

CENG 4513 Modeling and Simulation

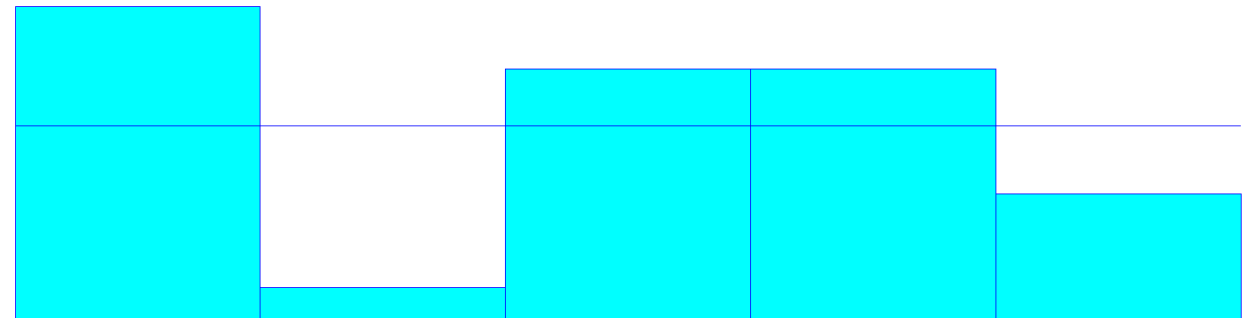
2022-2023 Fall

Project Assignment 01

Simulation Development Project Report

- 1) We have selected the option number 5, which is “Library”, to simulate as a real-world problem from the given list.
- 2) Our group consists of Mehmet Kadri GOFRALILAR (180709005) and Hasan Ali ÖZKAN (180709020).
- 3) After observing the Muğla Sıtkı Koçman University Menteşe Library for a day and talking to the staff about data, the information we got was like following:
  - Number of borrowed books daily (for October)
  - Number of returned books daily (for October)
  - Number of student entries daily (for October)
  
  - Average study time
  - Average registration time
  - Average time spent for book borrowing process
  - Average time spent for book returning process
  - Average time spent for looking for specific books
  
  - Number of total books
  - Number of chairs (for studying purposes)
  - Number of staff for processes
  
  - Times of the maximum queue length for borrowing/returning books (in a day)
  - Times that number of registration processes peak (in a term)
  - Times of the study rooms reaching maximum capacity (in a term)
  
  - Probability of a student finding the book they are looking for
  - Probability of a student finding a spot in the study rooms
- 4) We have performed input data analysis for our data, and the results are like the following:

Borrowed\_Book\_Count:



#### Distribution Summary

Distribution: Uniform  
Expression: UNIF(-0.001, 309)  
Square Error: 0.054943

#### Chi Square Test

Number of intervals = 5  
Degrees of freedom = 4  
Test Statistic = 8.52  
Corresponding p-value = 0.0784

#### Kolmogorov-Smirnov Test

Test Statistic = 0.118  
Corresponding p-value > 0.15

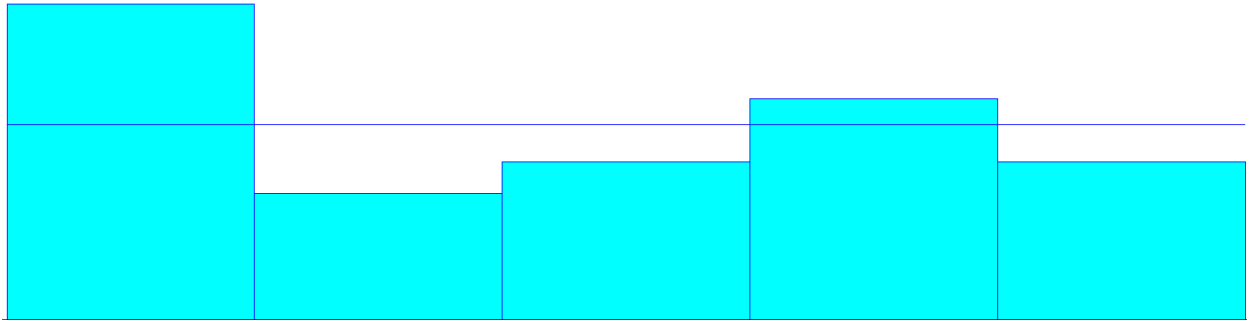
#### Data Summary

Number of Data Points = 31  
Min Data Value = 0  
Max Data Value = 309  
Sample Mean = 136  
Sample Std Dev = 104

#### Histogram Summary

Histogram Range = -0.001 to 309  
Number of Intervals = 5

Returned\_Book\_Count:



#### Distribution Summary

Distribution: Uniform  
Expression: UNIF(-0.001, 157)  
Square Error: 0.023725

#### Chi Square Test

Number of intervals = 5  
Degrees of freedom = 4  
Test Statistic = 3.68  
Corresponding p-value = 0.461

#### Kolmogorov-Smirnov Test

Test Statistic = 0.151  
Corresponding p-value > 0.15

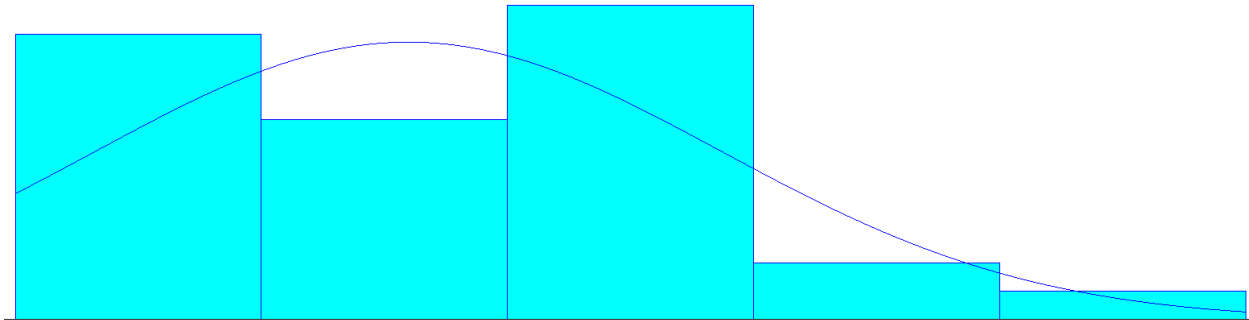
#### Data Summary

Number of Data Points = 31  
Min Data Value = 0  
Max Data Value = 157  
Sample Mean = 66.9  
Sample Std Dev = 55.3

#### Histogram Summary

Histogram Range = -0.001 to 157  
Number of Intervals = 5

Daily\_User\_Count:



#### Distribution Summary

Distribution: Normal  
Expression: NORM(798, 636)  
Square Error: 0.032638

#### Chi Square Test

Number of intervals = 3  
Degrees of freedom = 0  
Test Statistic = 4.52  
Corresponding p-value < 0.005

#### Kolmogorov-Smirnov Test

Test Statistic = 0.208  
Corresponding p-value = 0.12

#### Data Summary

Number of Data Points = 31  
Min Data Value = 0  
Max Data Value = 2.5e+03  
Sample Mean = 798  
Sample Std Dev = 646

#### Histogram Summary

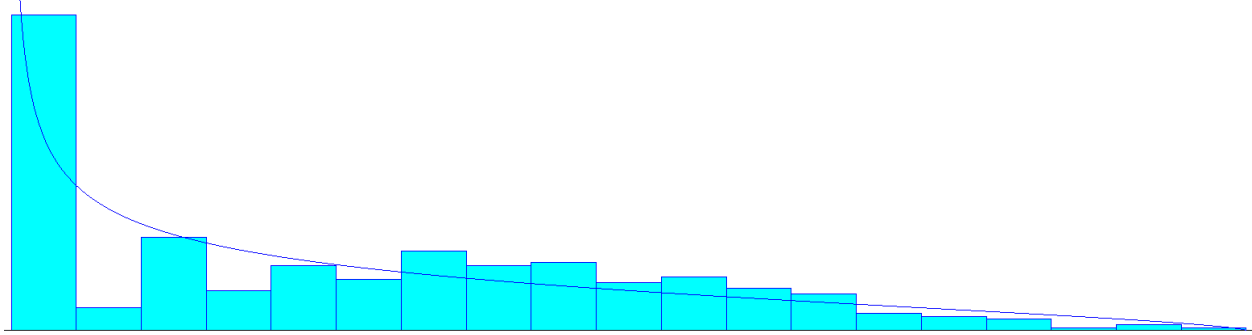
Histogram Range = -0.001 to 2.5e+03  
Number of Intervals = 5

But since we had data only for October, and we had to simulate a whole year, we generated a year's data by applying weight coefficients to all months (weight coefficients are set according to the information given by the directorate of the library). The process is like following:

- 1) First, after generating new data with python code, we changed year order and turned 2022 to 2023 from January to August.
- 2) After that, we fixed the problems caused by day/date crash by arranging the weekdays and weekends with respect to a real calendar. The order of fixing is like following:
  - a. Find the day that respective month actually starts with,
  - b. Shift up the data in a way that the first day "n" in the simulated data is in the index of the real day,
  - c. Shift the over-written days down if the remaining days are not weekends,
  - d. Copy the data from last week's respective days if there are still empty days left.
- 3) And finally, holidays are set to 0.

