

SIMULATION MODELLING OF A QUEUING SYSTEM TO IMPROVE CUSTOMER SATISFACTION

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Abstract: *This study aims to develop a Discrete Event Simulation (DES) model to represent and evaluate the existing service process at JPJ UTC Kota Bharu, Kelantan. The study focuses on the queuing system experienced by customers during the service process, where waiting times and queue formation may affect overall service efficiency. Arena simulation software was employed to model the existing system and evaluate its performance using key performance measures, including average waiting time, total time spent in the system, resource utilization, and queue length. The simulation model was further used to identify bottlenecks and assess the performance of alternative improvement scenarios. The results provide a comprehensive evaluation of the existing service system and demonstrate the potential effects of the proposed alternatives on queuing performance. The findings indicate that the selected alternative can improve the efficiency of the service process by reducing customer waiting time and overall time spent in the system. The proposed simulation approach provides useful insights for supporting operational decision-making and improving the efficiency and quality of customer services at JPJ UTC Kota Bharu.*

Keywords: *Discrete Event Simulation, Queuing System, Arena Simulation*

Introduction

Efficient public service delivery is important to ensure that customers receive services within a reasonable time. However, government service centres may experience long queues and waiting times when customer demand is higher than the available service capacity. These problems can reduce service efficiency and affect customer satisfaction. Therefore, analysing the performance of queuing systems is important for identifying bottlenecks and improving service operations.

The Jabatan Pengangkutan Jalan (JPJ) UTC Kelantan in Kota Bharu provides various services, including driving licence renewal, vehicle registration, and road tax payments. The centre serves a large number of customers daily, particularly during peak periods. However, the existing service process may experience congestion and long waiting times due to high customer arrivals and limited service capacity. In addition, the staggered opening of some service counters may further affect the efficiency of the system.

To address these issues, a Discrete Event Simulation (DES) approach can be used to analyse the existing queuing system and evaluate possible improvements. Simulation enables the service process to be represented under realistic operating conditions and allows different improvement alternatives to be tested without disrupting the actual system. Key performance measures, such as average waiting time, total time spent in the system, queue length, and resource utilization, can be used to evaluate system performance.

Therefore, this study aims to analyse the existing queuing system at JPJ UTC Kelantan and develop a DES model using Arena software to represent the current service process. The study also evaluates alternative scenarios to identify potential improvements to the queuing system. The results are expected to help identify bottlenecks, improve service efficiency, reduce customer waiting time, and support better resource allocation and operational decision-making at JPJ UTC Kelantan.

Scope And Limitation Project

This study focuses on the queuing system at Jabatan Pengangkutan Jalan (JPJ) UTC Kelantan in Kota Bharu. The simulation examines customer flow through six main counters, including one counter for ticket number issuance, while the photo and licence submission counter is excluded. The study focuses on front-line services, including driving licence renewal, vehicle registration, and road tax payment. The different operating times of Counters 1 and 2 are also considered to examine their effects on overall service performance. The simulation is used to identify bottlenecks, evaluate the existing queuing system, and assess alternative improvement scenarios.

Several limitations are considered in this study. The data were collected within a specific observation period and may not represent long-term variations in customer arrivals, such as seasonal demand, public holidays, or special campaigns. In addition, access to internal JPJ data, including digital queue records, staff schedules, and detailed back-office processing times, was limited. Therefore, some model parameters are based on direct observations and assumptions. Unpredictable factors, such as customer walk-outs, technical problems, sudden increases in arrivals, and system downtime, are also excluded from the simulation. Despite these limitations, the model provides a useful representation of the observed queuing system and supports the evaluation of potential improvements to service efficiency at JPJ UTC Kelantan.

Literature Review

Previous research has examined various approaches for evaluating and improving the performance of customer service systems. Among the approaches commonly reported in the literature are system dynamics (H. Sapiri et al. 2017; Rahim F.H.A et al. 2017), linear programming (S. Madankumar & C. Rajendran, 2019), service quality (P. Özkan et al., 2019), and discrete-event simulation (S. Gumus et al. 2017; H. He & Z. Hu, 2018; M. Z. H. A. Jalal et al. 2018). Among these methods, discrete-event simulation has been widely applied to examine service processes, locate system bottlenecks, and assess possible improvement strategies.

