

# SYSC3303

## Real Time Concurrent Systems

### Elevator Control System Final Project Report



#### Group B1-G1

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# 1 - Breakdown of Team Member Contributions

## Iteration 1:

- Scheduler subsystem: Liam Kavanagh
- Floor subsystem: Matthew Huybregts
- Elevator subsystem: Sean Pruss
- Test code: Joshua Robson
- UML diagrams and README: Abed Qubbaj

## Iteration 2:

- Liam Kavanagh: Scheduler State Diagram and Scheduler Coding
- Matthew Huybregts: Floor refactor and Scheduler Coding
- Sean Pruss: Elevator State Diagram and Elevator Coding
- Joshua Robson: JUnit tests
- Abed Qubbaj: Class diagram, sequence diagram and README.md

## Iteration 3:

- Liam Kavanagh: Scheduler algorithm and coding
- Matthew Huybregts: Coding, debugging, refactoring
- Sean Pruss: Debugging, also helped out with JUnit tests
- Joshua Robson: JUnit tests
- Abed Qubbaj: Updated diagrams and README.md

## Iteration 4:

- Liam Kavanagh: Implementing Door Faults and coding
- Matthew Huybregts: Implementing Timer Class
- Sean Pruss: Timing Diagrams
- Joshua Robson: JUnit tests, Debugging, Coding
- Abed Qubbaj: Updated diagrams and README.md

## Iteration 5:

- Liam Kavanagh: Implementing GUI
- Matthew Huybregts: Implementing Capacity Limits
- Sean Pruss: Implementing GUI
- Joshua Robson: JUnit tests, Debugging, Updated UML Diagrams
- Abed Qubbaj: Updated diagrams and README.md