These are the results of input data analysis of our one-year data:

Borrowed\_Book\_Count:



#### Distribution Summary

Distribution: Beta  
Expression:  $-0.001 + 494 * \text{BETA}(0.611, 1.64)$   
Square Error: 0.017246

#### Chi Square Test

Number of intervals = 14  
Degrees of freedom = 11  
Test Statistic = 64.2  
Corresponding p-value < 0.005

#### Kolmogorov-Smirnov Test

Test Statistic = 0.134  
Corresponding p-value < 0.01

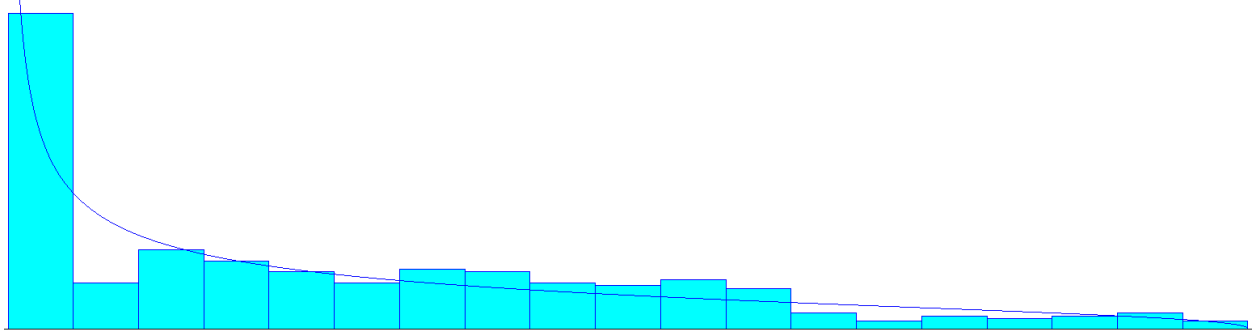
#### Data Summary

Number of Data Points = 365  
Min Data Value = 0  
Max Data Value = 494  
Sample Mean = 134  
Sample Std Dev = 122

#### Histogram Summary

Histogram Range = -0.001 to 494  
Number of Intervals = 19

Returned\_Book\_Count:



#### Distribution Summary

Distribution: Beta  
Expression:  $-0.001 + 251 * \text{BETA}(0.503, 1.41)$   
Square Error: 0.006555

#### Chi Square Test

Number of intervals = 15  
Degrees of freedom = 12  
Test Statistic = 32.8  
Corresponding p-value < 0.005

#### Kolmogorov-Smirnov Test

Test Statistic = 0.113  
Corresponding p-value < 0.01

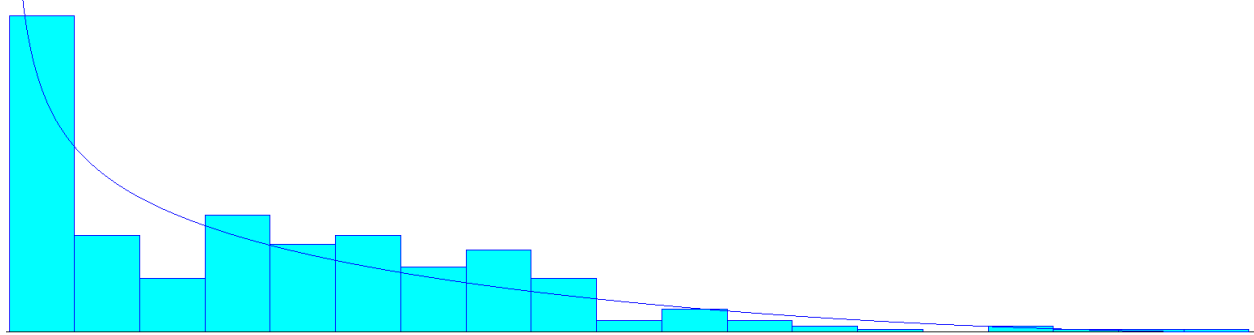
#### Data Summary

Number of Data Points = 365  
Min Data Value = 0  
Max Data Value = 251  
Sample Mean = 66.1  
Sample Std Dev = 64.8

#### Histogram Summary

Histogram Range = -0.001 to 251  
Number of Intervals = 19

Daily\_User\_Count:



#### Distribution Summary

Distribution: Beta  
Expression:  $-0.001 + 4e+03 * \text{BETA}(0.681, 2.73)$   
Square Error: 0.011385