Computer-based simulation has been utilized as a decision-support technique since the 1950s. Its application has expanded considerably across different fields because of its flexibility in representing a wide variety of real-world systems (R. M. Tahar, 2006). Simulation can support several activities, including system performance assessment, system design, planning, and decision-making (C. G. Panayiotou et al. 2000). In general, simulation represents the behaviour and operation of an actual system over a period of time. It also enables researchers to investigate alternative situations through "what-if" analysis and examine potential changes before they are implemented in the actual system (R.M.Tahar, 2006).

The application of simulation to queuing and service systems has been demonstrated in various sectors. M. H. Alhaag et al. (2015) investigated the outpatient queuing system at King Khalid Hospital in Riyadh, KSA. The patients were classified into three categories, namely Type 1, Type 2, and Type 3. Arena software was applied to construct the simulation model, through which three improvement alternatives were assessed. The evaluation focused on average waiting time, average queue size, and total service time.

Similarly, T.C.Xian et al. (2016) examined the queuing system at UniMall, where customers were served through a single payment counter based on the first-come, first-served (FCFS) principle. The limited service capacity contributed to extended queues and customer dissatisfaction. An Arena-based simulation model was developed to represent the system, and alternative scenarios were evaluated to determine an approach that could enhance service performance and customer satisfaction.

In another application, H. Eskandari et al. (2011) investigated the performance of an emergency department in a government hospital. The study focused on developing a framework for improving the movement of patients through the emergency department. Fourteen scenarios were developed and evaluated. The results identified the most effective scenario as one that prioritized emergency patients in the MRI and CT scan wards over non-emergency patients, together with the addition of five mobile beds in the inpatient ward and a financial department, respectively.

Simulation has also been applied to financial service operations. N. Madadi (2013) developed a simulation model of a bank queuing system in Johor Bahru, Malaysia, using FITNESS simulation software. The original system consisted of four service counters and two customer service tables. Server idle time and busy time were used to evaluate the system. Based on the simulation results, the preferred alternative involved introducing an additional counter, eliminating the service table, and implementing standardized shift schedules across the counters.

In the postal service sector, S. Sharifi et al. (2014), in their study titled "Simulation Process of Isfahan Post Office using Arena," developed a simulation model to examine the utilization and efficiency of service counters. The findings provided useful information for management in identifying inefficient or underutilized counters and improving the quality of customer service. J. Lim, N. Azriani & M. Nor (2016) also investigated a queuing system in the Department of Immigration in Johor Bahru, Malaysia. Their study focused on the long queues experienced by customers applying for or renewing passports.

In the airport sector, D.U. Kim, M.S. Jie & W.H. Choi (2018) examined the passenger check-in process. The study considered two check-in options: self-service kiosks and conventional counter-based check-in. An Arena simulation model was developed to evaluate the system. The findings indicated that the implementation of self-check-in kiosks and automatic immigration screening could substantially reduce passenger waiting times.

Overall, the reviewed studies demonstrate that discrete-event simulation is an effective technique for investigating queuing and service systems across different sectors. The approach provides an opportunity to examine system performance, identify bottlenecks, and compare alternative operating strategies without directly modifying the actual system. Therefore, discrete-event simulation is considered an appropriate approach for evaluating the queuing system at JPJ UTC Kelantan and identifying potential strategies to improve service efficiency and customer satisfaction.

Methodology

Consists of data collection, framework and conceptual model, model simulation and verify and validation model.

Data collection

Data collection for this simulation study was conducted at Jabatan Pengangkutan Jalan (JPJ) UTC Kelantan in Kota Bharu, Kelantan. The data were collected over a three-hour period, from 8:00 a.m. to 10:00 am., on a single day on 6 December 2025. Quantitative data were obtained through direct observation and manual recording of the customer service process.

The input data in minutes collected included customer arrival times, service times at each counter, the number of active counters, and counter numbers. These variables were required to represent the actual queuing and service processes in the simulation model. The output measures included the total time spent in the system by each customer, waiting time before receiving service, service completion time, and counter utilization.

The collected data were used to examine customer flow, identify potential inefficiencies in the service process, and evaluate the performance of the existing queuing system. The findings were subsequently used to develop and evaluate alternative scenarios aimed at improving operational efficiency and reducing customer waiting times. The data was simplified and shown in table 1.

