

Use Case 1: Calling the Elevator

Primary Actor: Passenger

Scope: Elevator in use

Level: User goal

Stakeholders and Interests:

- Passenger: A user aiming to access the elevator for transportation.
- Building safety service: Ensures elevator functionality and offers aid if needed.

Precondition: The floor is accessible via the elevator, and the user has access.

Minimal Guarantee: The elevator should be made inaccessible if there's a malfunction or repair.

Success Guarantee: The elevator door opens, aligning with the floor level on the user's floor.

Trigger: User presses the elevator call button on a specified floor.

Main Success Scenario:

1. User arrives on floor serviced by the elevators.
2. User presses "up" or "down" button.
3. Button illuminates and remains illuminated until elevator arrives.
4. Elevator rings upon arrival, button light turns off.
5. Elevator and floor doors open together.
6. Doors remain open briefly for entry or exit.
7. Doors close in sync after a bell rings.
8. User enters elevator. Proceed to ***Use Case 2.***

Extensions:

- 7a. If doors are obstructed, proceed to **Use Case 3.**

Use Case 2: Riding the Elevator

Actor: Passenger in the elevator

Scope: Elevator in use

Level: User goal

Stakeholders and Interests:

- Passenger: Seeks transportation via elevator.
- Building safety service: Ensures elevator functionality and offers aid if needed.

Precondition: User boards the elevator.

Minimal Guarantee: The elevator is inaccessible if there's a malfunction or repair. User is safe from any form of physical harm.

Success Guarantee: User reaches their destination promptly and safely.

Trigger: User selects destination floor.

Main Success Scenario:

1. User boards the elevator.
2. Weight sensor checks load.
3. User selects "close" or "open" door or waits for automatic closure.
4. Floor doors and elevator doors close simultaneously.
5. User selects destination floor(s) on the panel.

6. Elevator moves to selected floor.
7. Onboard display reads the current floor number.
8. Audio system indicates floor.
9. Elevator rings as doors open together.
10. User exits, enters, or remains in elevator.

Extensions:

- 2a. If weight exceeds limit, perform **Use Case 4**.
- 4a. If obstacle detected during door closure, perform **Use Case 3**.
- 1-10. If "Help" button pressed, perform **Use Case 5**.
- 1-10. If "Fire" button pressed or fire alarm received, perform **Use Case 6**.
- 1-10. If power outage signal received from ECS, perform **Use Case 7**.

Use Case 3: Obstacle Detection

Actor: Passenger

Scope: Elevator in use

Level: User goal

Stakeholders and Interests:

- Passenger: Requires elevator service.
- Building safety service: Ensures elevator functionality and offers aid if needed.

Precondition: Obstacle detected during door closure.

Minimal Guarantee: Elevator is inaccessible in case of malfunction.

Success Guarantee: User reaches destination promptly and safely.

Trigger: User boards the elevator.

Main Success Scenario:

1. Light sensor detects obstruction during door closure.
2. Control system halts door closure, reopens.
3. Elevator doors remains open until obstruction clears.
4. Doors closes cautiously.
5. Resume normal operation.

Extension:

- 3a. If repeated obstructions occur, warning is issued via audio and text.

Use Case 4: Elevator Overload

Actor: Passenger

Scope: Elevator in use

Level: User goal

Stakeholders and Interests:

- Passenger: Requires elevator service.
- Building safety service: Ensures elevator functionality and offers aid if needed.

Precondition: Elevator load surpasses limit.

Minimal Guarantee: Elevator is inaccessible in case of malfunction.

Success Guarantee: User reaches destination promptly and safely.

Trigger: User(s) enters and overloads elevator.

Main Success Scenario:

1. Sensor detects excessive load.
2. Elevator sends "Overload" signal to the ECS.
3. Door remains open.
4. Elevator alerts passengers with audio cues/instructions and displays message.
5. Elevator waits until weight decreases.
6. Normal operation resumes.

Use Case 5: Intercom Help Request

Actor: Passenger

Scope: Elevator in use

Level: User goal

Stakeholders and Interests:

- Passenger: Requires elevator service.
- Building safety service: Ensures elevator functionality and offers aid if needed.

Precondition: User presses "Help" button.

Minimal Guarantee: Elevator is inaccessible in case of malfunction.

Success Guarantee: User reaches destination promptly and safely.

Trigger: User boards the elevator.

Main Success Scenario:

1. User activates "Help" button, notifying control system.
2. User connects with safety service within 5 seconds.
3. Assistance promptly provided by Building Safety Services.

Extension:

- 2a. If no response, initiate 911 call.

Use Case 6: Fire Alarm

Actor: Passenger

Scope: Elevator in use

Level: User goal

Stakeholders and Interests:

- Passenger: Requires elevator service.
- Building safety service: Ensures elevator functionality and offers aid if needed.

Precondition: User activates "Fire" button or fire alarm received.

Minimal Guarantee: Elevator is inaccessible in case of malfunction.

Success Guarantee: User reaches safe floor.

Trigger: User boards the elevator.

Main Success Scenario:

1. User activates "Fire" signal or ECS receives "Fire" signal from the building.
2. Elevator bypasses selected floors, heads to safe floor.
3. Doors open simultaneously for safe evacuation.
4. Elevator alerts passengers of emergency, directs evacuation.

Use Case 7: Power Outage

Actor: Passenger

Scope: Elevator in use

Level: User goal

Stakeholders and Interests:

- Passenger: Requires elevator service.
- Building safety service: Ensures elevator functionality and offers aid if needed.

Precondition: Control system receives "Power Out" alarm from the ECS.

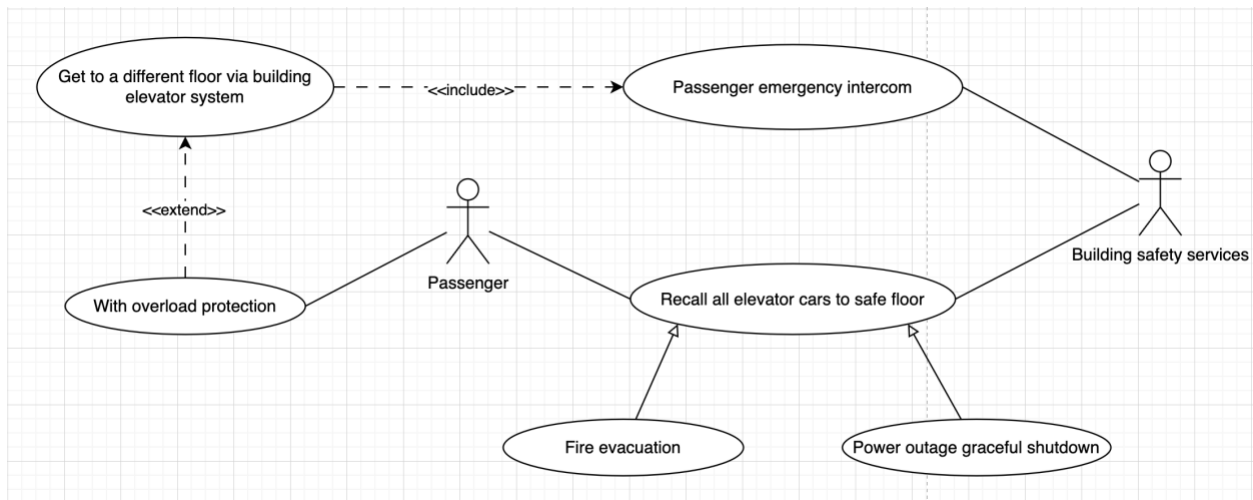
Minimal Guarantee: Elevator is inaccessible in case of malfunction.

