# Bank Analysis

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## 1 Introduction

The purpose of this code is for banks to know the days they normally have more customers base on customers arrival time and service time. The code is simulating a bank queue system and finding the waiting time of customers under two different scenarios. In each scenario, the arrival rate of customers is set to a different value and the waiting time is calculated for each customer at each time step. The results of these experiments are saved to a text file and displayed as histograms to show the distribution of waiting times. This code can help bank managers to understand how changes in the arrival rate affect the waiting time of customers. This information can be used to make decisions on staffing levels, improve customer experience and optimize resource allocations. This code can also help banks to know how the arrival time of customers and their service time will affect the number of customers they have in each day.

This paper is organized as follows: Sec. 2 explains the hypotheses we are testing to see if the bank has more customers on Tuesdays or other days base on the arrival time of the customers and service time of the banks. A description of the computer simulation developed to simulate these possibilities is provided in Sec. 3, with an analysis of the outputs included in Sec. **??**. Finally, conclusions are presented in Sec. **??**.

## 2 Hypothesis to explain the days the bank will have more customers

The Poisson distribution is a discrete probability distribution that models the number of events occurring in a fixed interval of time or space. In this case, the hypothesis is that the bank has more customers on Tuesday than on other days.

Let $\lambda_1$ be the average arrival rate for Tuesday, and $\lambda_2$ be the average arrival rate for the other days (Monday, Wednesday, Thursday, and Friday).

The likelihood of observing the waiting times $x_1$ for Tuesday, and $x_2$ for the other days given $\lambda_1$ and $\lambda_2$ can be represented as follows:

Likelihood Tuesday = $\text{Poisson}(x_1|\lambda_1) = \lambda_1^{x_1} * e^{-\lambda_1}/x_1!$

Likelihood Other = $\text{Poisson}(x_2|\lambda_2) = \prod(\lambda_2^{x_2} * e^{-\lambda_2}/x_2!)$

Where $\prod$ denotes the product over all days except Tuesday.

# 3 Code and Experimental Simulation

This code is a simulation of a hypothesis testing Problem about the waiting times at a bank. It tests the hypothesis that the bank has more customers on Tuesday compared to other days of the week. The code uses poisson distribution and maximum likelihood estimation to perform the hypothesis testing. The code also generates some visualizations,including histograms and the box plots to help understand the results of the simulation.

The code will be available in my github account including the result for each of the text files. Let's look at some simulated data:

# 4 Algorithm

The algorithm is implemented in Python and uses the following libraries:

- Numpy
- Matplotlib
- Scipy

The algorithm consists of the following steps:

1. Load the data from the text file `bank`$_{d}ata.txt$
2. Separate the data into the number of customers on each day of the week.
3. Define the hypothesis that the bank has more customers on Tuesday than on other days.
4. Compute the likelihood for the hypothesis that the bank has more customers on Tuesday.
5. Compute the likelihood for the hypothesis that the bank has fewer or equal customers on Tuesday.
6. Compare the likelihoods and make a decision.
7. Plot histograms for scenario 1 and scenario 2.
8. Plot a box plot to visualize the comparison of waiting times on different days of the week.

# 5 Complexity Analysis

The time complexity of the algorithm can be estimated as follows:

- Step 1: Loading data from a file takes $O(N)$ time, where $N$ is the number of data points.

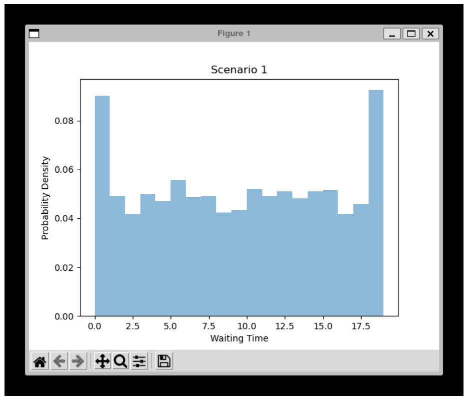


Figure 1: Histogram of waiting times in Scenario 1
Simulation of the average arrival and awaiting time recorded for scenario 1. Rate parameter(lambda=2 where lambda is the arrival rate for scenario 1)

- Step 2: Separating data into five different arrays takes $O(N)$ time.
- Step 3: Defining the hypothesis takes $O(1)$ time.
- Step 4: Computing the likelihood for the hypothesis that the bank has more customers on Tuesday takes $O(N)$ time.
- Step 5: Computing the likelihood for the hypothesis that the bank has fewer or equal customers on Tuesday takes $O(4N)$ time.
- Step 6: Comparing the likelihoods and making a decision takes $O(1)$ time.
- Step 7: Plotting histograms takes $O(N)$ time.
- Step 8: Plotting a box plot takes $O(N)$ time.

The overall time complexity of the algorithm is $O(N)$.

# 6 Conclusion

In this document, we have analyzed the algorithm for simulating the waiting times in a bank queue. The algorithm uses Poisson distribution to model the arrival of customers and makes a hypothesis test about which day of the week has more customers in the bank. The results are visualized using histograms and a box plot. From the result or figure it concluded that the likelihood are equal.

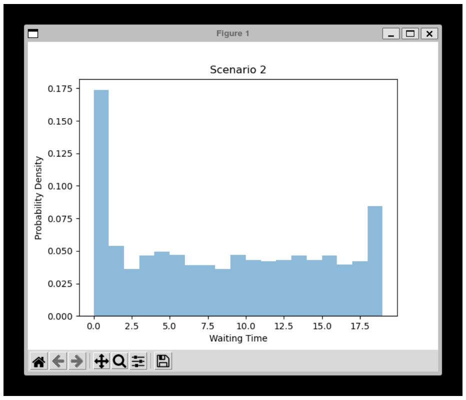


Figure 2: Histogram of waiting times in Scenario 2
Simulation of the average arrival and awaiting time recorded for scenario 2.
Rate parameter(lambda=4 where lambda is the arrival rate for scenario 2)

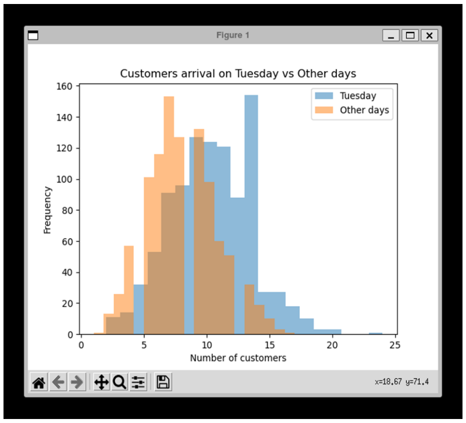


Figure 3: Comparison of the likelihood of the hypothesis that the bank has more customers on Tuesday and the hypothesis that the bank has fewer or equal customers on Tuesday
there are one million experiments shown for the hypothesis and the likelihood figure for the two hypothesis is superimposed.