Table 1: The input of interarrival time and service time(minutes)

Variable	Expression
Interarrival time	$-0.5 + \text{LOGN}(2.5, 2.07)$
Service time	$0.5 + \text{LOGN}(2.6, 2.47)$

Simulation is an experimental approach used to investigate and evaluate the behaviour of a model. It provides an alternative to conducting experiments directly on a real-world system by using either a computer-based or physical representation of the system under study. The simulation process generally begins with the development of a model that represents the important characteristics and behaviours of the actual system. Experiments are then conducted using the model to observe its performance under different conditions. The resulting observations can be analyzed to gain a better understanding of the system and its behaviour. In addition, simulation studies can be used to validate the model, interpret and communicate the findings, support recommendations, and evaluate different system designs or alternatives (White & Ingalls, 2009).

Scope And Limitation Project

This study models and evaluates the queuing system at the Road Transport Department (JPJ) located within the Urban Transformation Centre (UTC) Kelantan. Specifically, it investigates customer flow dynamics across the primary service counters, excluding the dedicated photograph and driving license submission counter. The simulation models a system comprising six operational counters, inclusive of a single automated queue ticket issuance unit. Given that Counters 1 and 2 operate on a delayed schedule relative to the remaining units, this project further examines the operational impact of staggered counter availability on overall service efficiency. The analytical focus is restricted to front-line counter transactions, namely driving license renewals, vehicle registrations, and road tax payments. By utilizing discrete-event simulation, this research aims to identify system bottlenecks, evaluate alternative queuing strategies, and propose empirical optimization measures based on observed performance metrics.

Although this study provides actionable insights, several methodological limitations must be acknowledged. First, data collection was restricted to a specific timeframe, which may fail to capture longitudinal trends, seasonal demand fluctuations, or peak surges associated with special public campaigns. Second, the analysis was constrained by the unavailability of internal administrative datasets, such as digital timestamp logs, staff shift rosters, and back-office processing durations. Consequently, the simulation relies on manual observational data and baseline assumptions, which may not fully reflect stochastic human behaviors, including patient abandonment, customer complaints, or unexpected service interruptions resulting from technical anomalies. Finally, exogenous variables such as public holidays, sudden demand spikes, and system network downtimes were excluded from the simulation model. Despite these constraints, the study provides a robust diagnostic snapshot of the existing operational framework and offers empirical evidence to assist JPJ UTC Kelantan in optimizing its public service delivery.

Conceptual Model And System

A theoretical framework can serve as a foundation for developing conceptual models that focus on specific health-related behaviours or outcomes within a community. A conceptual model provides a structured representation of the relationships between relevant variables and helps researchers understand how these variables may influence or predict particular outcomes. Unlike a conceptual model, a theory generally provides a broader framework that can be applied across different contexts and situations (Brady et al., 2020).

Swaen and George (2024) stated that a conceptual model helps researchers establish suitable research objectives and organize the relationships among those objectives to support

meaningful conclusions. It also provides a visual or structured representation of the expected relationships between the variables selected for the study. In this study, the conceptual model is used to illustrate the structure of the system being investigated. Figure 1 presents the layout of the study location.

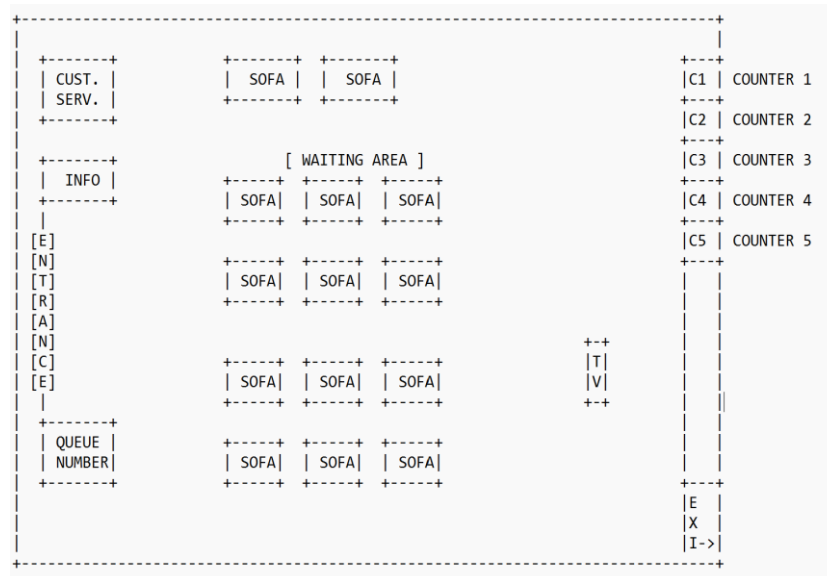


Figure 1: Layout of Jabatan Pengangkutan Jalan

Model of Simulation Process

The JPJ office in Kota Bharu, Kelantan operates from 8:00 a.m. to 9:00 p.m., providing a total operating period of 13 hours per day. The queuing process involves several important elements, including customers, a queue, service counters, and a service mechanism that determines the sequence in which customers are attended to. In this system, customers are generally served according to the first-come, first-served (FCFS) principle.

