Assignment 3: Analysis and Design of An Elevator Controller Simulator

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Elevator Control System Use Cases

Below you will find all 9 use cases and the use case diagram with detailed specifications.

USE CASE 1: Pressing Floor Button

Primary Actor: Passengers (building worker/tenants)

Preconditions:

- The elevator is in working order

Main Success Scenario:

1. To call for an elevator the passenger hits the "up" or "down" button on their present floor to indicate which direction they want to go.
2. When an elevator becomes available, the elevator control system assigns it to the requested floor. (The system finds the most optimal elevator to avoid wasted time and energy)
3. The direction button hit by the passenger will light up to show that the request has been received, and will stay lit until the elevator arrives.
4. The led panel above each elevator door slot will stay updated with the current position of the elevator using data from the elevator control system.

Success Condition:

- The Passengers has successfully requested for a elevator

USE CASE 2: Elevator Arrival

Primary Actor: Passengers (building worker/tenants), Elevator Control System

Preconditions:

- The elevator has been requested by a passenger on a floor by Pressing Floor Button or the passenger currently in the elevator car requested their destination.
- The elevator's sensor alerted the elevator control system that it had reached the floor.

Main Success Scenario:

1. The elevator bell rings to indicate it has arrived
2. For 10 seconds, the elevator and floor doors will remain open.
3. Either the Passengers exit or board the elevator
4. After the 10 seconds the bell rings again
5. The elevator and floor doors close
6. The elevator proceeds to its next floor

Success Condition:

- Passengers are successfully taken to their designated floor by the elevator.
- All floor and on-board requests are efficiently handled by the elevator control system.

Extension:

- The doors will stay open for a longer amount of time if a passenger holds down the "open door" button. (refer USE CASE 4 for more details)
- The doors will abruptly close if the "close door" button is pressed. (refer USE CASE 4 for more details)
- When the door is closing and the light sensor detects an interruption, the door will stop closing and reopen. A warning will be played on the audio system and a text message will be displayed if this happens several times in a short period of time. (refer USE CASE 5 for more details)

USE CASE 3: Selecting Destination Floor

Primary Actor: Passengers (building worker/tenants)

Preconditions:

- The elevator doors are open, and the Passengers is already inside.
- The Passengers know what floor they want to go to.

Main Success Scenario:

1. On the button panel inside the elevator, the user chooses their desired floor.
2. The destination floor is updated on the elevator's display.
3. The destination floor is added to the elevator's list of stops by the Elevator Control System.
4. The elevator starts ascending or descending to the desired floor based on what the Elevator Control System thinks is the most optimal path.

Success Condition:

- The Passengers reach the floor they selected.

USE CASE 4: Overriding Door Timing

Primary Actor: Passengers (building worker/tenants)

Preconditions:

- The elevator doors are open, and the Passengers are already inside.

Main Success Scenario:

1. The elevator doors are kept open for a longer period of time when the passenger holds the "open door" button.
2. The elevator doors close before the 10 second default when the passenger clicks the "close door" button.
3. After the elevator doors close, the normal operations continue.

Success Condition:

- Let the passengers override elevator doors timing by either holding the open door or close door button.

Extension:

- The elevator control system may issue a warning sound and display a text message if the "open door" button is held pressed for an extended period of time.
- The door will not close if the passenger tries to do so when the light sensor detects an obstruction. (refer USE CASE 5)

USE CASE 5: Door Obstacle

Primary Actor: Elevator Control System

Preconditions:

- Doors are trying to close

Main Success Scenario:

1. When the elevator doors are about to close, the light sensor notices an obstruction.
2. The door closure is prevented and opened by the control system.
3. Until the obstruction is removed, the doors are left open.
4. Once more, the doors close, and the elevator continues to the next stop.

Success Condition:

- Elevator doors open and close properly, avoiding injury to users or nearby items.

Extension:

- The audio system plays a warning and a text message is presented if the obstruction is not removed and the sensor is interrupted more than once in a short period of time.

USE CASE 6: Help Button

Primary Actor: Passengers (building worker/tenants), Safety Services (911, Building Safety)

Preconditions:

- Elevator is in use
- Passenger are inside the elevator

Main Success Scenario:

1. Inside the elevator, a passenger presses the "Help" button.
2. The elevator sends a "Help" warning signal to the control system.
3. A voice connection is established by the control system between the passenger and the building security service.
4. The passenger informs the building safety staff of the circumstance.
5. The building safety service acts as necessary.

Success Condition:

- In an emergency or time of need, the passenger gets assistance.
- Building safety services can react to the problem promptly and successfully.
- 911 emergency services are informed in the event of no response and can take the necessary action.

Extension:

- The control system dials 911 if there is no response from the building safety service after five seconds.

USE CASE 7: Fire Alarm

Primary Actor: Elevator Control System, Safety Services (911, Building Safety)

Preconditions:

- The elevator is in use
- The building fire alarm system or elevator detects a fire

Main Success Scenario:

1. The building or elevator sends a "Fire" alert signal to the control system.
2. All elevators are instructed to move to a safe floor by the control system.
3. Passengers are informed of an emergency and asked to disembark as soon as they reach the safe floor via an audio and text message.
4. When the elevator reaches the safe floor, the door is opened for passengers to exit.
5. Until the fire is put out and it is declared safe to operate, the elevator doors close, and it is no longer in use.

Success Condition:

- The passenger arrives at a safe floor in case of a fire

USE CASE 8: Overload Alarm

Primary Actor: Elevator Control System

Preconditions:

- The elevator door is open ready to take passengers
- The sensor in the elevator detects that the passenger or cargo load exceeds the carrying capacity

Main Success Scenario:

1. The control system receives an "Overload" alarm signal from the elevator
2. The elevator does not move and doors stay open
3. An audio and text message are presented to the passengers, asking for the load to be reduced before attempting to move again

Success Condition:

- By prohibiting the elevator from moving with an overloaded load, the safety of the passengers is preserved.

Extension:

- The elevator will not move, and the control system will go through the same process again if the weight is reduced but still exceeds the carrying capacity.

USE CASE 9: Power Outage

Primary Actor: Building Safety Team, Elevator Control System

Preconditions:

- The elevator system is in use.
- There is a power outage inside the building.

