# Marmara University
# Faculty of Engineering



# IE 3081
## Modeling and Discrete Simulation

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# HAIR SYTLING SALOON

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# STEP 1

## System Components:

- **Entities:**
  - Appointment_Customer
  - Customer
  - Employee
- **Attributes:**
  - Appointment_Customer : Priority
  - Customer : Priority
  - Employee :
- **Activities:**
  - Customer activities:
    - Go to receptionist
    - Waiting in the queue
    - Shaving

- - - ■ Leave
    - ○ Appointment_Customer
        - ■ Go to receptionist
        - ■ Waiting in the queue
        - ■ Shaving
        - ■ Leave
    - ○ Employee activities :
        - ■ Go to barber chair
        - ■ Shave the customers
        - ■ Leave
- **Events:**
    - ○ Hour Counter
    - ○ Create Customer
    - ○ Pause
- **State Variables:**
    - ○ hour
    - ○ inSystemAppointmentCustomer
    - ○ numberOfServicedCustomer
    - ○ servicearea1isAvailable
    - ○ servicearea2isAvailable
    - ○ servicearea3isAvailable
    - ○ servicearea4isAvailable
    - ○ chair1isAvailable
    - ○ chair2isAvailable
    - ○ chair3isAvailable
    - ○ chair4isAvailable
    - ○ numberOfEmployee
    - ○ InSystemnumberOfEmp
- **Functions:**
    - ○ waitOtherCustomers()
    - ○ decreaseAppointmentCustomers()
    - ○ decreaseAppointmentCustomers1()
    - ○ decreaseAppointmentCustomers2()
    - ○ decreaseAppointmentCustomers3()
    - ○ DecrNumberOfEmployee
    - ○ IncNumberOfEmployee
    - ○ createEmp
    - ○ run
- **Buttons:**
    - ○ run
    - ○ IncNumberOfEmployee
    - ○ DecrNumberOfEmployee

**Relations Between System Components:**

1. **Customer-Employee Relation:**
   ○ A customer is assigned to an employee based on availability.
2. **Customer - Reception**
   ○ Customers always come over to Reception
3. **Queue:**
   ○ Customers waiting for service form a queue. If customer is an Appointment_Customer, it has a priority. For this reason, Appoint_Customer waits shorter than non-appointment customer.

# STEP 2

**Objectives:**

1. **Efficient Appointment Scheduling:**
   ○ Minimize waiting times for customers.
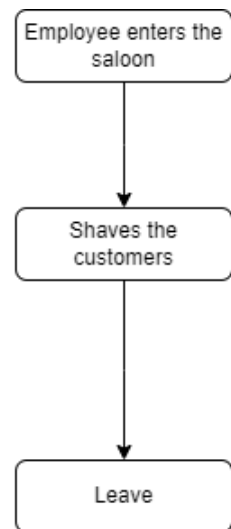   ○ Optimize the allocation of Employee's time.

**Performance Metrics and Outputs:**

1. **Waiting Time:**
   ○ Average and maximum waiting times for customers.
2. **Service Time:**
   ○ The average time is taken for shaving.

