IE3081 – Modeling and Discrete Simulation Course

Project Report

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Introduction:

The bank will have 4 drive-thru servers. These servers will be lined up side by side in 2 pairs. So we will have two queue. When two vehicles come to the left queue at the same time, the one that comes first will be processed on the server that front second car will be processed on the server that rear. Even if the operation of the vehicle in front is finished, the ordinary vehicle on the left will not be able to access the server. Because the vehicle operating on the back server is there and there is no space to pass by. Therefore, the vehicle processing on the back server will be expected to leave.

System Components:

- **Main:** The purpose of main is to combine all components, inputs, outputs, variables, source, queue, servers and elements such as sink.
    - **Variables:**
        - numberOfCustomer: Holds total number of customer in the system.
        - AverageTimeSpentPerCustomer: Holds average time spent per customer in the system.
        - AverageTimeSpendFirstQueuePerCustomer: Holds average time of customers waiting in the first queue in the system.
        - AverageTimeSpendSecondQueuePerCustomer: Holds average time of customers waiting in the second queue in the system.
    - **Distributions:**
        - sourceDistribution: Determines what time interval customers will arrive.
        - ATM1Distribution: Determines how long the processing time of customers coming to first ATM will be.
        - ATM2Distribution: Determines how long the processing time of customers coming to second ATM will be.
        - ATM3Distribution: Determines how long the processing time of customers coming to third ATM will be.
        - ATM4Distribution: Determines how long the processing time of customers coming to fourthATM will be.
    - **Dataset:**
        - dataset: Keeps customers arrival data by time.

- **Source:** Thanks to the source, customers log in to the system at the time interval we set.
- **SelectOutput:** We can direct the customers logging into our system to the queue order via selectoutput.
- **Queue:** If our servers are full, our customers will wait here.
- **Hold:** While transferring customers from queue to server, we wait for a while with hold so that we don't get any errors.
- **ATM's:** Customers handle their transactions in ATMs (servers).
- **Sink:** Through sink, customers leave the system.

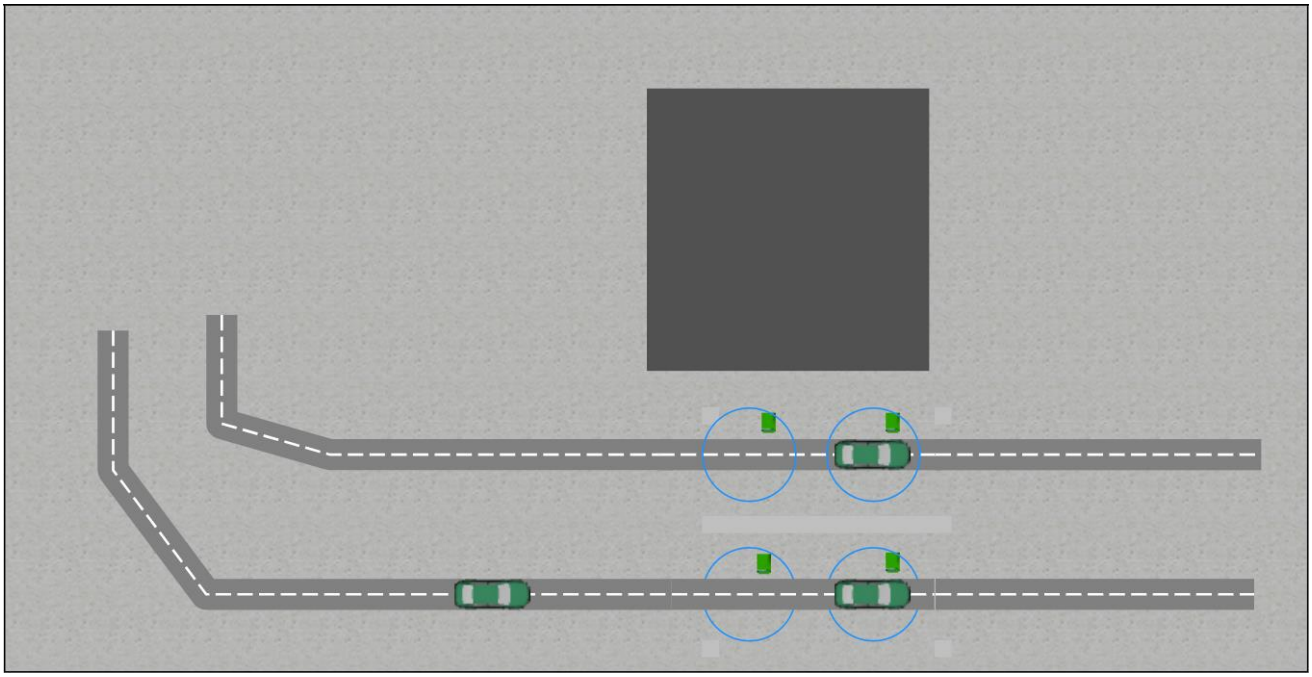
Relation between system components:

It directs customers to selectoutput via the source connector. Selectoutput sends customers to the top or bottom queue with 50% probability. If there are customers at ATMs, component of hold tells to queue customers to wait. If ATMs are available, the next customer is sent to the selectoutput. Selectoutput decides which server the client will go to. The customer leaves the system via sink after processing the transaction according to the processing time of the ATM from the customdistribution.

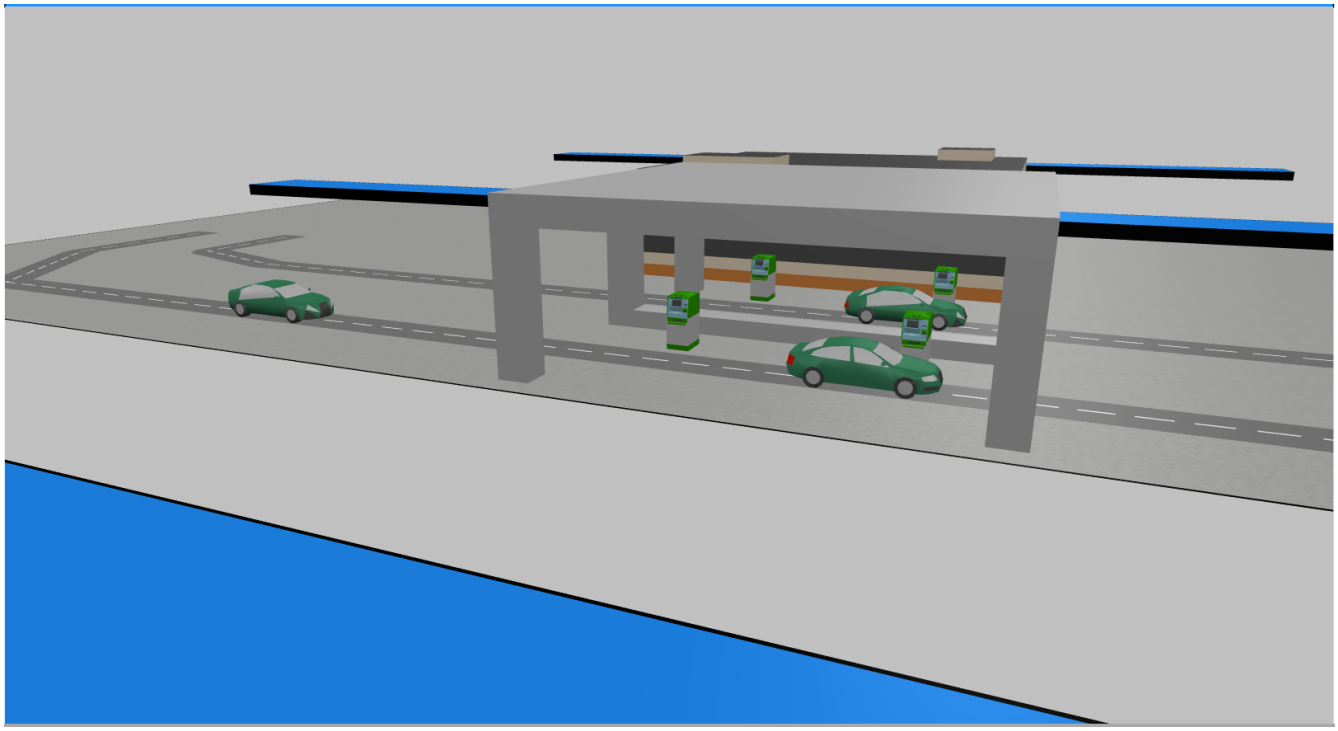
Generation of random variates:

Through selectoutputs, it is determined which path the customers will follow randomly.