Upon arrival at the JPJ office, customers obtain a queue number and wait until their number is announced or displayed on the electronic screen. The display also indicates the counter assigned to the customer. Once the number is called, the customer proceeds to the designated counter and presents the necessary documents to obtain the required service. The services may include vehicle registration, driving licence renewal, and other transportation-related transactions. In the observed system, all service counters are capable of providing the same range of services. At the service counter, the JPJ officer checks the submitted documents and enters the relevant information into the system to process the customer's request. Once the transaction has been completed, the customer makes the required payment at the same counter. Depending on the facilities available at the counter, payment can be made using cash or a card. This process continues for each customer according to the assigned queue number until the required service has been completed. Figure 2 show the flowchart process.

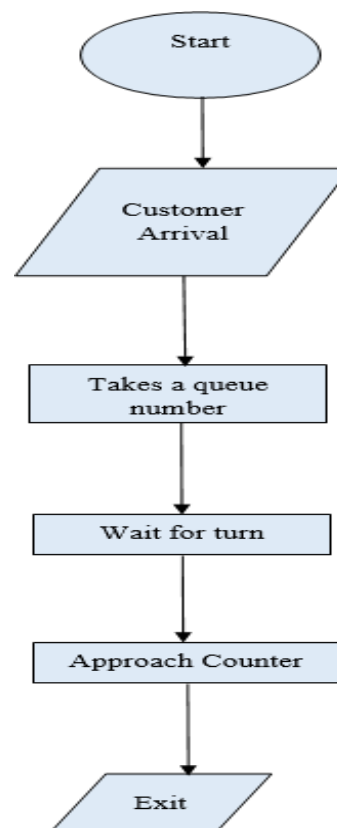


Figure 2: Flowchart Process JPJ Counters

Model of Simulation Process

Figure 3 illustrates the simulation model developed to represent the service process at Jabatan Pengangkutan Jalan (JPJ) UTC Kelantan in Kota Bharu, Kelantan, using Arena simulation software. The model was developed to examine the current queuing and service operations and to identify aspects of the system that may require improvement. The processes incorporated into the simulation were constructed based on data obtained through direct observation of the actual operations at the JPJ service counters.

Each process in the simulation model was assigned an appropriate statistical expression using the Input Analyzer in Arena. The resulting input distributions were incorporated into the model to provide a representation of customer arrivals and service activities observed at the study location. The developed model was subsequently tested and validated against the observed operating conditions to determine whether it adequately represented the actual queuing process. The analysis focused on important performance indicators, particularly the number of customers waiting in the queue and the amount of time customers spent waiting for service. These measures were used to identify potential bottlenecks and areas of inefficiency within the existing system. The simulation results can therefore provide useful information for evaluating possible improvements to the JPJ service process, with the aim of reducing customer waiting time, improving counter utilization, and enhancing the overall efficiency of service delivery.

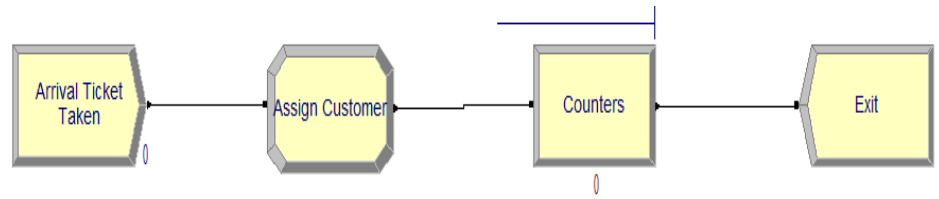


Figure 3: Simulation Model of JPJ Counters

Validation And Verification Process

Before the simulation model is applied to evaluate the JPJ queuing system, its reliability must first be established through model verification and validation. Verification is conducted to determine whether the model has been constructed correctly and whether the programmed processes operate according to the intended design. In contrast, validation assesses whether the simulation provides a sufficiently accurate representation of the actual JPJ service system.