**Alternative System Designs to Test:**

**Number Of Employees**

In our model we initially have increaseNumberOfEmployees and decreaseNumberOfEmployees buttons. With these buttons we can change the number of employees. Each employee works for 20 minutes. After 20 minutes of work, there is a 2.5 minute break and a new employee comes. In our alternative simulation, we observe what changes occur in the system when the number of employees changes. A maximum of 4 employees can work. At least 1 employee can work.

```
                                    ┌─────────────────┐
                                    │ Customer enters │
                                    │   the saloon    │
                                    └────────┬────────┘
                                             │
                                             ▼
┌──────────────────┐    Yes         ╱◇────────◇╲
│ Customers enter  │◄──────────────◇   Has an   ◇
│ the queue based  │                ◇ Appointment? ◇
│  on priority     │                 ╲◇────────◇╱
└────────┬─────────┘                     │
         │                               │ No
         │                               ▼
         │                    ┌─────────────────┐
         │                    │ Customer enters │
         │                    │ the end of the  │
         │                    │     queue       │
         │                    └────────┬────────┘
         │                             │
         └──────────────┐              ▼
                        │       ╱◇────────────◇╲
         ┌────────┐ No  │      ◇  Is it at the   ◇
         │ Waits  │◄────┼─────◇ head of the queue? ◇
         └───┬────┘     │      ╲◇────────────◇╱
             │          │              │
             └──────────┘              │ Yes
                                       ▼
                                ╱◇──────────◇╲          ┌─────────────────┐
         ┌────────┐  No        ◇ Are the chairs ◇       │ Employee enters │
         │ Waits  │◄──────────◇    empty?      ◇        │   the saloon    │
         └───┬────┘            ╲◇──────────◇╱           └────────┬────────┘
             │                      │                            │
             └──────────────────────┤ Yes                       ▼
                                     ▼                  ┌─────────────────┐
                              ┌─────────────┐           │  Shaves the     │
                              │ Hair cutting│           │  customers      │
                              └──────┬──────┘           └────────┬────────┘
                                     │                           │
                                     ▼                           ▼
                              ┌─────────────┐           ┌─────────────────┐
                              │    Leave    │           │     Leave       │
                              └─────────────┘           └─────────────────┘
```
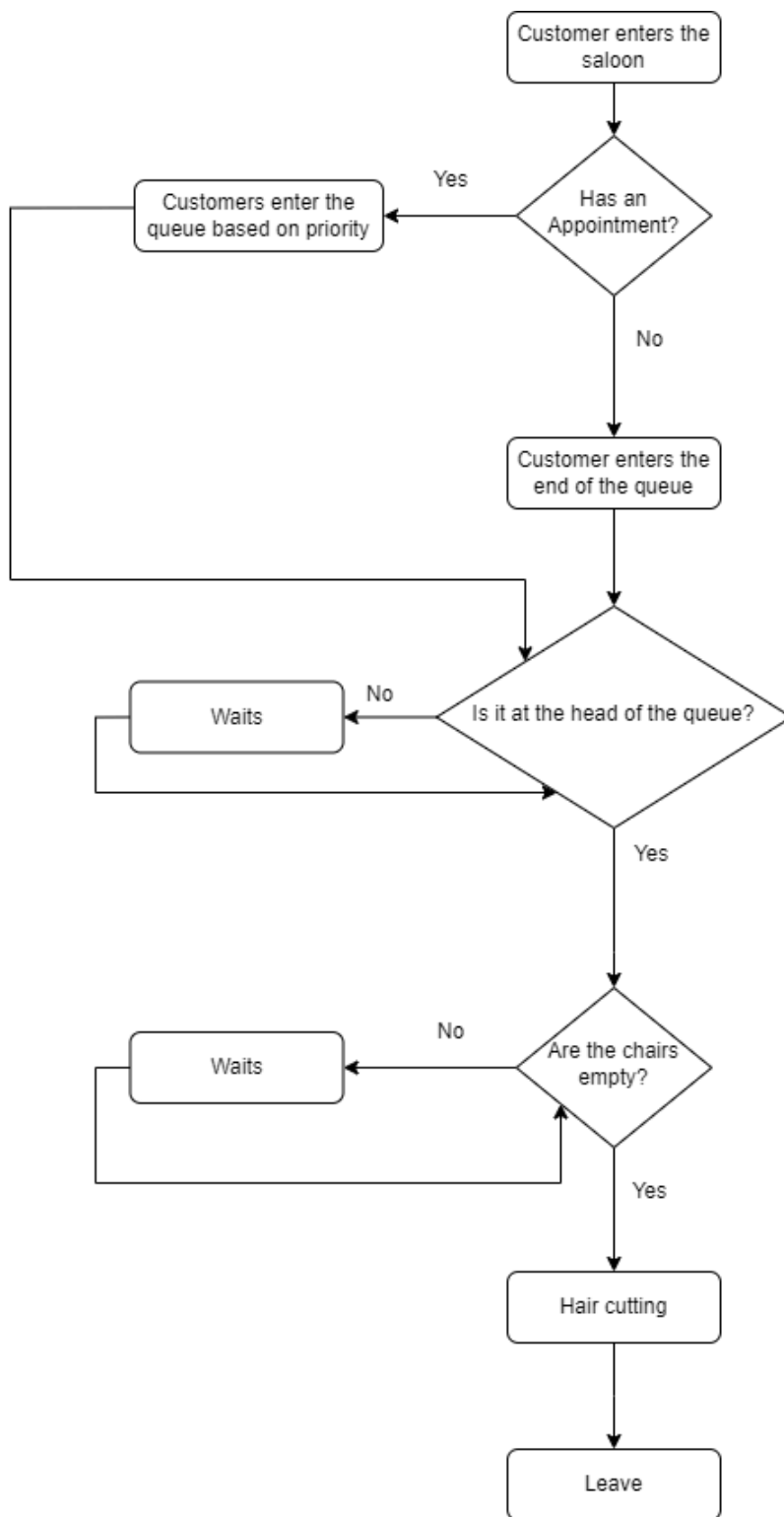
# STEP 3