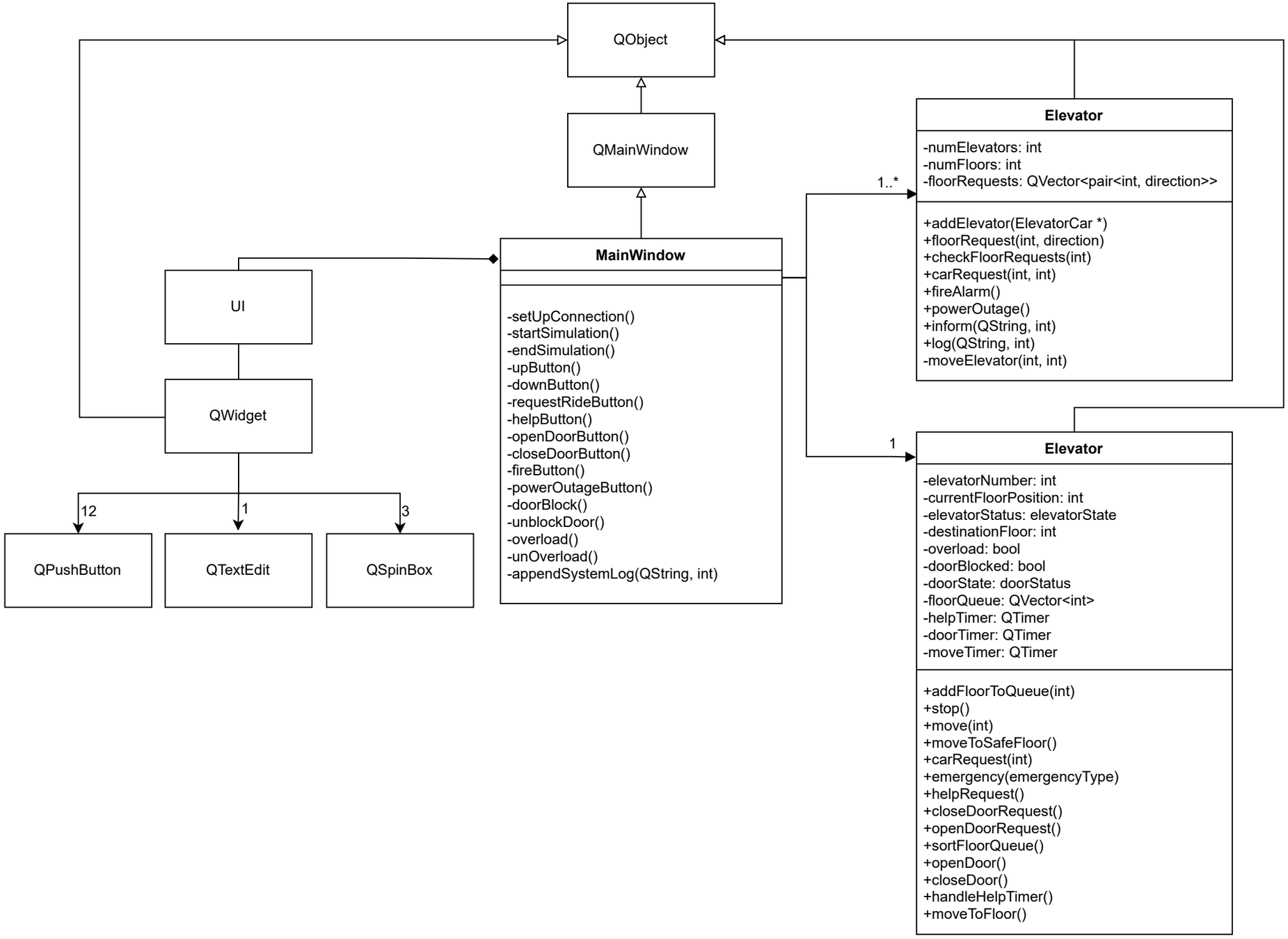
Main Success Scenario:

1. To protect the passengers, the control system turns to battery backup power.
2. The electrical system of the building sends a "Power Out" alarm signal to the control system.
3. The control system notifies the users of every elevator of the power outage via voice and text message.
4. All elevators are directed to the closest safe floor by the control system.
5. The passengers are prompted to exit the elevator by an audio and text message from the control system.

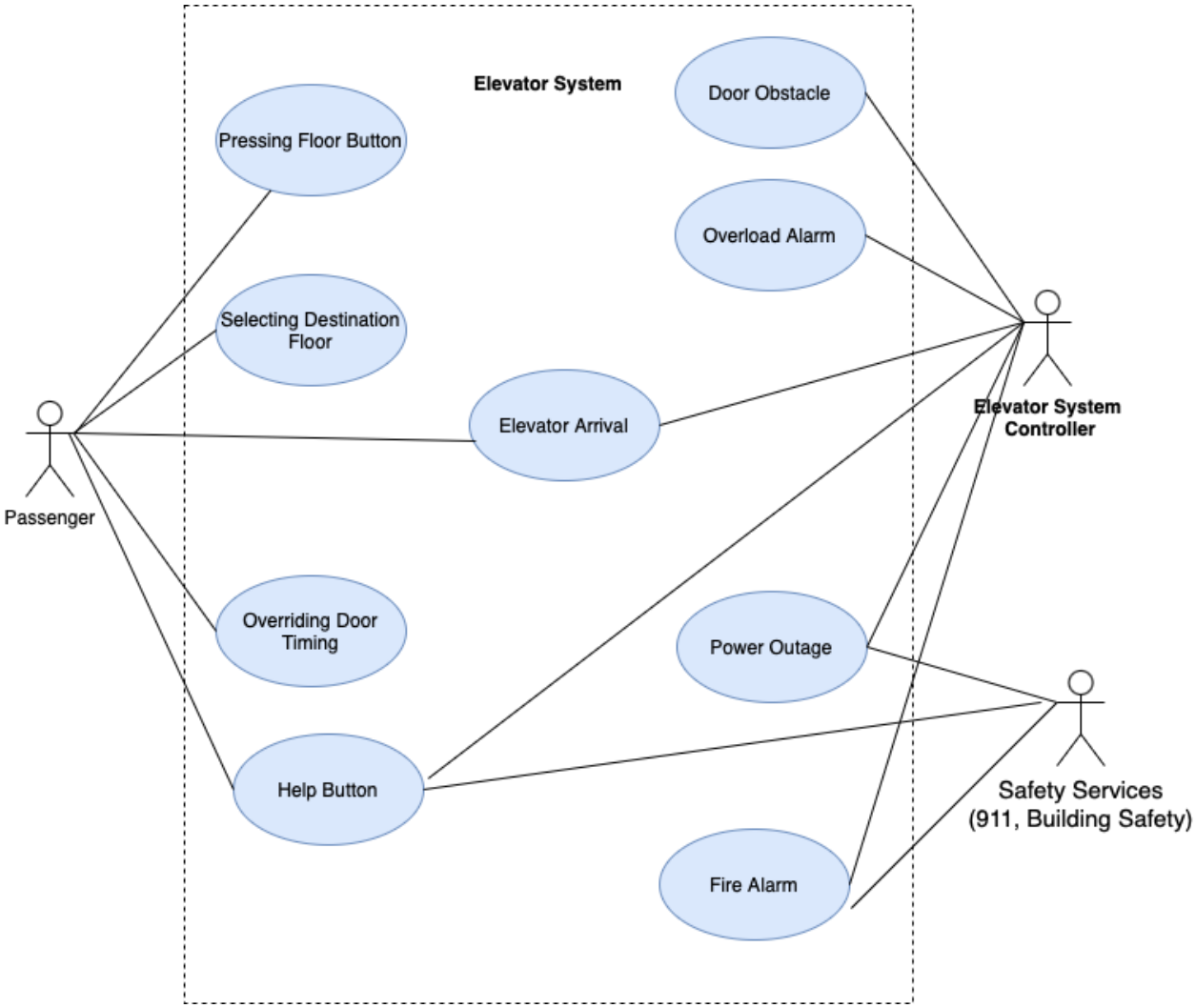
Success Condition:

- The elevators have safely evacuated all of the passengers, and they are in a secure condition.
- The building safety service is informed and is prepared to act further as needed.
- When power is restored, the control system will be prepared to restart regular use.