Success Guarantee: User reaches safe floor.

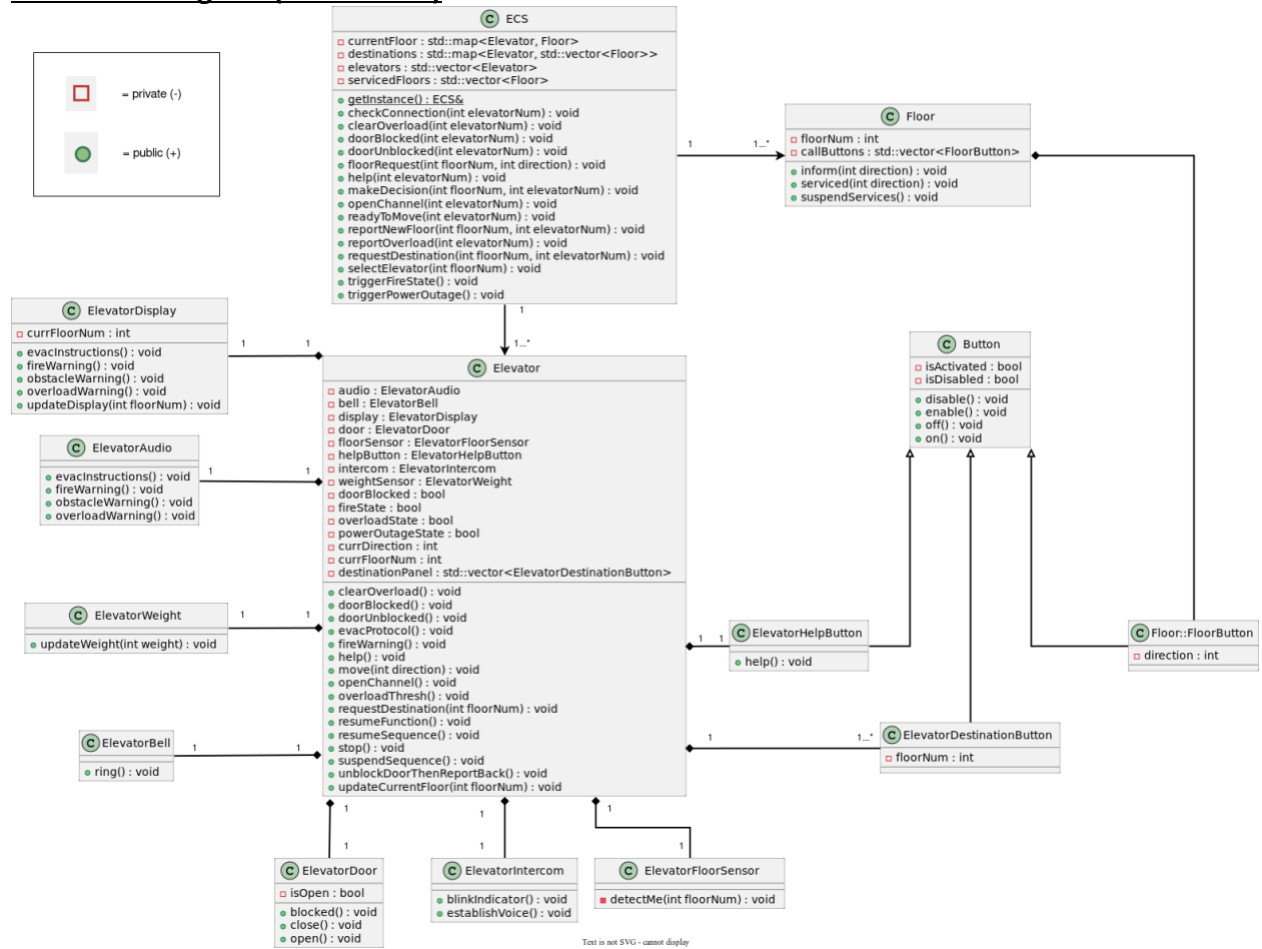
Trigger: User boards the elevator.

Main Success Scenario:

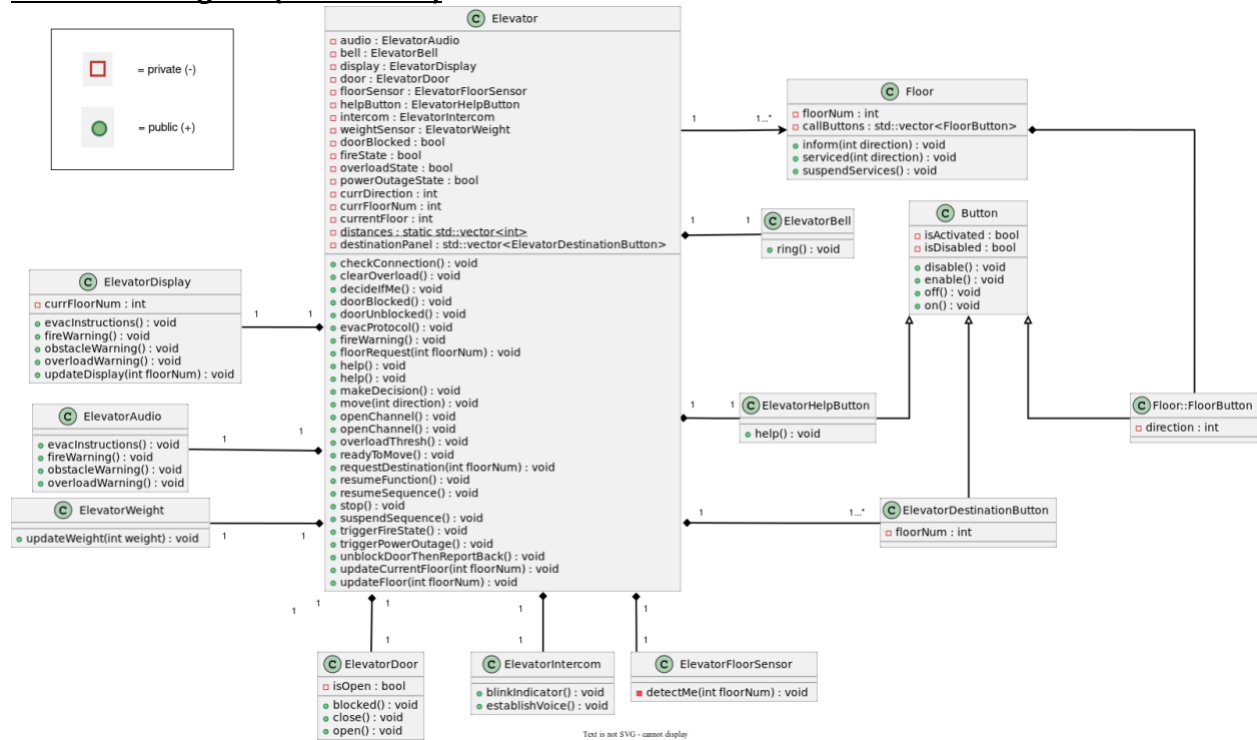
1. Control system detects power outage.
2. Passengers informed of outage.
3. Elevator switches to backup power.
4. Elevator heads directly to safe floor.
5. Doors open for evacuation.