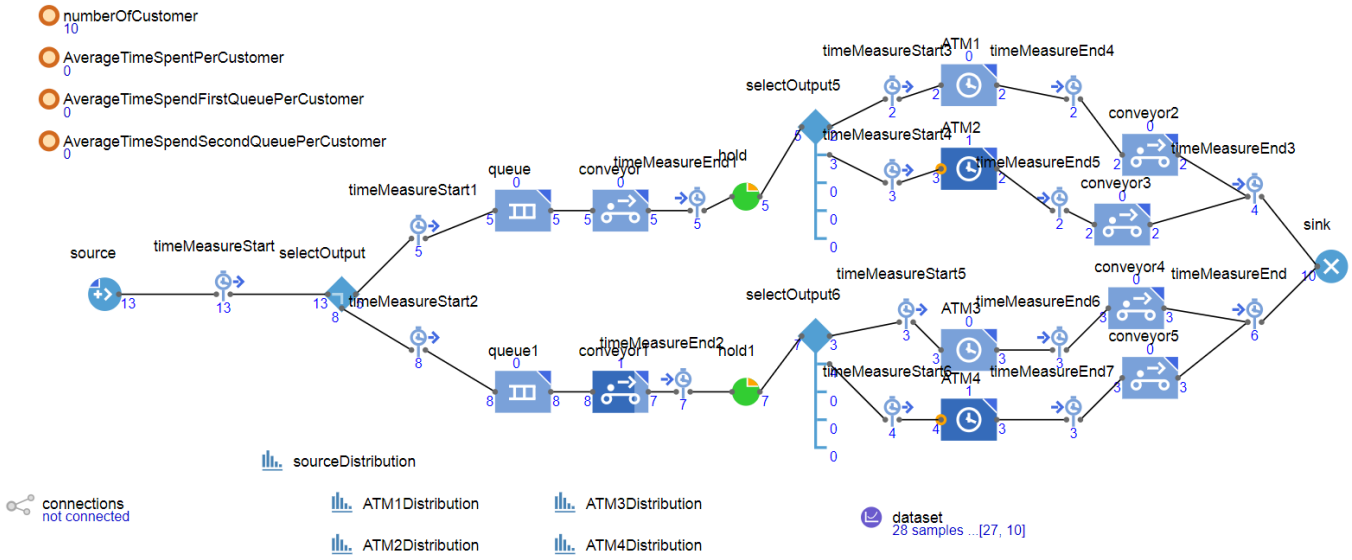
2D view of the model:



3D view of the model:



Logic of the model:



Input variables:

Uncontrollable input variables:

- selectOutput: float
- selectOutput5: float
- selectOutput6: float

Controllable input variables:

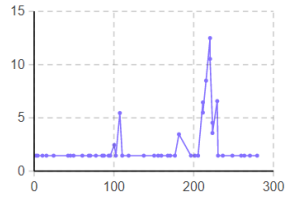
- sourceDistribution: float
- ATM1Distribution: float
- ATM2Distribution: float
- ATM3Distribution: float
- ATM4Distribution: float
- ATM1 Capacity: int
- ATM2 Capacity: int
- ATM3 Capacity: int
- ATM4 Capacity: int

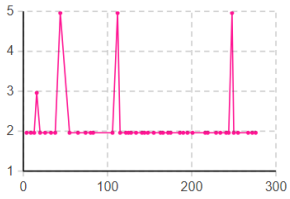
Outputs:

Situation 1:

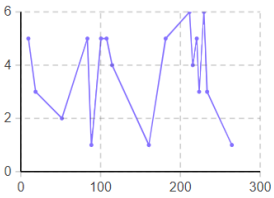
- sourceDistribution:
    - interval: 1 number of observations: 0.4
    - interval: 2 number of observations: 0.2
    - interval: 3 number of observations: 0.2
    - interval: 4 number of observations: 0.1
    - interval: 5 number of observations: 0.1
- ATM1Distribution:
    - interval: 1 number of observations: 0.2
    - interval: 2 number of observations: 0.2
    - interval: 3 number of observations: 0.2
    - interval: 4 number of observations: 0.2
    - interval: 5-6 number of observations: 0.2
- ATM2Distribution:
    - interval: 1 number of observations: 0.4
    - interval: 2 number of observations: 0.2
    - interval: 3 number of observations: 0.2
    - interval: 4 number of observations: 0.1
    - interval: 5 number of observations: 0.1
- ATM3Distribution:
    - interval: 1 number of observations: 0.4
    - interval: 2 number of observations: 0.2
    - interval: 3 number of observations: 0.2
    - interval: 4 number of observations: 0.1
    - interval: 5 number of observations: 0.1
- ATM4Distribution:
    - interval: 1 number of observations: 0.4
    - interval: 2 number of observations: 0.2
    - interval: 3 number of observations: 0.2
    - interval: 4 number of observations: 0.1
    - interval: 5 number of observations: 0.1

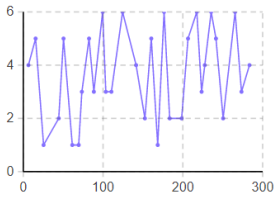
Replication 1.1:



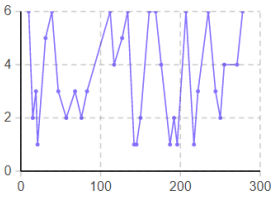


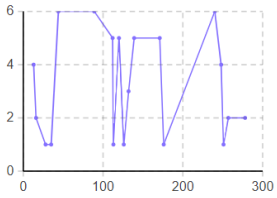
Time spent in first queue per customer Time spent in second queue per customer



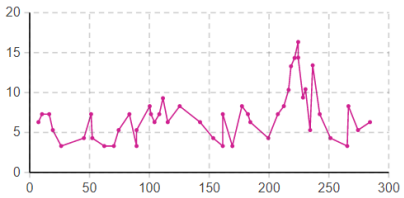


Time spent in ATM1 per customer Time spent in ATM2 per customer

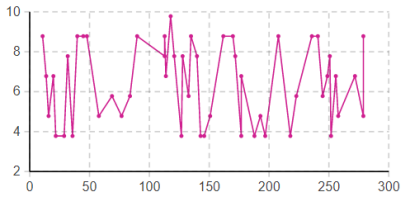




Time spent in ATM4 per customer Time spent in ATM3 per customer



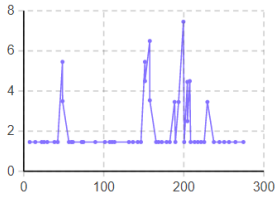
Time spent in the system per customers for first queue



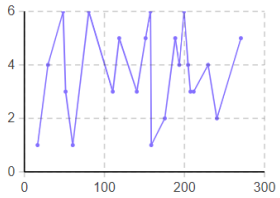
Time spent in the system per customers for second queue

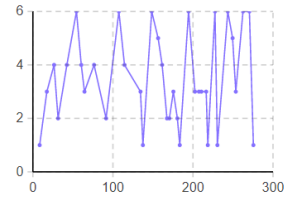
Average Time Spent per Customer: 6.776553941375349
Average Time Spent in First Queue per Customer: 2.5696643955712117
Average Time Spent in Second Queue per Customer: 2.209999999999994

Replication 1.2:

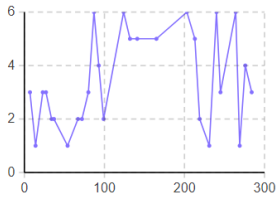


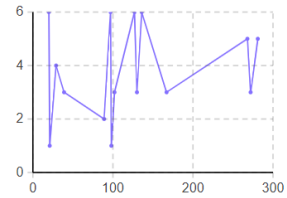
Time spent in first queue per customer Time spent in second queue per customer