## 2 - Diagrams of the Elevator System

### 2.1 UML Class Diagrams

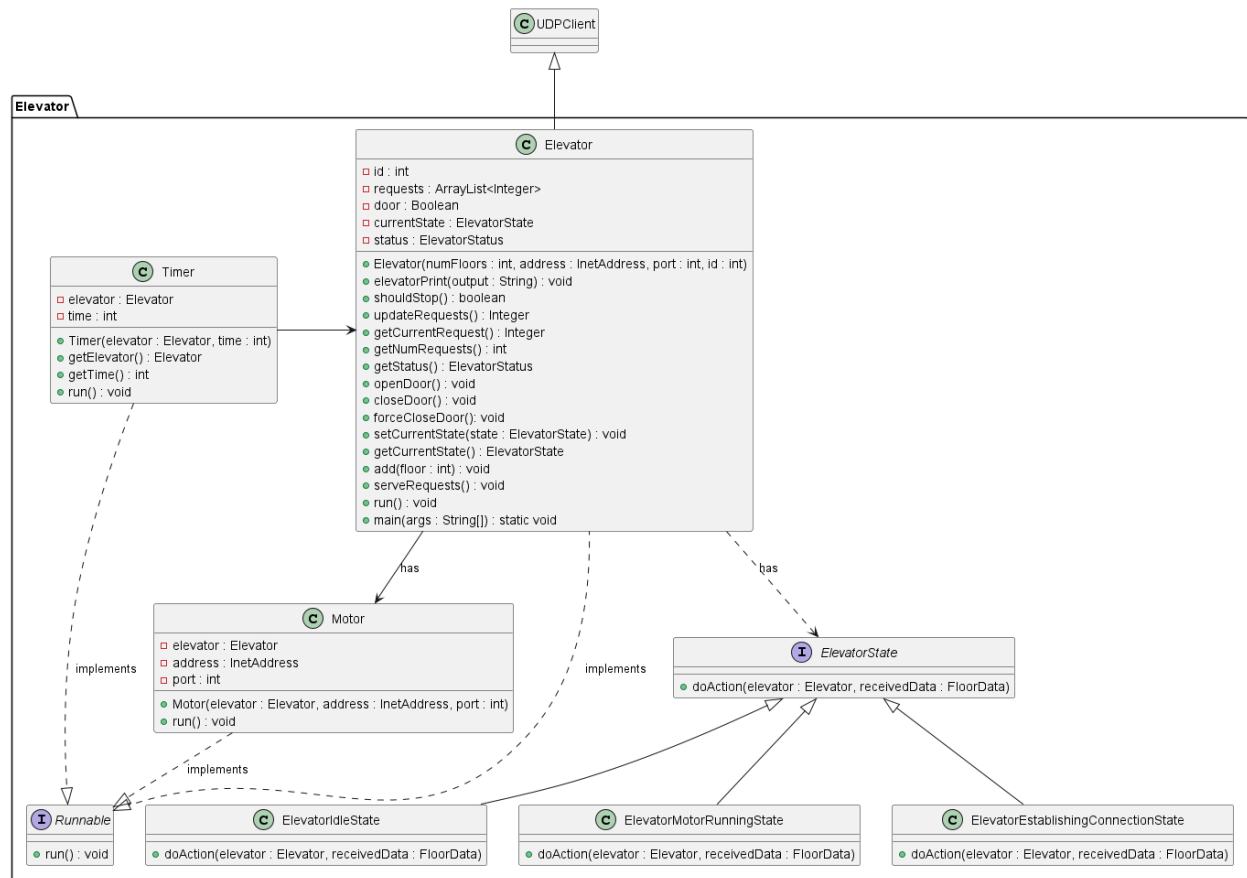


Figure 1: Elevator Class Diagram

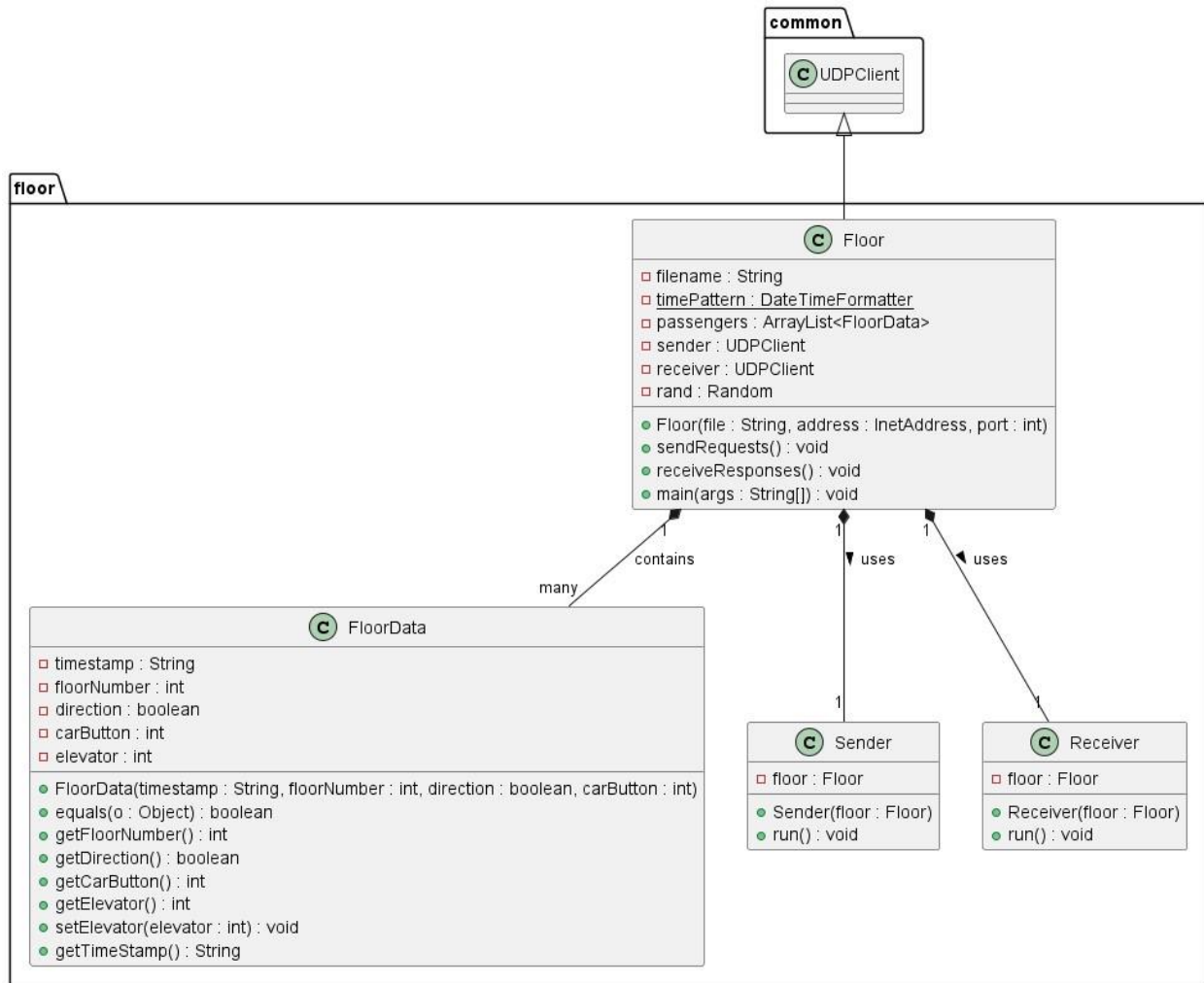


Figure 2: Floor Subsystem Diagram

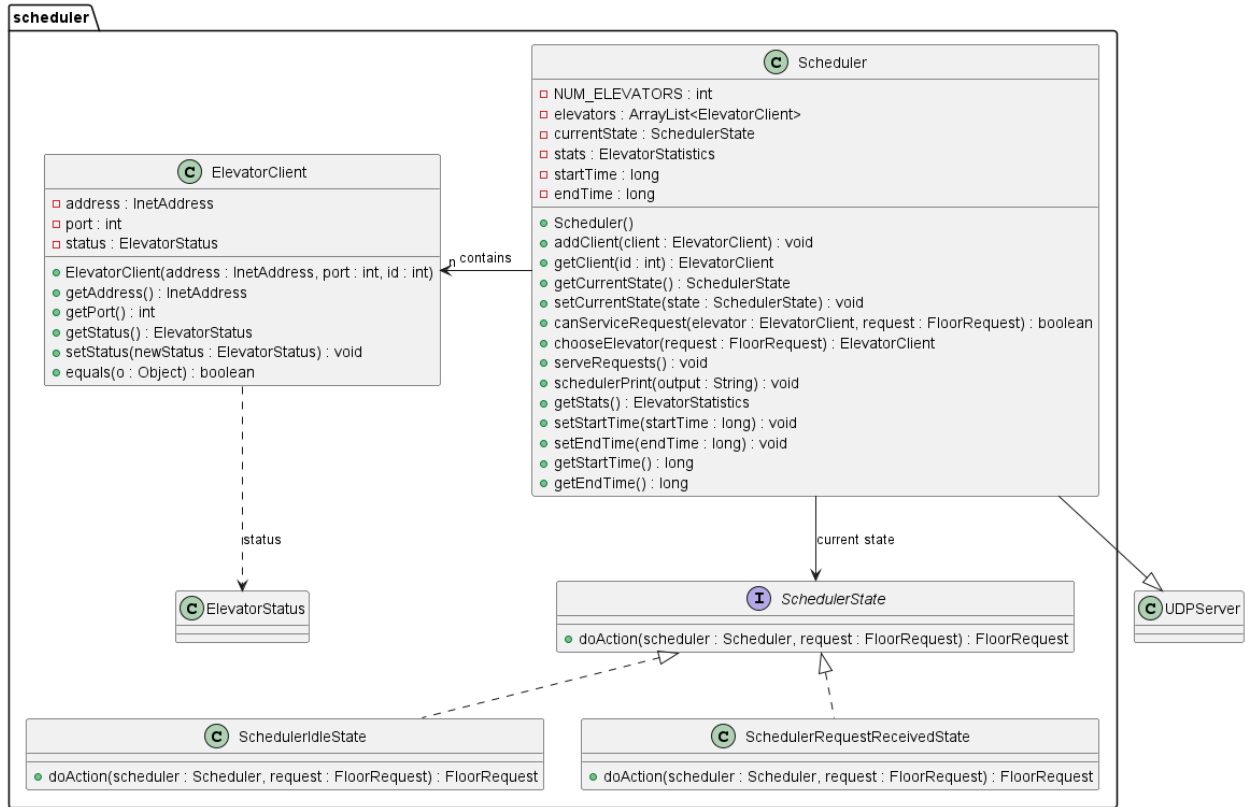


Figure 3: Scheduler Subsystem Diagram