UML Class Diagram (Centralized)

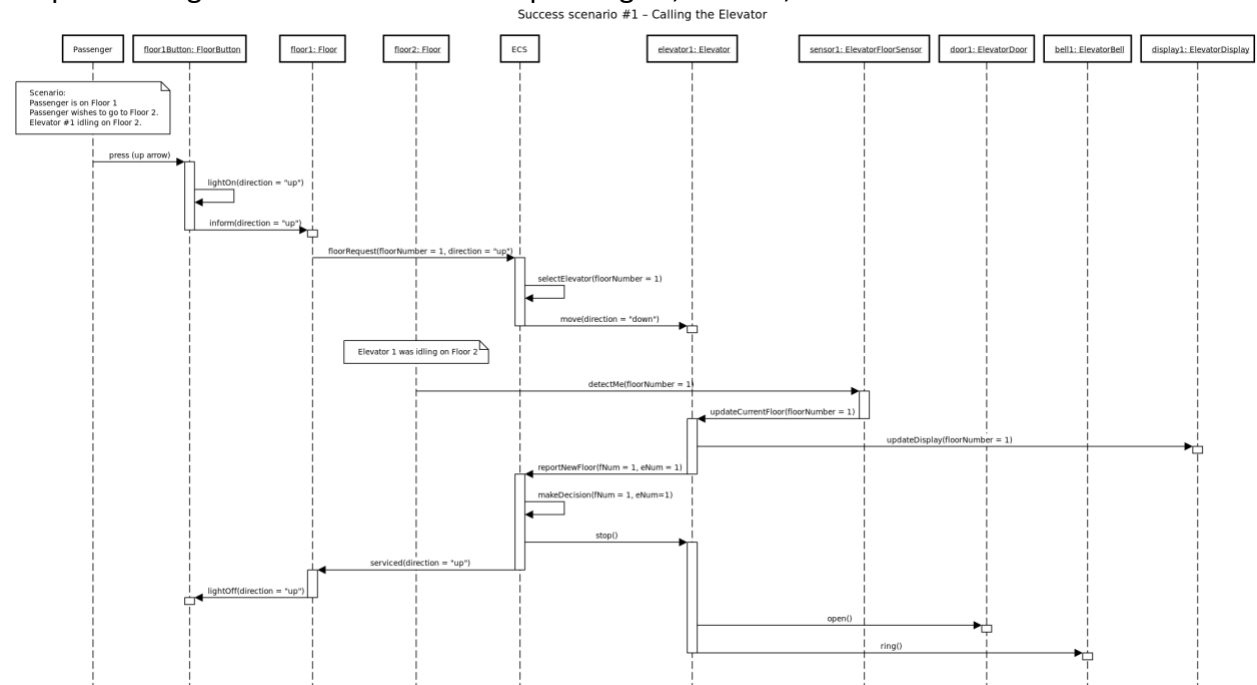


UML Class Diagram (Distributed)