ASSIGNMENT 3 - UML DIAGRAM



USE CASE DIAGRAM:



Overall System and Class Diagram Description

In an elevator, the only way for a user to interact with the system is by using buttons within the UI. The UI has an admin view and a passenger view.

The Admin view is responsible for deciding the number for floors and elevators through a QSpinBox and then starting the simulation by pressing the startSimulationButton (QPushButtons). Admins also have access to fireAlarm and powerOutage Buttons for emergency testing. There is also a system log (QTextEdit) which shows all the activity of the simulator such as elevators moving, requests and emergency actions.

The passenger view of the elevator UI consists of three main panels. The first panel is the floor panel, which includes a spin box for selecting the desired floor, as well as up and down buttons to indicate the direction of travel. This panel allows passengers to input their desired destination and indicate whether they want to travel up or down.

The second panel is the elevator panel, which allows passengers to select the car number and floor for making requests. In addition to the selection buttons, there are also help, open door, and close buttons for additional functionality. The help button can be used to request assistance from the elevator operator or building security in case of an emergency. The open door button allows passengers to manually open the elevator doors, while the close button is used to close them.

The passenger view of the elevator UI also includes a floor testing panel. This panel allows users to simulate certain scenarios for testing purposes. Specifically, there are buttons for holding the overload button and door block button, which simulate an overload condition and a blocked door, respectively.

By providing these testing buttons, the passenger view of the elevator UI allows for more thorough testing of the system's functionality and responsiveness in various scenarios. This can help identify potential issues and improve the overall reliability of the elevator control system.

On each floor, there is a corresponding floor number, and there can be up to one or two floorButtons. Passengers can use these buttons to request the elevator to come to their floor.

In terms of class design, the elevator control system is responsible for managing all requests made by passengers, both from the floors and from within the elevator cars. When a button is pressed, the MainWindow class sends the request to the elevator control system, which then uses one of two available allocation strategies to determine the best elevator to assign to the request.

The elevator class is responsible for actually operating the elevator car, managing things like the door and internal requests. It is also equipped to handle emergencies within the elevator, such as the help button. Additionally, the open and close door buttons are handled by the elevator class, which determines when to open and close the doors based on these inputs.

To maintain a clear and structured design, several enums are used, including DoorState, EmergencyType, ElevatorState, and Direction. These help to ensure that interactions between classes are more concrete and consistent.

Regarding safety features, the elevator class is designed to provide audio and visual messages to passengers in the event of an emergency, which are forwarded to the system log in the UI.

Overall, the class design of the elevator control system and elevator class allows for efficient and effective operation of the elevator simulator. By providing clear and distinct roles for each class, the system is able to handle a variety of scenarios and requests from both passengers and administrators. For a more detailed walkthrough of the simulator's interface and functionality, please see the video linked HERE (https://www.youtube.com/watch?v=kbqeA26Ul-Q).

Sequence Diagrams Descriptions

Sequence Diagram 1-1 (Basic Use Case - FIFO allocation strategy)

This is a simple scenario where a passenger requests an elevator from a floor. The elevator may not be on the same floor, but it will come to the passenger's requested floor. Once the elevator arrives, the passenger enters and selects their desired destination floor. The elevator takes them to that floor, the doors open, the passenger exits, and the doors close again. This sequence diagram is quite long but shows a regular use case scenario from top to bottom with no obstructions. However this use case uses the FIFO allocation strategy which is less efficient (explained in video).

Sequence Diagram 1-1 (Basic Use Case - Efficient allocation strategy)

Same scenario as above However this use case uses the more Efficient allocation strategy (explained in video).

Sequence Diagram 1-2 (Basic Use Case - Open Button)

The elevator doors are open, and there's a 10-second wait for passengers to enter. However, the passengers feel like they need more time, so they decide to press and hold the open door button. This keeps the elevator doors open until the passengers release the button. Once they do, the doors close as usual.

Sequence Diagram 1-3 (Basic Use Case - Close Button)

The elevator doors are open, waiting for passengers to enter. Normally, the doors stay open for 10 seconds, but in this case, there's a 5-second wait. That's because the passenger inside the elevator has pressed the close button, which overrides the usual timing and closes the doors earlier than expected.

Sequence Diagram 2 (Help Button Use Case)

The passengers are inside the elevator and there seems to be an emergency. To get help, the passengers press the help button, which initiates a call using the ElevatorInternalDisplayAndAudio class. If the building safety team doesn't answer the call within

5 seconds, the system automatically calls emergency services and establishes a connection with them.

Sequence Diagram 3 (Obstacles Use Case)

In this scenario, the passengers are trying to board the elevator, but there is an obstacle in the way. As a result, the doors cannot close, and instead, they open and wait for 5 seconds before attempting to close again. However, if this cycle repeats more than two times, an alert is sent to the ElevatorInternalDisplayAndAudio class, asking the passengers to remove the obstacle. After this, the doors will try to close again, hoping for success. If the doors still cannot close, the cycle will repeat until a resolution is found.

Sequence Diagram 4 (Fire Alarm Use Case)

The elevator control system receives a signal indicating that there is a fire in the building. The system then sends an emergency signal to all elevators. As a result, all the elevators move to the safest floor, open their doors, and display a message such as "Please exit the elevator due to the fire alarm." This ensures that all passengers are safely evacuated from the elevators in response to the emergency situation.

Sequence Diagram 5 (Overload Use Case)