For this study, the performance of the simulation model was assessed by comparing its output with the results obtained from the actual system. This comparison was used to determine whether the model could reasonably reproduce the observed queuing and service conditions. The simulation experiment was conducted using seven replications to obtain consistent performance measures and reduce the influence of random variation.

Model validation was subsequently performed by calculating the difference between the simulated results and the corresponding actual observations. The percentage difference was used as the main criterion for determining the accuracy of the model. A difference of less than 10 % between the simulated and observed results was considered an acceptable level of agreement. If the results satisfied this criterion, the model was regarded as sufficiently representative of the real JPJ service system and suitable for further analysis.

$$\text{Validation model} = \frac{\text{Simulation output} - \text{Actual output}}{\text{Actual output}} \times 100$$

Result And Discussion

The simulation model, which ran for 2 hours from 8 a.m. to 10 a.m., will be examined and discussed in this section. The Arena simulation results indicate that the existing JPJ service system experiences minimal queuing and operates with sufficient service capacity. The average time spent by a customer in the system was 2.7752 minutes, as indicated by the Customer.TotalTime measure. Meanwhile, the recorded average waiting time was 0.0000

minutes, suggesting that customers experienced virtually no delay before receiving service. This finding is further supported by the queue statistics, which recorded an average queue size close to zero.

The resource utilization results also indicate that the service counters were not heavily occupied during the simulation period. The utilization of the five counters ranged from approximately 9% to 25%, with each counter being utilized approximately 8 to 9 times during the simulation. The relatively low utilization levels across all counters suggest that the available service capacity exceeded the observed customer demand. Although this condition contributes to short waiting times and smooth customer flow, it may also indicate that some service resources remain underutilized for a considerable portion of the operating period.

In terms of system throughput, 44 customers entered the system, while 43 customers completed the process during the simulation. No significant evidence of customer loss or rejection was observed. Overall, the existing system demonstrates stable performance with minimal customer waiting. However, the low utilization of the service counters suggests an opportunity to improve resource allocation. Therefore, alternative configurations involving the number or allocation of active counters could be investigated to determine whether similar service performance can be maintained while achieving more efficient resource utilization.

Therefore, summary statistics such as the average, minimum, and maximum values were used to analyze the queuing system's characteristics shown in table 2 below.

Table 2: Result from Arena for Each Input Variable

	Average	Minimum	Maximum
	1.4232	0.03756	4.2627
Waiting	0.0000	0.0000	0.0000
Service Time Counter 1	0.24839	0.0000	1.0000
Service Time Counter 2	0.20839	0.0000	1.0000
Service Time Counter 3	0.23187	0.0000	1.000
Service Time Counter 4	0.09003	0.0000	1.0000
Service Time Counter 5	0.25079	0.0000	1.000

Conclusion

The simulation model, which ran for 2 hours from 8 a.m. to 10 a.m., will be examined and discussed. Simulation provides an effective means of evaluating complex service systems because different operating conditions can be examined without disrupting the actual service environment. In this study, ARENA was used to model and evaluate the JPJ service process based on empirical data collected during the selected operating period. The model provided an overview of customer processing and the utilization of available service resources.

The simulation findings indicate that the average value-added processing time (Customer.VATime) was 2.7752 minutes, while the maximum recorded value was 8.9655 minutes. The difference between the average and maximum processing times reflects variation

in the duration required to complete customer transactions. In contrast, both the average waiting time (Customer.WaitTime) and transaction time (Customer.TranTime) were recorded as 0 minutes. These results suggest that customer queuing was not a major issue during the simulated period. Nevertheless, the utilization of the service counters was not evenly distributed. Counter utilization varied from 9.903% for Counter 4 to 25.079% for Counter 5, indicating differences in the workload handled by individual counters.

In addition to the physical service system, JPJ has introduced digital services through the MyJPJ application, which allows customers to complete selected transactions electronically. Such digital services have the potential to reduce the demand placed on physical service counters. Based on the simulation findings, the existing physical service system demonstrates relatively low waiting times, although differences in counter utilization remain an area that could be examined further. Overall, the findings suggest that improvements to the JPJ service system should consider both physical and digital service channels. While digital platforms can help reduce the demand for face-to-face services, effective management of physical counters remains important for customers who require in-person assistance. Future improvements could therefore focus on balancing counter utilization and maintaining efficient service delivery while continuing to strengthen digital service options for customers.

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