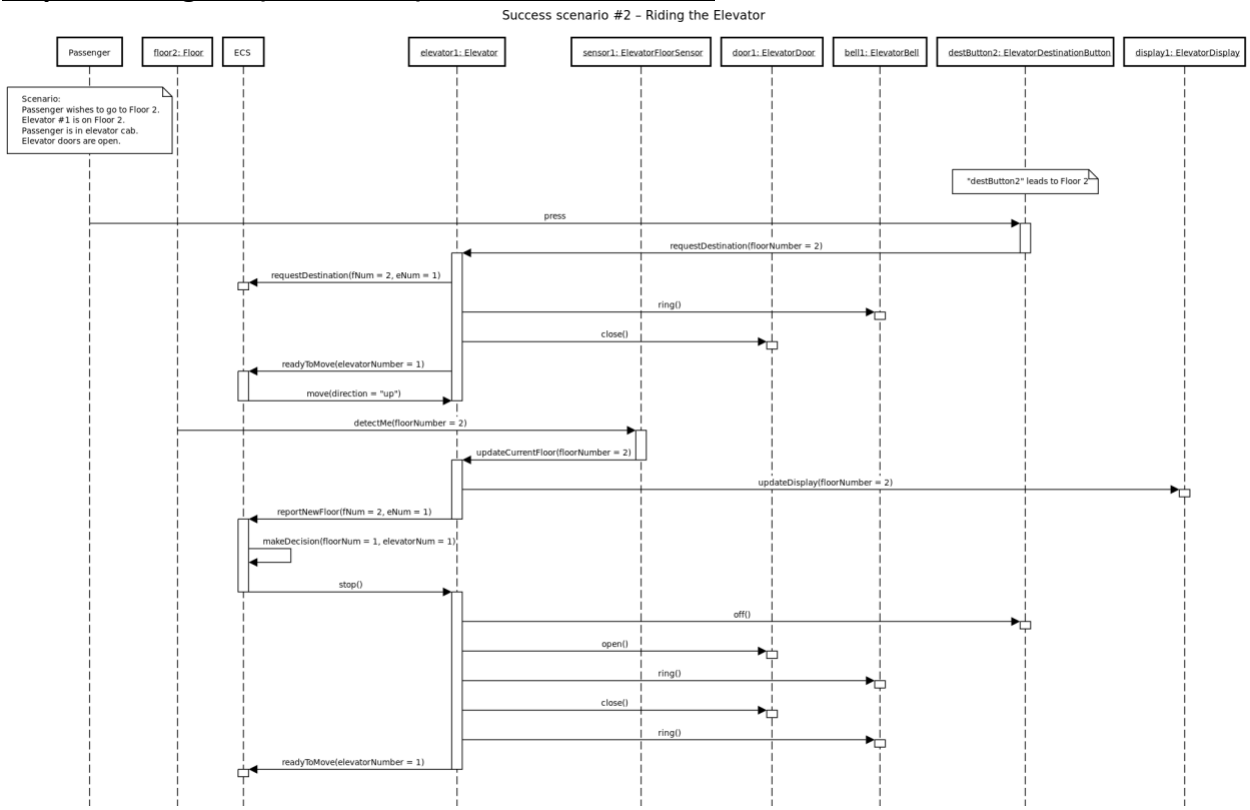


Sequence Diagram (Centralized) – Success scenario #1

Sequence Diagrams assume there are 3 passengers, 7 floors, and 3 elevators.

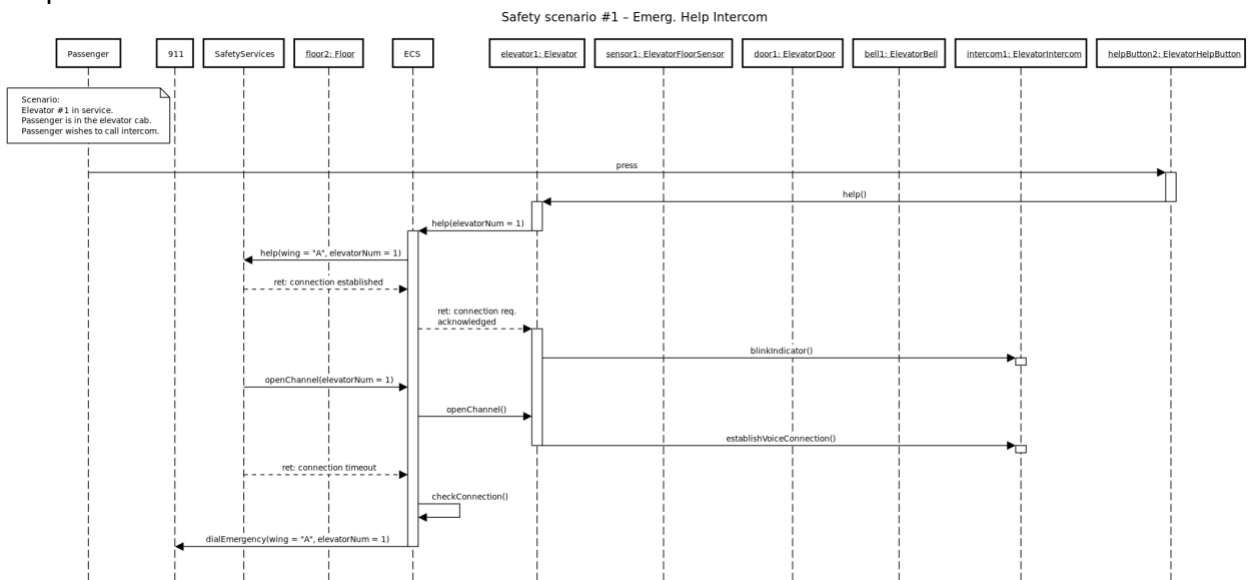


Sequence Diagram (Centralized) – Success scenario #2



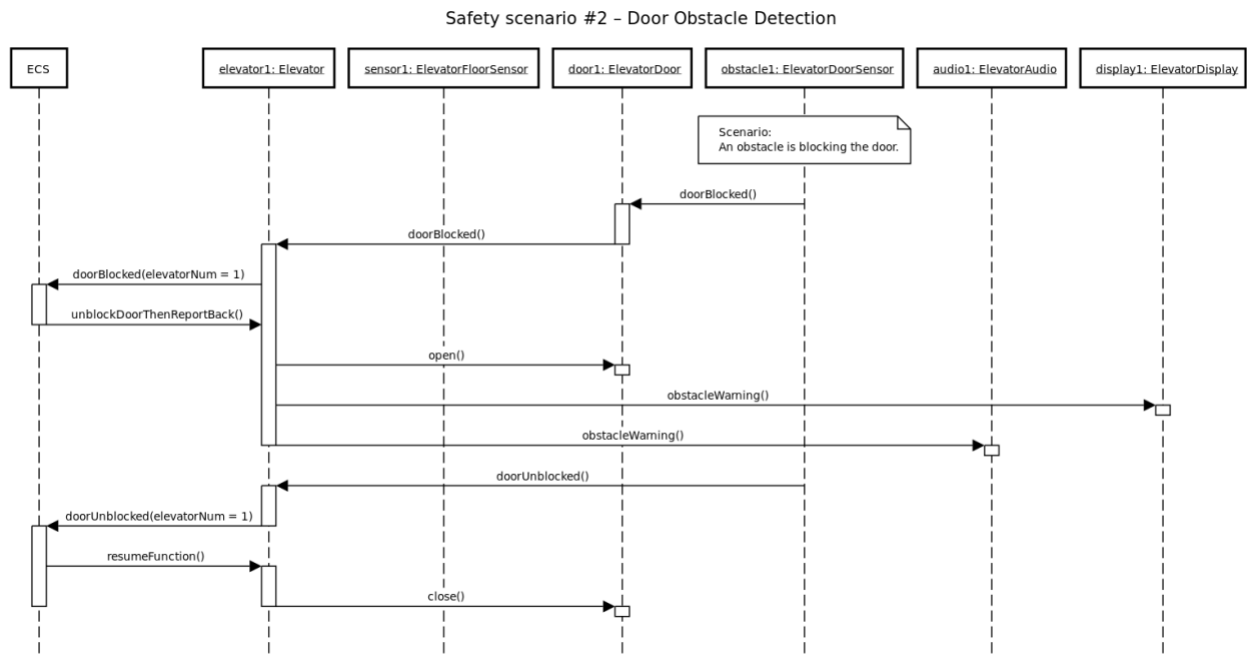
Sequence Diagram (Centralized) – Safety scenario #1

