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1. INTRODUCTION

Hospitals need a schedule to show their operations. While doing this, they use data such as the number of operation rooms, the day of the operation, the priority of the patient, and when it will start and end. When these data are ignored, it can lead to bad results such as overlaps in operations, decrease in efficiency, and decrease in patient satisfaction. Therefore, a good operation plan is very important for both the hospital and the patients. In this project, we will make the operation schedule of the hospital called 'Metu Hospital' as the operations are desired. We have been given an excel table with information about the patients who will be operated on. In this table, the patient's name, surname, ID number, the day of the operation, the time interval for the operation, the duration of the operation, and the complexity of the operation are included. There are 3 rooms in total in the Metu Hospital where we can perform these operations. We are asked for an operation schedule in which we place the patients according to the available time intervals using the information that we received from the excel table. These charts were requested to be in the form of Gantt Chart. In addition, we were asked to make these operation schedule separately according to 3 different objectives. The first objective is to maximize the number of operations which is completed within its initial available time interval. The second objective is to

maximize the utilization of the rooms. The third objective is to minimize the late completion time. We aim to schedule 3 different objectives by using object-oriented programming.

2. MAIN BODY

Assumptions and Additional Methods/Properties
Assumptions:

-The sanitisation period of the rooms is not included in the utilization level of the rooms.
- If the postponed operations are not performed within the next day, they will not be included in the schedule again.

Additional Properties and Methods

While designing the project, I had to define additional properties and methods within the classes.

-In Interval Class:

overlap(method): Checks for conflicts between operations

-In Operation class:

operationRoom(property): room number where the operation will take place
patientName(property): name of the patient to be operated on
patientSurname(property): surame of the patient to be operated on

-In Patient class

getPatientName(method): The method that brings the name of the patient to be operated on
getPatientSurname(method): The method that brings the surname of the patient to be operated on
-In Schedule class:

FoVCounter(property): number of operations that fit own available interval.
roomOR(property): Occupancy Ratio of Rooms
priPost(property): Priority level of postponed operations

Reporting(method): method that prints the objective function value, utilization of the rooms, the number of operations shifted in each priority level and the number of operations that are postponed to the next day, values that need to be analyzed for objectives
2.1 Report of the schedule_objective_1

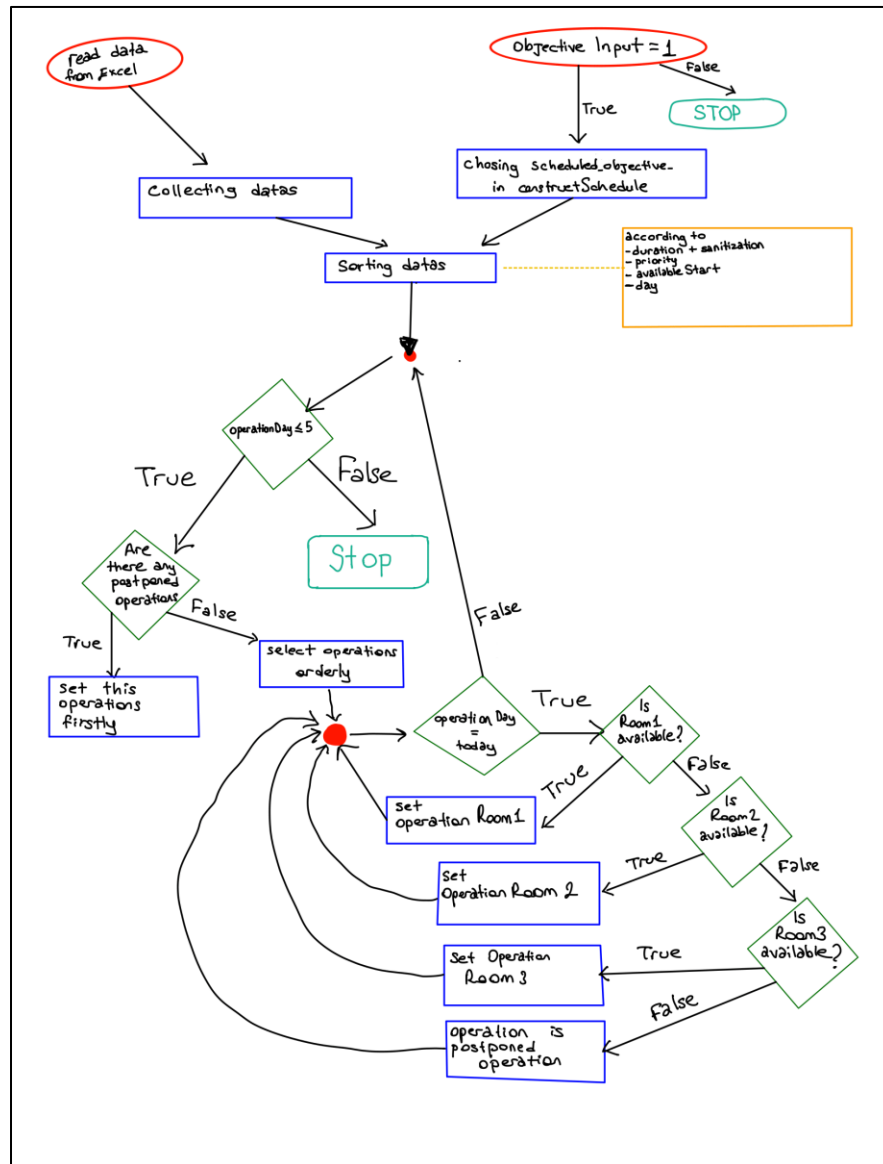### 2.1.1 Flowchart for the schedule_objective_1

Figure 1. *Flowchart for the schedule_objective_1.*

In the schedule_objective_1, we aim to maximize the number of operations which is completed within its initial available time interval. For this, I first started by collecting the data from the excel table. Then we sorted these data according to duration+sanitization, priority, avaliableStart and day values. The reason for this ranking is based on many reasons. When running the algorithm, we start by placing the operations by day, so the day is sorted at the end. This shows that the data is sorted by the last day. The value of avaliableStart indicates the earliest time the operation can start. To operate on as many patients as possible, I assigned this value after the day value. Secondly, I used the priority value because if we don't treat high priority operations first, arranging a room for patients when their operations are delayed can complicate things and cause fewer patients to undergo the operation than desired. First, I sorted them according to the sum of the duration and sanitization values. This total shows how long the room will not be available for another operation. If we order this value from low to high, we can perform more operations. That's why I used these sorting criteria. After finishing

the sorting, we took the day into a loop in order from one to five, and in this loop, we defined the rooms by using interval class methods and properties. Afterwards, we placed the operations, which we initially listed according to certain features, in the rooms according to their availability, if they provide the necessary restrictions. When the days were over, we placed the postponed operations on the next day with priority. Afterwards, we continued the placement process as normal, and we did this every day. At the end of the loop, we obtained the Gantt charts and the values we wanted to examine by using the printSchedule and Reporting methods. Figure 1 shows the flowchart described above. The 5-day planned program can be seen below. Figure 3.1, Figure 3.2, Figure 3.3, Figure 3.4 and Figure 3.5, respectively.

2.1.2 The objective function value

Objective function value = 67

Objective function value means that how many operations are scheduled in the available interval. In scheduled_objective_1, objective function value is 67.

2.1.3 Utilization of the rooms

```
Utilization of Rooms:
Days ---> 1    2    3    4    5    Average
Rooms
1 ------>75   88   96   83   83    85
2 ------>88   92   75   79   79    83
3 ------>75   62   67   54   92    70
Average->79   81   79   72   85
```

Figure 2. Rate of utilization of the room per day for the schedule_objective_1.

Utilization of room means how long an operation has taken place within the available time. In scheduled_objective_1: On Day 1, Utilization of Room 1 is 75. Utilization of Room 2 is 88. Utilization of Room 3 is 75. On Day 2, Utilization of Room 1 is 88. Utilization of Room 2 is 92. Utilization of Room 3 is 62. On Day 3, Utilization of Room 1 is 96. Utilization of Room 2 is 75. Utilization of Room 3 is 67. On Day 4, Utilization of Room 1 is 83. Utilization of Room 2 is 79. Utilization of Room 3 is 54. On Day 5, Utilization of Room 1 is 83. Utilization of Room 2 is 79. Utilization of Room 3 is 92. These values can be seen in Figure 2 above.
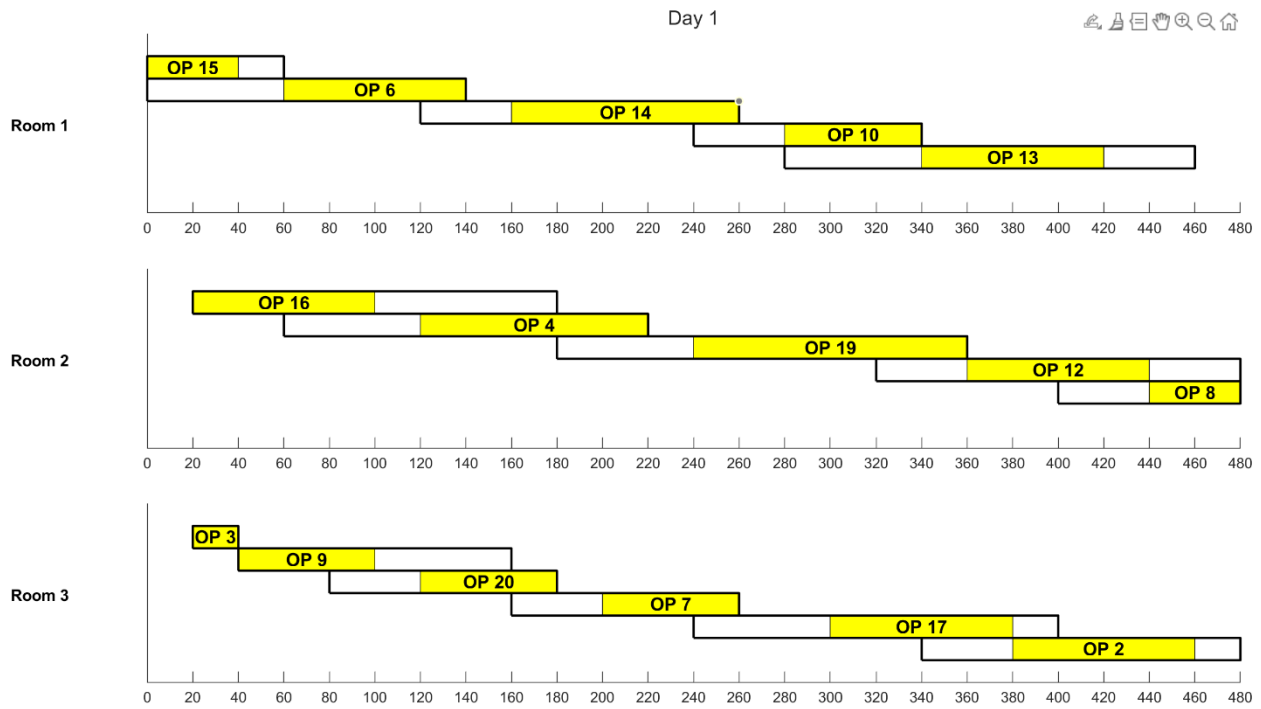
Figure 3.1 *Gantt chart of the planned operations in schedule_objective_1 for Day 1.*
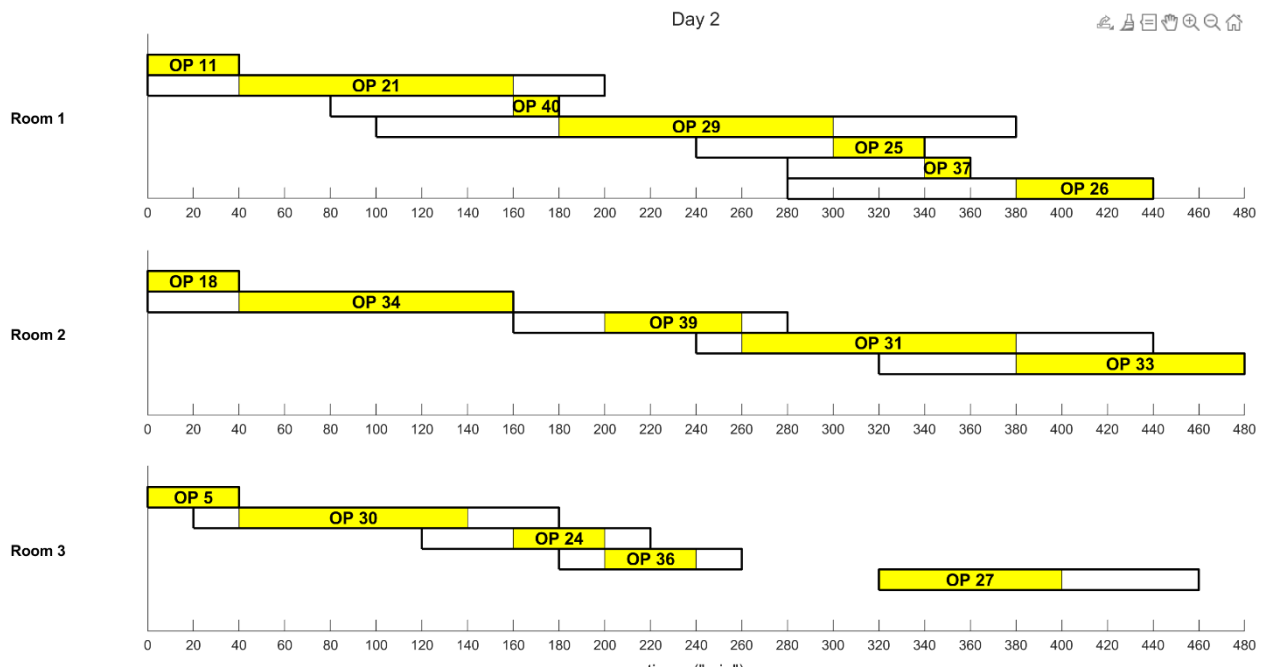

