. Audio and text messages are presented to passengers informing them of the power outage

3b2. Elevator moves to safe floor

4a. Doors do not close

4a1. Light sensor sees that an obstacle in the way

4a2. Doors reopen to clear obstacle

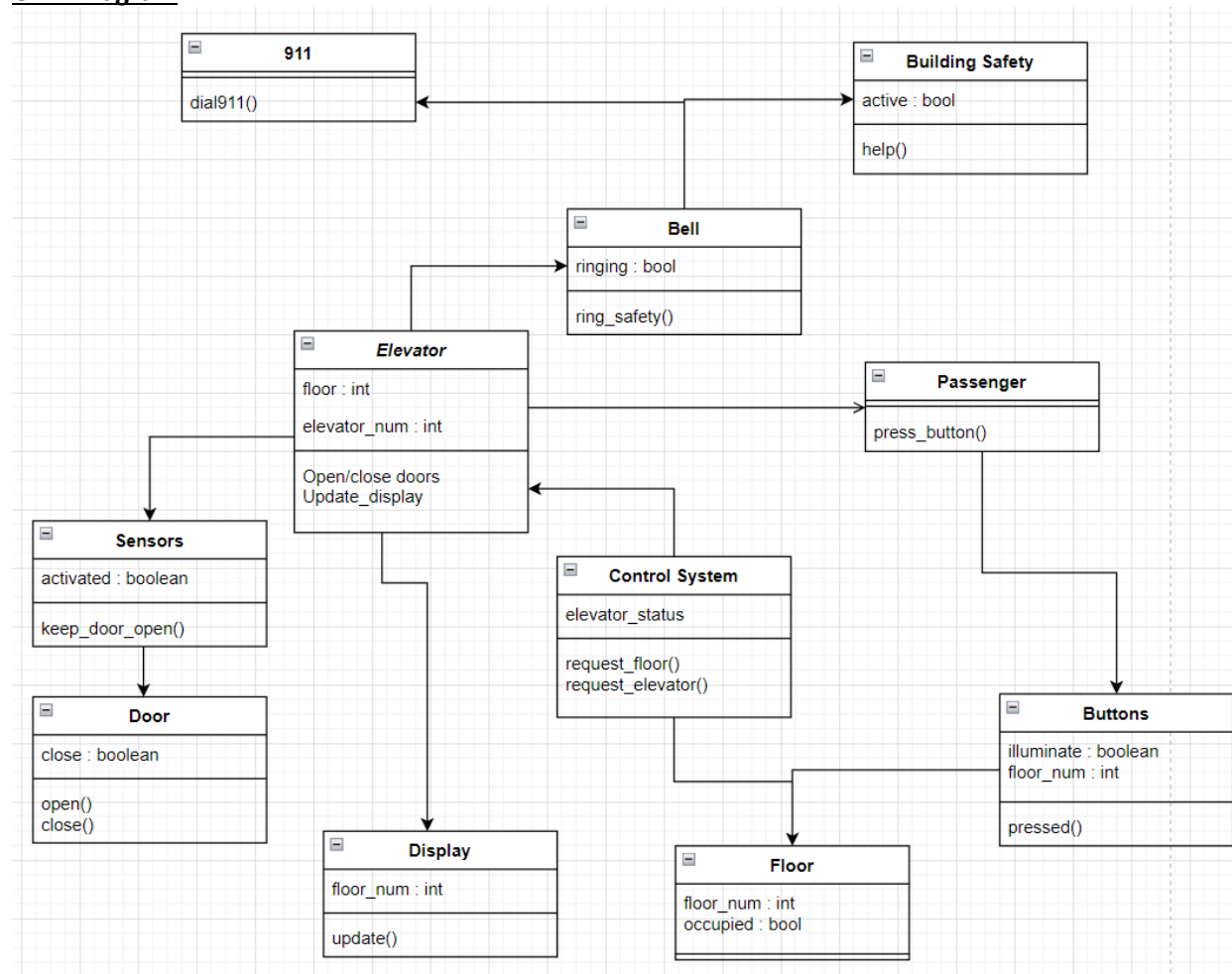
5a. Open door is pressed

5a1. Door reopens

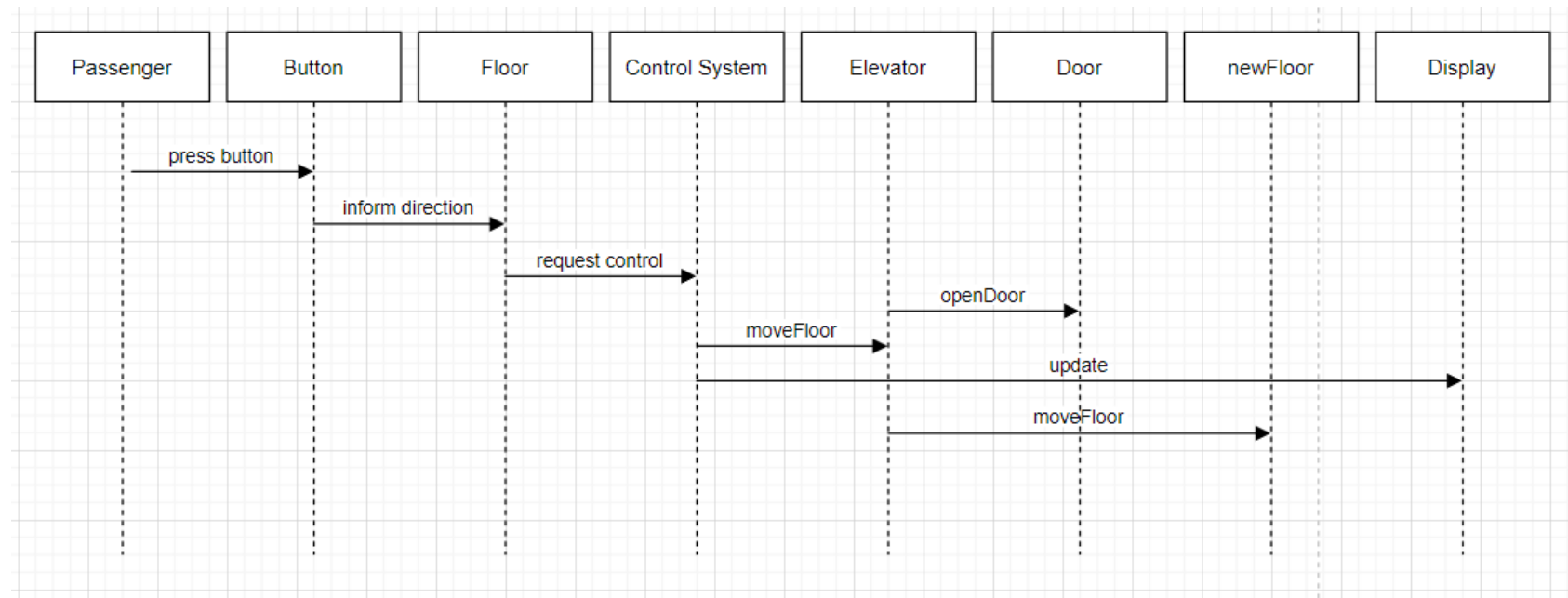
5b. Elevator does not take off

- 5b1. Audio warning plays
- 5b2. Help button is pressed
- 5b3. Building safety response?
- 5b4. 911 call