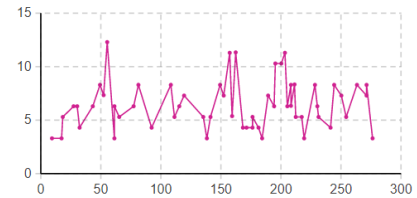


Time spent in ATM1 per customer Time spent in ATM2 per customer

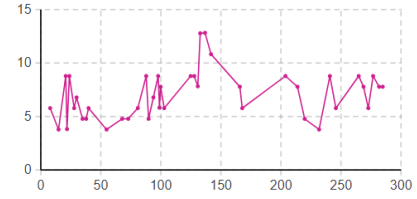




Time spent in ATM4 per customer Time spent in ATM3 per customer



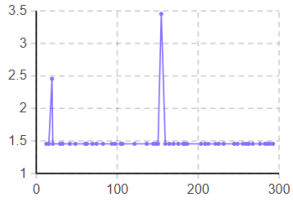
Time spent in the system per customers for first queue



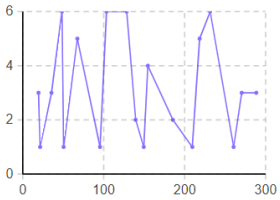
Time spent in the system per customers for second queue

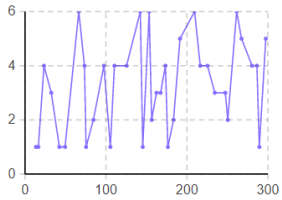
Average Time Spent per Customer: 6.794400979394807
Average Time Spent in First Queue per Customer: 2.131905774881554
Average Time Spent in Second Queue per Customer: 2.679047619047624

Replication 1.3:

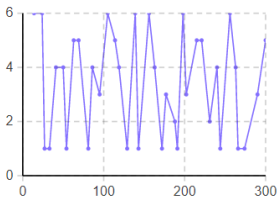


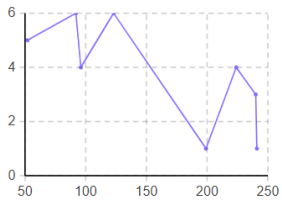
Time spent in first queue per customer Time spent in second queue per customer



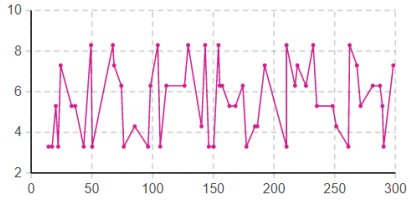


Time spent in ATM1 per customer Time spent in ATM2 per customer

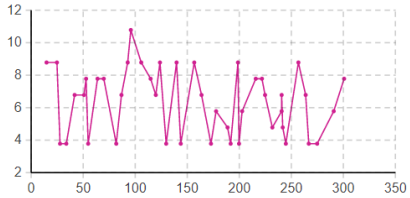




Time spent in ATM4 per customer Time spent in ATM3 per customer



Time spent in the system per customers for first queue



Time spent in the system per customers for second queue

Average Time Spent per Customer: 6.0303278341492454

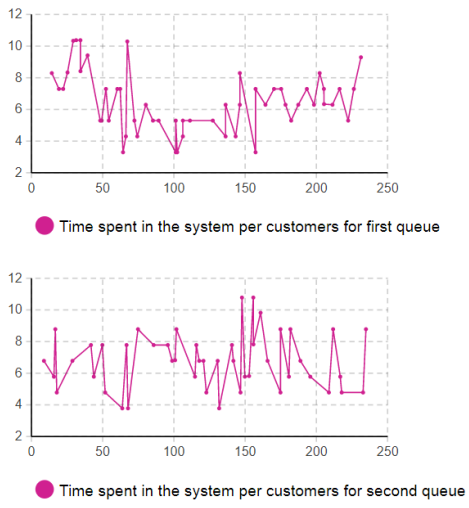
Average Time Spent in First Queue per Customer: 1.5092098501166686

Average Time Spent in Second Queue per Customer: 2.183111111111108

Situation 2(Changed System):