Figure 4: Common Subsystem Diagram

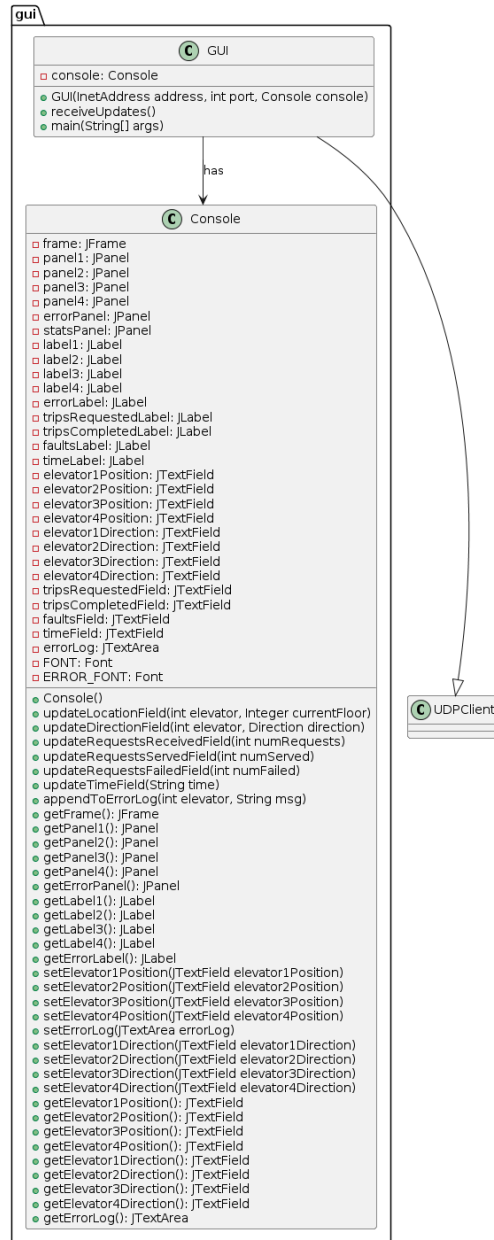


Figure 5: GUI subsystem diagram



## 2.2 - State Machines

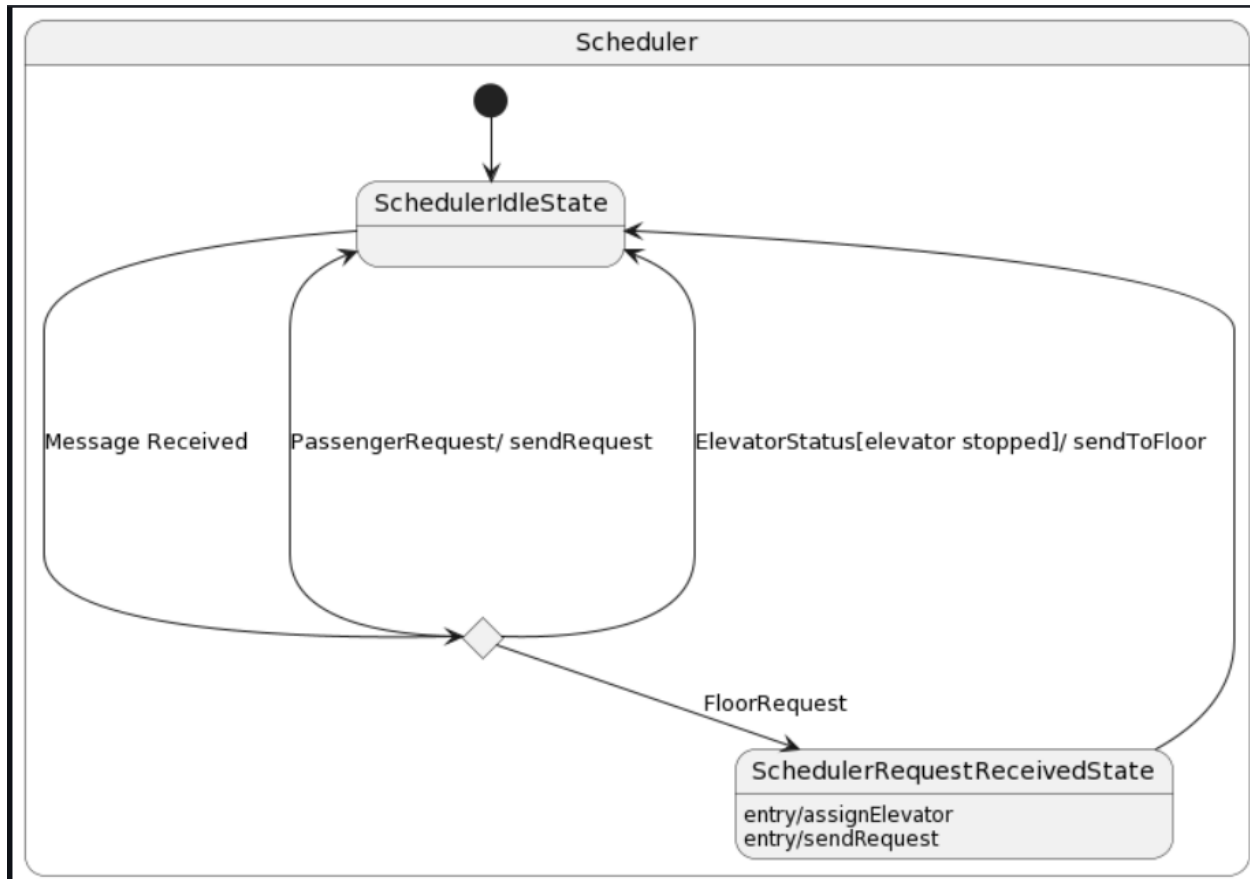


Figure 6: Scheduler State Diagram

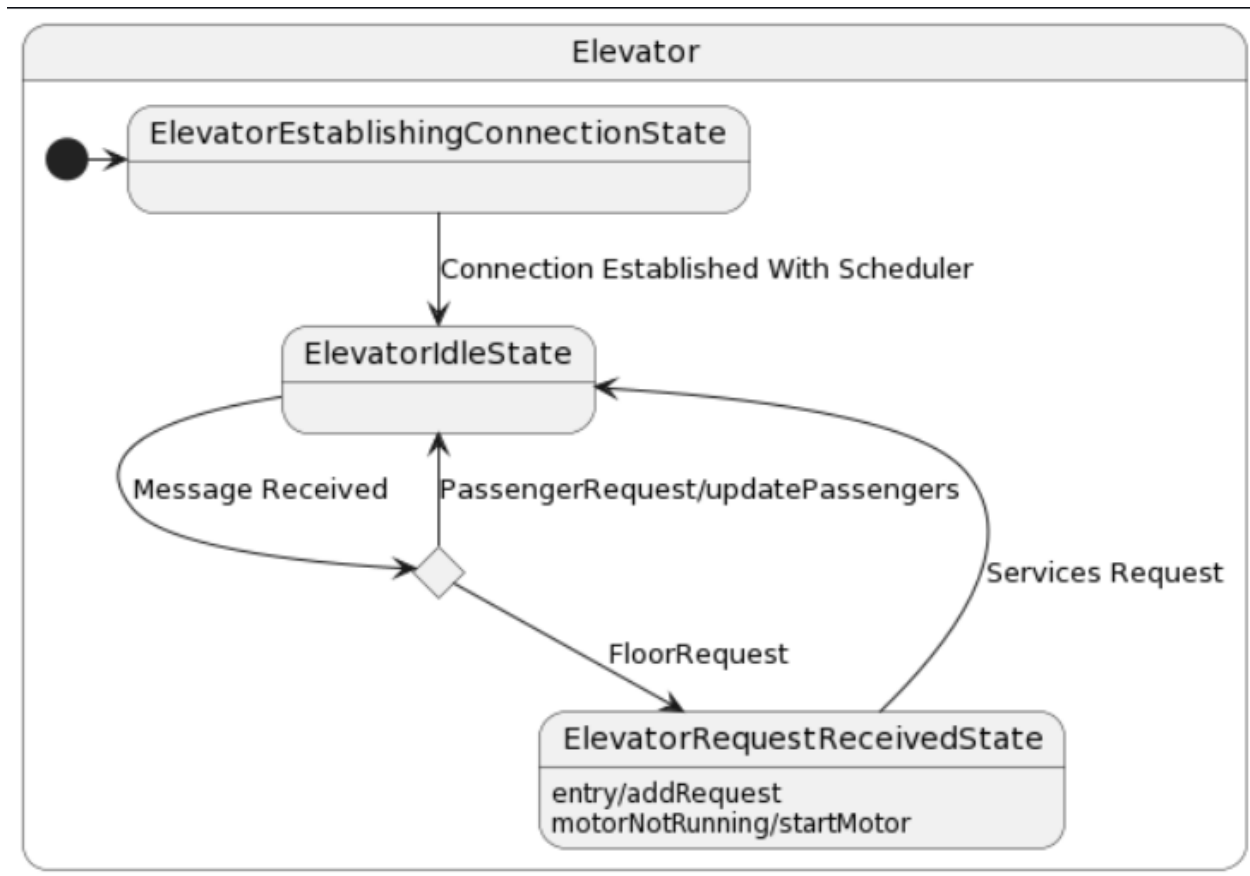