Help Button Intercom



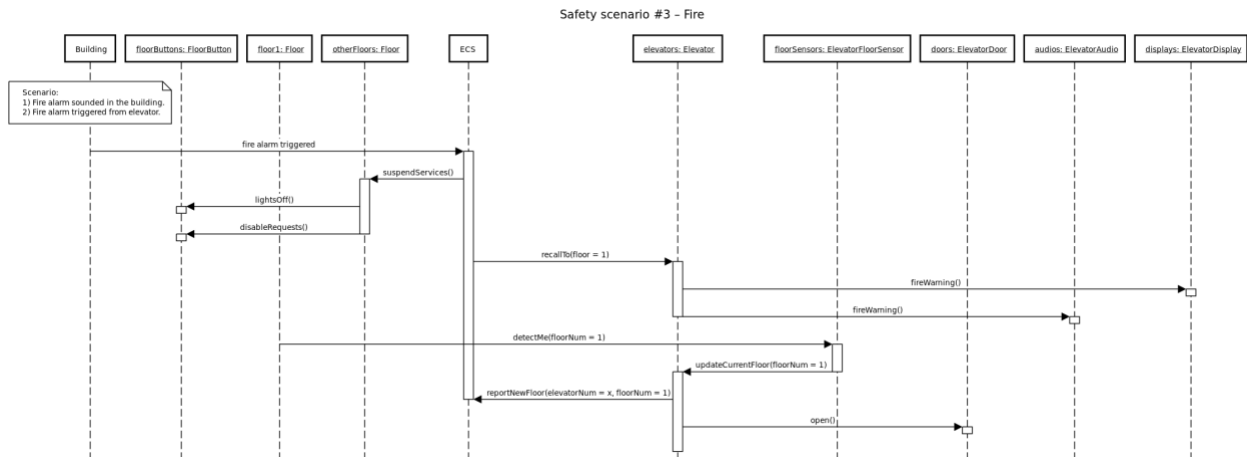
Sequence Diagram (Centralized) – Safety scenario #2