## System Components

We have consolidated the system components within AnyLogic, encompassing variables, functions, and events. This serves as a central repository for our variables, functions, and events, facilitating a streamlined organization and management of essential elements for our simulation model. Through this structure, we maintain a clear overview of the system's intricacies, promoting efficiency in development and enhancing the overall coherence of our simulation framework.
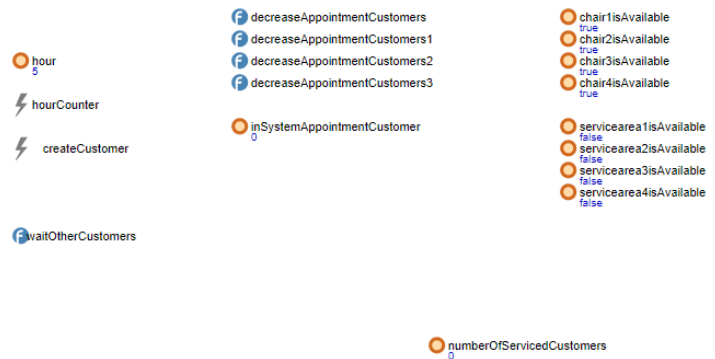


## Aktor Event Flow

We simulated and interlinked the flows of actors within our system in AnyLogic. This detailed simulation considered various actors, including customers with appointments and walk-in customers, as well as our employees. This approach provides a holistic view of the system, accommodating scheduled and unscheduled interactions, and enhances the overall realism and applicability of our model.
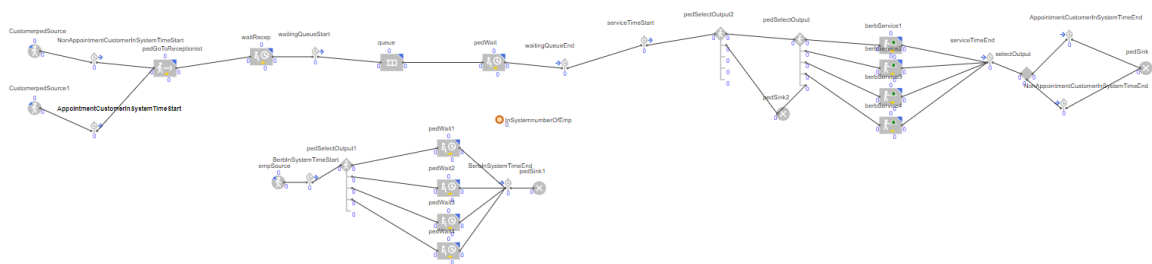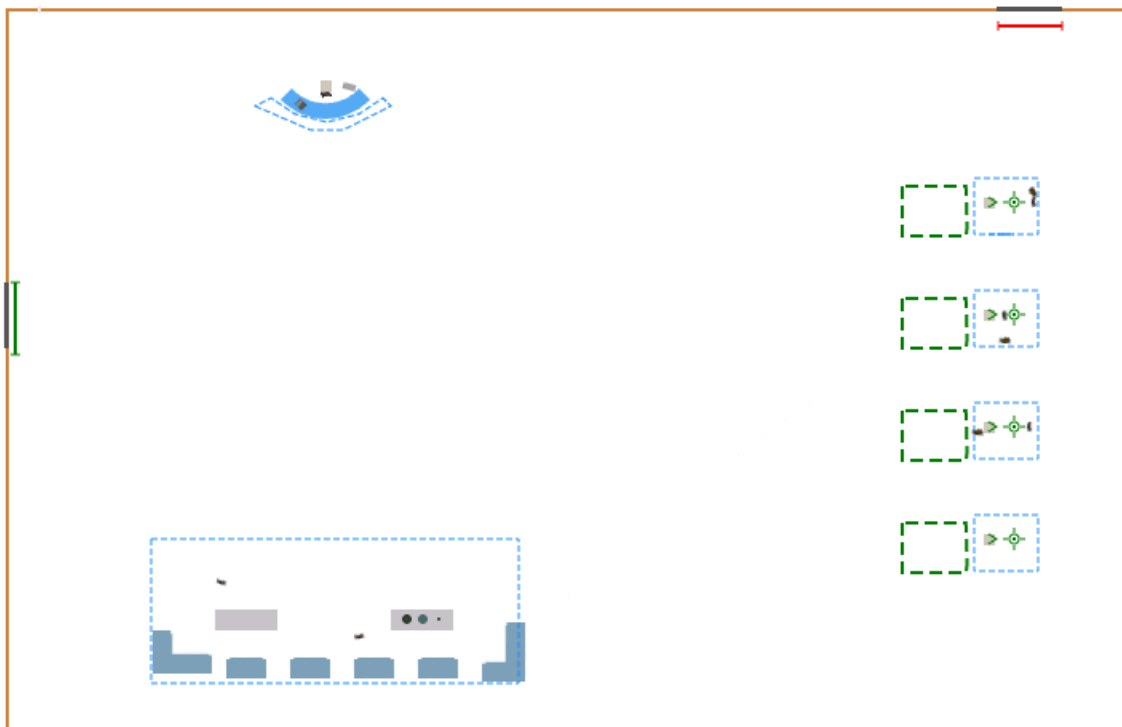
# Simulation