Figure 3.2 *Gantt chart of the planned operations in schedule_objective_1 for Day 2.*
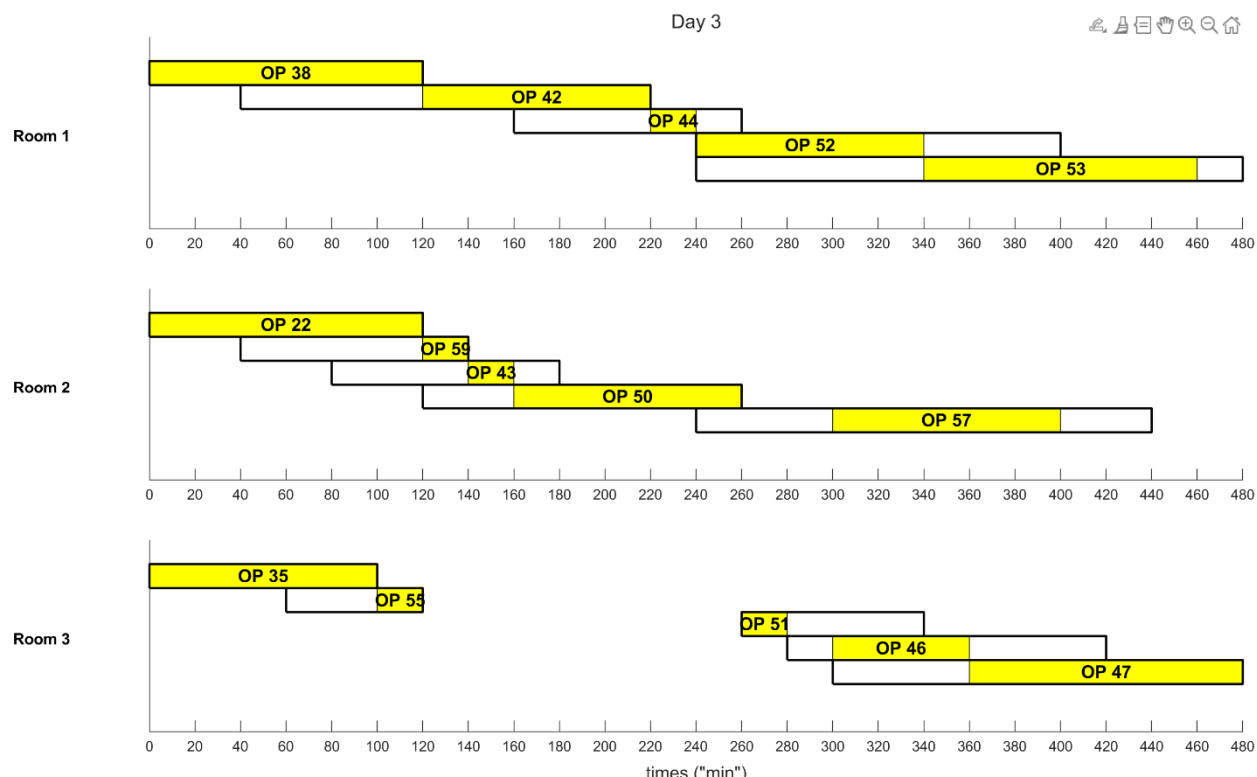
Figure 3.3 *Gantt chart of the planned operations in schedule_objective_1 for Day 3.*
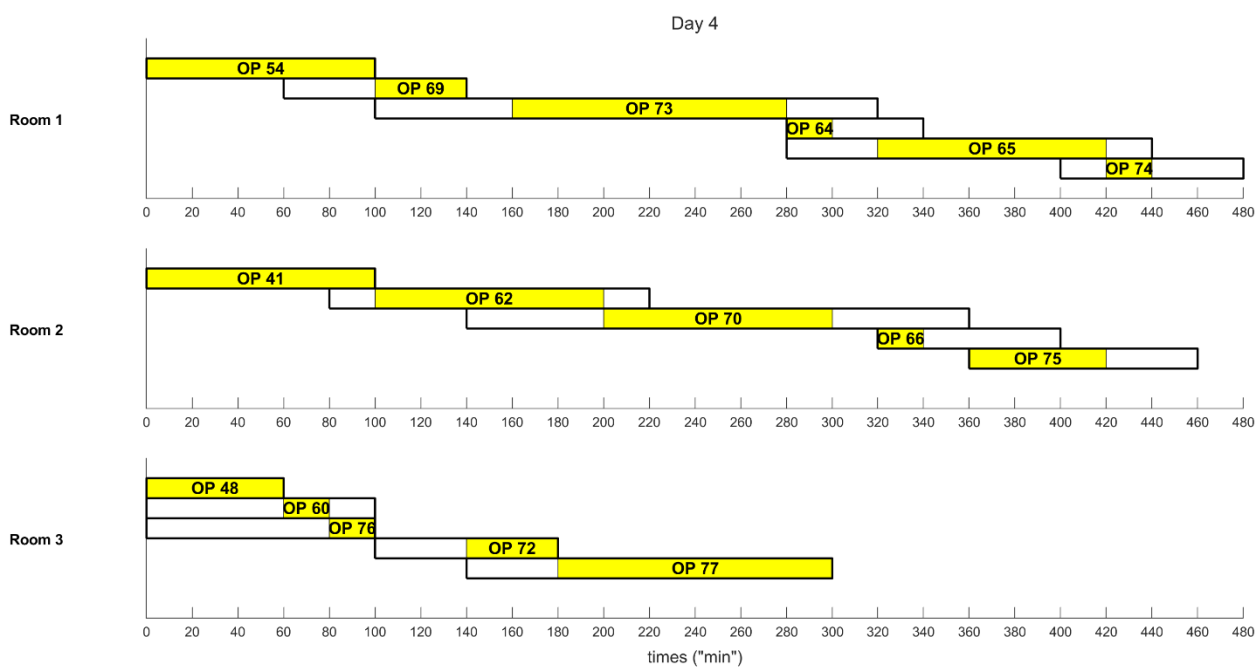

Figure 3.4 *Gantt chart of the planned operations in schedule_objective_1 for Day 4.*
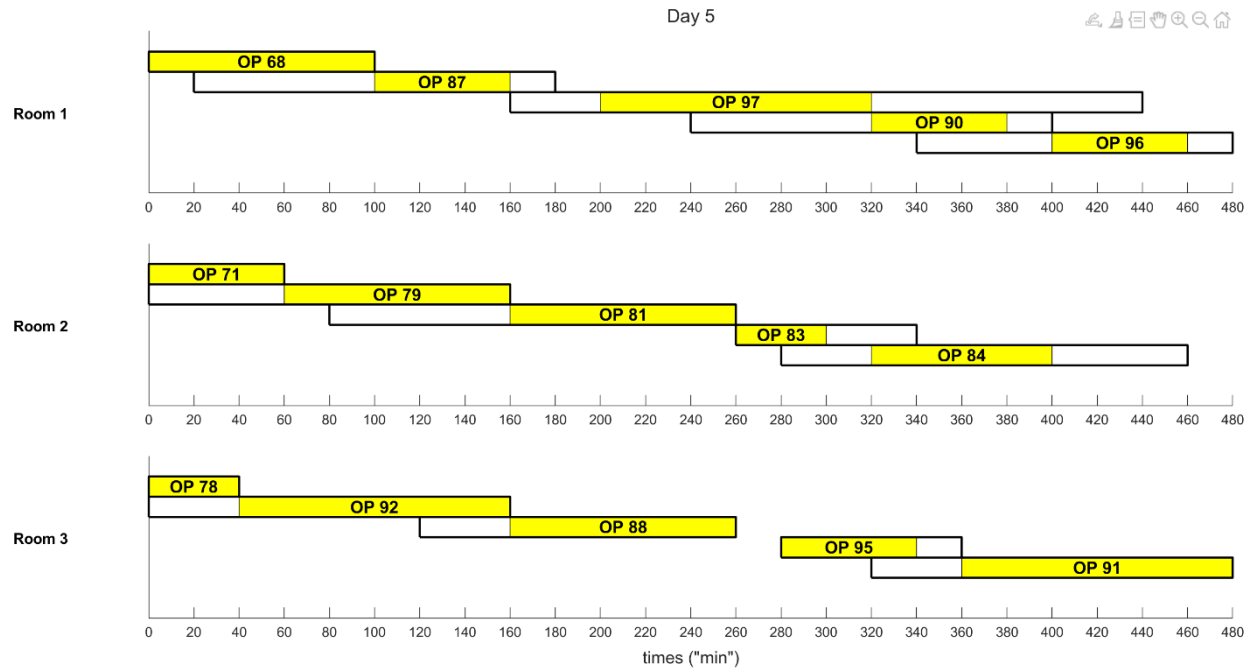
Figure 3.5 *Gantt chart of the planned operations in schedule_objective_1 for Day 5.*

```
# of operations shifted in each priority levels:
priority levels # of shifts
1 ---> 1
2 ---> 2
3 ---> 2
4 ---> 4
```

Figure 4. *The number of operations shifted in each priority levels.*

In scheduled_objective_1,
The number of operations shifted in priority level 1: 1.
The number of operations shifted in priority level 2: 2.
The number of operations shifted in priority level 3: 2.
The number of operations shifted in priority level 4: 4.

2.1.4 Increasing the number of rooms by 1 for schedule_objective_1

If the number of rooms is increased by 1 for scheduled_objective_1:

Changes in the schedule can be seen in Figure 6.1, Figure 6.2, Figure 6.3, Figure 6.4, and Figure 6.5.

The objective function value is goes from 67 to 87. That is, the number of operations performed on available time increases by 20.

The number of operations that postponed to the next day goes to 29 to 9. That is the number of operations performed on available time increase by 20.

The change in the number of operations shifted in priority levels:

Level 1: 3 to 1

Level 2: 7 to 2

Level 3: 11 to 2

Level 4: 8 to 4

As can be seen in Figure 5, the usage of rooms is not fair. While the occupancy rate for room 1 is 86, it is 46 for room 4. As the room number increases, the usage decreases. The basis for this is to start the sort from the 1st room. Because when sorting, it starts with values with less sanitization value. This leads to differences in the usage rate of the rooms.

```
Objective Function Value = 87

Utilization of Rooms:
Days ---> 1    2    3    4    5    Average
Rooms
1 ------>75   92   96   75   92    86
2 ------>88   62   75   75   71    74
3 ------>75   71   67   50   79    68
4 ------>38   67   42   38   46    46
Average->69   73   70   59   72

# of operations shifted in each priority levels:
priority levels # of shifts
1 ---> 1
2 ---> 2
3 ---> 2
4 ---> 4

# of operations that postponed to the next day = 9
```

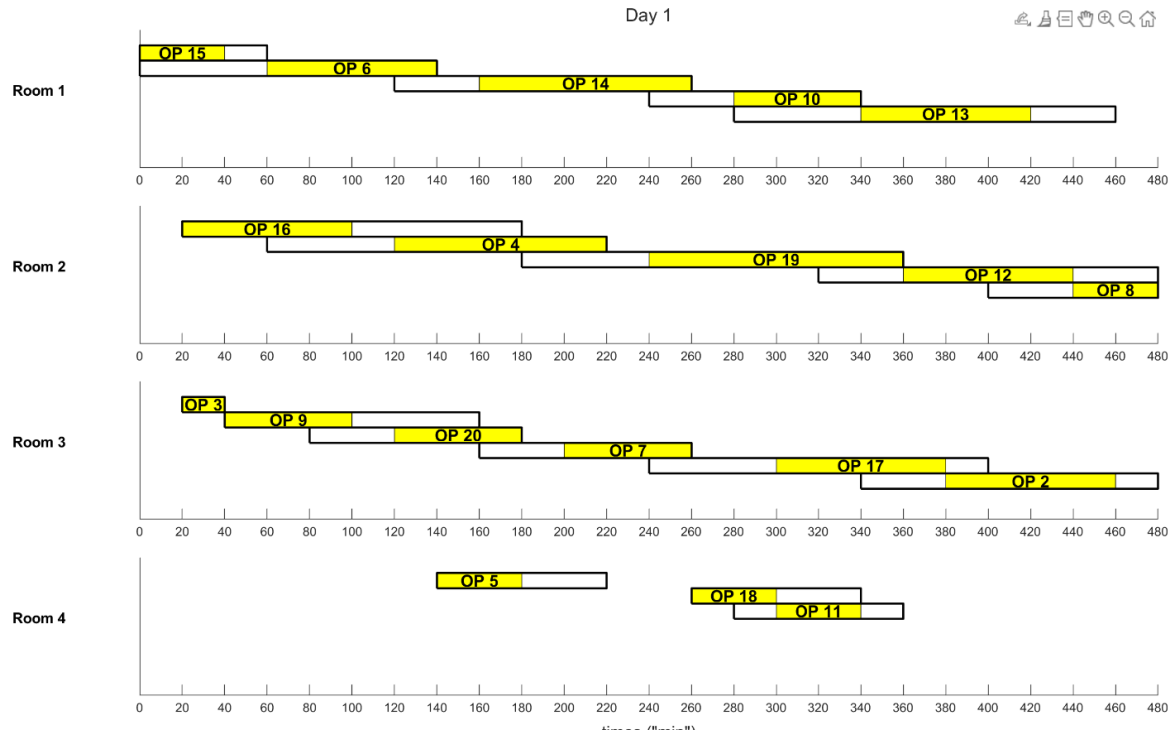*Figure 5. Changes in the schedule if the number of rooms is increased by 1 for both objectives.*