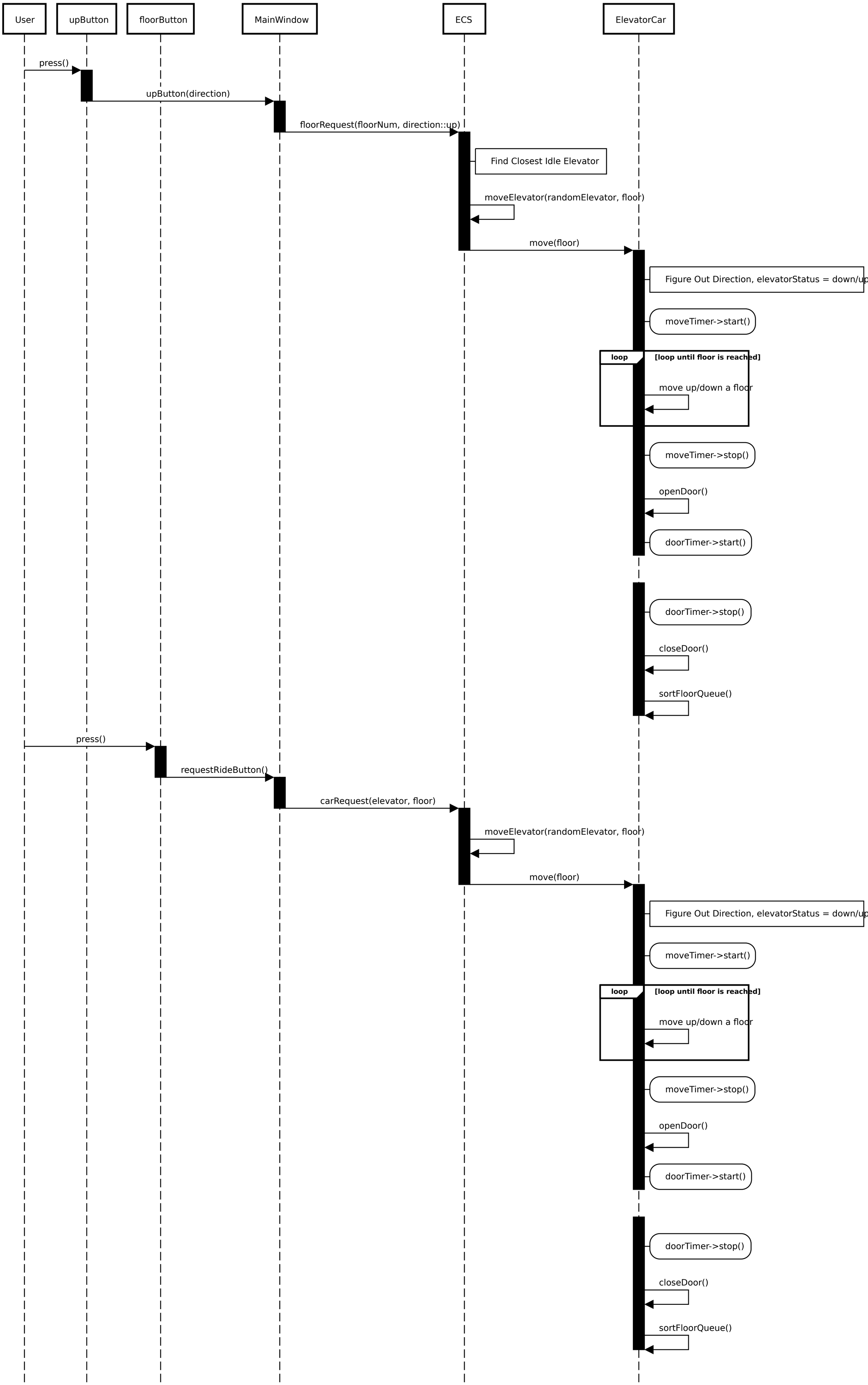
The elevator doors are open, and after the 10-second wait, it's discovered that the elevator is overloaded with too much weight. This initiates a display and alert to inform the passengers of the overload. The doors will stay open until the problem is resolved, at which point the doors will close, and the elevator will resume regular operation. This ensures that passengers are aware of the situation and that the elevator is not operated beyond its safe capacity.

Sequence Diagram 6 (Power Outage Alarm Use Case)

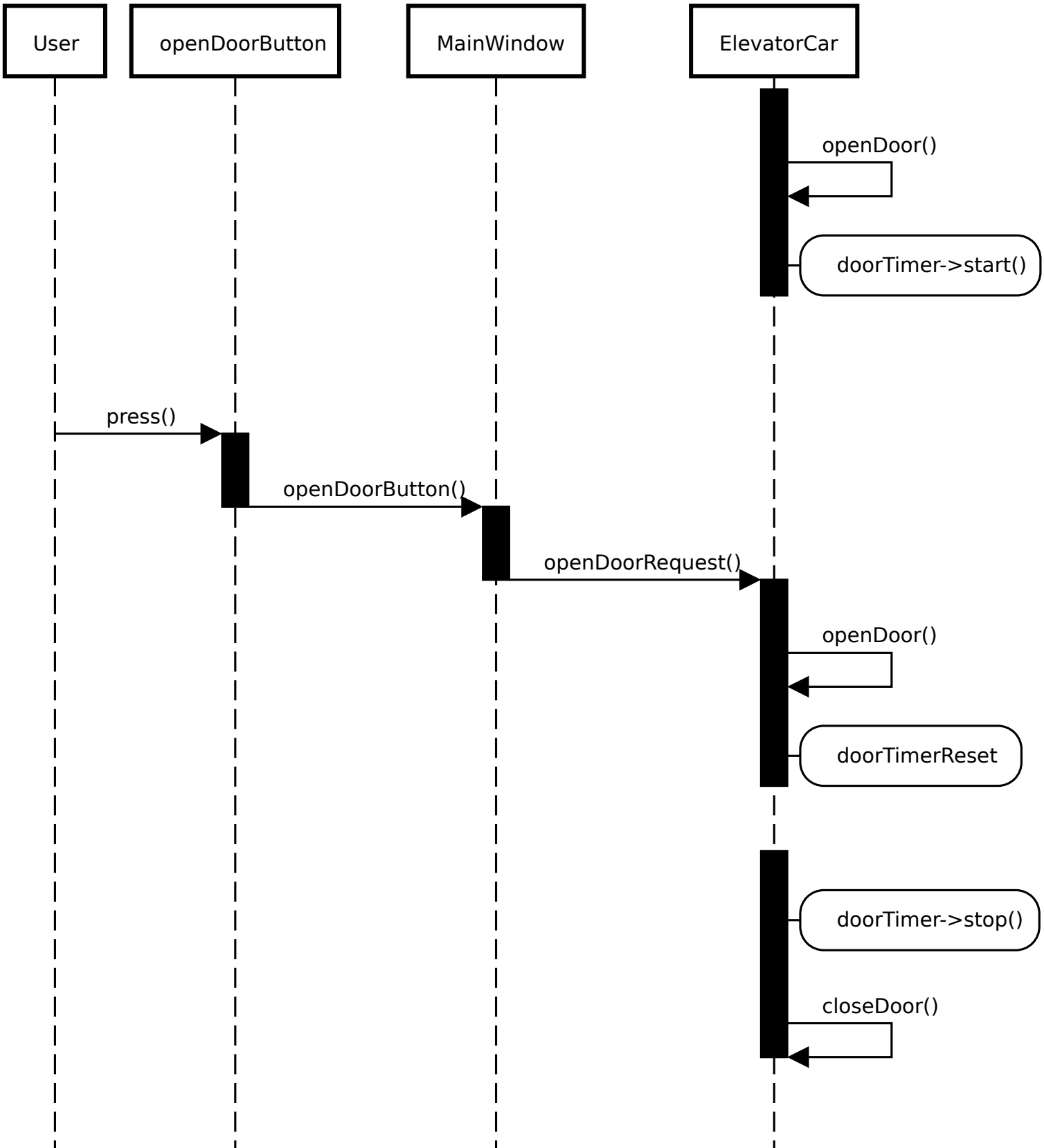
A power outage occurs within the building, which triggers the backup power of the elevator control system. The system then sends an emergency call to all elevators, instructing them to move to the safest floor, open their doors, and display a message such as "Power Outage." This ensures that passengers are informed of the situation and can exit the elevators safely until the power is restored.