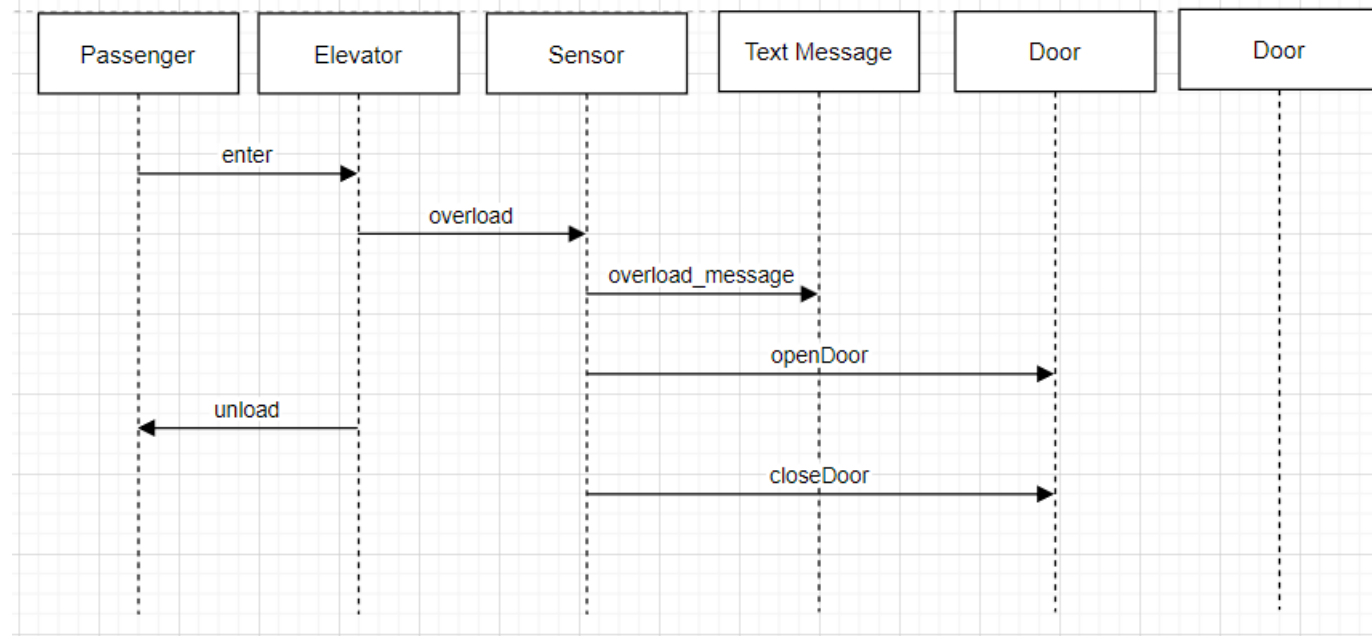
UML Diagram



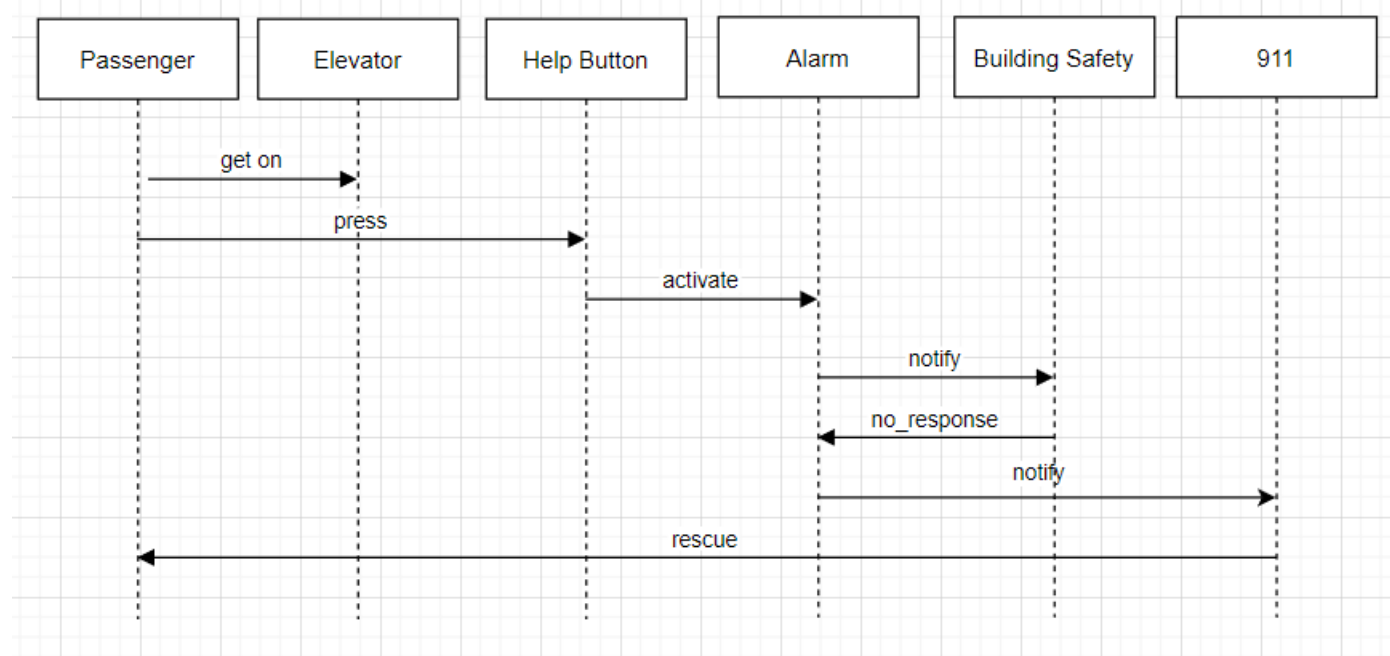
Sequence Diagram: Basic use case



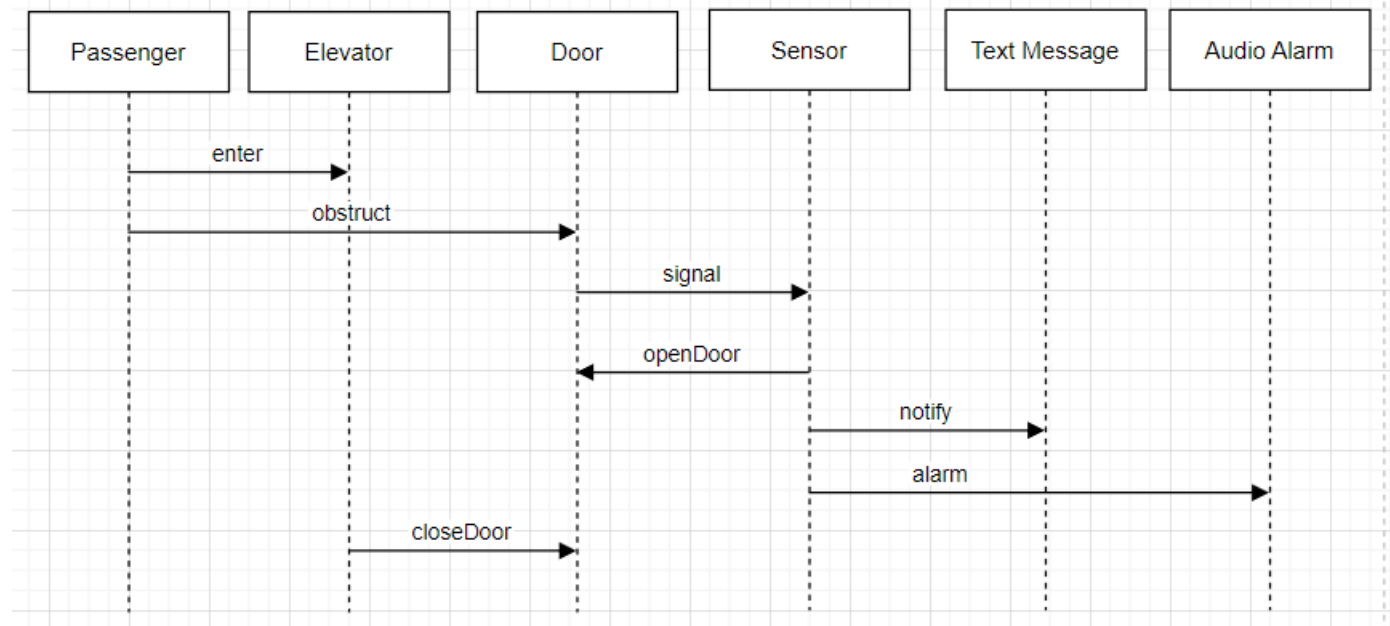
Sequence Diagram: Overload case



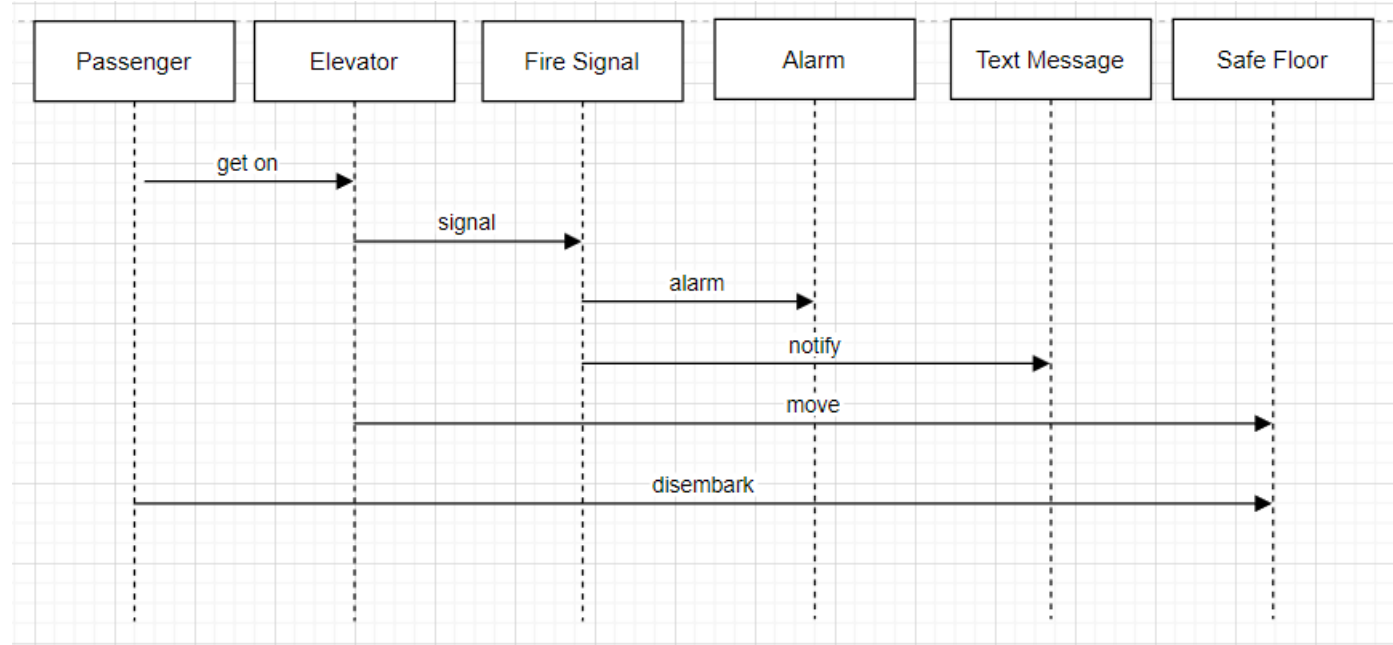
Sequence Diagram: Help button case



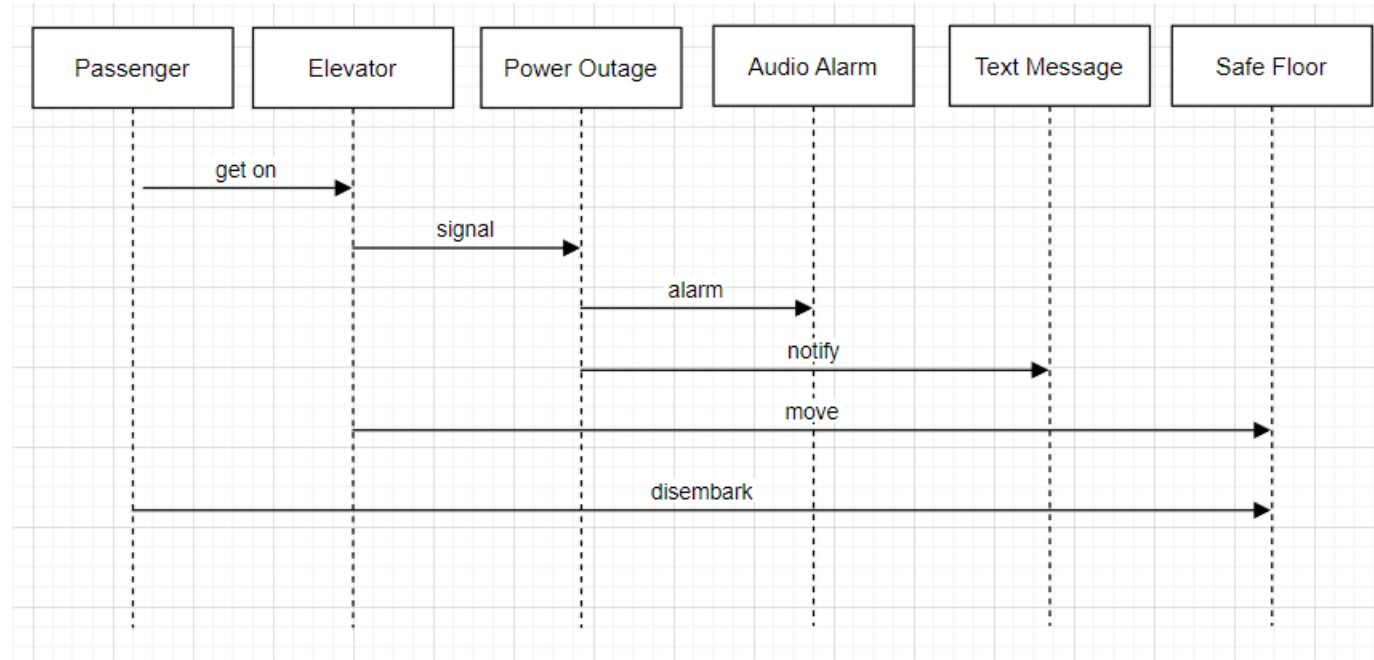
Sequence Diagram: Door obstruct case



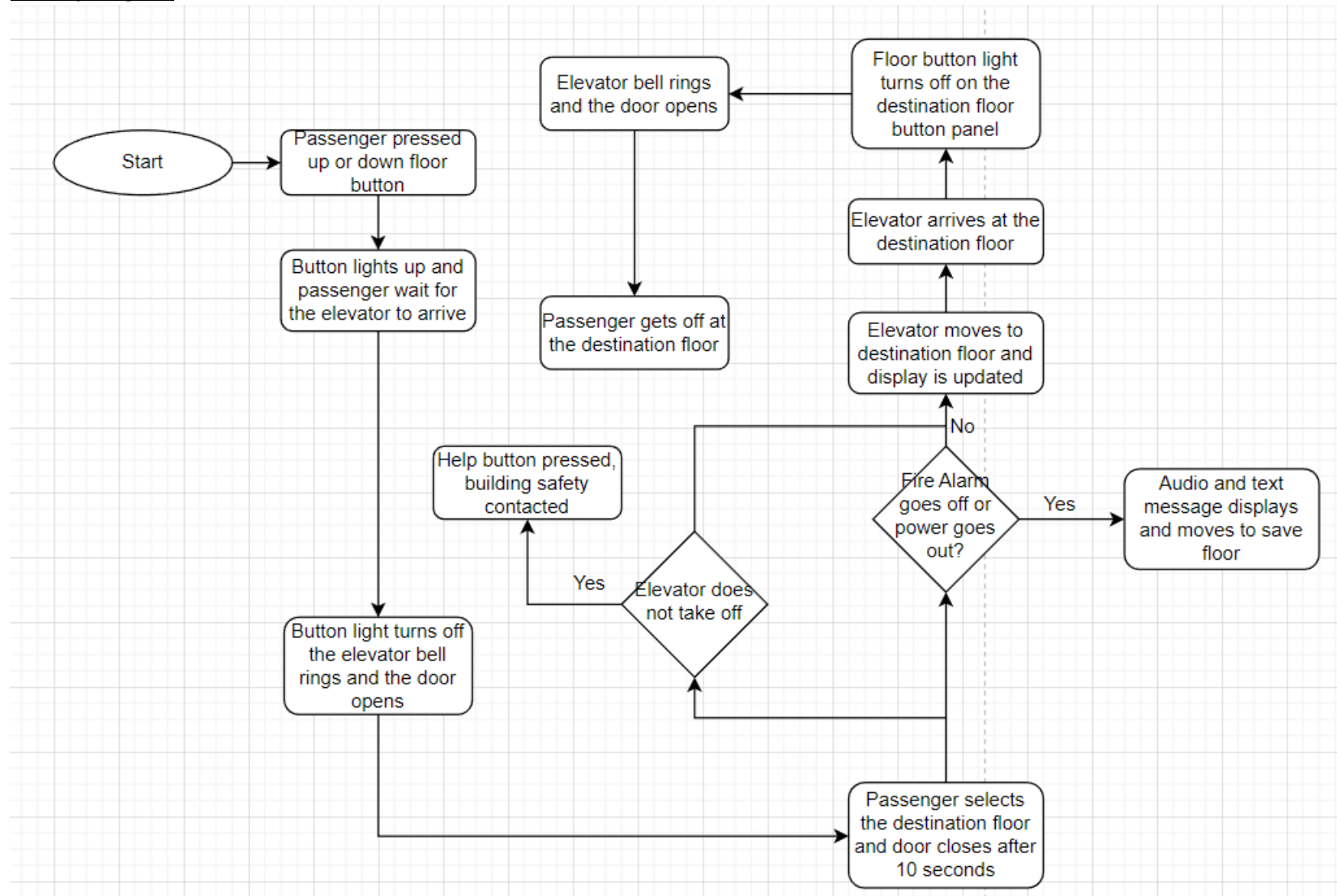
Sequence Diagram: Fire case



Sequence Diagram: Power outage case



Activity Diagram



Textual explanation of your design decisions including use of design patterns, if any.
Went with the mediator design pattern

```
class ECS {
    void requestFloor();
    void requestElevator();
};

class Passenger {