When simulating the system, it offers three buttons: buttons to increase or decrease the number of employees and a button to run the simulation.
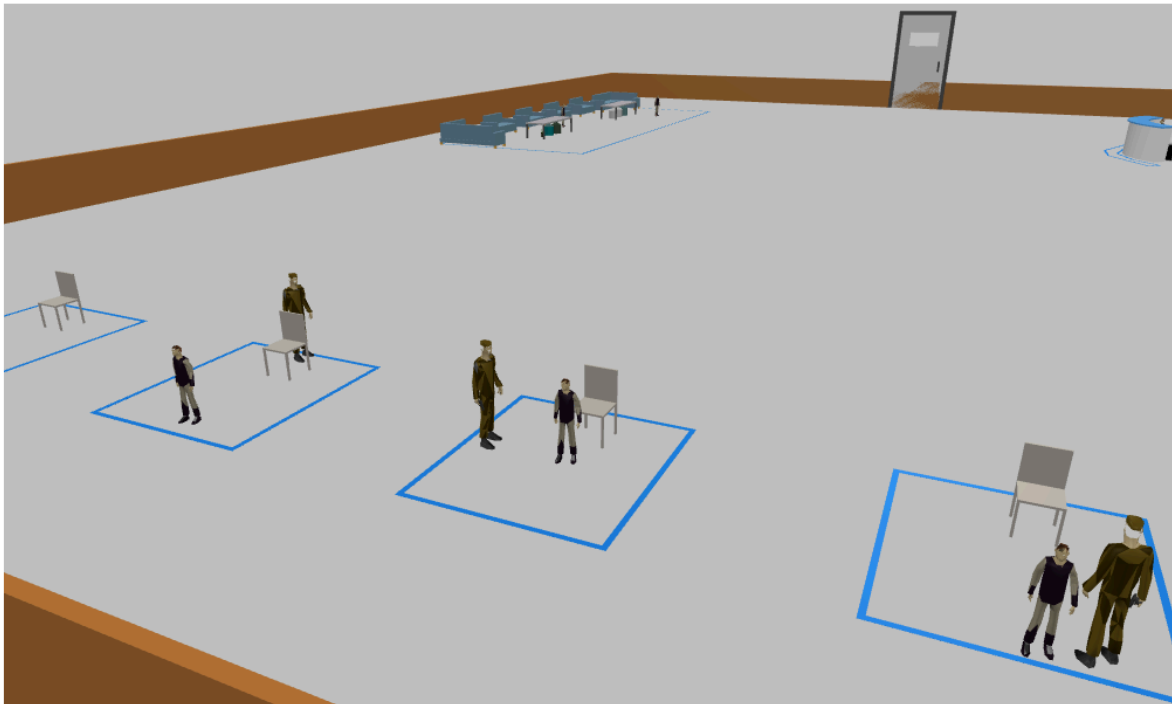
| DecrNumberOfEmployee |
| IncNumberOfEmployee |
| run |

○ numberOfEmployee
0
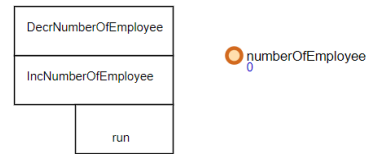
You can view our 2D and 3D simulations below:

## 2D

3D



**Note: *20 minutes in simulation is equal to 8 hours in real life. The simulation can simulate at most 1 hour because we have a student membership of the AnyLogic program.**
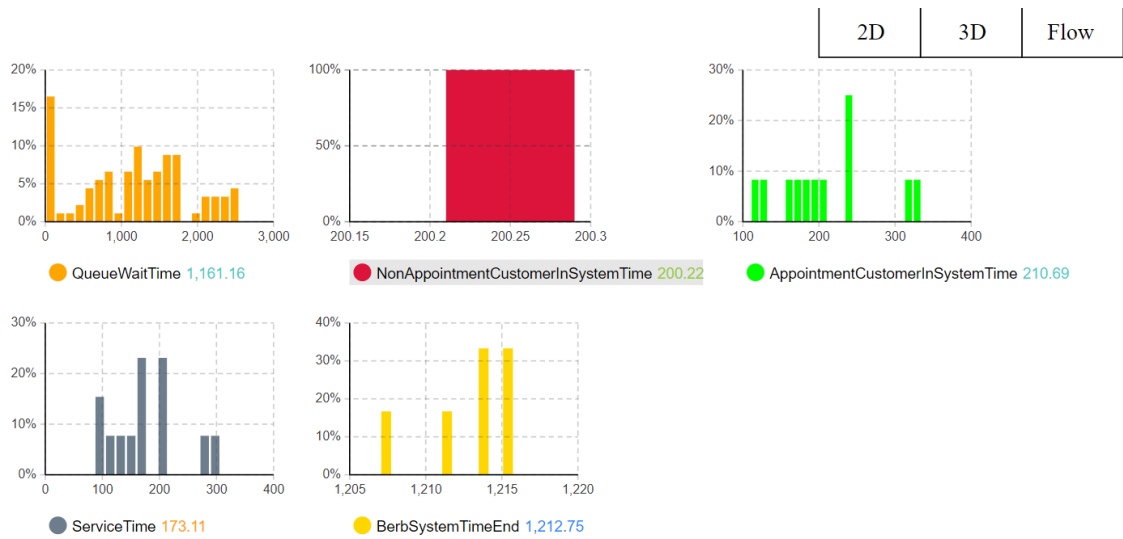
# STEP 4

Input

numberOfEmployees : 3
Seed : 1

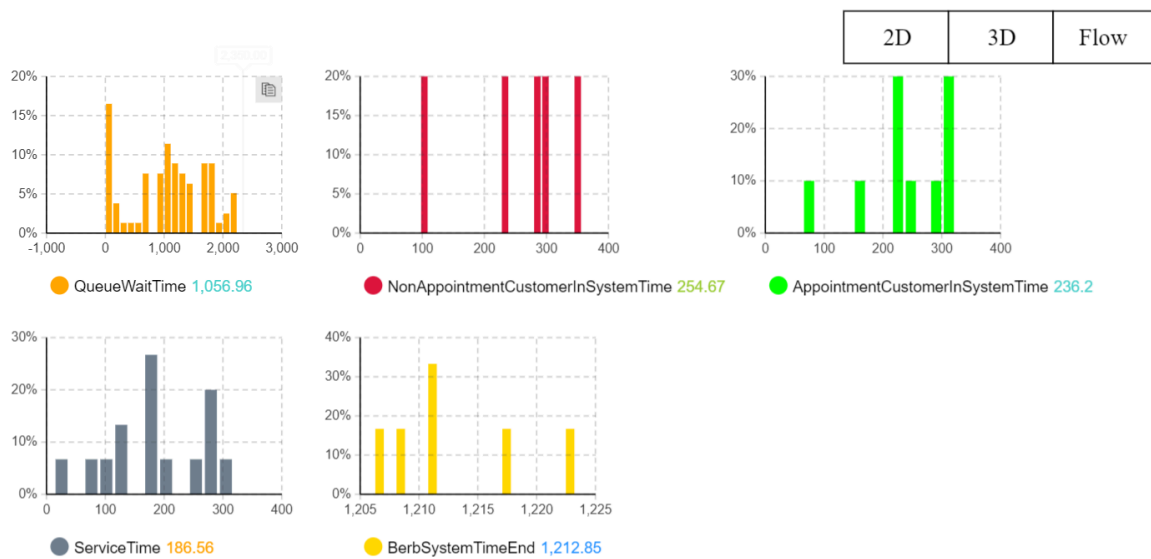Outputs

All of outputs measure mean values.

| | 2D | 3D | Flow |

- QueueWaitTime 1,161.16
- NonAppointmentCustomerInSystemTime 200.22
- AppointmentCustomerInSystemTime 210.69
- ServiceTime 173.11
- BerbSystemTimeEnd 1,212.75

Input

numberOfEmployees : 3
Seed : 11
All of outputs measure mean values.



| | 2D | 3D | Flow |

- QueueWaitTime 1,056.96
- NonAppointmentCustomerInSystemTime 254.67
- AppointmentCustomerInSystemTime 236.2
- ServiceTime 186.56
- BerbSystemTimeEnd 1,212.85

Input

numberOfEmployees : 3

Seed : 111

All of outputs measure mean values.