Figure 7: Elevator State Diagram

## 2.3 - Sequence Diagrams

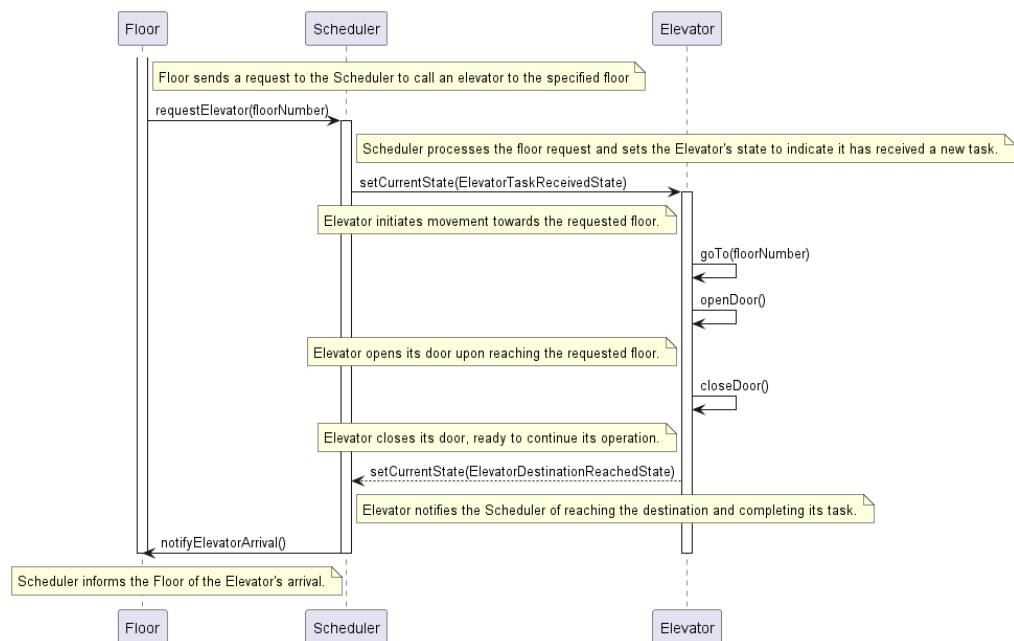


Figure 8: Elevator System Sequence Diagram

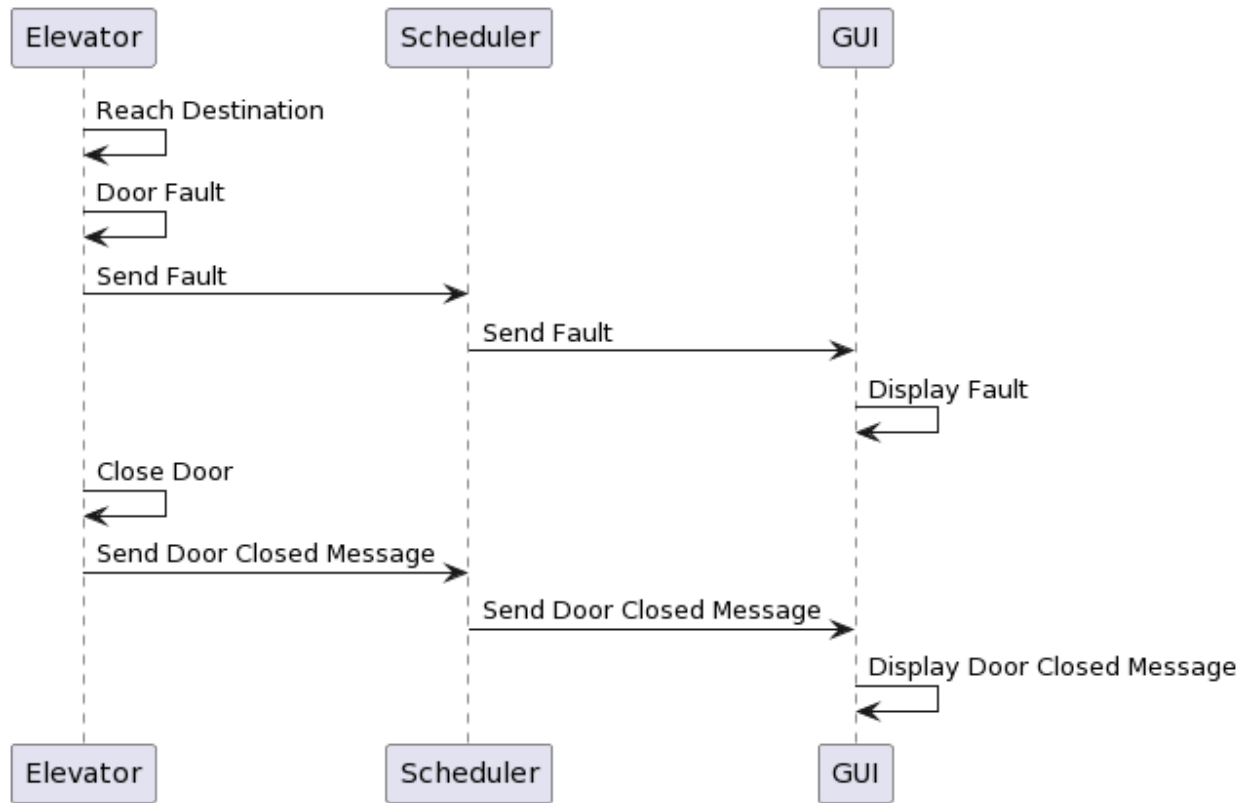


Figure 9: Door Fault Sequence Diagram

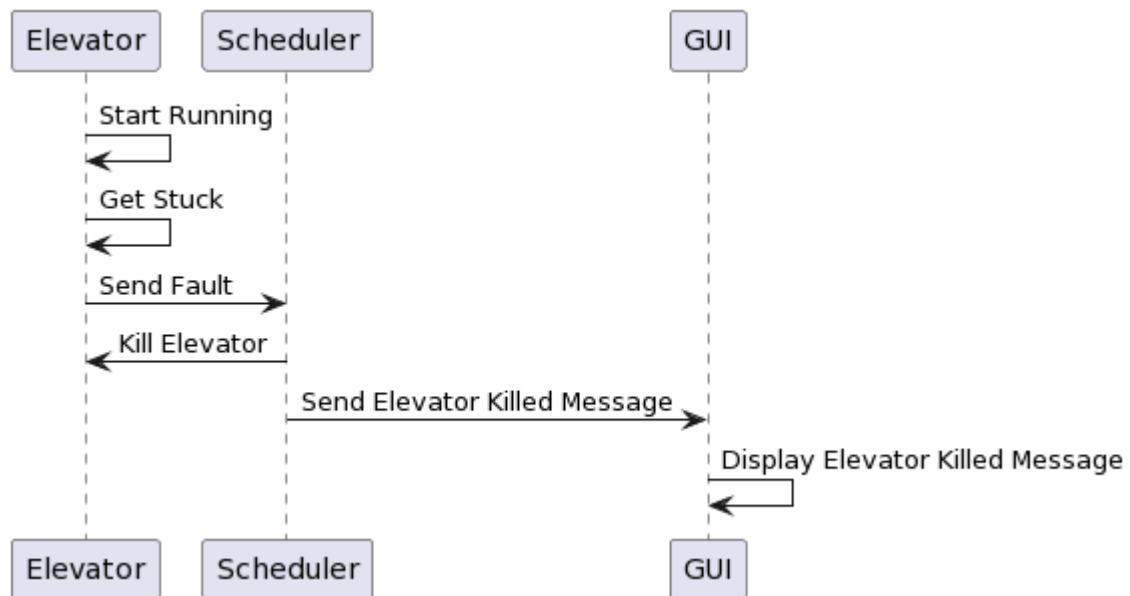


Figure 10: Elevator Stuck Fault Sequence Diagram