#### Chi Square Test

Number of intervals = 12  
Degrees of freedom = 9  
Test Statistic = 56.4  
Corresponding p-value < 0.005

#### Kolmogorov-Smirnov Test

Test Statistic = 0.134  
Corresponding p-value < 0.01

#### Data Summary

Number of Data Points = 365  
Min Data Value = 0  
Max Data Value =  $4e+03$   
Sample Mean = 799  
Sample Std Dev = 762

#### Histogram Summary

Histogram Range = -0.001 to  $4e+03$   
Number of Intervals = 19



5)

Our system includes:

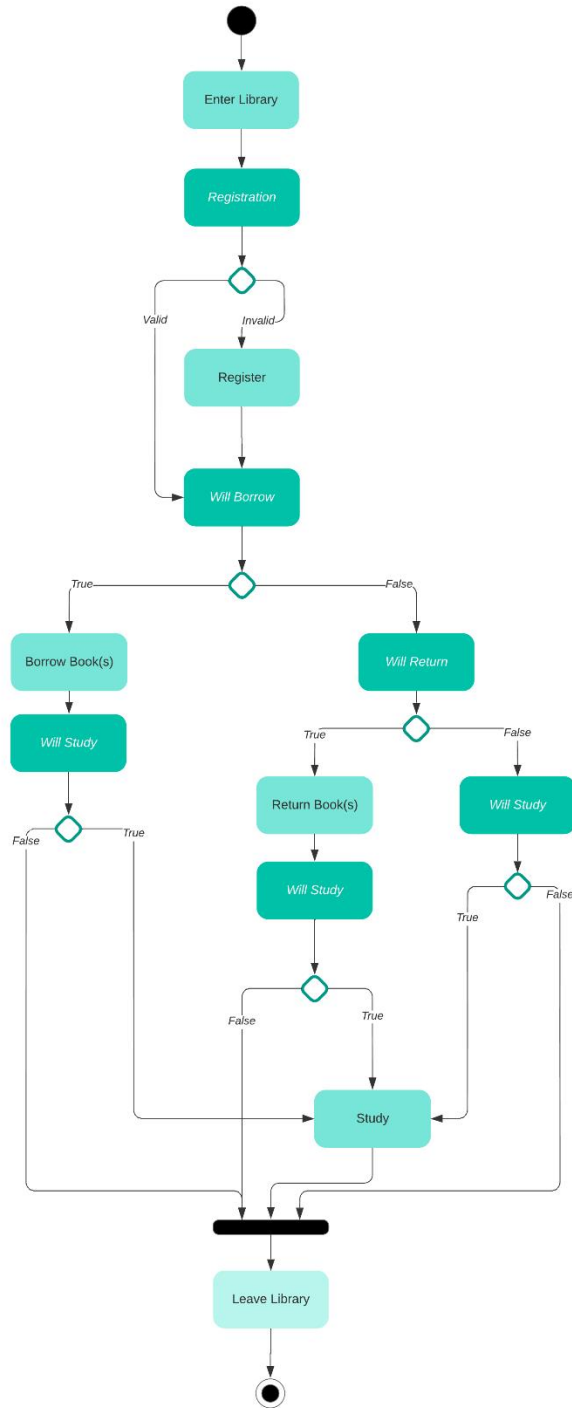
- Two different types of entity arrival types:  
Registered and not registered user
- Four processes:  
Registering, returning book, borrowing book and studying
- One Queue limit:  
Registering queue is limited
- Routes:  
Most of the probable routes are covered according to the information given by the directorate of the library such as “entrance/desk/study hall/outside” (returning book and studying), “entrance/bookshelves/desk/study hall/outside” (borrowing book and studying), “entrance/bookshelves/desk/outside” (borrowing book), “entrance/study hall/outside” (studying), “entrance/desk/outside” (returning book) etc.
- Stations:  
Chairs in the study halls are stations for studying, and the desk in the entrance floor is a station for registration, book borrow and book return
- Failures:  
A user might not find the book they are looking for, might try to borrow more than 5 books etc.
- Assignments  
Chairs are assigned with study when a user starts using it, staff members are assigned with respective tasks when a user comes for a process.
- Decisions:  
A user might choose to study or not after borrowing book/returning book etc.
- Tallies and Recording to output files:  
We record the outputs of processes in two different files. (output\_all\_year\_daily.txt, output\_each\_month\_daily.txt)
- Run time statistical representations:  
Simulation for one year (separated each month and day) took approximately 6 minutes, average runtime is 283 seconds when we ran the simulation ten times.