| | | | 2D | 3D | Flow |
|---|---|---|---|---|---|



● QueueWaitTime 797.78
● NonAppointmentCustomerInSystemTime 250.07
● AppointmentCustomerInSystemTime 273.01
● ServiceTime 209.13
● BerbSystemTimeEnd 1,213.2
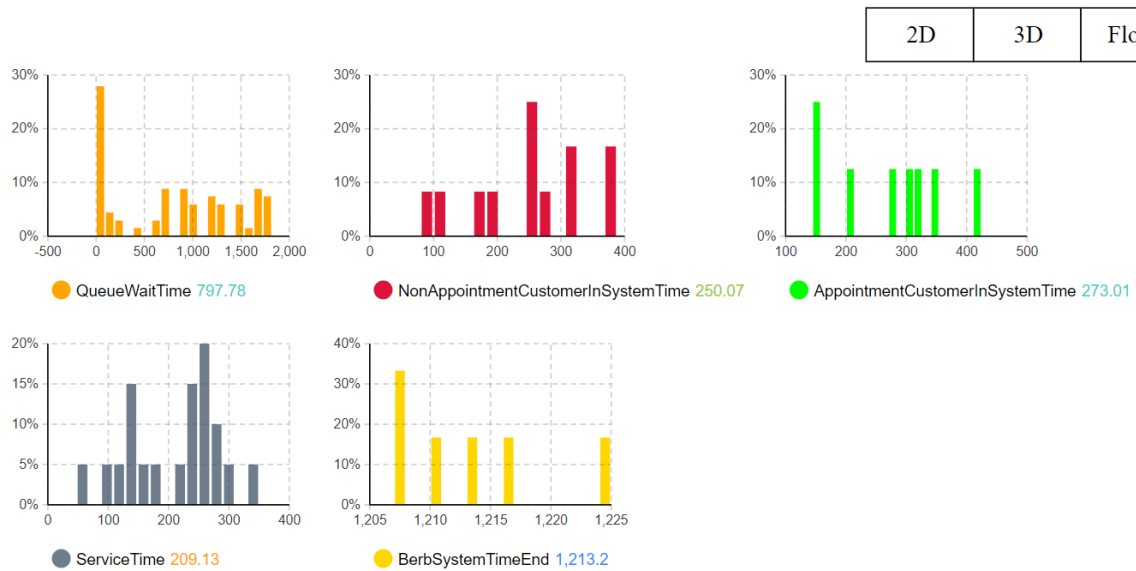
Input

numberOfEmployees : 4

Seed : 1

Outputs

All of outputs measure mean values.

| | | | 2D | 3D | Flow |
|---|---|---|---|---|---|



● QueueWaitTime 1,103.85
● NonAppointmentCustomerInSystemTime 200.22
● AppointmentCustomerInSystemTime 236.42
● ServiceTime 199.6
● BerbSystemTimeEnd 1,214.83
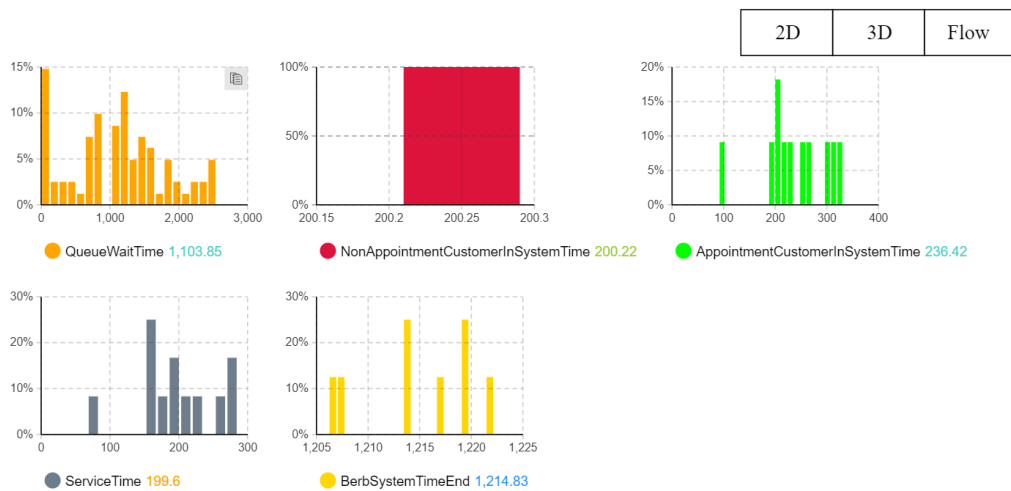
## Input

numberOfEmployees : 4

Seed : 11

## Outputs

All of outputs measure mean values.