- sourceDistribution:
  - interval: 1 number of observations: 0.4
  - interval: 2 number of observations: 0.4
  - interval: 3 number of observations: 0.1
  - interval: 4 number of observations: 0.2
- ATM1Distribution:
  - interval: 1 number of observations: 0.2
  - interval: 2-3 number of observations: 0.4
  - interval: 4 number of observations: 0.1
  - interval: 5-6 number of observations: 0.3
- ATM2Distribution:
  - interval: 2 number of observations: 0.1
  - interval: 3 number of observations: 0.5
  - interval: 4 number of observations: 0.3
  - interval: 5-6 number of observations: 0.1
- ATM3Distribution:
  - interval: 1 number of observations: 0.2
  - interval: 2-3 number of observations: 0.6
  - interval: 4 number of observations: 0.2
- ATM4Distribution:
  - interval: 3 number of observations: 0.35
  - interval: 4 number of observations: 0.25
  - interval: 5-6 number of observations: 0.4

Replication 2.1:

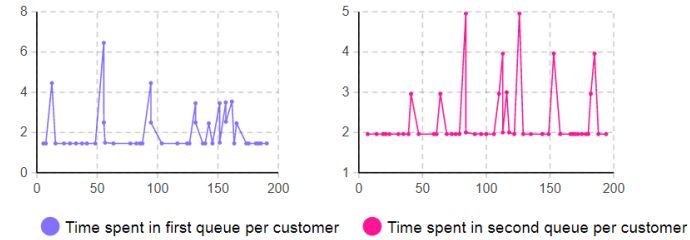


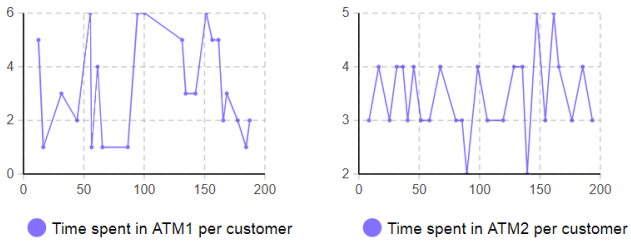
Average Time Spent per Customer: 6.638911608464045

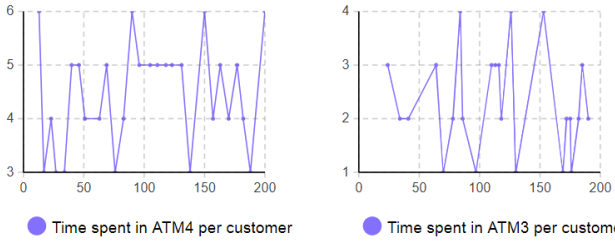
Average Time Spent in First Queue per Customer: 2.030513452174987

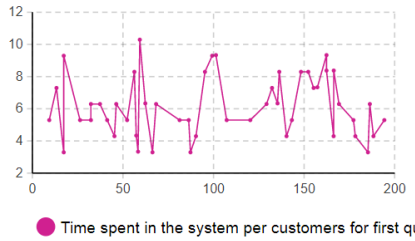
Average Time Spent in Second Queue per Customer: 2.282553191489353

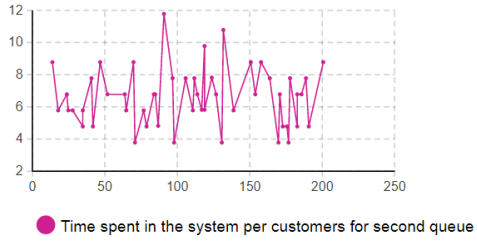
Replication 2.2:









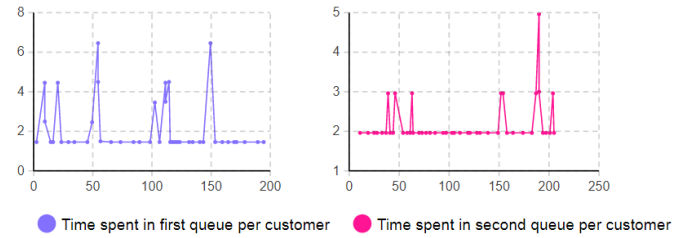


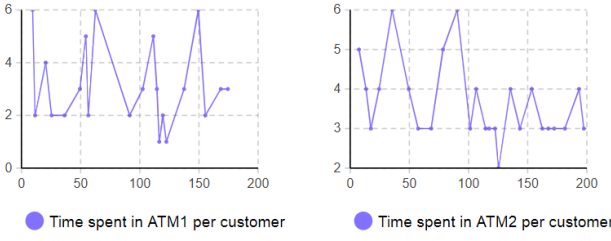
Average Time Spent per Customer: 6.3843587556087344

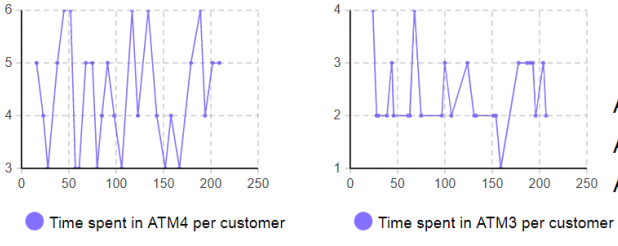
Average Time Spent in First Queue per Customer: 1.9738480690406022

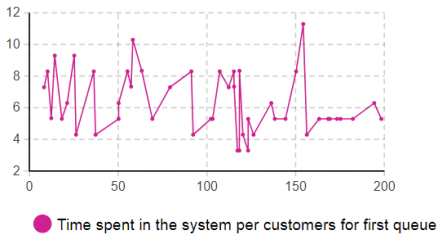
Average Time Spent in Second Queue per Customer: 2.296470588235291

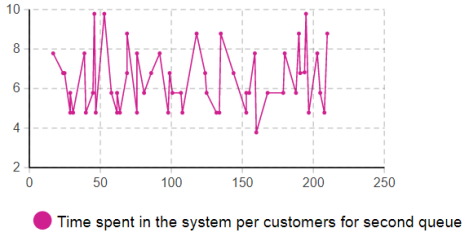
Replication 2.3:











Average Time Spent per Customer: 6.371862230704112

Average Time Spent in First Queue per Customer: 2.1184941828052604

Average Time Spent in Second Queue per Customer: 2.168301886792448

Situation 1:

Mean for average time spent per customer:

(6.77+6.79+6.03)/3 **= 6.53**

Standard deviation:

√ (((6.53-6.77)^2+(6.53-6.79)^2+(6.53-6.03)^2)/2)

√(0.0576+0.0676+0.25 / 2) = 0.433

Confidence Interval (%95):

CI =$\bar{X}$ ± Z×σ/√n

=6.53 ± 1.9600×0.433/√300

=6.53 ± 0.0490

Total Number of Replications:

Upper Limit:

6.53+3*0.433 = 7.829

Lower Limit:

6.53-3*0.433 = 5.231

(6.79-6.03)*0.9 = 0.684

0.684 = 2*1.96*0.433 / √n

N = 0.402

95% prediction intervals

6.53-1.96*0.433*√(1+1/3) < μ < 6.53+1.96*0.433*√(1+1/3)

= 5.55 < μ < 7.50

Situation 2(Changed System):

Mean for average time spent per customer:

(6.63+6.38+6.37)/3 **= 6.46**

Standard deviation:

√ (((6.46-6.63)^2+(6.46-6.38)^2+(6.46-6.37)^2)/2)

√(0.0289+0.0064+0.0081 / 2) = 0.147

Confidence Interval (%95):

CI =$\bar{X}$ ± Z×σ/√n

=6.46 ± 1.9600×0.147/√300

=6.46 ± 0.0166

Total Number of Replications:

Upper Limit:

6.46+3*0.147 = 6.901

Lower Limit:

6.46-3*0. 147 = 6.019

(6.63-6.37)*0.9 = 0.234

0.234= 2*1.96*0.147/ √n

N = 0.164

95% prediction intervals:

6.46-1.96*0.147*√(1+1/3) < μ < 6.46+1.96*0.147*√(1+1/3)

= 6.12 < μ < 6.79