Sequence Diagram 1-0 (Basic Use Case | FIFO Allocation Strategy)

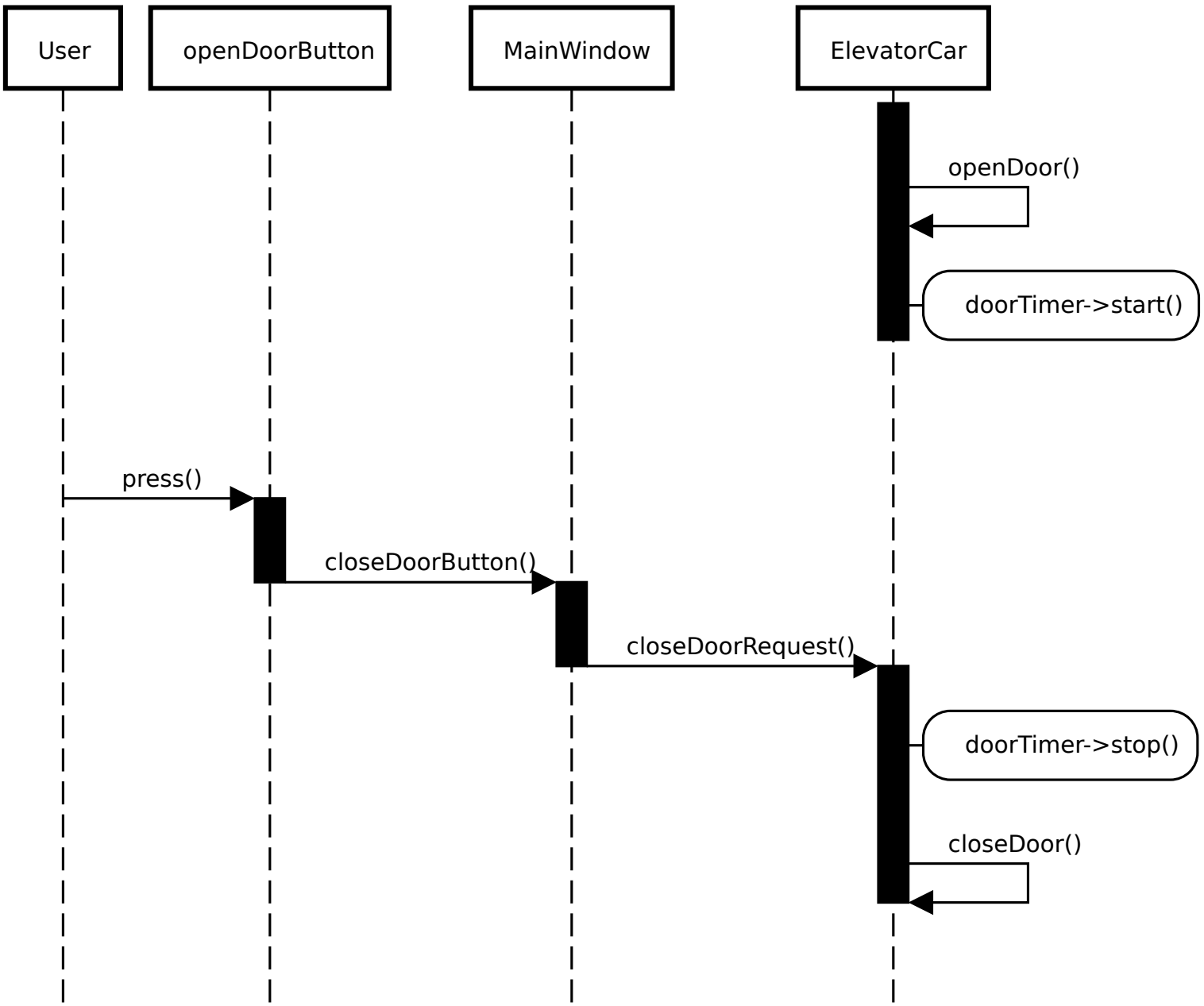
Sequence Diagram 1-1 (Basic Use Case | Efficent Allocation Strategy)



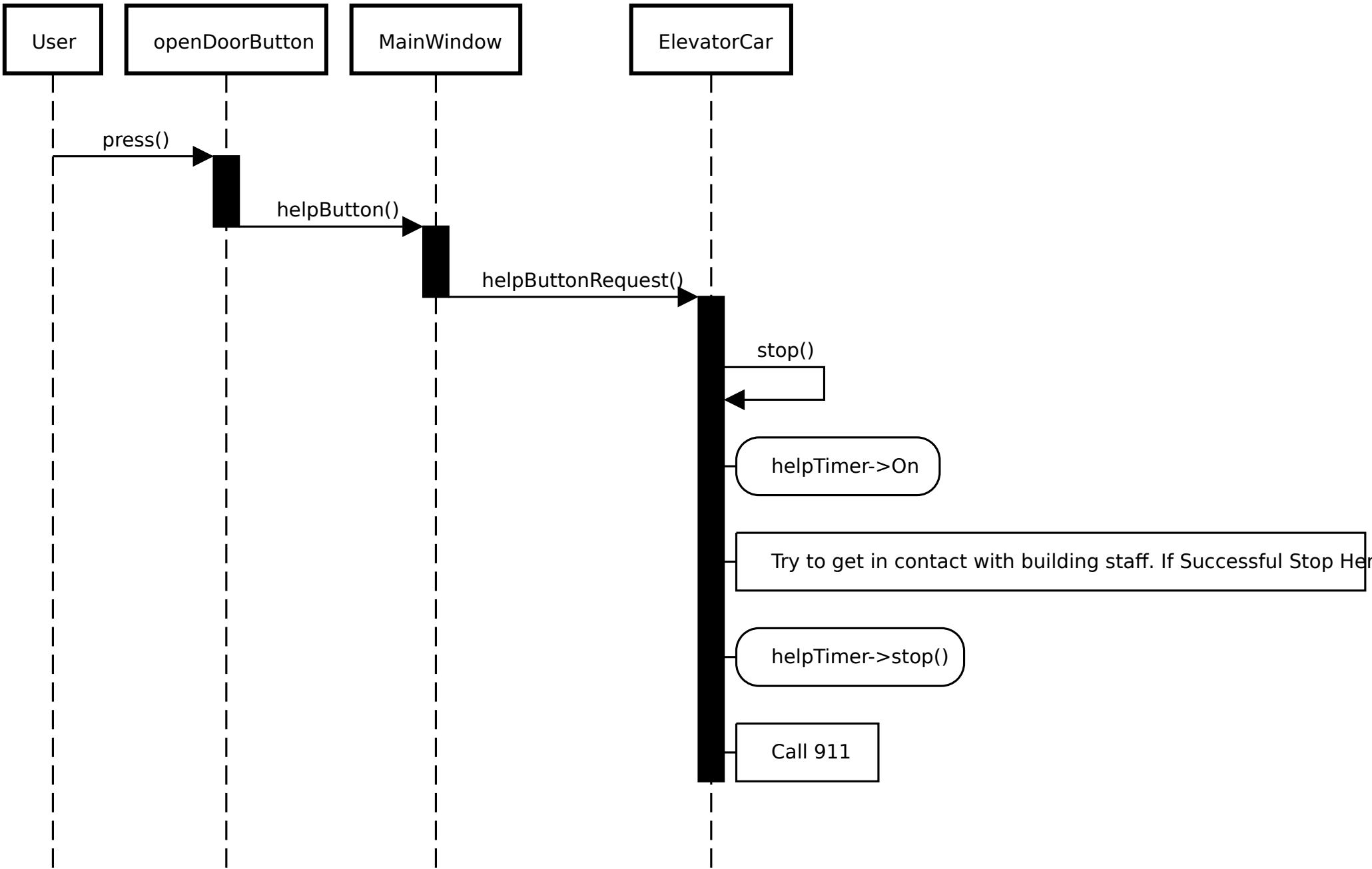
Sequence Diagram 1-2 (Basic Use Case - Open-Door Button)