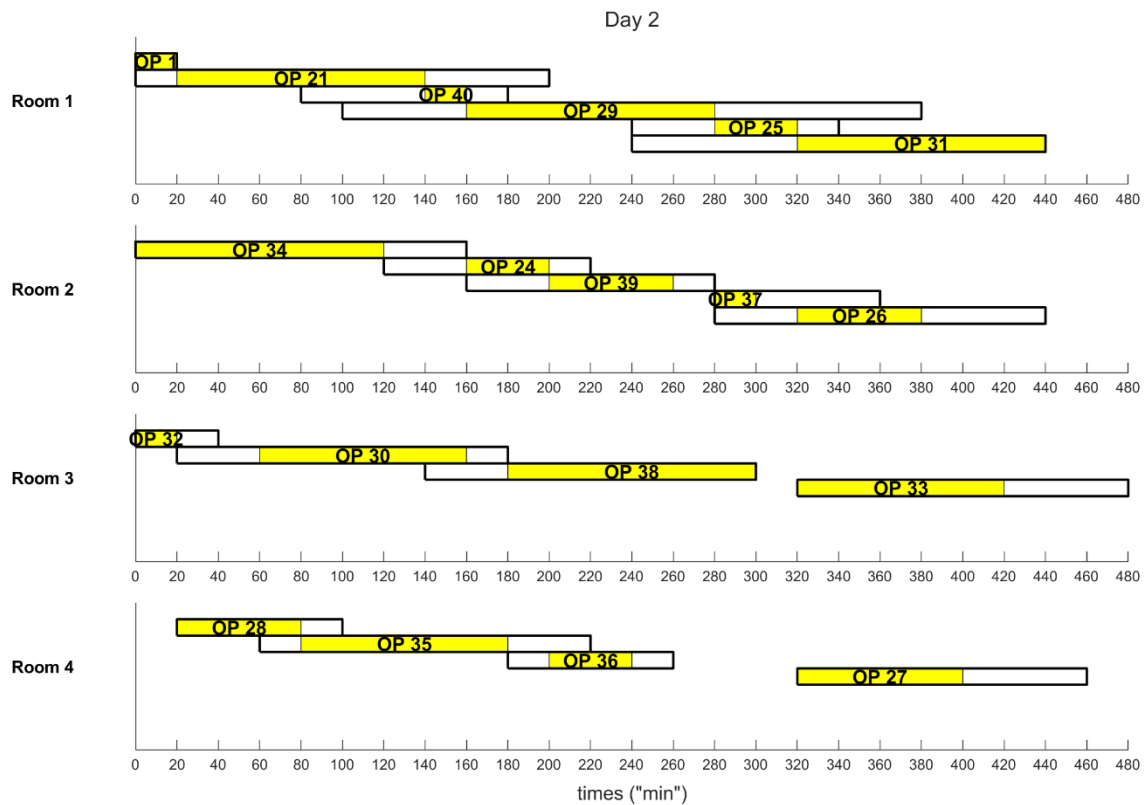**Figure 6.1** *Gantt chart of increasing the number of rooms by 1 in schedule_objective_1 on Day 1.*

Figure 6.2 *Gantt chart of increasing the number of rooms by 1 in schedule_objective_1 on Day 2.*
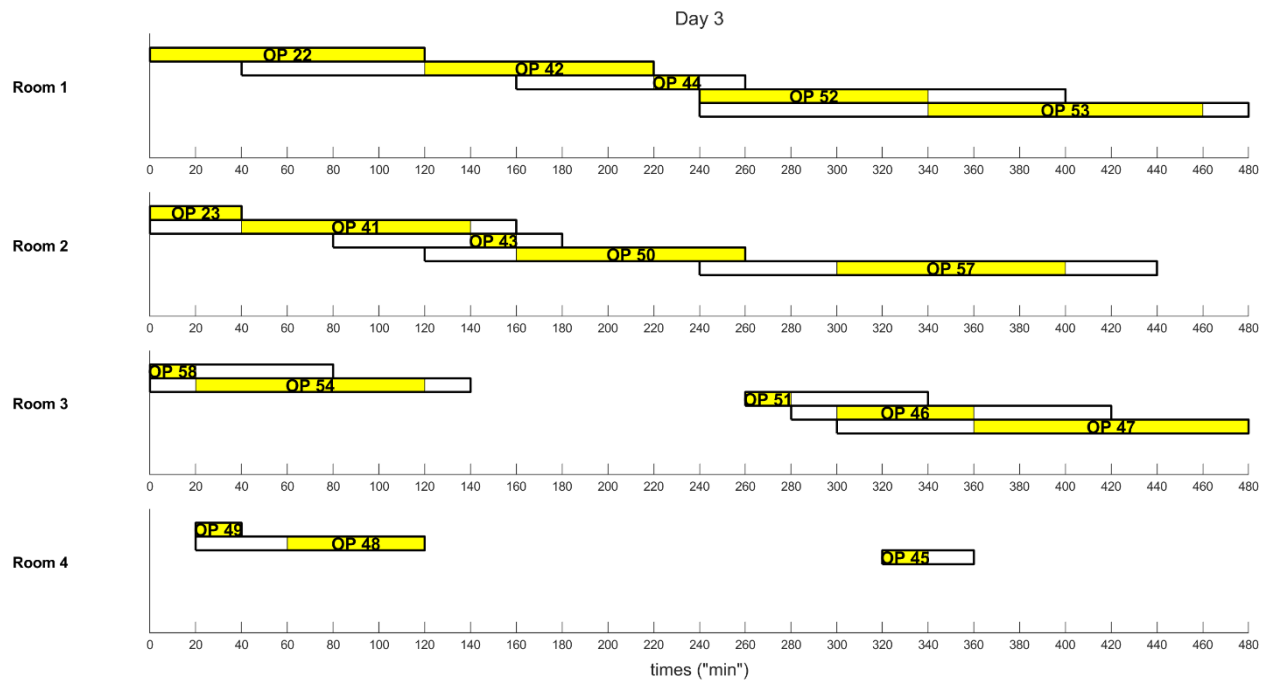
Figure 6.3 *Gantt chart of increasing the number of rooms by 1 in schedule_objective_1 on Day 3.*
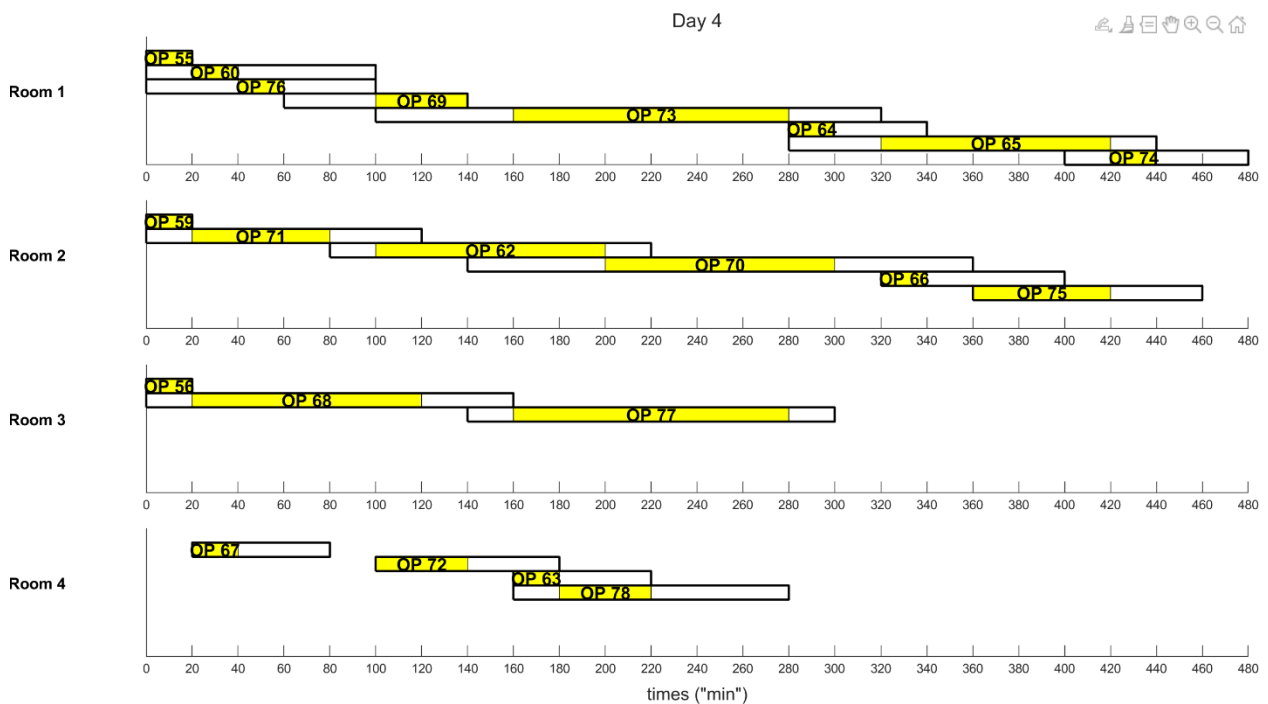

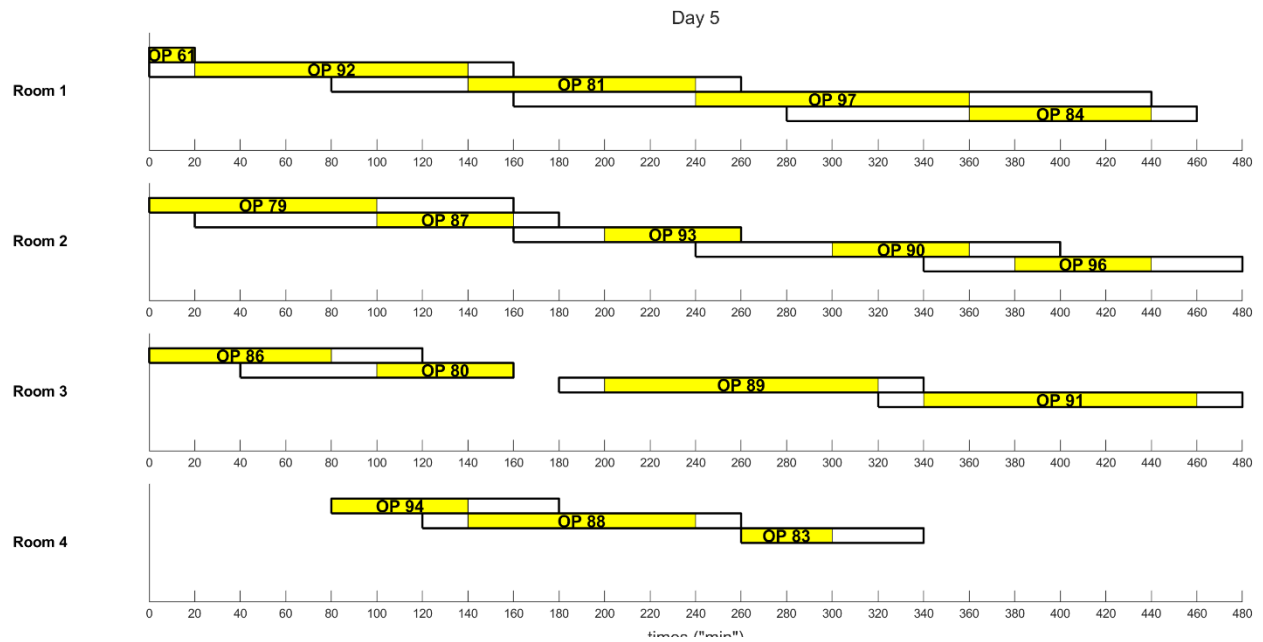**Figure 6.4** *Gantt chart of increasing the number of rooms by 1 in schedule_objective_1 on Day 4.*

Figure 6.5 *Gantt chart of increasing the number of rooms by 1 in schedule_objective_1 on Day 5.*

2.2 Report of the schedule_objective_2
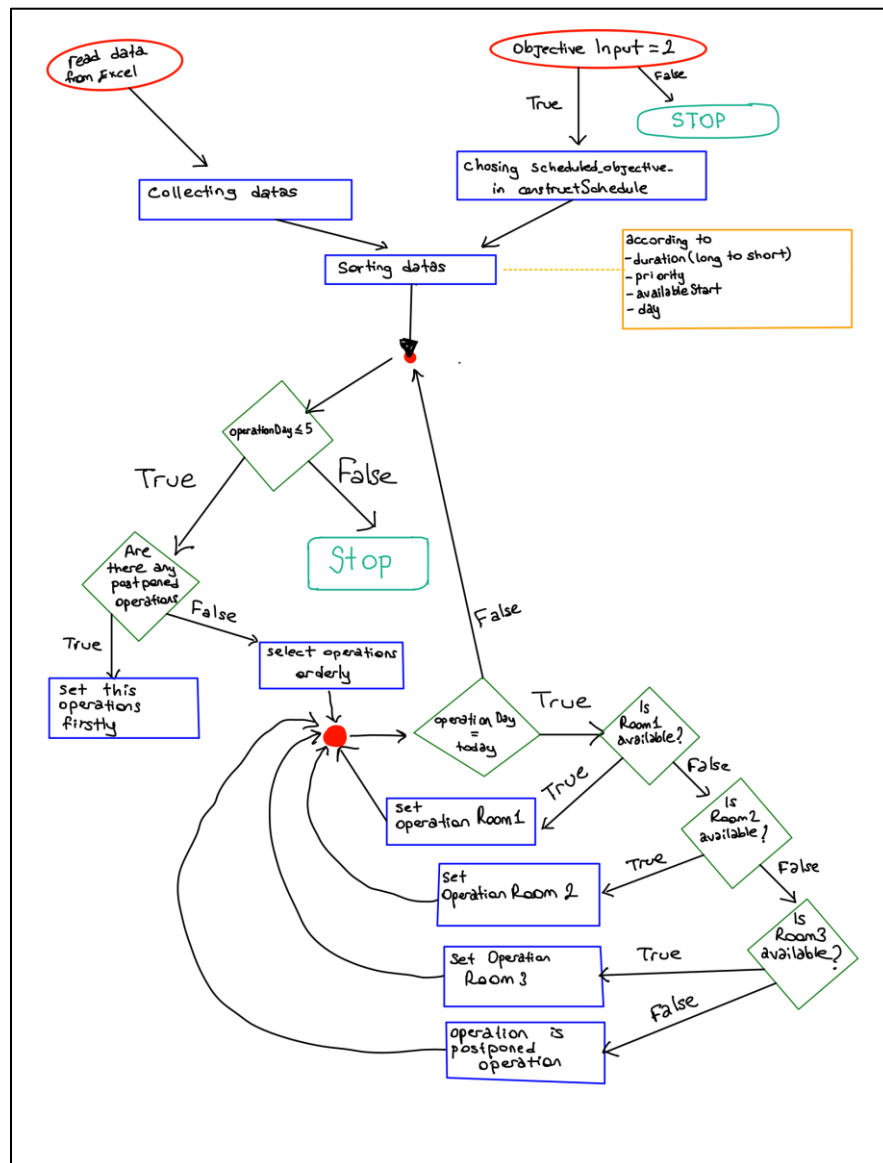## 2.2.1 Flowchart for the schedule_objective_2

Figure 7. *Flowchart for the schedule_objective_2.*

In the schedule_objective_2, we aim to maximize the utilization of the rooms. For this, I first started by collecting the data from the excel table. Then we sorted these data according to duration (long to sort), priority, availableStart, and day values. The reason for this ranking is based on many reasons. When running the algorithm, we start by placing the operations by day, so the day is sorted at the end. This shows that the data is sorted by the last day. The value of avaliableStart indicates the earliest time the operation can start. To operate on as many patients as possible, I assigned this value after the day value. Secondly, I used the priority value because if we don't treat high priority operations first, arranging a room for patients when their operations are delayed can

complicate things and cause fewer patients to undergo the operation than desired. First, I sorted them according to the duration (long to short) values. . This total actually shows how long the room will not be available for another operation. If we order this value from high to low, we can perform more utility. That's why I used these sorting criteria. After finishing the sorting, we took the day into a loop in order from one to five, and in this loop, we defined the rooms by using interval class methods and properties. Afterwards, we placed the operations, which we initially listed according to certain features, in the rooms according to their availability, if they provide the necessary restrictions. When the days were over, we placed the postponed operations on the next day with priority. Afterwards, we continued the placement process as normal, and we did this every day. At the end of the loop, we obtained the Gantt charts and the values we wanted to examine by using the printSchedule and Reporting methods. Figure 1 shows the flowchart described above. The 5-day planned program can be seen below. Figure 8.1, Figure 8.2, Figure 8.3, Figure 8.4 and Figure 8.5, respectively.