    void pressButton();
};

class Door {
    bool closed;

    void open();
    void close();
};

class Buttons {
    bool illuminate;
    int floorNum;

    void pressed();
};

class Floor {
    int floorNum;
    bool occupied;
};

class Display {
    int floorNum;

    void update();
};

class Sensors {
    bool activated;

    void keepDoorOpen();
};
```

```
class Bell {
    bool ringing;

    void ring();
};

class Safety {
    bool active;

    void help();
};

class Elevator {
    int floor;
    int elevatorNum;

    void openClose();
    void update();
};
```


Traceability Matrix

ID	Requirement	Related UseCase	Fulfilled By	Test	Description
1	<p>When a button is pressed it illuminates, and remains illuminated, until an elevator arrives to transport the customers who, at this floor, have requested an elevator going in a certain direction. When the elevator arrives, it rings a bell, opens its doors (the elevator and floor doors) for a fixed time (10 seconds) allowing people to exit or board, rings the bell again, closes its doors and proceeds to another floor. Once on-board passengers select one or more destination floors using a panel of buttons; there is one button for every floor. The elevator has a display which shows passengers the current floor of the elevator. There is also a pair of buttons on the elevator control panel marked “open door” and “close door”. These buttons can be used by a passenger to override the default timing of the doors. The door will remain open beyond its default period if the “open door” button is held depressed; the doors can be closed prematurely by pressing the “door close” button. Inside the elevator there is also a help button linked to building safety service.</p>	Using an Elevator	ECS, Passenger, Door, Elevator, Display, Buttons, Floors	Basic use	Basic use case of the elevator.
2	<p>Each elevator has a sensor that notifies it when it arrives at a floor. The elevator control system should ensure that the group of elevators services all (floor and on-board) requests expeditiously.</p>	Using an Elevator	ECS, Elevator, Floor	Basic use	Basic control system for the elevator.

3	Each elevator has a display and an audio system. The display shows the current floor number and warning messages that are synced with audio warnings.	Using an Elevator	Display, Bell, Floor, ECS	Basic use	<i>Basic interface and display system for the elevator</i>
4	Help: The control system receives a “Help” alarm signal from an elevator indicating that the “Help” button has been pressed. In that case, the passenger is connected to building safety service through a voice connection. If there is no response from building safety within 5 seconds or if there is no response from a passenger a 911 emergency call is placed.	Using an Elevator	Display, Bell, Buttons, Safety	Help button	Help button contacts the building safety and if no response then contact 911