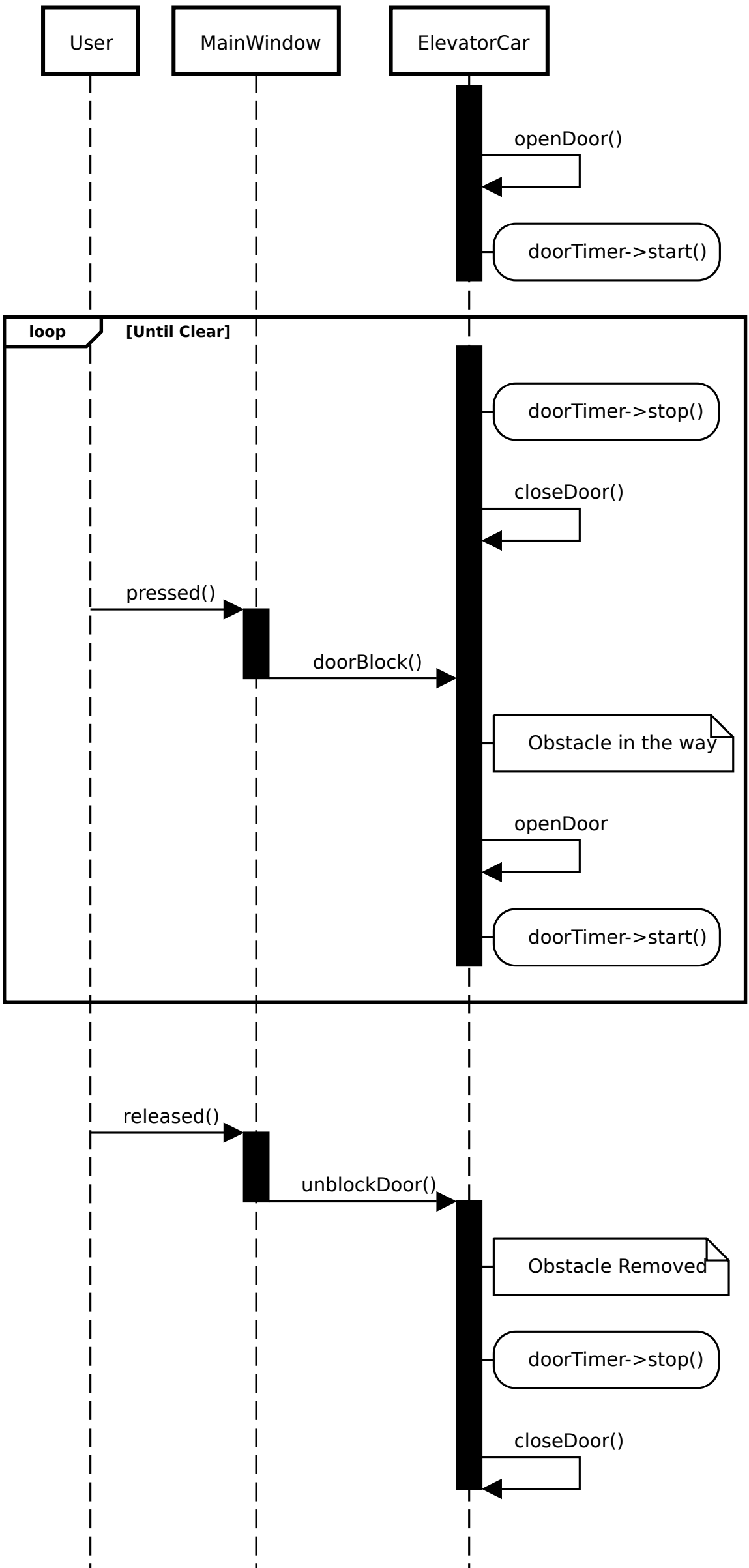
Sequence Diagram 1-3 (Basic Use Case - Close-Door Button)