2.2.2 The objective function value

Objective function value = 67

Objective function value means that how many operations are scheduled in the available interval. In scheduled_objective_2, objective function value is 67.
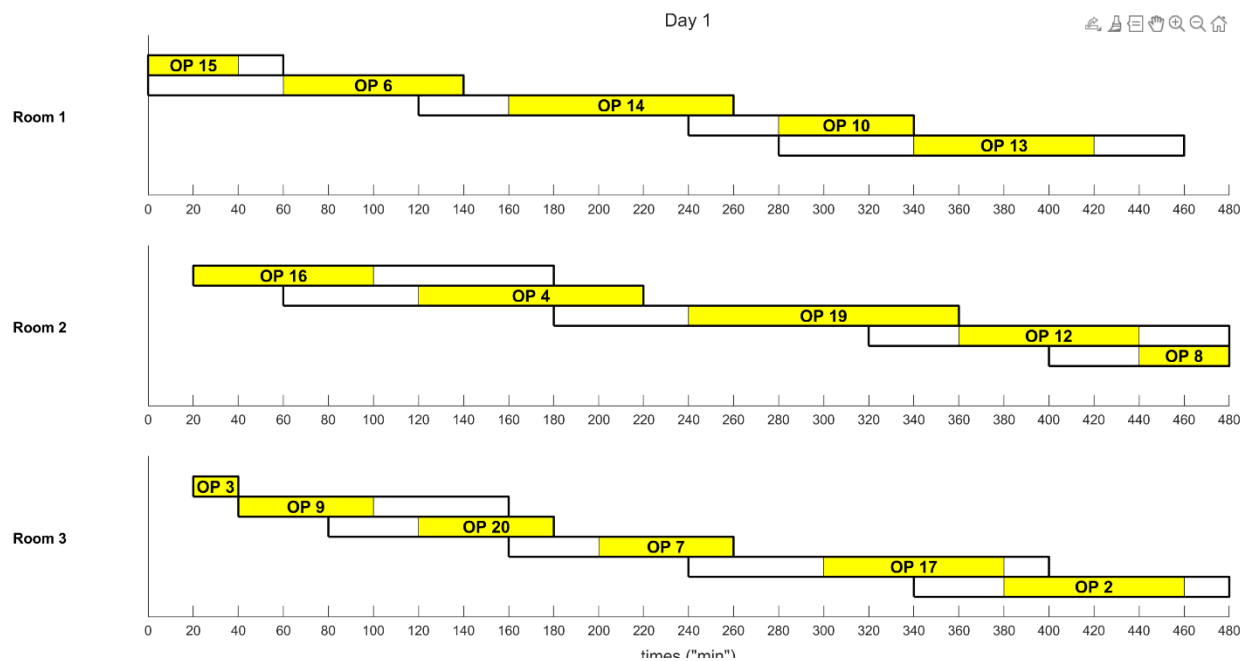
2.2.3 Utilization of the room

Figure 8.1 *Gantt chart of the planned operations in schedule_objective_2 for Day 1.*
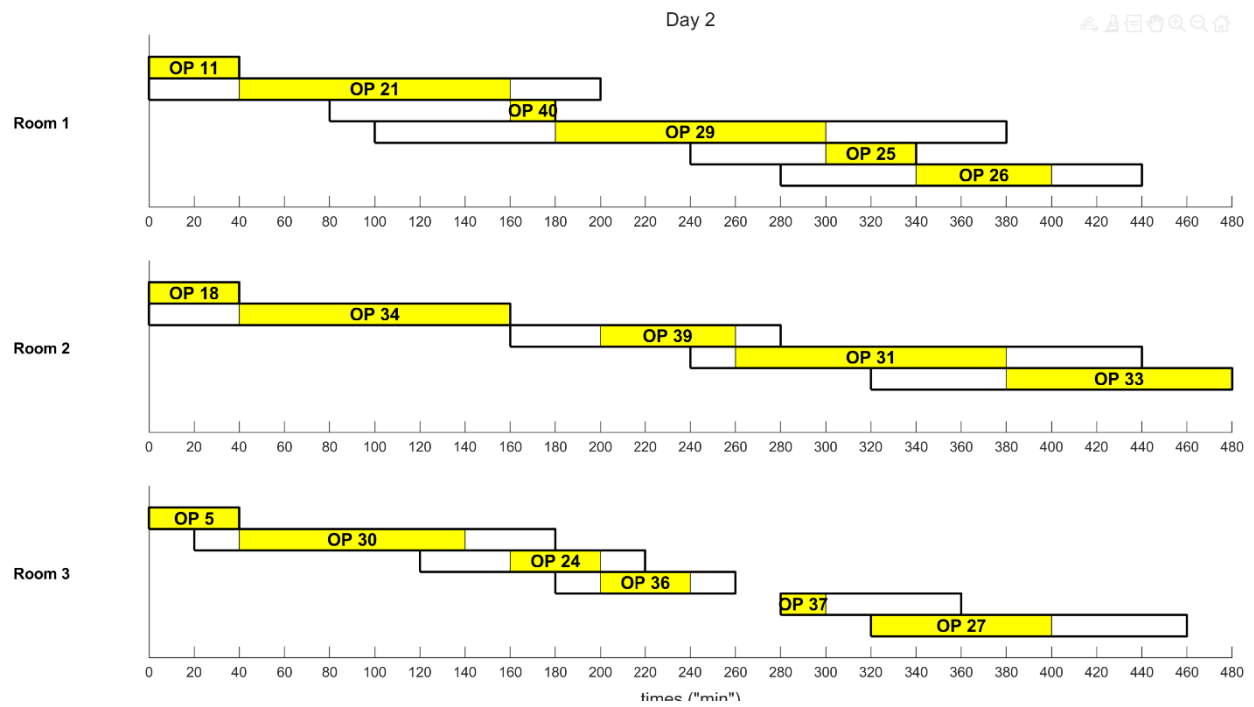
Figure 8.2 *Gantt chart of the planned operations in schedule_objective_2 for Day 2.*

Figure 8.3 *Gantt chart of the planned operations in schedule_objective_2 for Day 3.*

Figure 8.4 *Gantt chart of the planned operations in schedule_objective_2 for Day 4.*
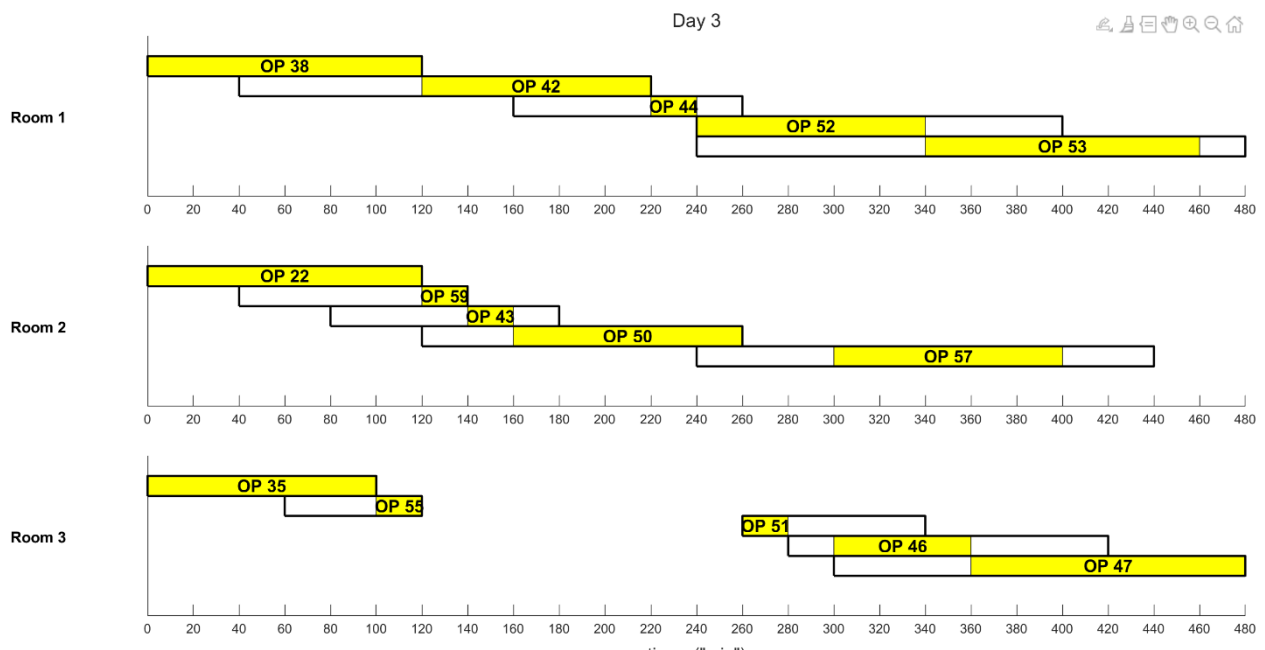

Figure 8.5 *Gantt chart of the planned operations in schedule_objective_2 for Day 5.*
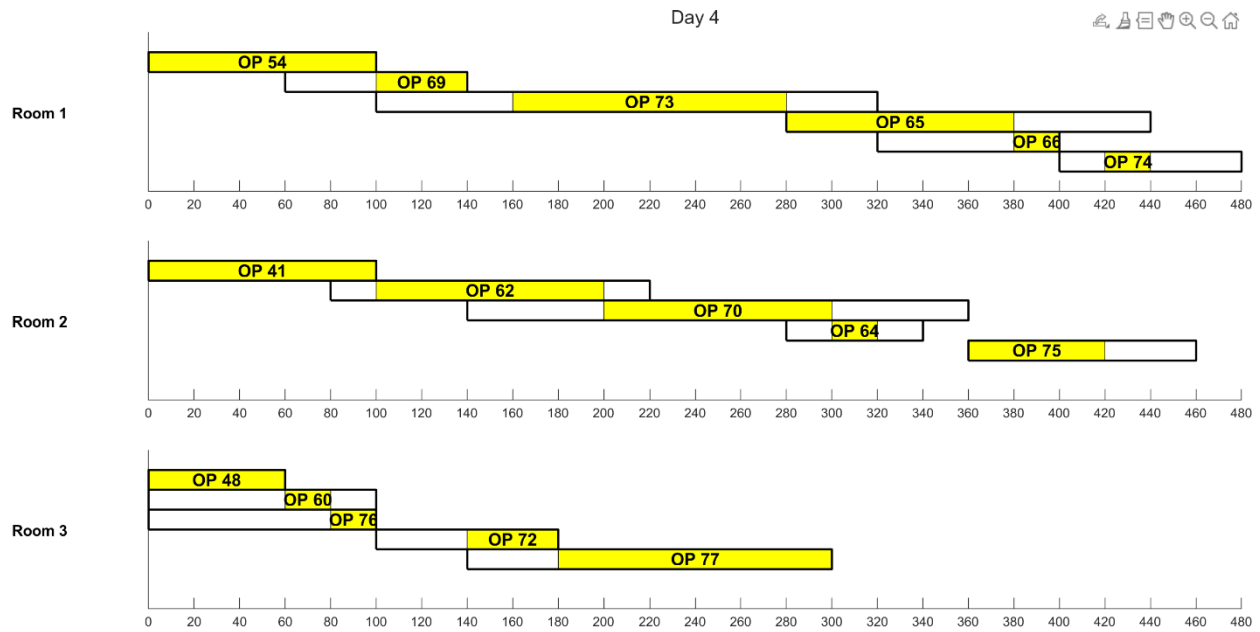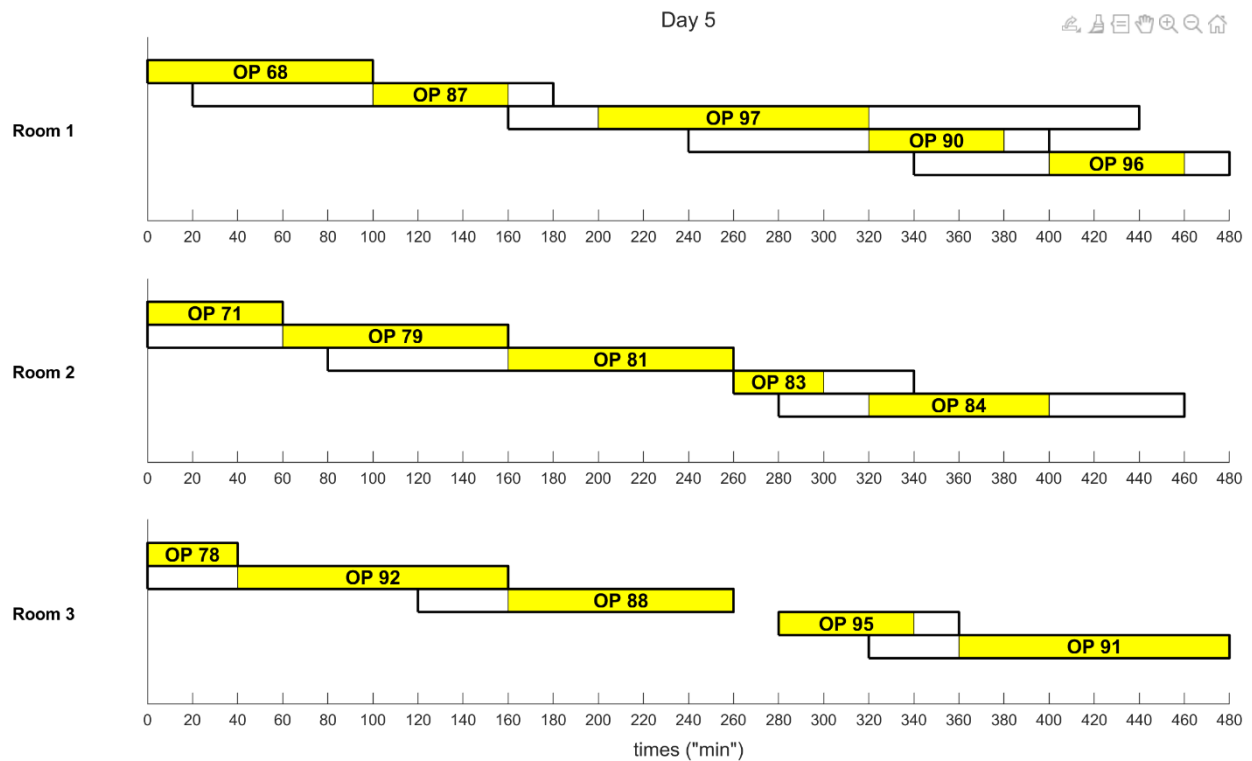
2.2.4 Number of the operations that are postponed to the next day

Number of the operations that are postponed to the next day is 29 in scheduled_objective_2.

```
# of operations shifted in each priority levels:
priority levels # of shifts
1 ---> 3
2 ---> 7
3 ---> 11
4 ---> 8
```

Figure 9. The number of operations shifted in each priority levels.