| 2D | 3D | Flow |
|----|----|------|



QueueWaitTime 835.34

NonAppointmentCustomerInSystemTime 228.13

AppointmentCustomerInSystemTime 240.29

ServiceTime 193.54

BerbSystemTimeEnd 1,217.64
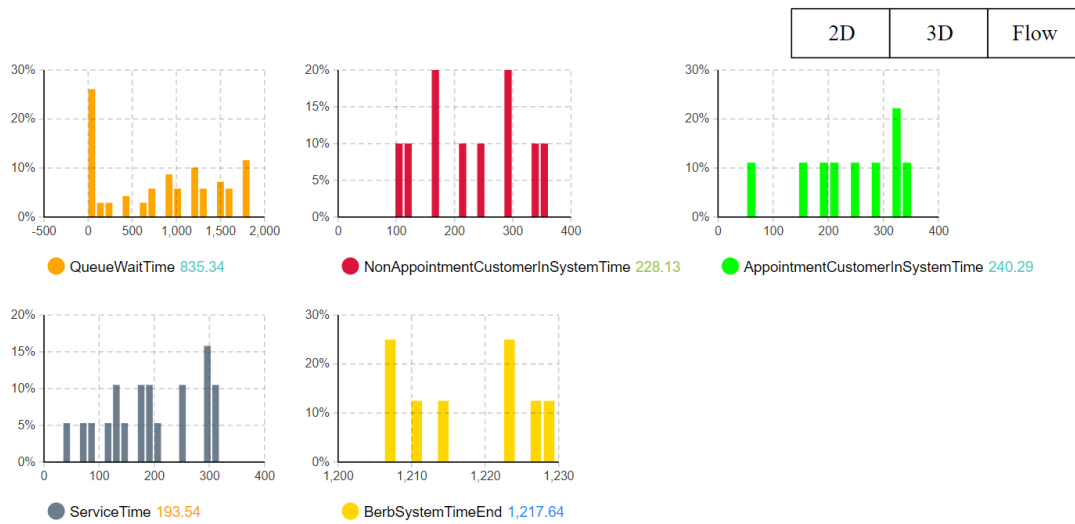
## Input

numberOfEmployees : 4

Seed : 111

## Outputs

All of outputs measure mean values.
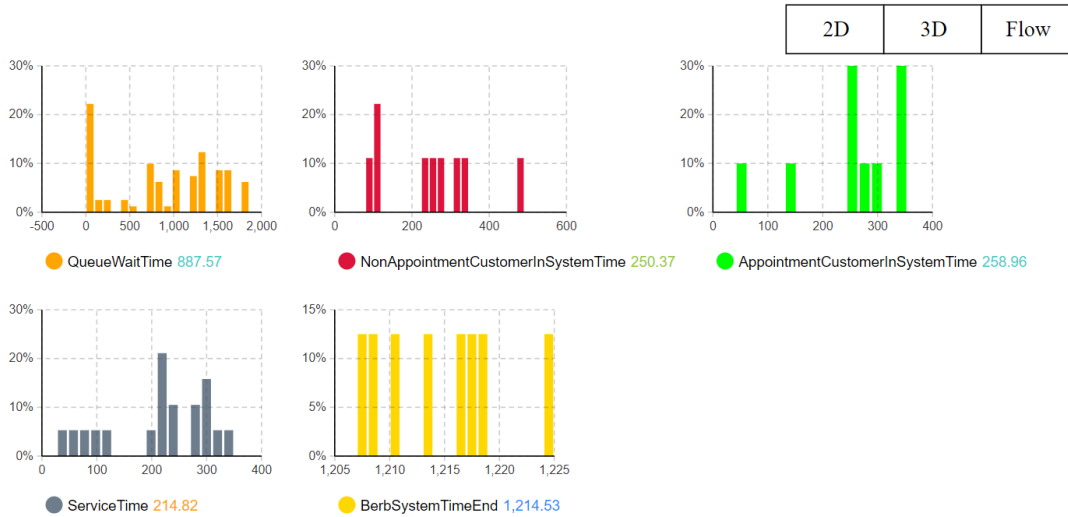
QueueWaitTime 887.57