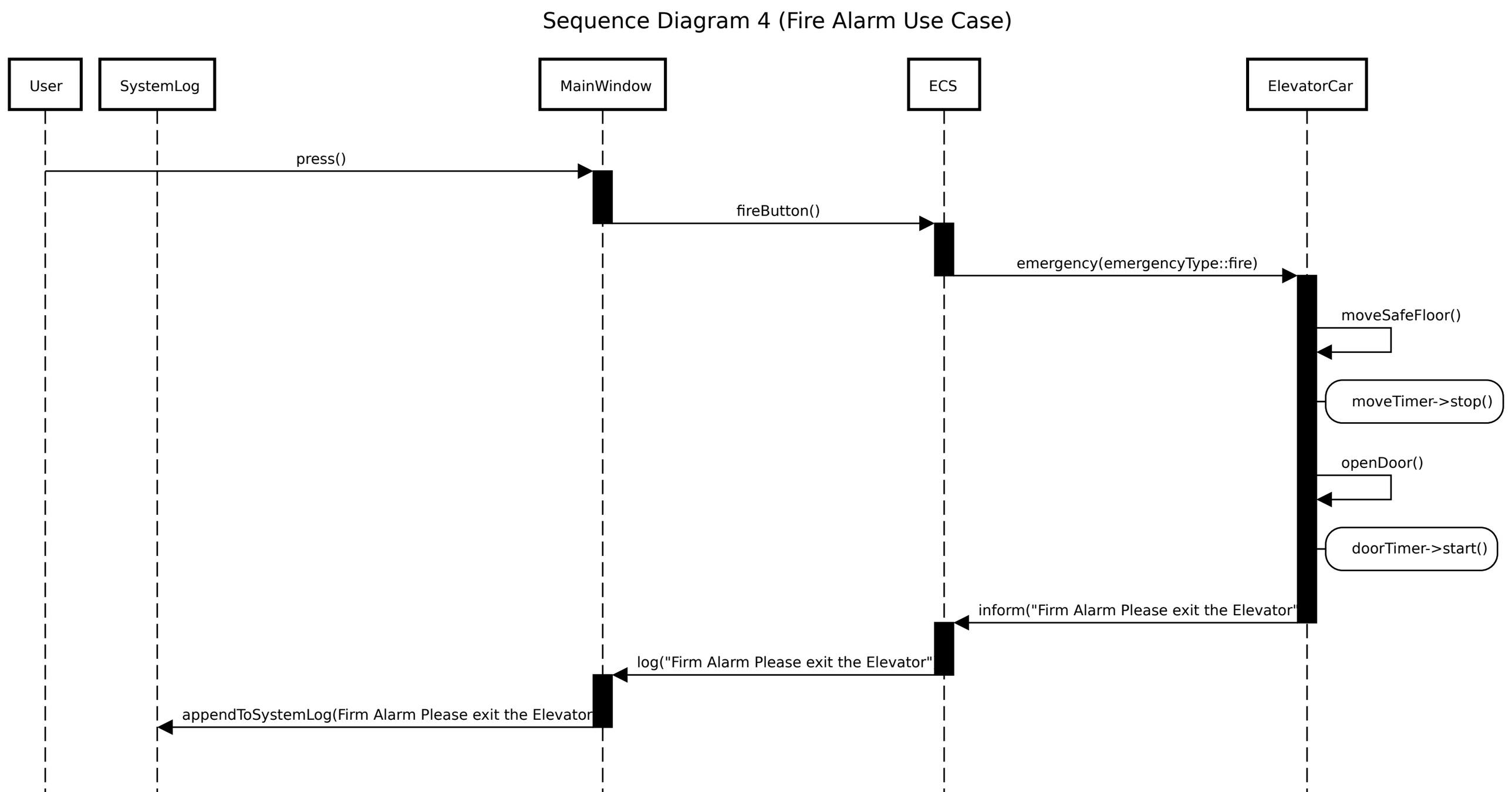


Sequence Diagram 2 (Help Button Use Case)

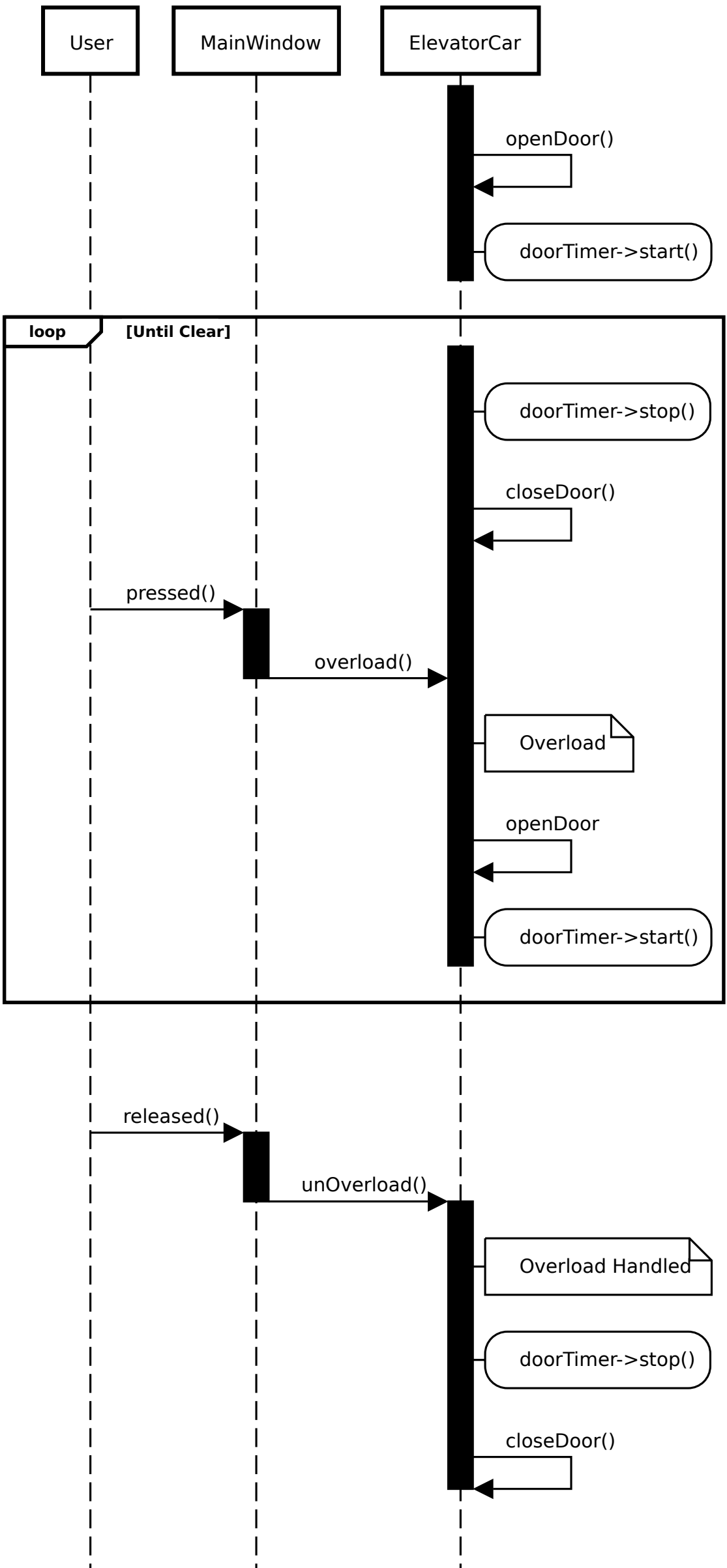


Sequence Diagram 3 (Obstacles Use Case)