5	Door obstacles: If the light sensor is interrupted when the door is closing, the control system stops the door from closing and opens it. If this occurs repeatedly over a short period of time, a warning is sounded over the audio system and a text message is displayed.	Using an Elevator	Door, Sensor, Display, Bell	Door obstacles	If something or someone is blocking the obstacle it will not close.
6	Fire: The control system receives a "Fire" alarm signal from the building and commands all elevators to move to a safe floor. Similarly, a "Fire" alarm signal from the elevator itself will cause that elevator to go to a safe floor. In both cases an audio and text message are presented to passengers informing them of an emergency and asking them to disembark once the safe floor is reached.	Using an Elevator	Bell, Elevator, Floor, Display	Fire	If fire is to occur it will move to safe floor.
7	Overload: The control system receives an "Overload" alarm signal from an elevator if the sensors indicate that the passenger or cargo load exceeds the carrying capacity. In that case, the elevator does not move and an audio and a text message are presented to passengers asking for the load to be reduced before attempting to move again.	Using an Elevator	Elevator, Sensor, ECS, Passenger	Passenger overload	If Passengers overload then it will ask to reduce load.

8	<p>Power out: The control system receives a “Power Out” alarm signal. In that case, an audio and a text messages are presented to passengers informing them of the power outage. Each elevator is then moved to a safe floor and passengers are asked to disembark via audio and text messages. The battery backup power is sufficient to do all of this.</p>	<p>Using an Elevator</p>	<p>Display, Passenger, Floor, Elevator</p>	<p>Power out</p>	<p>If power goes out then moves to safe floor.</p>
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Elevator system specification (same as Assignment 1)

<Paragraph 1> A building is serviced by a group of M elevators (also called cars). On each of the N floors is a pair of buttons marked “up” and “down”. When a button is pressed it illuminates, and remains illuminated, until an elevator arrives to transport the customers who, at this floor, have requested an elevator going in a certain direction. When the elevator arrives, it rings a bell, opens its doors (the elevator and floor doors) for a fixed time (10 seconds) allowing people to exit or board, rings the bell again, closes its doors and proceeds to another floor. Once on-board passengers select one or more destination floors using a panel of buttons; there is one button for every floor. The elevator has a display which shows passengers the current floor of the elevator. There is also a pair of buttons on the elevator control panel marked “open door” and “close door”. These buttons can be used by a passenger to override the default timing of the doors. The door will remain open beyond its default period if the “open door” button is held depressed; the doors can be closed prematurely by pressing the “door close” button. Inside the elevator there is also a help button linked to building safety service.

<Paragraph 2> Each elevator has a sensor that notifies it when it arrives at a floor. The elevator control system should ensure that the group of elevators services all (floor and on-board) requests expeditiously.

<Paragraph 3> Each elevator has a display and an audio system. The display shows the current floor number and warning messages that are synced with audio warnings.

Safety features:

<Paragraph 4> Help: The control system receives a “Help” alarm signal from an elevator indicating that the “Help” button has been pressed. In that case, the passenger is connected to building safety service through a voice connection. If there is no response from building safety within 5 seconds or if there is no response from a passenger a 911 emergency call is placed.

<Paragraph 5> Door obstacles: If the light sensor is interrupted when the door is closing, the control system stops the door from closing and opens it. If this occurs repeatedly over a short period of time, a warning is sounded over the audio system and a text message is displayed.

<Paragraph 6> Fire: The control system receives a “Fire” alarm signal from the building and commands all elevators to move to a safe floor. Similarly, a “Fire” alarm signal from the elevator itself will cause that elevator to go to a safe floor. In both cases an audio and text message are presented to passengers informing them of an emergency and asking them to disembark once the safe floor is reached.

<Paragraph 7> Overload: The control system receives an “Overload” alarm signal from an elevator if the sensors indicate that the passenger or cargo load exceeds the carrying capacity. In that case, the elevator does not move and an audio and a text messages are presented to passengers asking for the load to be reduced before attempting to move again.

<Paragraph 8 > Power out: The control system receives a “Power Out” alarm signal. In that case, an audio and a text messages are presented to passengers informing them of the power outage. Each elevator is then moved to a safe floor and passengers are asked to disembark via audio and text messages. The battery backup power is sufficient to do all of this.