NonAppointmentCustomerInSystemTime 250.37

AppointmentCustomerInSystemTime 258.96

ServiceTime 214.82

BerbSystemTimeEnd 1,214.53

| | Replication 1 | Replication 2 | Replication 3 | Mean | Standart Dev | Current Half Width | Lower Bound | Upper Bound | 10% Enhanced Half Width | Required Std Error | Required Replications | New Margin | New Lower Bound | New Upper Bound |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Queue Wait Time | 1161 | 1056 | 797 | 1004,666667 | 187,3508296 | 212,0074217 | 792,659245 | 1216,674088 | 190,8066795 | 97,35034669 | 3,703703704 | 413,821978 | 590,8446887 | 1418,488645 |
| Non Appointment In System Time | 200 | 254 | 250 | 234,6666667 | 30,08875759 | 34,0486345 | 200,6180322 | 268,7153012 | 30,64377105 | 15,63457706 | 3,703703704 | 66,46028316 | 168,2063835 | 301,1269498 |
| Appointment In System Time | 210 | 236 | 273 | 239,6666667 | 31,65964835 | 35,82626473 | 203,8404019 | 275,4929314 | 32,24363826 | 16,45083585 | 3,703703704 | 69,93007895 | 169,7365877 | 309,5967456 |
| Service Time | 173 | 186 | 209 | 189,3333333 | 18,23001189 | 20,62920045 | 168,7041329 | 209,9625338 | 18,5662804 | 9,472592042 | 3,703703704 | 40,26659287 | 149,0667405 | 229,5999262 |
| Berber System Time | 1212 | 1212 | 1213 | 1212,333333 | 0,577350269 | 0,653333333 | 1211,68 | 1212,986667 | 0,588 | 0,3 | 3,703703704 | 1,275255791 | 1211,058078 | 1213,608589 |

NumberOfEmployee is 3
Replication 1 is seed 1
Replication 2 is seed 11
Replication 3 is seed 111

We have 4 replications. We added the replications and divided by 4. Then we found the standard deviation for each replication. We used the formula 1.96*StandardDeviation/TotalReplicationNumber to find the current half-width. Then we subtracted the current half-width from the mean value to find the lower bound. For the upper bound, we added the mean value and the current half-width. For the enhanced half-width, we multiplied the current half-width by 0.9. For the required standard deviation error, we divided the current half-width by 1.96. We found the number of required replications by dividing the standard deviation value by the required standard deviation. The number of required replications we found was 3.70. We rounded it to 4. Then we made our new margin, new lower and upper bounds according to 4.

| | Replication 1 | Replication 2 | Replication 3 | Mean | Standart Dev | Current Half Width | Lower Bound | Upper Bound | 10% Enhanced Half Width | Required Std Error | Required Replications | New Margin | New Lower Bound | New Upper Bound |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Queue Wait Time | 1103 | 835 | 887 | 941,6666667 | 142,1173224 | 160,8208897 | 780,8457769 | 1102,487556 | 144,7388008 | 73,84632692 | 3,703703704 | 313,9098536 | 627,7568131 | 1255,57652 |
| Non Appointment In System Time | 200 | 228 | 250 | 226 | 25,05992817 | 28,3579783 | 197,6420217 | 254,3579783 | 25,52218047 | 13,02152065 | 3,703703704 | 55,3525654 | 170,6474346 | 281,3525654 |
| Appointment In System Time | 236 | 240 | 258 | 244,6666667 | 11,71893055 | 13,26121831 | 231,4054484 | 257,927885 | 11,93509648 | 6,089334939 | 3,703703704 | 25,88486549 | 218,7818012 | 270,5515322 |
| Service Time | 199 | 193 | 214 | 202 | 10,81665383 | 12,24019608 | 189,7598039 | 214,2401961 | 11,01617647 | 5,620498199 | 3,703703704 | 23,89190959 | 178,1080904 | 225,8919096 |
| Berber System Time | 1214 | 1217 | 1214 | 1215 | 1,732050808 | 1,96 | 1213,04 | 1216,96 | 1,764 | 0,9 | 3,703703704 | 3,825767374 | 1211,174233 | 1218,825767 |

NumberOfEmployee is 4

Replication 1 is seed 1

Replication 2 is seed 11

Replication 3 is seed 111

| Main System - Alternative System | Mean Diff | Std Dev Diff | Current Half Width | Lower Bound | Upper Bound | New Lower Bound | New Upper Bound |
|---|---|---|---|---|---|---|---|
| Queue Wait Time Diff | 63 | 45,23350713 | 51,18653193 | 11,81346807 | 114,1865319 | -36,91212441 | 162,9121244 |
| Non Appointment In System Time Diff | 8,666666667 | 5,028829418 | 5,690656196 | 2,976010471 | 14,35732286 | -2,441051094 | 19,77438443 |
| Appointment In System Time Diff | -5 | 19,94071779 | 22,56504642 | -27,56504642 | 17,56504642 | -49,04521346 | 39,04521346 |
| Service Time Diff | -12,66666667 | 7,413358059 | 8,389004371 | -21,05567104 | -4,277662296 | -29,04134994 | 3,70801661 |
| Berber System Time Diff | -2,666666667 | -1,154700538 | -1,306666667 | -1,36 | -3,973333333 | -0,116155084 | -5,217178249 |

We changed the design of the system. In this system, we have 4 employee. For this reason mean queue wait time value is decreased compared to 3 employee system. Also standard deviation is decreased for every output. Mostly, all the values are decreased. We added a difference table. So we can observe what has changed for 2 system designs