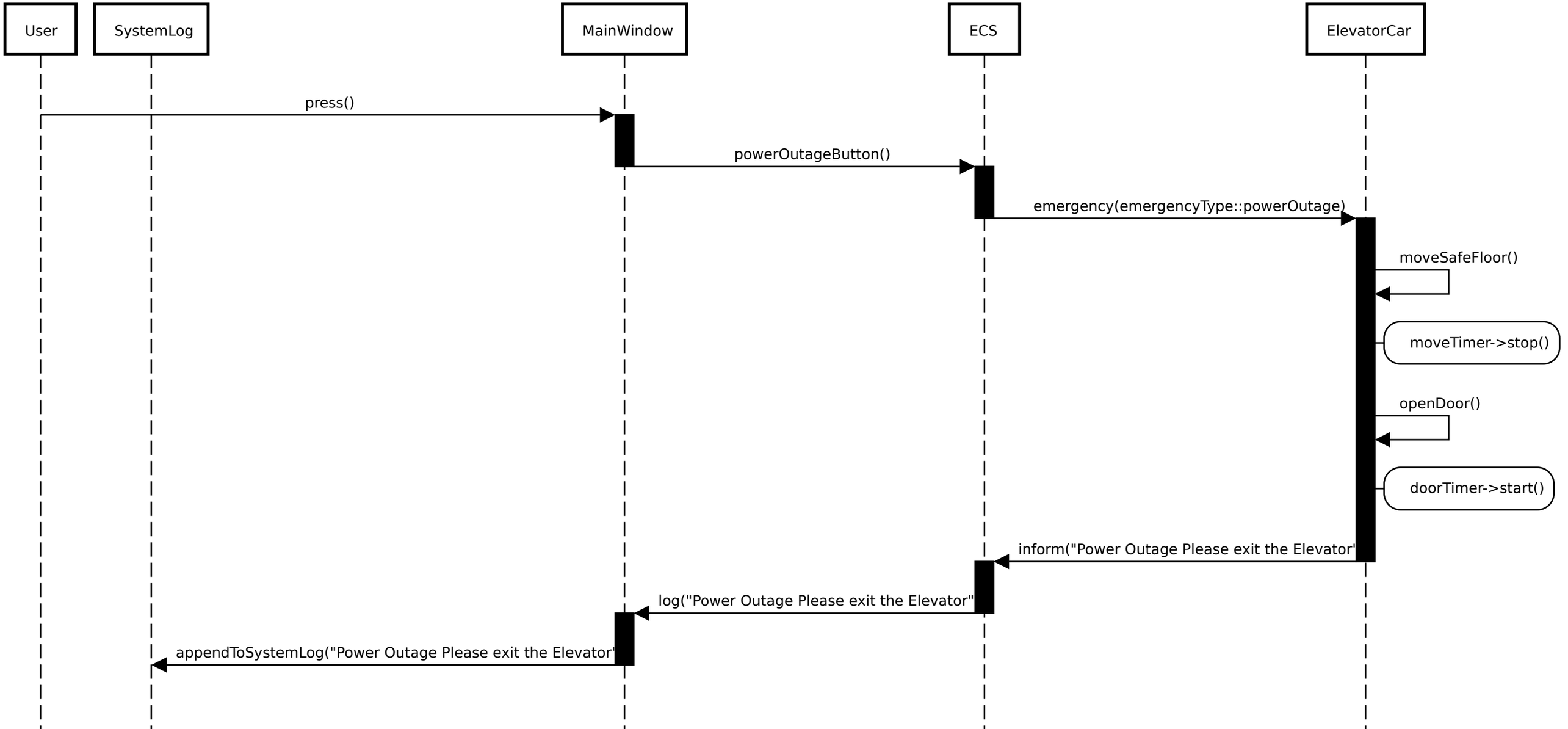



Sequence Diagram 4 (Fire Alarm Use Case)
User
SystemLog
MainWindow
ECS
ElevatorCar
press()
fireButton()
emergency(emergencyType::fire)
moveSafeFloor()
moveTimer->stop()
openDoor()
doorTimer->start()
inform("Firm Alarm Please exit the Elevator"
log("Firm Alarm Please exit the Elevator"
appendToSystemLog(Firm Alarm Please exit the Elevator

Sequence Diagram 5 (Overload Use Case)



Sequence Diagram 6 (Power Outage Use Case)



Traceability Matrix

ID	Requirement	Related Use Case or Related System	Fulfilled By	Tested-by	Description
1	The building is serviced by M elevators.	Building Design	MainWindow.ui	Run the simulator in Qt to observe the ui.	A building has multiple elevators (also called cars) to transport passengers between floors.
2	On each of the N floors is a pair of buttons marked “up” and “down”.	USE CASE 1: Pressing Floor Button	MainWindow.ui	Run the simulator in Qt to observe the ui (floor panel).	Each floor has a pair of buttons to request an elevator going in a certain direction.
3	An elevator rings a bell, opens its doors, and proceeds to another floor.	USE CASE 2: Elevator Arrival	MainWindow.ui, ElevatorCar	Elevators moves and log there movements in the UI	When an elevator arrives at a floor, it rings a bell, opens its doors (the elevator and floor doors), and then proceeds to another floor.
4	Passengers can select one or more destination floors using a panel of buttons.	USE CASE 3: Selecting Destination Floor	MainWindow.ui, ElevatorCar	Run the simulator in Qt to observe the ui (elevator panel).	Inside the elevator, passengers can select one or more destination floors using a panel of buttons.
5	The elevator has a display which shows passengers the current floor of the elevator.	Display And Audio System	MainWindow.ui, ElevatorCar	Elevators moves and log there movements in the UI	Inside the elevator, there is a display that shows passengers the current floor number.
6	There is a pair of buttons on the elevator control panel marked “open door” and “close door”.	USE CASE 4: Overriding Door Timing	MainWindow.ui, ElevatorCar	Run the simulator in Qt to observe the ui (elevator panel).	Inside the elevator, there is a pair of buttons to open or close the elevator doors.
7	The door will remain open beyond its default period if	USE CASE 4: Overriding Door	MainWindow.ui, ElevatorCar	Run the simulator in Qt to observe the ui	If the "open door" button is held down, the elevator doors will remain open for a longer

	the “open door” button is held depressed.	Timing		hold the buttons on the elevator panel.	period.
8	The doors can be closed prematurely by pressing the “door close” button.	USE CASE 4: Overriding Door Timing	MainWindow.ui, ElevatorCar	Run the simulator in Qt to observe the ui press the buttons on the elevator panel.	If the "door close" button is pressed, the elevator doors will close prematurely.
9	Each elevator has a sensor that notifies it when it arrives at a floor.	Elevator Sensors	ECS	Elevators moves and log there movements in the UI	Each elevator has a sensor that detects when it arrives at a floor.
10	The elevator control system should ensure that the group of elevators services all (floor and on-board) requests expeditiously.	Elevator Control System Algorithm	MainWindow.ui, ECS	Depending on Allocation Strat the ECS makes those decisions	The elevator control system should efficiently handle all requests from both floors and passengers inside the elevator.
11	Each elevator has a display and an audio system.	Display And Audio System	MainWindow.ui, ElevatorCar	Elevators log there movements in the UI	Each elevator has a display and an audio system that shows current floor numbers and warning messages that are synced with audio warnings.
12	Help button linked to building safety service.	USE CASE 6: Help Button	MainWindow.ui, ElevatorCar, ECS	Elevator Panel in UI Have a button to test this	Inside the elevator, there is a help button that connects passengers to the building safety service.
13	The control system receives a “Help” alarm signal from an elevator indicating that the “Help” button has been pressed.	USE CASE 6: Help Button	MainWindow.ui, ElevatorCar, ECS	Elevator Panel in UI Have a button to test this	The control system receives a "Help" alarm signal when a passenger presses the "Help" button inside the elevator.

14	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.	USE CASE 6: Help Button	MainWindow.ui, ElevatorCar, ECS	ECS handled and makes calls	If there is no response from building safety within 5 seconds, or if there is no response from a passenger, the control system places a 911 emergency call.
15	The control system stops the door from closing and opens it if the light sensor is interrupted.	USE CASE 5: Door Obstacle	MainWindow.ui, ElevatorCar	Passenger View in UI Have a button to test this	If the light sensor is interrupted when the door is closing, the control system stops the door from closing and opens it.
17	Fire alarm	USE CASE 7: Fire Alarm	MainWindow.ui, ElevatorCar, ECS	Admin View in UI Have a button to test this	The control system receives a "Fire" alarm signal from the building or elevator, and commands all elevators to move to a safe floor. Once the safe floor is reached, an audio and text message is presented to passengers informing them of the fire and asking them to leave the elevator.
18	Overload alarm	USE CASE 8: Overload Alarm	MainWindow.ui, ElevatorCar	Admin View in UI Have a button to test this	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.
19	Power outage alarm	USE CASE 9: Power Outage	MainWindow.ui, ElevatorCar, ECS		The control system receives a "Power Out" alarm signal. In that case, an audio and a text message are presented to passengers informing them of the power outage. Each

					elevator is then moved to a safe floor, and passengers are asked to leave the elevator via audio and text messages. The battery backup power is sufficient to do all of this.