## 2.4 - Timing Diagrams



Figure 11: Elevator too slow to reach destination diagram

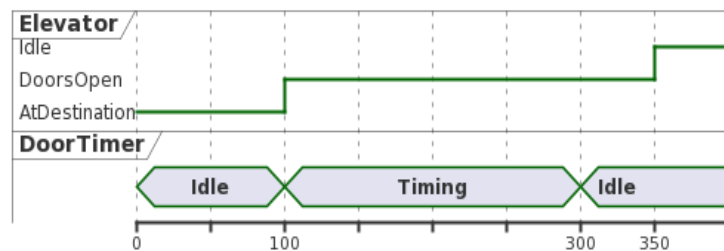


Figure 12: Elevator doors stuck open timing diagram

## 3 - Detailed Set-Up and Instructions

### Requirements

Java SDK 21, and Language Level set to Default SDK in IntelliJ.

### Usage

**[IMPORTANT]** Run the files in this order for the system to initialize properly

1. Run `scheduler.Scheduler.java`
2. Run `gui.GUI.java`
3. Run `elevator.Elevator.java`
4. Run `floor.Floor.java`

**Running Test Cases:** Run them in any order and anytime as they are independent of each other and the system files

## Input File Format

The floor.Floor subsystem reads input from a file, and each line in the file represents an event. The format is as follows:

[timestamp] [floor\_number] [direction (up/down)] [requested\_floor]