In scheduled_objective_2,
The number of operations shifted in priority level 1 is 3.
The number of operations shifted in priority level 2 is 7.
The number of operations shifted in priority level 3 is 11.
The number of operations shifted in priority level 4 is 8.

2.2.5 Increasing the number of rooms by 1 for schedule_objective_2

```
Objective Function Value = 86

Utilization of Rooms:
Days ---> 1    2    3    4    5    Average
Rooms
1 ------>75   92   96   88   92    88
2 ------>88   79   75   71   88    80
3 ------>75   71   67   50   67    66
4 ------>38   46   42   25   46    39
Average->69   72   70   58   73

# of operations shifted in each priority levels:
priority levels # of shifts
1 ---> 1
2 ---> 3
3 ---> 2
4 ---> 4

# of operations that postponed to the next day = 10
```

Figure 10. Changes in the schedule if the number of rooms is increased by 1 for both objectives.

If the number of rooms is increased by 1 for scheduled_objective_2:

Changes in the schedule can be seen in Figure 10.1, Figure 10.2, Figure 10.3, Figure 10.4, and Figure 10.5.

The objective function value is goes from 67 to 86. That is, the number of operations performed on available time increases by 19.

The number of operations that postponed to the next day goes to 29 to 10. That is the number of operations performed on available time increase by 19.

The change in the number of operations shifted in priority levels:
Level 1: 3 to 1
Level 2: 7 to 3
Level 3: 11 to 2
Level 4: 8 to 4

As can be seen in Figure 10, the usage of rooms is not fair. While the occupancy rate for room 1 is 88, it is 39 for room 4. As the room number increases, the usage decreases. The basis for this is to start the sort from the 1st room. This leads to differences in the usage rate of the rooms.
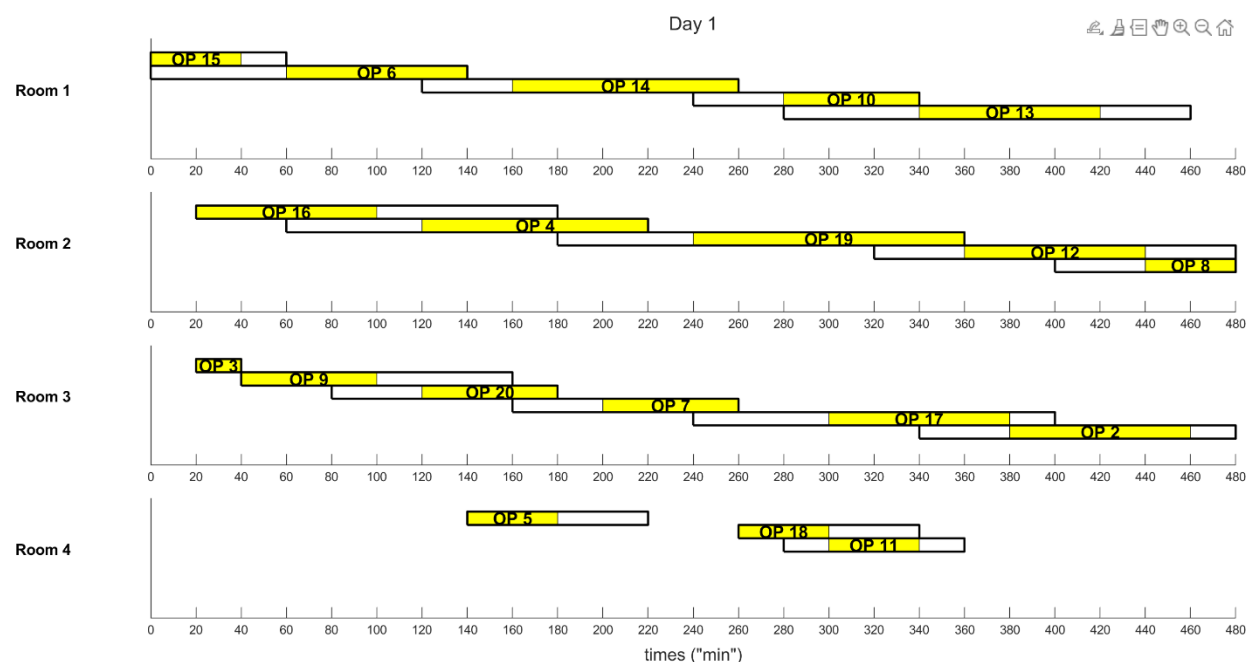
Figure 10.1 *Gantt chart of increasing the number of rooms by 1 in schedule_objective_2 on Day 1.*
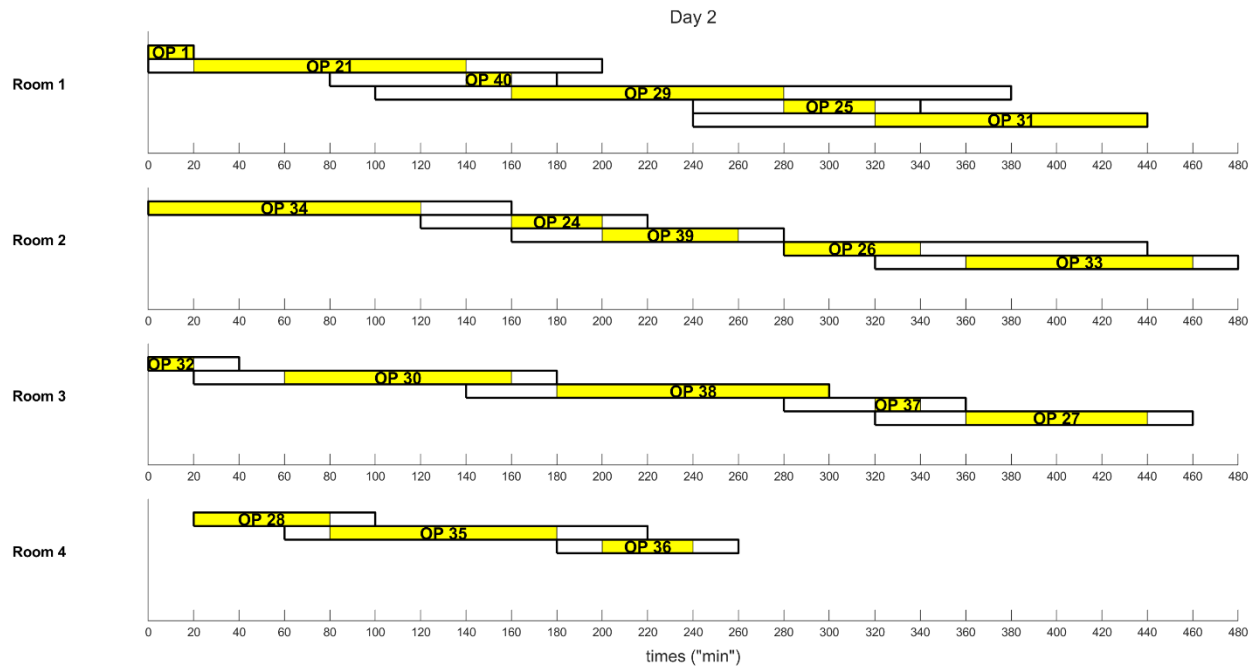

Figure 10.2 *Gantt chart of increasing the number of rooms by 1 in schedule_objective_2 on Day 2.*

Figure 10.3 *Gantt chart of increasing the number of rooms by 1 in schedule_objective_2 on Day 3.*

Figure 10.4 *Gantt chart of increasing the number of rooms by 1 in schedule_objective_2 on Day 4.*
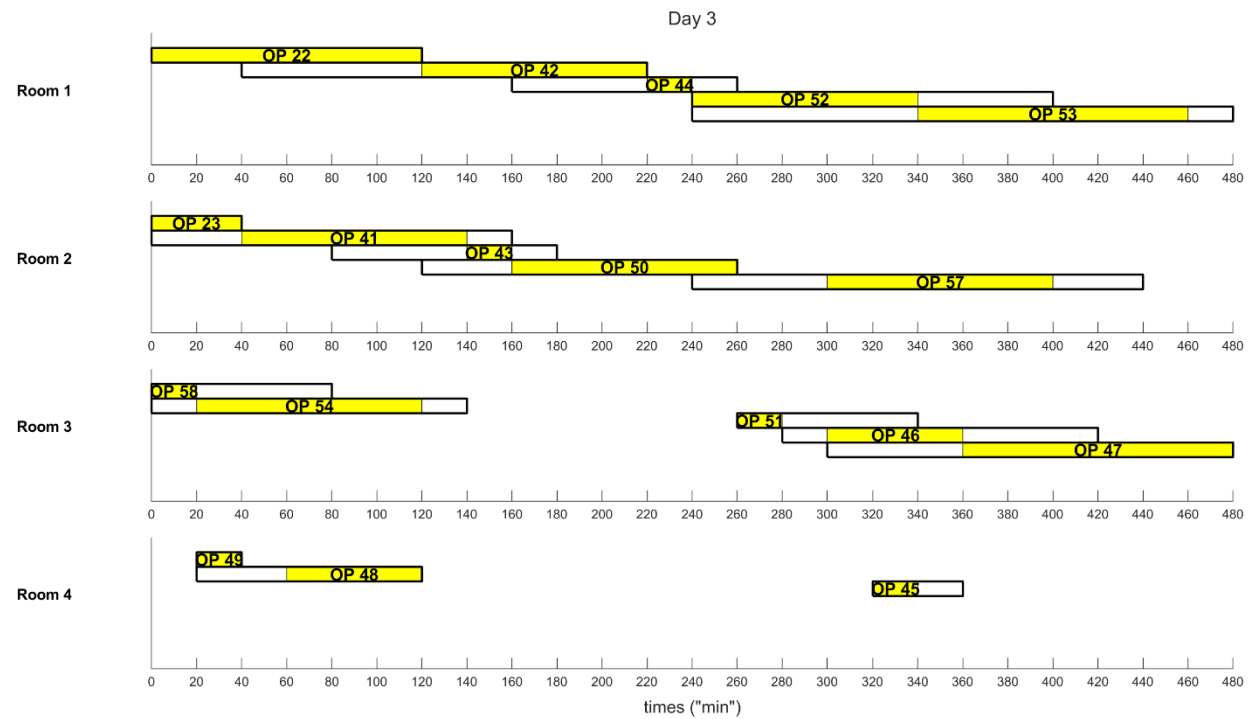