UML Diagrams of our system are below:

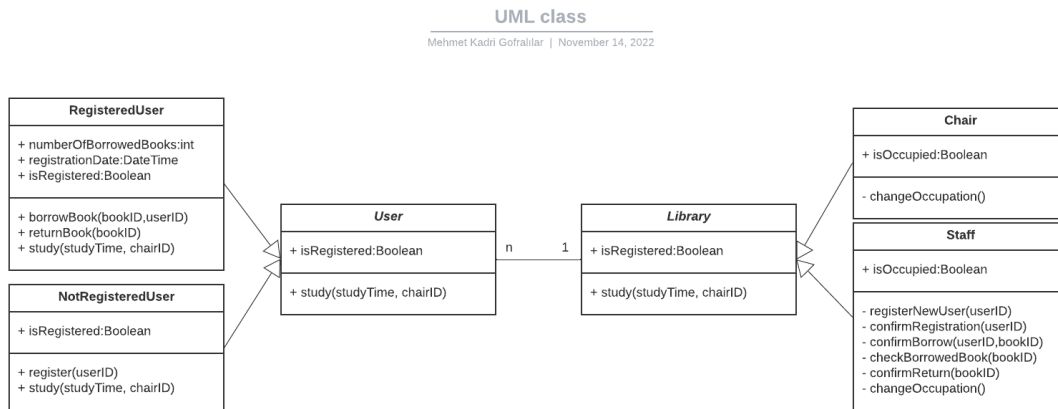
## Activity Diagram:

### Activity diagram

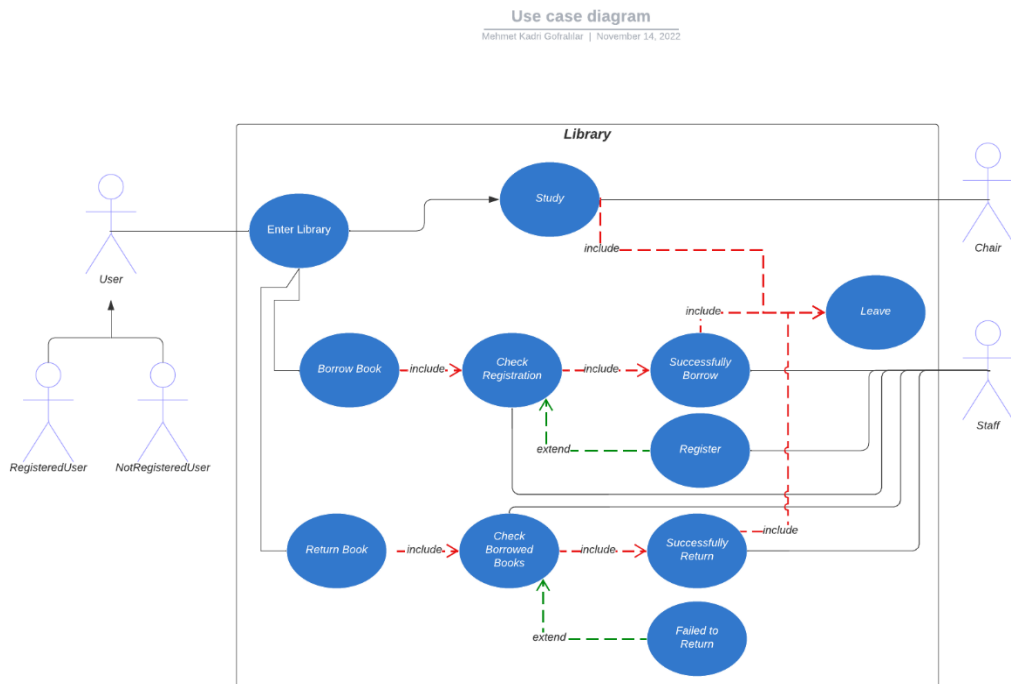
Mehmet Kadri Gofrafililar | November 14, 2022



## Class Diagram:



## Use Case Diagram:



- 6) "Queue lengths and waiting time vary from time to time and almost impossible to predict using a short observation data" said the Directorate of Library. Therefore, we couldn't extract the real data for queue lengths and waiting time, so we couldn't compare the simulated queue length vs. real queue length and simulated waiting time vs. real waiting time. Simulated served user count and the real served user count is compared. And the results are in compared\_data.csv. We can see that the simulated counts are less than the real counts. The reason behind this is the sensor in the entrance of the library that counts each movement (entrance/exit). So a student may enter/exit multiple times in a day, which is the problem.
- 7) We tried adding multiple staff members to the system since queue can be a problem for the processes that require the help of staff members. This results with decrease in queue length.
- 9) The source codes are attached in the same file directory as this report.