Door obstacles

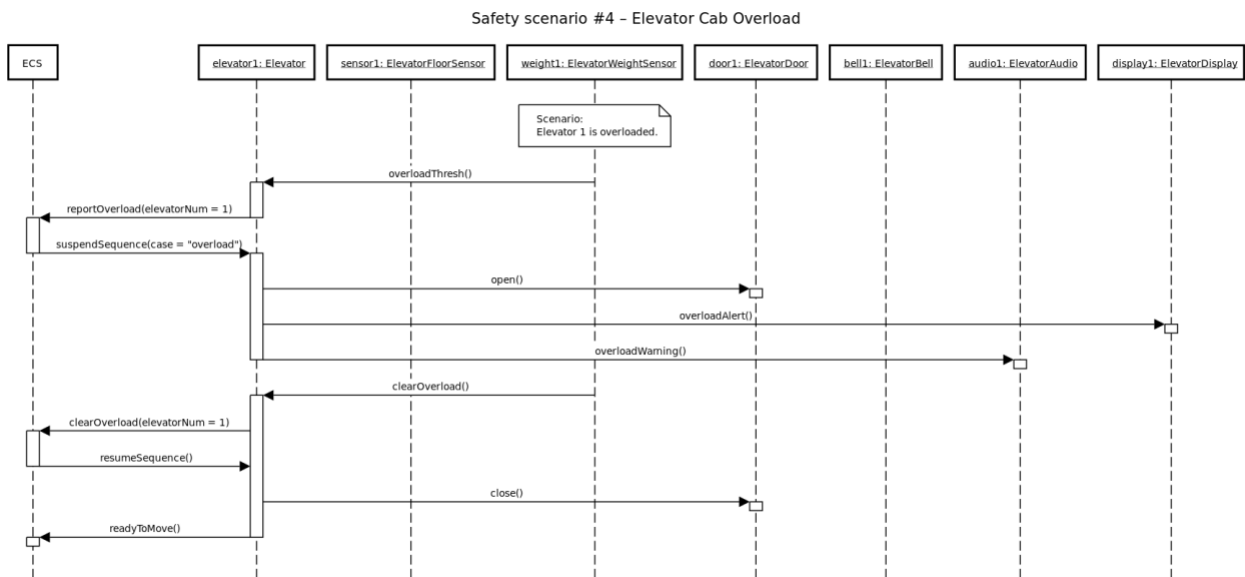


Sequence Diagram (Centralized) – Safety scenario #3

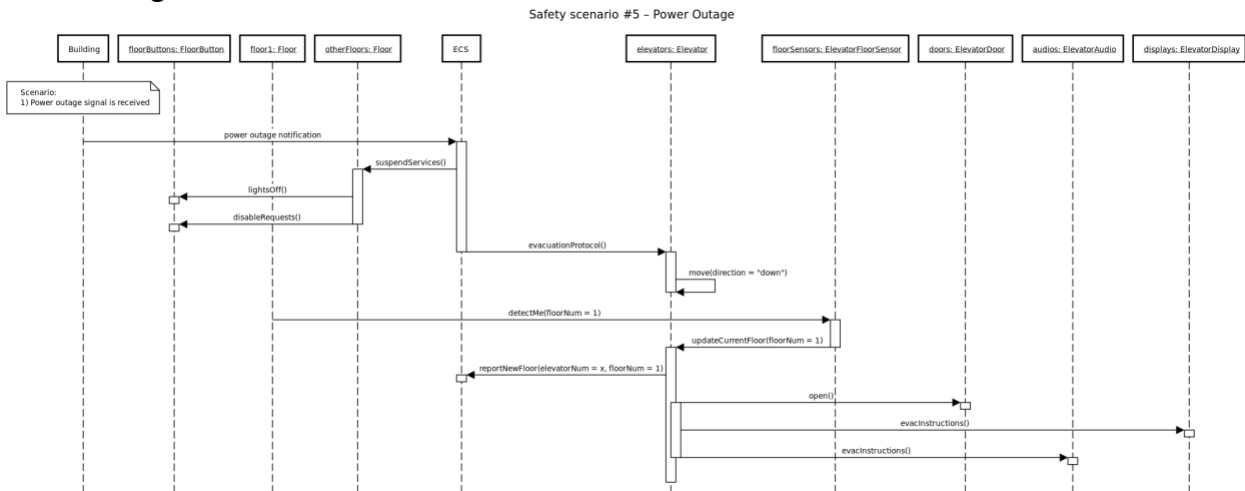
Fire



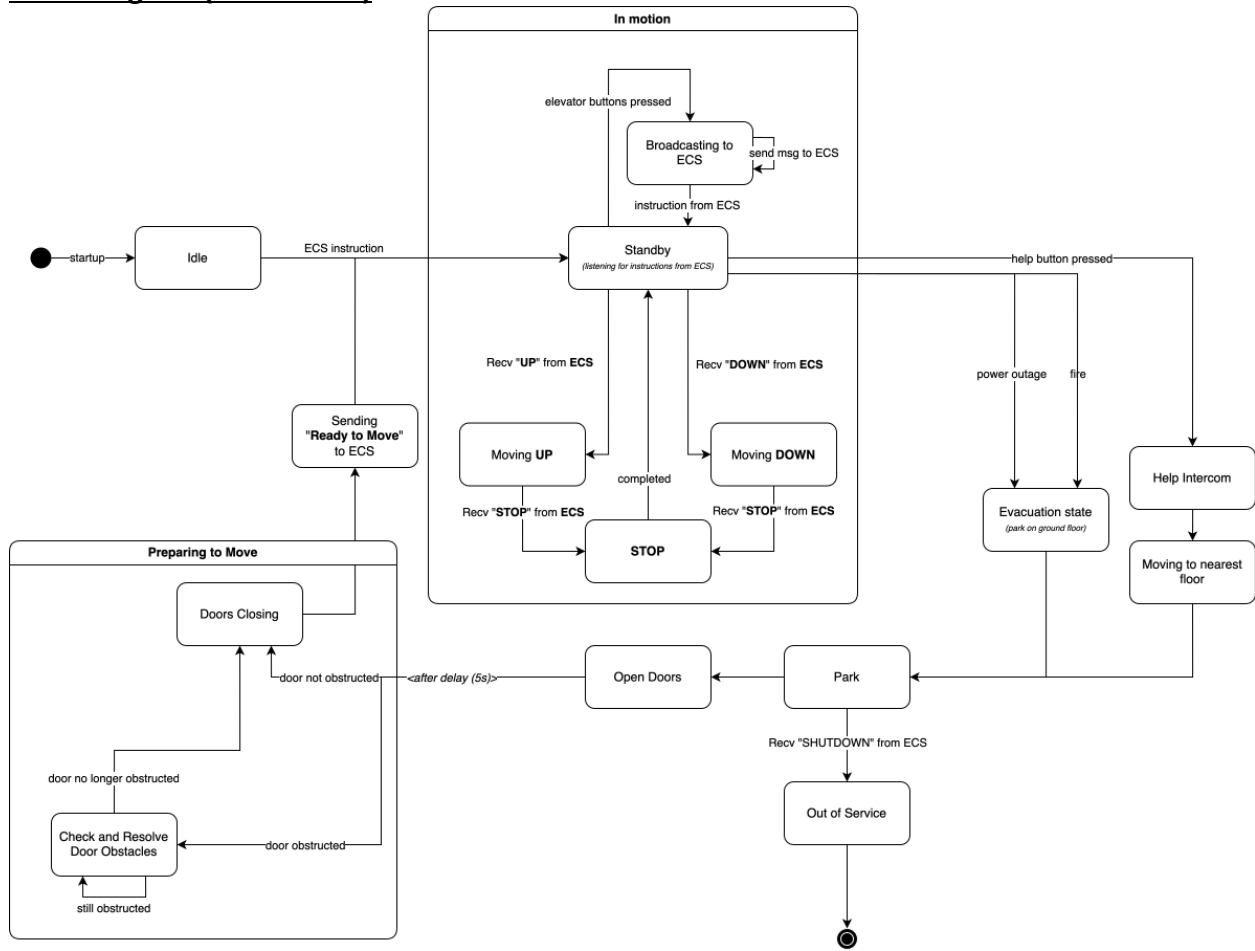
Sequence Diagram (Centralized) – Safety scenario #4
Overload



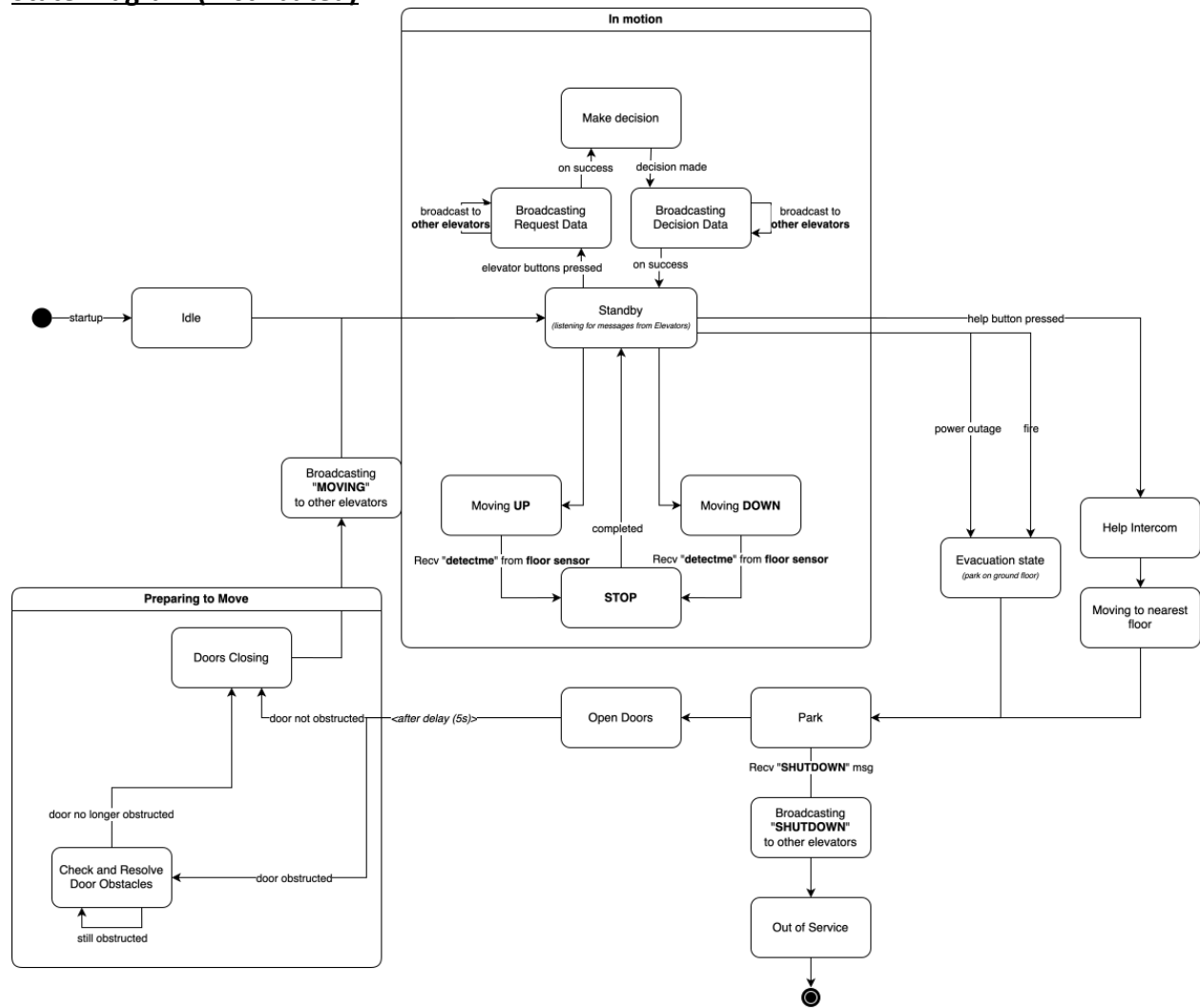
Sequence Diagram (Centralized) – Safety scenario #5
Power outage