Figure 10.5 *Gantt chart of increasing the number of rooms by 1 in schedule_objective_2 on Day 5.*
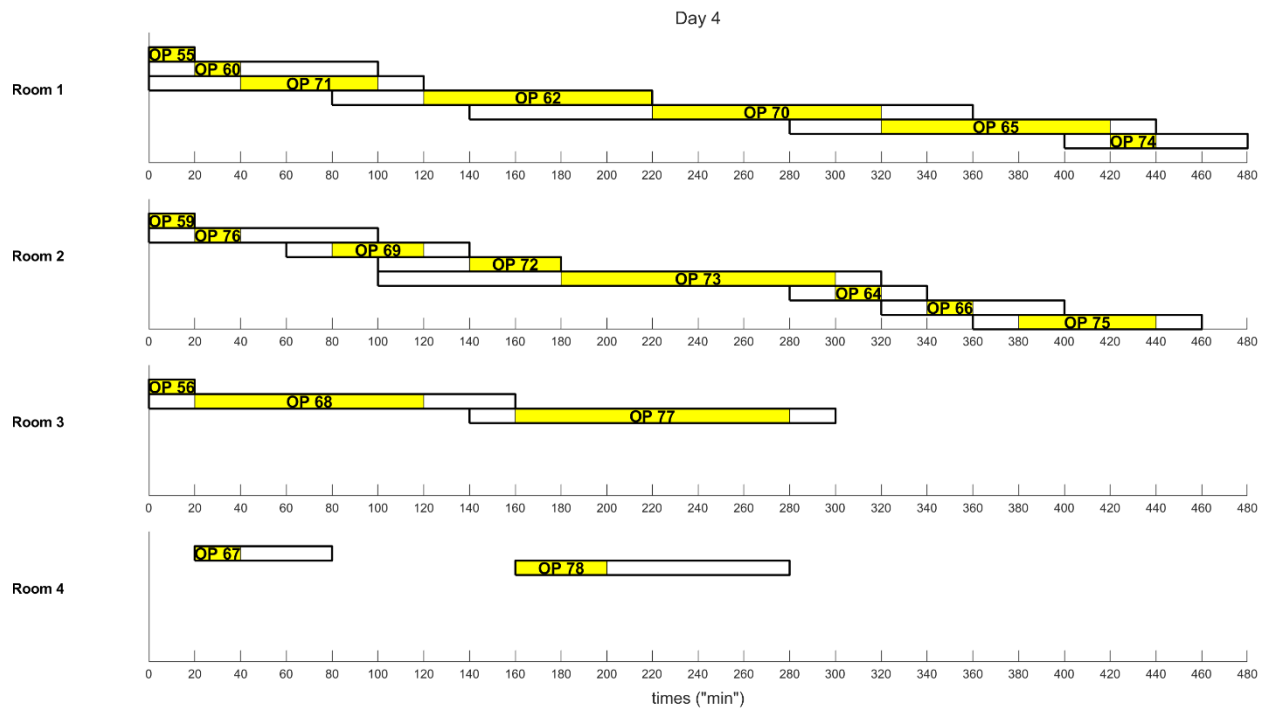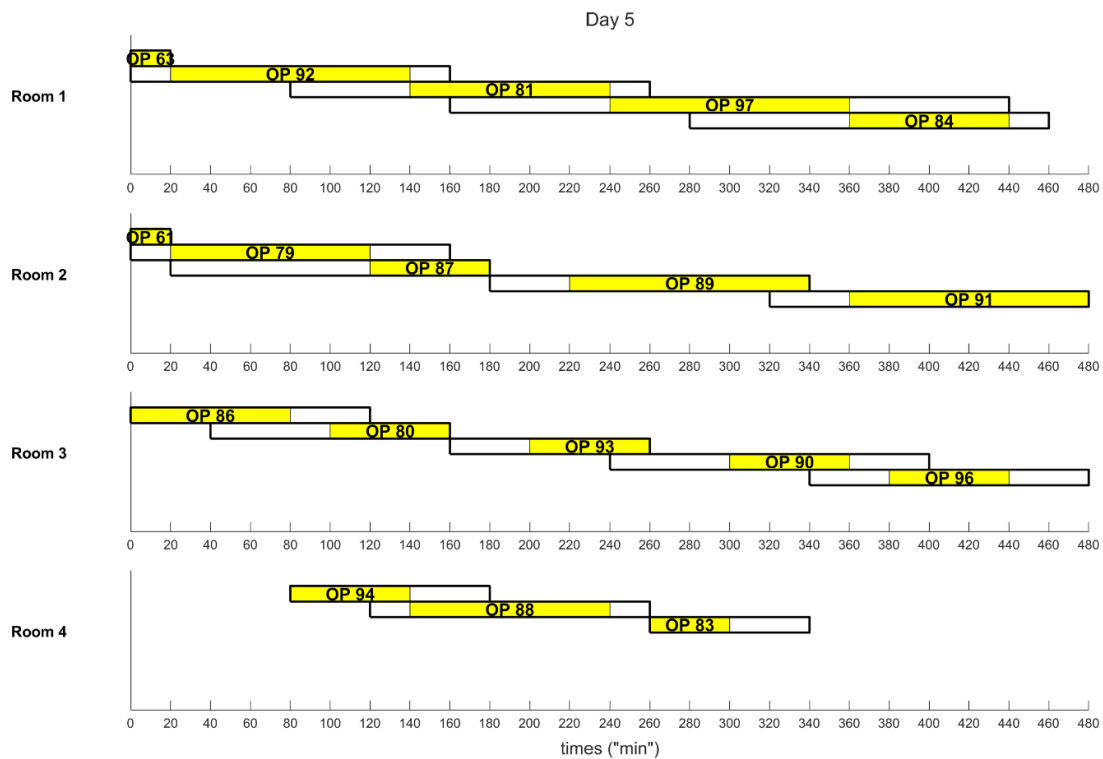
2.3 Report of the schedule_objective_3

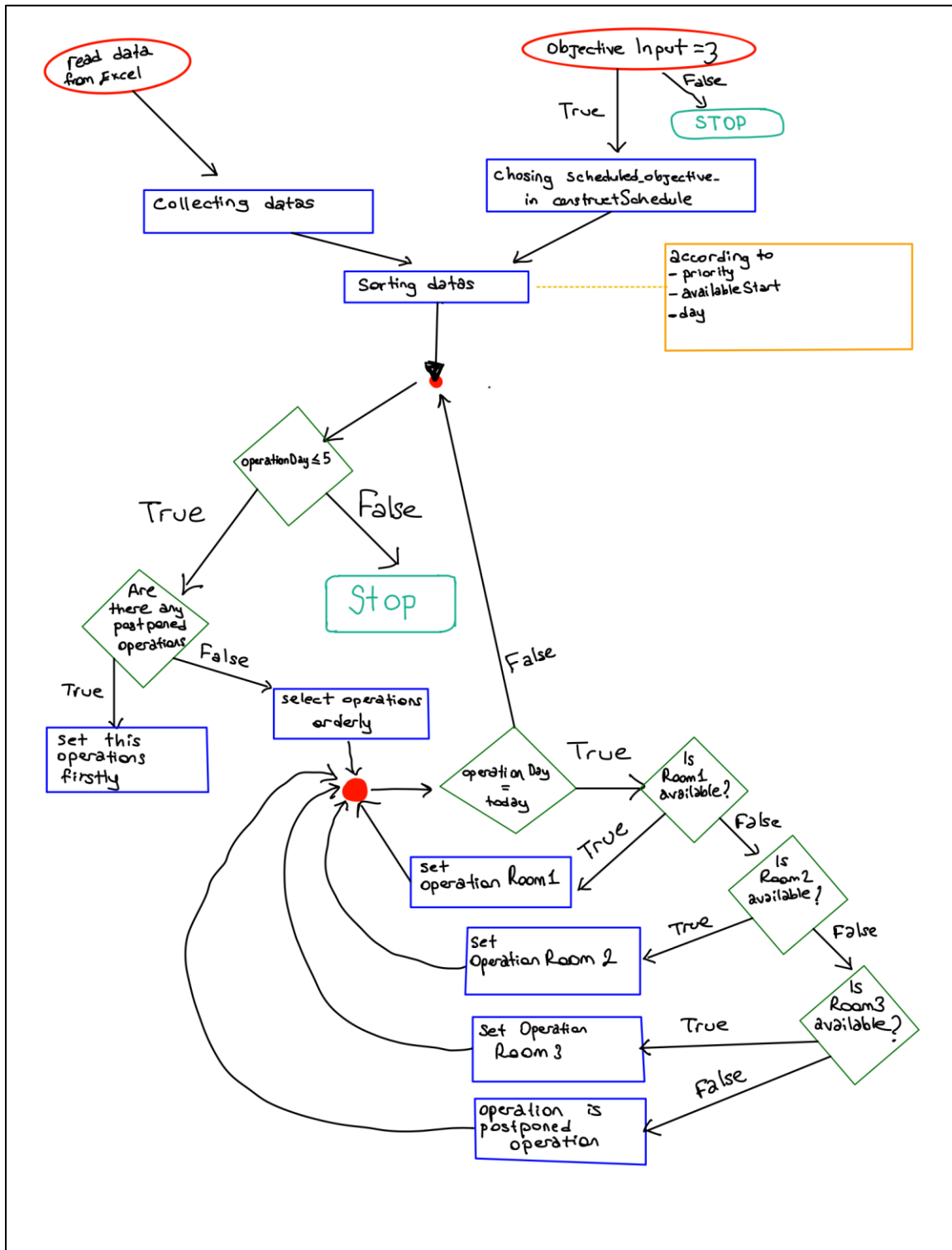### 2.3.1 Flowchart for the schedule_objective_3

Figure 11. *Flowchart for the schedule_objective_3.*

In the schedule_objective_3, we aim to maximize the utilization of the rooms. For this, I first started by collecting the data from the excel table. Then we sorted these data according to priority, availableStart, and day values. The reason for this ranking is based on many reasons. When running the algorithm, we start by placing the operations by day, so the day is sorted at the end. This shows that the data is sorted by the last day. The value of avaliableStart indicates the earliest time the operation can start. To operate on as many patients as possible, I assigned this value after the day value. Secondly, I used the priority value because if we don't treat high priority operations first, arranging a room for patients when their operations are delayed can complicate things and cause fewer patients to undergo the operation than desired. This total shows how long the room will not be available for another operation. If we order this value from high to low, we can perform less late competition time. That's why I used these sorting criteria. After finishing the sorting, we took the day into a loop in order from one to five, and in this loop, we defined the rooms by using interval class methods and properties. Afterwards, we placed the operations, which we initially listed according to certain features, in the rooms according to their availability, if they provide the necessary restrictions. When the days were over, we placed the postponed operations on the next day with priority. Afterwards, we continued the placement process as normal, and we did this every day. At the end of the loop, we obtained the Gantt charts and the values we wanted to examine by using the printSchedule and Reporting methods. Figure 1 shows the flowchart described above. The 5-day planned program can be seen below. Figure 13.1, Figure 13.2, Figure 13.3, Figure 13.4 and Figure 13.5, respectively.

2.3.2 The objective function value
Objective function value = 67

Objective function value means that how many operations are scheduled in the available interval. In scheduled_objective_3, objective function value is 67.

2.3.3 Utilization of the room

```
Utilization of Rooms:
Days ---> 1    2    3    4    5    Average
Rooms
1 ------>75   83   96   83   83    84
2 ------>88   92   75   79   79    83
3 ------>75   67   67   54   92    71
Average->79   81   79   72   85
```

Figure 12. Rate of utilization of the room per day for the schedule_objective_3.

Utilization of room means how long an operation has taken place within the available time. In scheduled_objective_3: On Day 1, Utilization of Room 1 is 75. Utilization of Room 2 is 88. Utilization of Room 3 is 75. On Day 2, Utilization of Room 1 is 83. Utilization of Room 2 is 92. Utilization of Room 3 is 67. On Day 3, Utilization of Room 1 is 96. Utilization of Room 2 is 75. Utilization of Room 3 is 67. On Day 4, Utilization of Room 1 is 83. Utilization of Room 2 is 79.

Utilization of Room 3 is 54. On Day 5, Utilization of Room 1 is 83. Utilization of Room 2 is 79. Utilization of Room 3 is 85. These values can be seen in Figure 12 above.
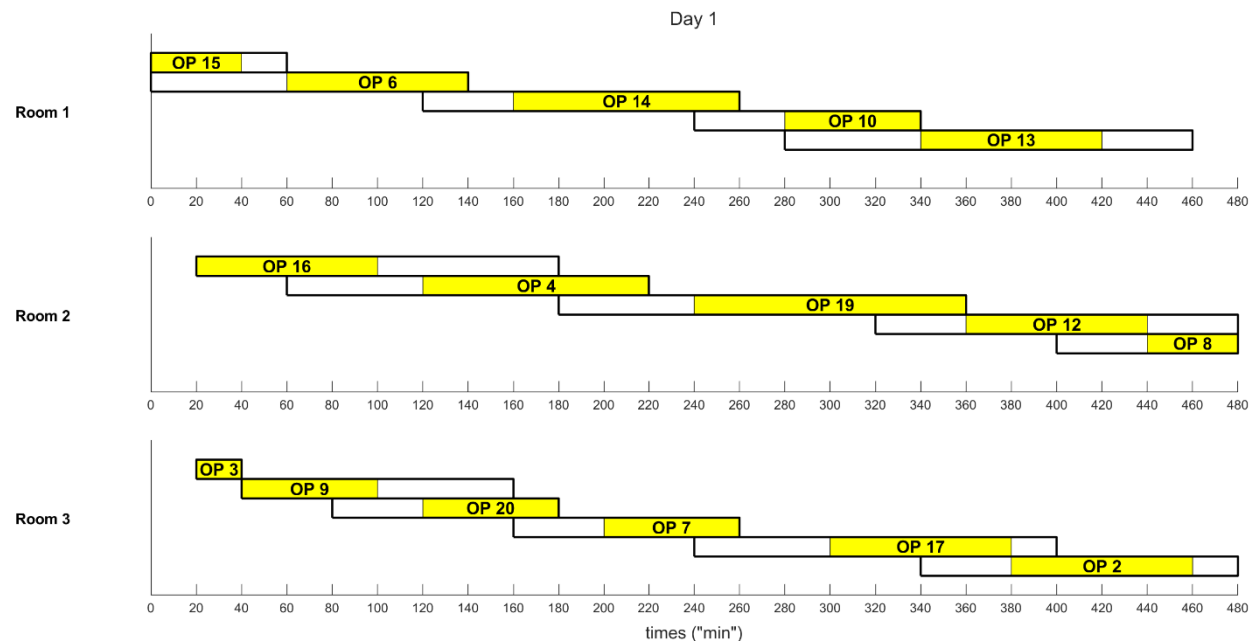