## 4 - Result from the Measurements

|    | A                                       | B                                 | C   | D                                  |
|----|---|-----------------------------------|---|------------------------------------|
| 1  | Split                                   | Total Time (s)                    | Loading Time (note we were only able to get samples for 2 people) | Time Between Floors (Column B - C) |
| 2  | 1 (total and loading time is junk data) | 4.85                              | 0   | 4.85                               |
| 3  | 2                                       | 19.82                             | 12.29   | 7.53                               |
| 4  | 3                                       | 17.37                             | 11.67   | 5.7                                |
| 5  | 4                                       | 18.17                             | 10.99   | 7.18                               |
| 6  | 5                                       | 18.2                              | 13.1  | 5.1                                |
| 7  | 6                                       | 19.74                             | 12.33   | 7.41                               |
| 8  | 7                                       | 19.27                             | 12  | 7.27                               |
| 9  | 8                                       | 19.46                             | 12.65   | 6.81                               |
| 10 | 9                                       | 18.31                             | 12.34   | 5.97                               |
| 11 | 10                                      | 18.58                             | 12.87   | 5.71                               |
| 12 | 11                                      | 18.16                             | 12.45   | 5.71                               |
| 13 | 12                                      | 18.3                              | 12.09   | 6.21                               |
| 14 | 13                                      | 18.24                             | 12.53   | 5.71                               |
| 15 | 14                                      | 18.54                             | 13.02   | 5.52                               |
| 16 | 15                                      | 18.32                             | 12.39   | 5.93                               |
| 17 | 16                                      | 18.76                             | 12.78   | 5.98                               |
| 18 | 17                                      | 17.98                             | 11.97   | 6.01                               |
| 19 | 18                                      | 18.51                             | 12.22   | 6.29                               |
| 20 | 19                                      | 18.45                             | 12.91   | 5.54                               |
| 21 | 20                                      | 20.62                             | 12.42   | 8.2                                |
| 22 | 21                                      | 18.16                             | 12.56   | 5.6                                |
| 23 |   |                                   |   |                                    |
| 24 | Mean                                    | 18.99                             | 12.425  | 5.225                              |
| 25 | Standard Deviation                      | 1.173797257                       | 0.190918831   | 0.530330086                        |
| 26 | Confidence Interval (95% confidence)    | 18.475, 19.504                    | 12.34, 12.509   | 4.999, 5.452                       |
| 27 |   |                                   |   |                                    |
| 28 | Split                                   | Time (not including loading time) |   |                                    |
| 29 | 1                                       | 34.05                             |   |                                    |
| 30 | 2                                       | 34.69                             |   |                                    |
| 31 |   |                                   |   |                                    |
| 32 | Mean                                    | 34.37                             |   |                                    |
| 33 | Standard Deviation                      | 0.45254834                        |   |                                    |
| 34 | Confidence Interval (95% Confidence)    | 33.743, 34.997                    |   |                                    |
| 35 |   |                                   |   |                                    |

Figure 13: Excel sheet of the Data collection

### Assumptions:

- There is a distance of 4 meters between floors
- The rate of acceleration is the same as that of the deceleration
- Assume the rate of acceleration is the same no matter the number of floors
- For an adjacent floor, the elevator never maintains a constant speed. It speeds up and slows again

#### 1. Average Speed (Adjacent Floors)

$$v = \Delta d / \Delta t$$

$$v = 4m / 5.225s$$

$$v = 0.766m/s$$

## 2. Average Speed (Multiple Floors)

$$v = \Delta d / \Delta t$$

$$v = 84m / 34.37s$$

$$v = 2.44m/s$$

## 3. Acceleration

Since we're assuming that the elevator speeds up and then immediately slows down for a single floor, we will assume the maximum velocity is 1.532 m/s (2x the average).

$$a = v / (t/2)$$

$$a = 1.532m/s / (5.225/2)s$$

$$a = 0.586m/s^2$$

## 4. Max Speed (Multiple Floors)

We estimated it takes around 4.73 seconds for the elevator to reach its top speed based on how it felt (may or may not be accurate)

$$v = at$$

$$v = (0.586m/s^2)(4.73s)$$

$$v = 2.77m/s$$

## 5 - Reflection Of Our Design

### 5.1 Aspects of the Design We Liked

Our design allowed us to easily implement additional features incrementally. When we approached our design, we wanted to reduce the amount of possible refactoring as much as possible so we could focus on new features. Our project is also well structured, with directories for documentation, source code, and library files which are split into subdirectories such as common, elevator, scheduler, floor, and GUI for the src directory. Our GUI was a separate subsystem of the project, which made it a lot easier to implement the scheduler sending updates to it.

### 5.2 What Can Be Improved Upon

One improvement we can add is to make the Scheduler and GUI multithreaded. With a multithreaded Scheduler and GUI, we can process requests from multiple elevators and display them at once. This would increase the throughput through increased parallelism. We should also implement a way to deal with the case in which there is no elevator currently available for a passenger. This could be done by notifying the floor when there are no available elevators and having the floor resend the request after a set time and a maximum number of retries for these requests.