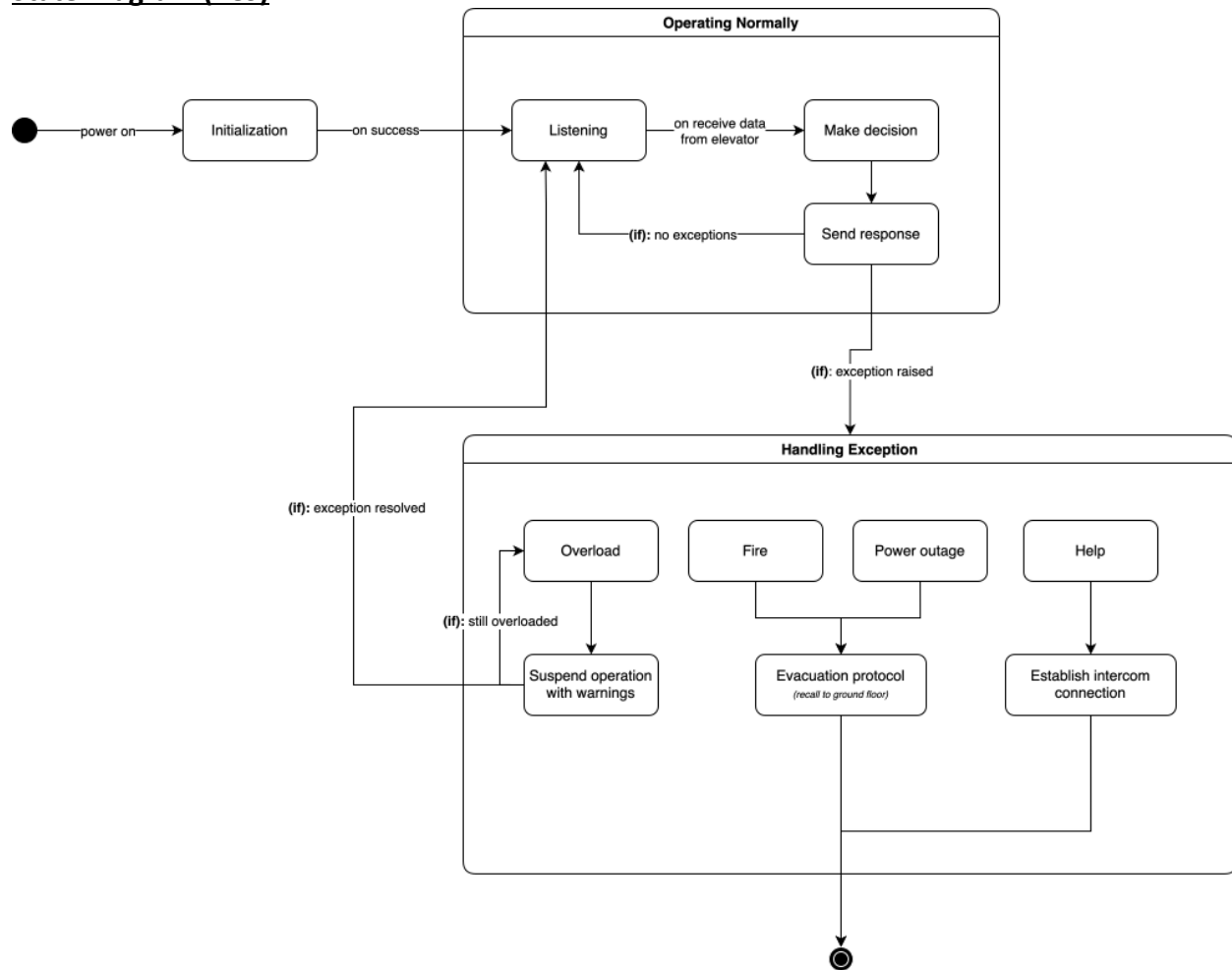
State Diagram (Centralized)



State Diagram (Distributed)



State Diagram (ECS)



Design Decision Discussion (Design Patterns)

Centralized

- “**Mediator**” pattern used from the Gang of Four Design Patterns.
- Mediator is used because elevators communicate with each other in well-defined but complex ways. The resulting interdependency of elevators and sensors become messy and hard to understand.
- Having a centralized “Elevator Control System (ECS)” abstracts the communication between elevator cars (colleagues) and allows for easier maintenance as elevators are modular and can be independently modified/fixed without detrimental impact to the rest of the system. (Colleague decoupling)

In the centralized elevator system, the ECS acts as the mediator between elevators. Elevator components (such as sensors) are considered part of the elevators’ entity and communicate with the ECS through their container elevators. (This is called a composition relationship) On top of that, the ECS follows the “**Singleton**” Creational Pattern. Since the ECS acts as the mediator, there should always only be a single instance of the ECS at any given time.

For example, this is how the implementation could look like *(as shown in the UML)*:

```
static ECS & getInstance() {  
    static ECS instance;  
    return instance;  
}
```

Distributed

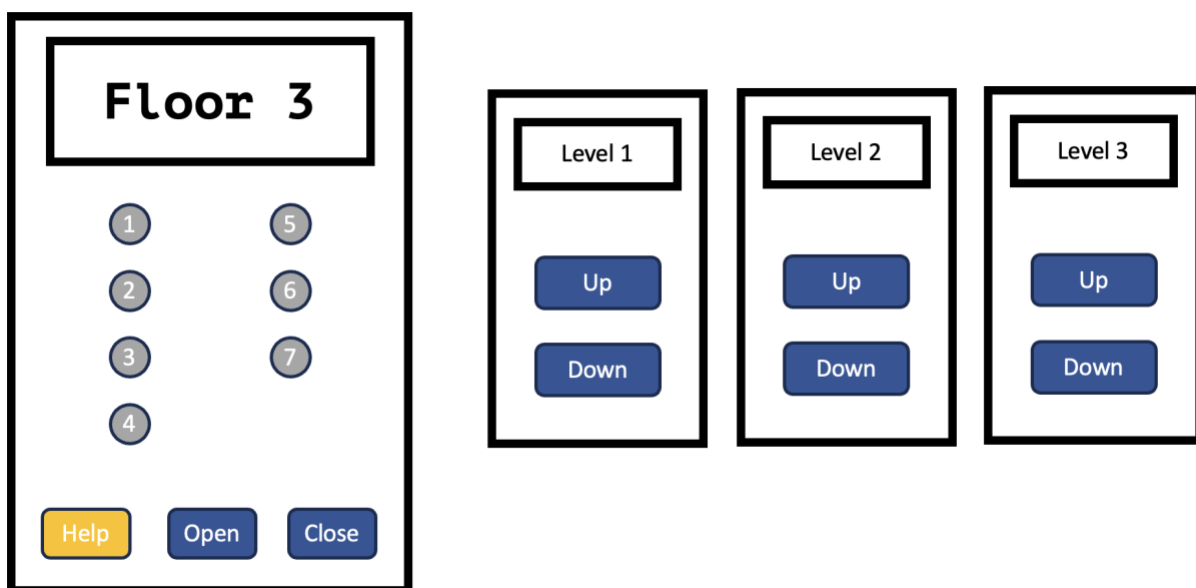
- Interactions between floors and elevators: **Observer Pattern**

