Use case

Name: Elevator Operation

Primary Actor:
Passengers

Stakeholders and Interests:
Passengers: Interested in transportation between floors.
Building Administrators: Interested in the overall safety and performance of the elevator system.
Safety Service: Monitors help button for emergencies.

Pre-condition:
The building is equipped with 3 operational elevators
There are active requests for elevator service.

Success Guarantee:
Customers are safely transported to their selected destination floors.
Elevators respond to floor requests.

Main Success Scenario:

1. The customer presses the "up" or "down" button on a floor.
2. The button illuminates, indicating the request.
3. The elevator control system dispatches an available elevator to the requested floor.
4. Upon arrival, the elevator rings a bell and opens its doors for 10 seconds.
5. Customers enter or exit the elevator during the door open period.
6. The elevator rings the bell again and closes its doors, proceeding to another floor.
7. On-board passengers select the destination floors using the panel of buttons.
8. The elevator displays the current floor, and the audio system provides warnings.
9. The elevator proceeds to the selected destination floors.
10. The process repeats for subsequent requests.

Extensions:

4a. The "open door" button is held, the elevator doors remain open beyond 10 seconds.
4b The elevator door is open, the floor door remains closed.

Name: Help Assitant

Primary Actor:
Passenger
Stakeholders and Interests:
Passenger: Requires immediate assistance in an emergency.

Building Safety Service: Responsible for responding to help alarms promptly.

Pre-condition:
An elevator has received a "Help" alarm signal.
The control panel is functional.

Success Guarantee:
The passenger is connected to building safety service through a voice connection.
Building safety service responds within 5 seconds.

Main Success Scenario:

1. The passenger inside the elevator presses the "Help" button.
2. The elevator sends a "Help" alarm signal to the control system.
3. The control system initiates a voice connection between the passenger and building safety service.
4. Building safety service responds to the help alarm.
5. If there is no response from building safety within 5 seconds, or if there is no response from the passenger, a 911 emergency call is automatically placed.

Extensions:

1a. the passenger cancels the "Help" request, the system ends the assistance process.
5a. the 911 emergency call cannot be completed

Name: Door Obstacles Handling

Primary Actor:
Elevator Control System

Stakeholders and Interests:
Building Maintenance: Interested in the proper functioning of the elevator system.

Pre-condition:
The elevator is operational.
The door is in the process of closing.

Success Guarantee:
The control system responds appropriately to door obstacles.
Warnings are sounded and a text message is displayed in case of repeated obstacles.

Main Success Scenario:

1. The elevator door starts closing.

2. The light sensor detects an obstacle in the doorway.
3. The control system stops the door from closing and opens it to prevent injury or damage.
4. If this occurs repeatedly over a short period, a warning is sounded over the audio system.
5. A text message is displayed on the elevator's control panel to alert passengers and maintenance.

Extensions:

4a. obstacles persist, and warnings are ignored.

Name: Fire Emergency Response

Primary Actor:
Elevator Control System, Fire Alarm System

Stakeholders and Interests:
Passengers: Interested in a safe evacuation during a fire emergency.
Building Management: Interested in efficiently responding to fire alarms and ensuring passenger safety.

Pre-condition:
A "Fire" alarm signal is received by the elevator control system or from the building fire alarm system.

Success Guarantee:
All elevators are moved to safe floors.
Passengers are informed of the emergency and asked to disembark once the safe floor is reached.

Main Success Scenario:

1. The elevator control system receives a "Fire" alarm signal from the building or an individual elevator.
2. The control system commands all elevators to move to a predefined safe floor.
3. An audio message is played, and a text message is displayed inside each elevator, informing passengers of the fire emergency.
4. Passengers are instructed to disembark once the elevators reach the designated safe floor.
5. Elevators remain on the safe floor.

Extensions:

2a. the safe floor is unreachable due to the fire's location or other factors, the elevators move to the nearest possible safe floor.
2b. there is a failure in the elevator control system
4a. passengers refuse to disembark.

Name: Overload Handling

Primary Actor:
Elevator Control System

Stakeholders and Interests:
Passengers: Interested in a safe and efficient elevator operation.
Building Management: Interested in ensuring compliance with elevator load capacity for safety

Pre-condition:
An "Overload" alarm signal is received by the elevator control system.

Success Guarantee:
The elevator remains stationary until the load is reduced within the acceptable capacity. Passengers are informed through audio and text messages about the overload condition and the need to reduce the load.

Main Success Scenario:

1. The elevator control system receives an "Overload" alarm signal from the elevator sensors.
2. The elevator is prevented from moving to avoid potential safety hazards due to excess load.
3. An audio message is played, and a text message is displayed inside the elevator, notifying passengers of the overload condition.
4. Passengers are informed that the elevator will not move until the load is reduced within the acceptable capacity.
5. Passengers are asked to disembark any excess cargo or passengers to meet the safety requirements.
6. Once the load is reduced, the elevator resumes normal operation.

Extensions:

6a. the overload condition persists despite passengers' attempts to reduce the load.

Name: Power Outage Handling

Primary Actor:
Elevator Control System

Stakeholders and Interests:
Passengers: Interested in a safe evacuation and communication during a power outage.
Building Management: Interested in the orderly response to a power outage and ensuring passenger safety.

Pre-condition:
A "Power Out" alarm signal is received by the elevator control system.

Success Guarantee:
Each elevator is moved to a safe floor.
Passengers are informed through audio and text messages about the power outage.
Passengers disembark safely using battery backup power.