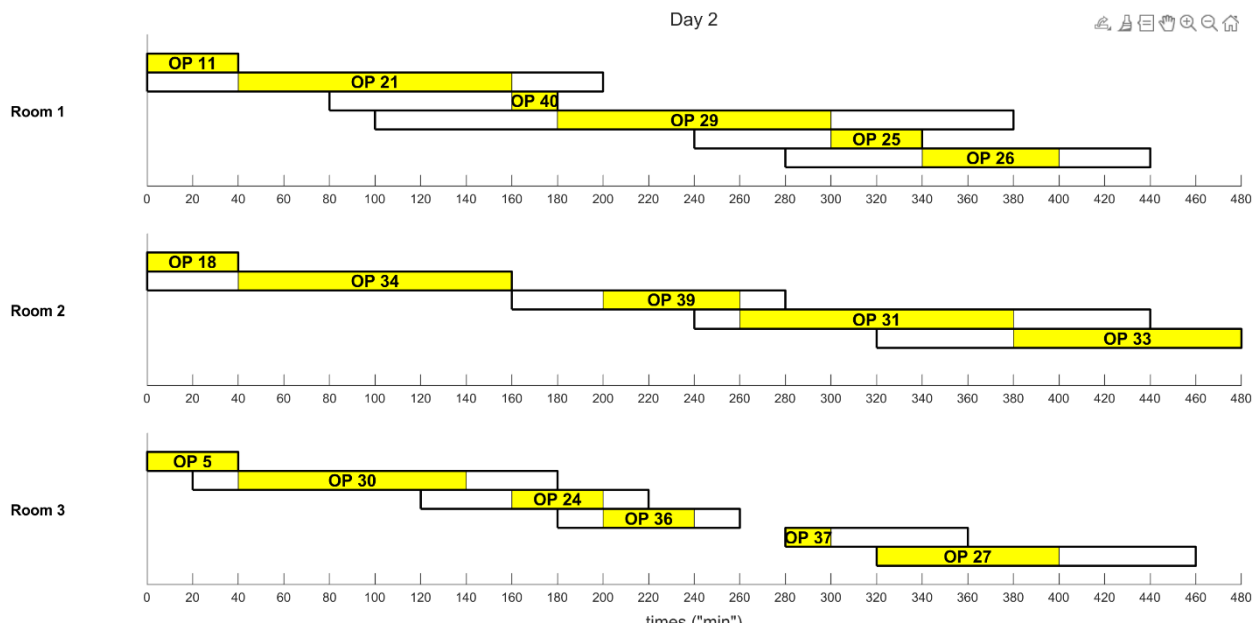**Figure 13.1** *Gantt chart of the planned operations in schedule_objective_3 for Day 1.*

Figure 13.2 *Gantt chart of the planned operations in schedule_objective_3 for Day 2.*
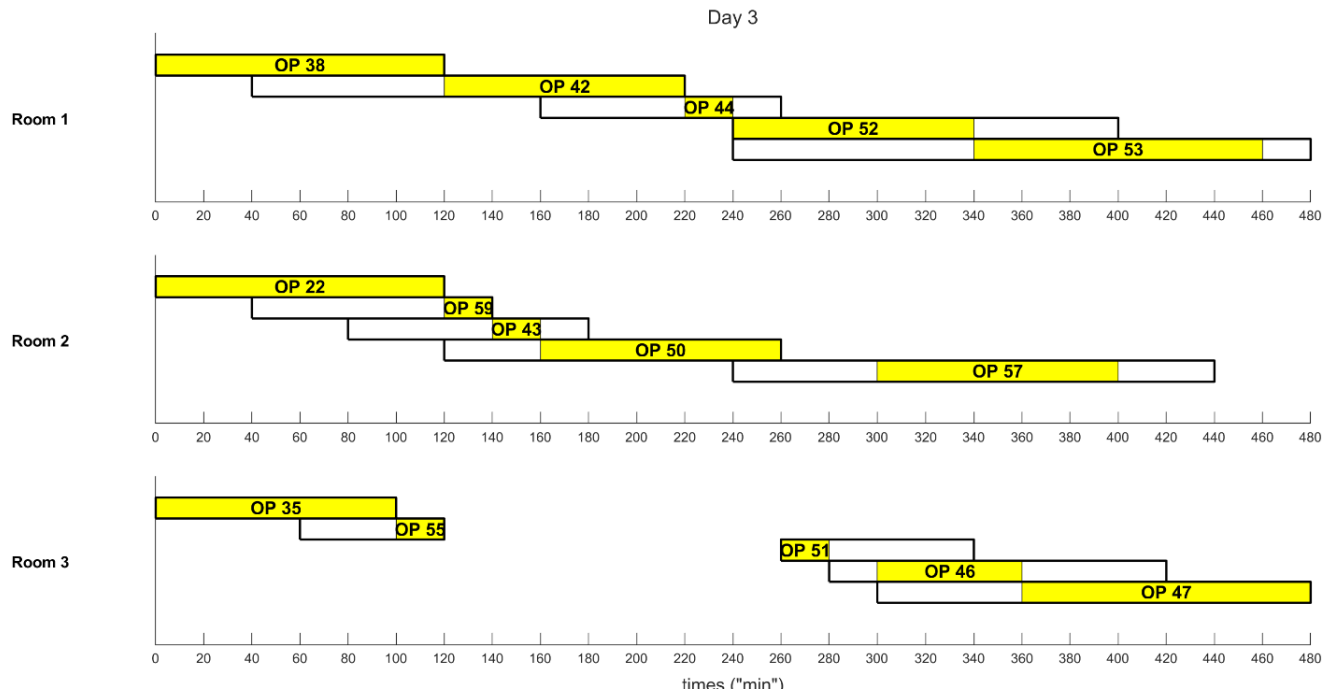
Figure 13.3 *Gantt chart of the planned operations in schedule_objective_3 for Day 3.*

Figure 13.4 *Gantt chart of the planned operations in schedule_objective_3 for Day 4.*

Figure 13.5 *Gantt chart of the planned operations in schedule_objective_3 for Day 5.*
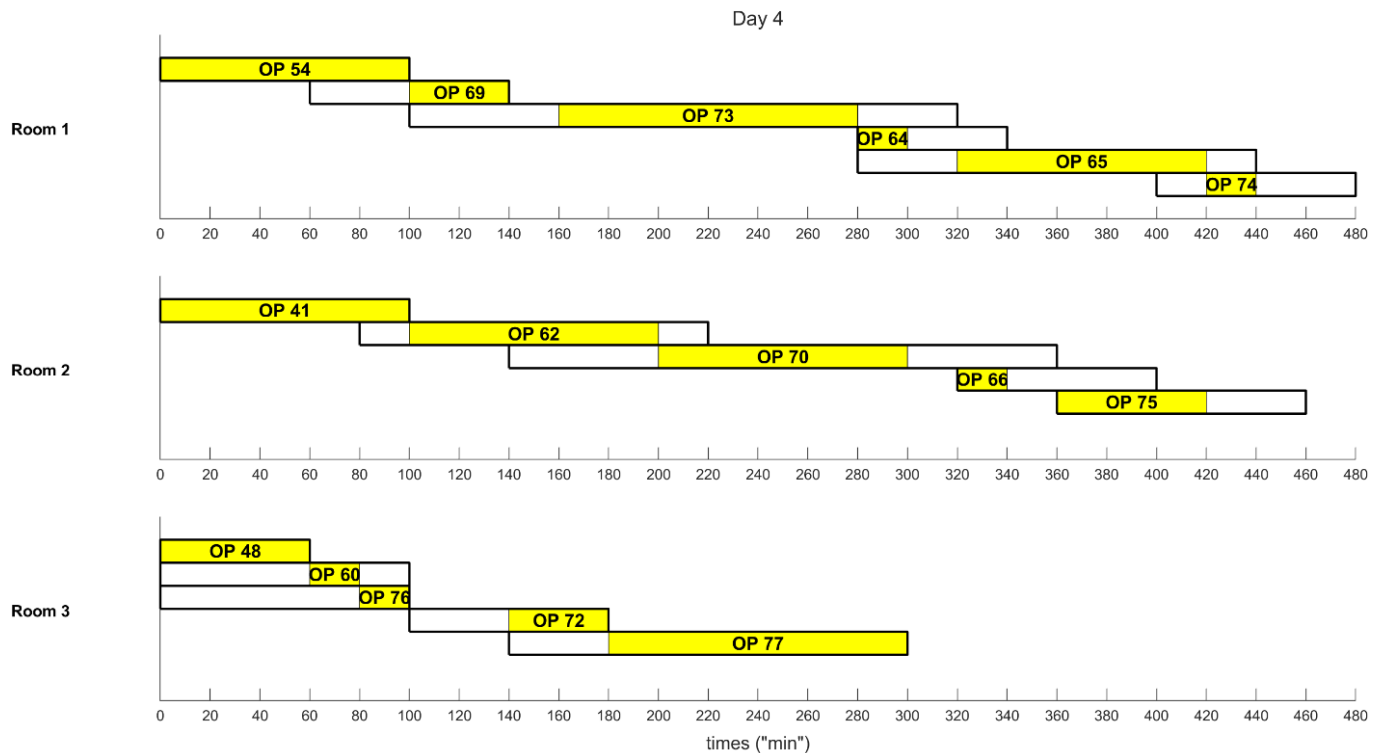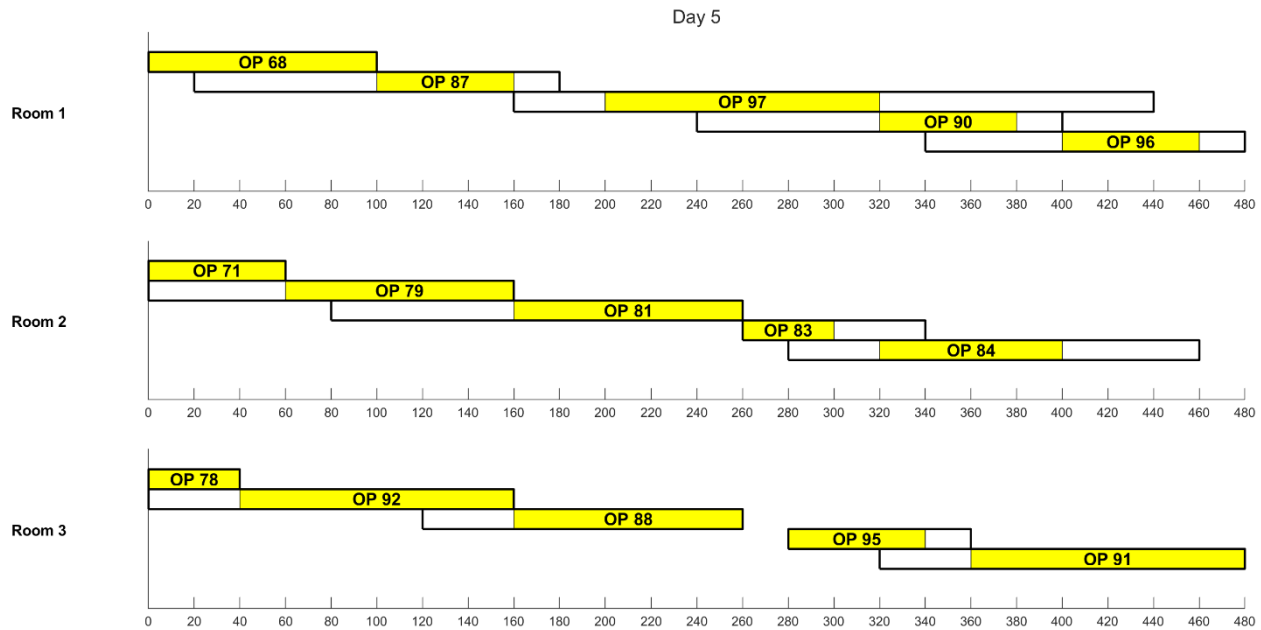
2.3.4 The number of operations that are postponed to the next day

The number of operations that are postponed to the next day is 29 in scheduled_objective_3.

```
# of operations shifted in each priority levels:
priority levels # of shifts
1 ---> 3
2 ---> 7
3 ---> 11
4 ---> 8
```

Figure 14. *The number of operations shifted in each priority levels.*

In scheduled_objective_2,
The number of operations shifted in priority level 1 is 3.
The number of operations shifted in priority level 2 is 7.
The number of operations shifted in priority level 3 is 11.
The number of operations shifted in priority level 4 is 8.

2.3.5 Increasing the number of rooms by 1 for schedule_objective_3

If the number of rooms is increased by 1 for scheduled_objective_3:

Changes in the schedule can be seen in Figure 16.1, Figure 16.2, Figure 16.3, Figure 16.4, and Figure 16.5.

The objective function value is goes from 67 to 87. That is, the number of operations performed on available time increases by 20.

The number of operations that postponed to the next day goes to 29 to 9. That is the number of operations performed on available time increase by 20.

The change in the number of operations shifted in priority levels:
Level 1: 3 to 1
Level 2: 7 to 2
Level 3: 11 to 2
Level 4: 8 to 4

As can be seen in Figure 15, the usage of rooms is not fair. While the occupancy rate for room 1 is 88, it is 39 for room 4. As the room number increases, the usage decreases. The basis for this is to start the sort from the 1st room. Because when sorting, it starts with values with less sanitization value. This leads to differences in the usage rate of the rooms.

```
Objective Function Value = 87

Utilization of Rooms:
Days ---> 1    2    3    4    5    Average
Rooms
1 ------>75   92   96   83   92    88
2 ------>88   79   75   75   71    78
3 ------>75   71   67   50   79    68
4 ------>38   46   42   29   46    40
Average->69   72   70   59   72

# of operations shifted in each priority levels:
priority levels # of shifts
1 ---> 1
2 ---> 2
3 ---> 2
4 ---> 4

# of operations that postponed to the next day = 9
```

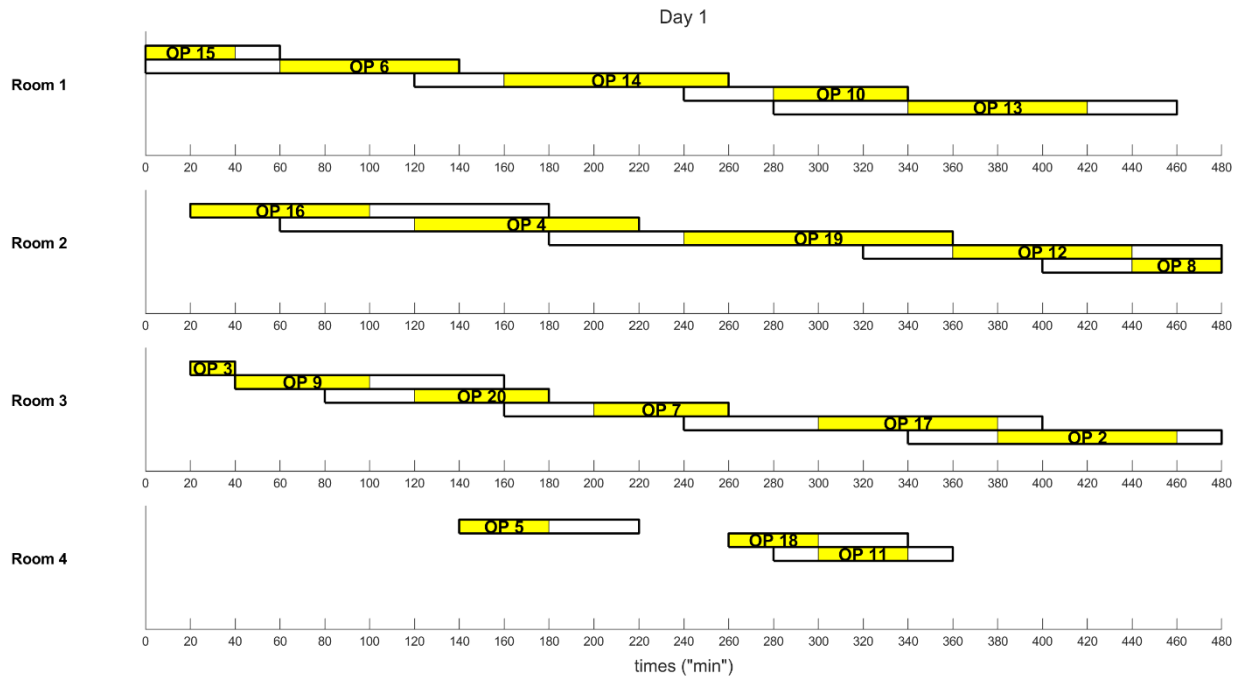*Figure 15. Changes in the schedule if the number of rooms is increased by 1 for both objectives.*