In my version of the distributed elevator system, the Observer pattern facilitates communication between different components of the system. Each elevator act as observers and subscribe to updates from floors (floor sensors and elevator call buttons). When notified of a new request, the elevators evaluate themselves to figure out whether they are the best candidate to respond based on their current state (e.g., position, load).

Centralized vs Distributed

- Comparing the Centralized and Distributed systems, the elevators in the centralized system has a more surface-level and **limited** view of the state of the entire system, while the elevators in the distributed system have a more **complete** picture as to the current state of the system as a whole at any given time.
- As a result, it becomes easier to incorporate special features in individual elevators in the distributed system. The trade-off is the significant increase in complexity of inter-elevator communication (as compared to having the “ECS” mediator in Centralized).

GUI Sketch



C++ Header Files

Note to TA: Header files are included in the zip file in the folder called "headers".

Requirements Traceability Matrix

ID	Requirement	Related Use Case	Fulfilled By (Centralized)	Fulfilled By (Distributed)
1	User presses "up" or "down" button.	Calling the Elevator (UC1)	Elevator, ECS, FloorButton, Floor	Elevator, FloorButton, Floor
2.	Button illuminates and remains illuminated until elevator arrives.	Calling the Elevator (UC1)	Elevator, ECS, FloorButton, Floor	Elevator, FloorButton, Floor
3.	Elevator rings upon arrival, button light turns off.	Calling the Elevator (UC1)	Elevator, ECS, FloorButton, Floor, ElevatorBell, ElevatorSensor	Elevator, FloorButton, Floor, ElevatorBell, ElevatorSensor
4.	Elevator and floor doors open together; Doors remain open briefly for entry or exit.	Calling the Elevator (UC1)	Elevator, ECS, ElevatorDoor	Elevator, ElevatorDoor
5.	Doors close in sync after a bell rings; Sensors in doors ensure that doors are not obstructed before closing. <i>(If repeated obstructions occur, warning is issued via audio and text.)</i>	Calling the Elevator (UC1), Obstacle Detection (UC3)	Elevator, ECS, ElevatorDoor, ElevatorDoorSensor, ElevatorBell, ElevatorDisplay, ElevatorAudio	Elevator, ElevatorDoor, ElevatorDoorSensor, ElevatorBell, ElevatorDisplay, ElevatorAudio
6.	User boards the elevator; Weight sensor checks load.	Riding the Elevator (UC2)	Elevator, ECS, ElevatorWeight, ElevatorAudio, ElevatorDisplay	Elevator, ElevatorWeight, ElevatorAudio, ElevatorDisplay
7.	User selects "close" or "open" door or waits for automatic closure; Floor doors and elevator doors close simultaneously.	Riding the Elevator (UC2)	Elevator, ECS, ElevatorDoor	Elevator, ElevatorDoor

8.	User selects destination floor(s) on the panel; Elevator moves to selected floor.	Riding the Elevator (UC2)	Elevator, ECS, ElevatorDestinationButton	Elevator, ElevatorDestinationButton
9.	Onboard display reads the current floor number; Audio system indicates floor.	Riding the Elevator (UC2)	Elevator, ECS, ElevatorFloorSensor, ElevatorDisplay, ElevatorAudio	Elevator, ElevatorFloorSensor, ElevatorDisplay, ElevatorAudio
10.	Elevator rings as doors open together; User exits, enters, or remains in elevator.	Riding the Elevator (UC2)	Elevator, ECS, ElevatorDoor, ElevatorBell	Elevator, ElevatorDoor, ElevatorBell
11.	Sensor detects excessive load and notifies elevator control system (centralized only).	Elevator Overload (UC4)	Elevator, ECS, ElevatorWeight	Elevator, ElevatorWeight
12.	Door remains open. Elevator alerts passengers with audio cues/instructions and displays message.	Elevator Overload (UC4)	Elevator, ECS, ElevatorWeight, ElevatorAudio, ElevatorDisplay, ElevatorDoor	Elevator, ElevatorWeight, ElevatorAudio, ElevatorDisplay, ElevatorDoor
13.	Elevator waits until weight decreases, normal operation resumes.	Elevator Overload (UC4)	Elevator, ECS, ElevatorWeight, ElevatorDoor	Elevator, ElevatorWeight, ElevatorDoor
14.	User activates "Help" button, notifying control system; User then connects with safety service within 5 seconds. 911 is dialed if no response is received within 5 seconds.	Intercom Help Request (UC5)	Elevator, ECS, ElevatorIntercom, ElevatorHelpButton	Elevator, ElevatorIntercom, ElevatorHelpButton
15.	User activates "Fire" signal or ECS receives "Fire" signal from the	Fire Alarm (UC6)	Elevator, ECS, ElevatorDisplay,	Elevator, ElevatorDisplay, ElevatorAudio, ElevatorFloorSensor, Floor

	building (<i>centralized only</i>). Elevator bypasses selected floors, heads to safe floor.		ElevatorAudio, ElevatorFloorSensor, Floor	
16.	Doors open simultaneously for safe evacuation. Elevator alerts passengers of emergency, directs evacuation.	Fire Alarm (UC6)	Elevator, ECS, ElevatorDisplay, ElevatorAudio, ElevatorDoor	Elevator, ElevatorDisplay, ElevatorAudio, ElevatorDoor
17.	Passengers informed of power outage. Elevator switches to backup power and heads directly to safe floor; Doors open for evacuation.	Power Outage (UC7)	Elevator, ECS, ElevatorDisplay, ElevatorAudio, ElevatorDoor, ElevatorFloorSensor, Floor	Elevator, ElevatorDisplay, ElevatorAudio, ElevatorDoor, ElevatorFloorSensor, Floor