Main Success Scenario:

1. The elevator control system receives a "Power Out" alarm signal.
2. An audio message is played, and a text message is displayed inside each elevator, notifying passengers of the power outage.
3. The control system commands each elevator to move to a predefined safe floor using battery backup power.
4. Passengers are informed through audio and text messages that the elevator has reached a safe floor and are asked to disembark.
5. The battery backup power is sufficient to carry out these operations.

Extensions:

5a. The battery backup power is insufficient.

Discussions

Class diagram:

The centralized elevator class diagram has a central controller class to process all floor and elevator requests and then assigns elevators to service these requests based on specific criteria, such as location, direction, and load. It also handles emergencies like fire alarms, help assistance, etc.

In a decentralized diagram, the elevator makes its own decisions on responding to calls based on shared information among elevators such as updated locations. There's no controller; elevators communicate with each other to coordinate their movements and service requests.

The sequence diagram illustrates two successful scenarios that simulate distinct situations. In the first scenario, after a passenger reaches the destination floor, the elevator remains on that floor. Subsequently, when the next passenger sends an elevator request from a nearby location, the elevator control system evaluates the positions of all elevators and dispatches the closest one. The second scenario envisions a situation where all three passengers are on the first floor, showcasing the system's ability to efficiently manage and respond to concurrent service requests

Comparison between two design:
Centralized systems have a top-down approach to control and coordination, while decentralized systems rely on a bottom-up approach, with each elevator participating in decision-making. The impact of a failure in a centralized system can be more significant, potentially affecting the entire system, compared to a decentralized system where the failure of one unit has a lesser impact on the overall system operation.

Requirements Traceability matrix

Centralized Elevator

ID	Requirement	Relative Use Case	Fulfilled by
1	A building is serviced by M elevators (also called cars).	Elevator Operation	Floor and Elevator class

	On each of the N floors is a pair of buttons marked “up” and “down”.		
2	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	Elevator Operation	Floor class(when passenger press floor buttons on each floor) Elevator controller(dispatch elevators) , elevator class, Button class
3	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.	Elevator Operation	Elevator, Button class
4	Once on-board passengers select one or more destination floors using a panel of buttons; there is one button for every floor.	Elevator Operation	Passenger class, Elevator, Button class
5	The elevator has a display which shows passengers the current floor of the elevator.	Elevator Operation	Elevator class void displayFloor(); void showMessage(const string& message)

6	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	Elevator Operation	Elevator class
			void goToFloor(int floor);
			void openDoors();
			void closeDoors();

7	Inside the elevator there is also a help button linked to building safety service	Elevator Operation	Safety Service, elevator, elevator control class.
8	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.	Elevator Operation	Sensor, Elevator controller class

9	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
		Elevator Operation	Elevator class,
			void displayFloor();
			void showMessage(const string& message);
			void audioWarning();

10	The control system receives a “Help” alarm signal from an elevator indicating that
	the “Help” button has been pressed.
		Help Assistant	Elevator, elevator control class
			void receiveHelpAlarm(Elevator* elevator);
			void sendleHelpAlarm();

11	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		void connectToSafetyService(); void placeEmergencyCall();
12	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.	Door Obstacles	Sensor, Elevator class bool checkDoorObstacle();
13	The control system receives a “Fire” alarm	Fire Alarm	Elevator, controller, sensor class

	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.
			void fireAlarm(bool internal);
			void handleBuildingFireAlarm();
			
			bool detectFire();

14	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
		Overload	Sensor:
			bool checkOverload();
			Elevator:
			void sensorTriggered();

15	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
		Power Outage	Elevator :
			void powerOut();
			
			ElevatorController:
			void handlePowerOutage();

Decentralized Elevator

ID	Requirement	Relative Use Case	Fulfilled by
1	A building is serviced by M elevators (also called cars). On each of the N floors is a pair of buttons marked “up” and “down”.	Elevator Operation	Floor and Elevator class
2	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	Elevator Operation	Floor class(when passenger press floor buttons on each floor) Elevator class (dispatch elevators), Button class
3	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.	Elevator Operation	Elevator, Button class
4	Once on-board passengers select one or more destination floors using a panel of buttons; there is one button for every floor.	Elevator Operation	Passenger class, Elevator, Button class
5	The elevator has a display which shows passengers the current floor of the elevator.	Elevator Operation	Elevator class void displayFloor(); void showMessage(const string& message)

6	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	Elevator Operation	Elevator class
			void goToFloor(int floor);
			void openDoors();
			void closeDoors();

	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		
7	Inside the elevator there is also a help button linked to building safety service	Elevator Operation	Safety Service, elevator.
8	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.	Elevator Operation	Sensor, Elevator class

9	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	Elevator Operation	Elevator class,
			void displayFloor();
			void showMessage(const string& message);
			void audioWarning();

10	The control system receives a “Help” alarm signal from an elevator indicating that the “Help” button has been pressed.	Help Assistant	Elevator:
			void receiveHelpAlarm(Elevator* elevator);
			void sendleHelpAlarm();

11	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		void connectToSafetyService(); void placeEmergencyCall();
12	If the light sensor is interrupted when the door is closing, the control system stops the door from closing and opens it. If this	Door Obstacles	Sensor, Elevator class bool checkDoorObstacle();

	occurs repeatedly over a short period of time, a warning is sounded over the audio system and a text message is displayed.		

13	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.
		Fire Alarm	Elevator, sensor class
			void fireAlarm(bool internal);
			void handleBuildingFireAlarm();
			
			bool detectFire();

14	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
		Overload	Sensor:
			bool checkOverload();
			Elevator:
			void sensorTriggered();

15	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	Power Outage	Elevator: void handlePowerOutage();

	messages. The battery backup power is sufficient to do all of this		