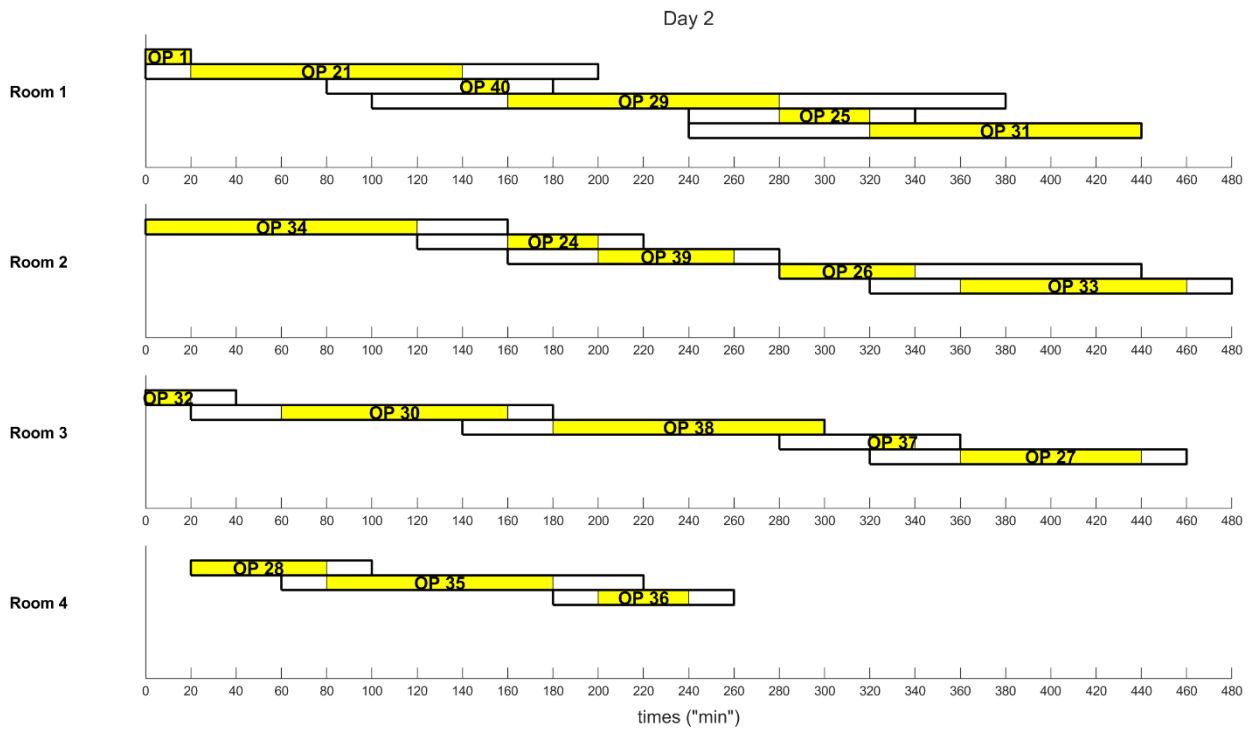**Figure 16.1** *Gantt chart of increasing the number of rooms by 1 in schedule_objective_3 on Day 1.*

Figure 16.2 *Gantt chart of increasing the number of rooms by 1 in schedule_objective_3 on Day 2.*

Figure 16.3 *Gantt chart of increasing the number of rooms by 1 in schedule_objective_3 on Day 3.*

Figure 16.4 *Gantt chart of increasing the number of rooms by 1 in schedule_objective_3 on Day 4.*
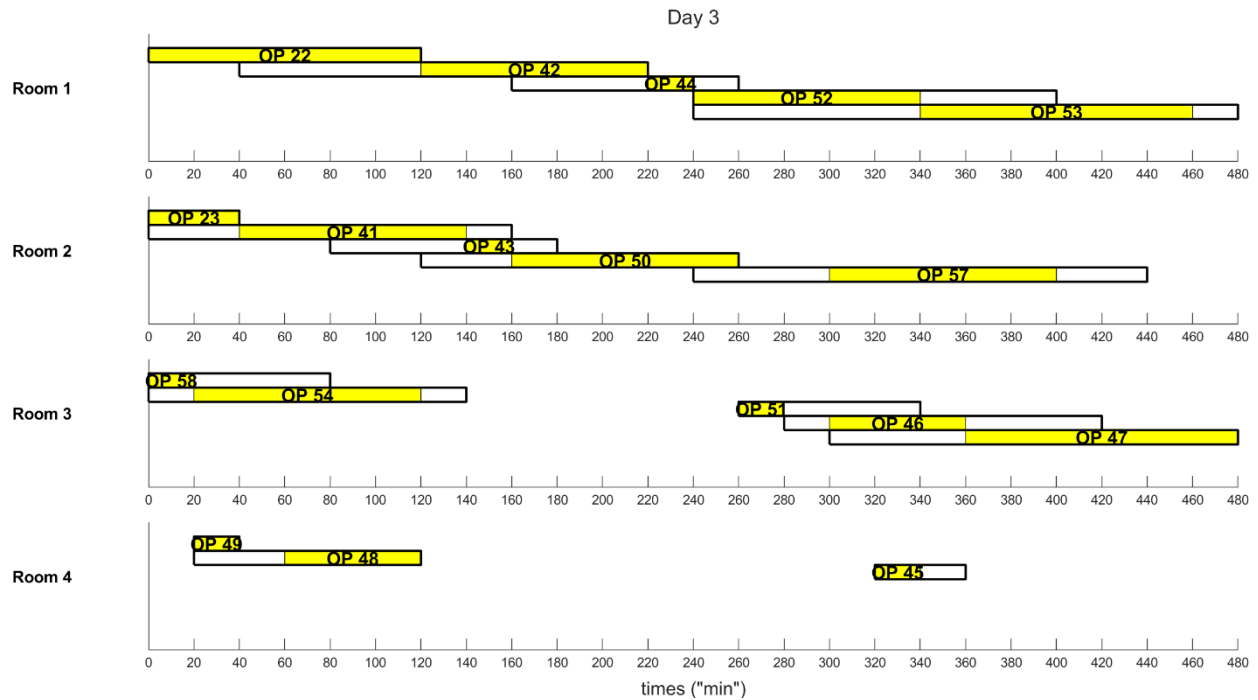
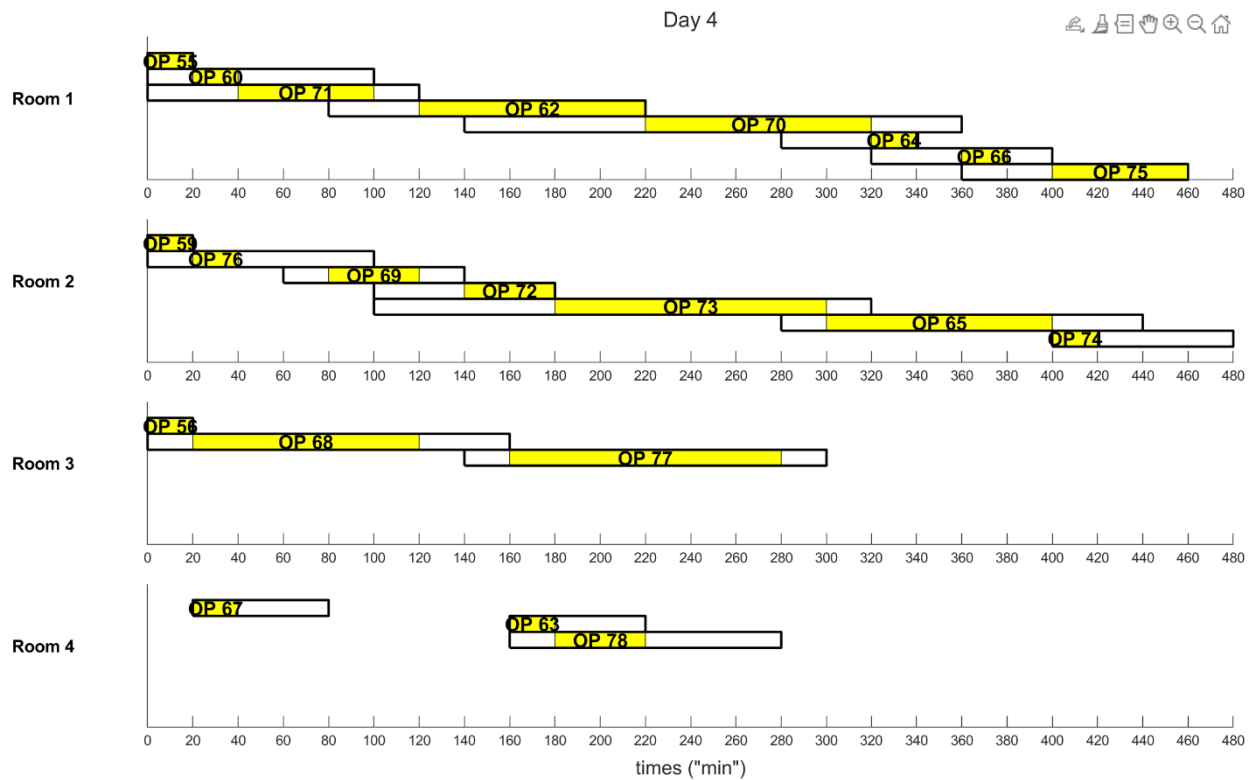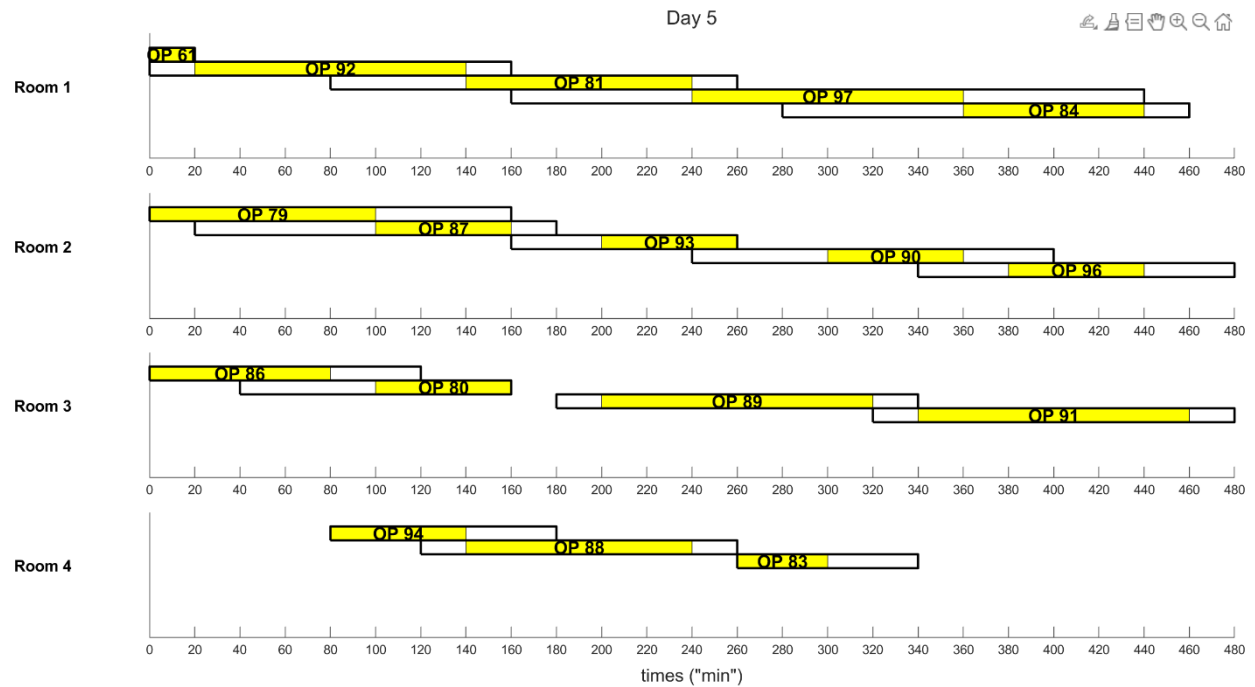**Figure 16.5** *Gantt chart of increasing the number of rooms by 1 in schedule_objective_3 on Day 5.*

3. CONCLUSION

Firstly, these algorithms are based on sorting. After deciding on this, the second step is to create separate algorithms for the determined goals. The results that can be obtained because of these are: Minimizing the sum of duration and sanitization for scheduled_objective_1 is a good practice. For scheduled_objective_2, ordering duration from largest to smallest is a consistent approach to increasing operation time. For scheduled_objective_3, sequencing regardless of duration and sanitization time is the right approach to reach the goal. Especially when the number of rooms is increased by 1, this situation becomes clearer. Comparing the results from these 3 objectives, the objective function value and the number of postponed operations are almost the same for all of them. However, the occupancy rates of the rooms differ from each other due to some changes we have made in the sequencing. In addition, when we compare the operation ids, there are obvious differences, although the number of operations performed is almost the same. Based on these data, it can be said that the algorithms act differently from each other. As a result, it would not be wrong to say that these algorithms work for their own purposes.