Management Analysis on Queuing System in Terminal Bus Using Multichannel Model

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ABSTRACT

Queuing system is a common behavior of people that arrive in a facility to wait for certain services that are being offered by the service facility to make our life easier. There has been three problem that were outlined in the research. First is failure in management. Second, awareness of the application that were built by the terminal bus. Last but not least, lack of networking between different gate terminals. Hence, three objectives were discussed in the study such as analysing the SIT and Duta Bus Station datasets by using a multichannel queuing model, evaluating daily queuing system cost for SIT and Duta Bus Station by referring to queuing theory, and measuring the performance of either average service rate is greater than the average arrival rate in both terminals mentioned earlier. In this research, we used only one method which is the multichannel queuing model M/M/C by selecting only 10 counters for both terminals as a channel, m. The datasets were collected by contacting higher officers in both terminals. From the result we can say that SIT has a greater average arrival rate and average service rate compared to Duta Bus Station meanwhile Duta Bus Station has a greater total daily service cost and waiting cost compared to SIT. Finally, what we can conclude from the research is we know for sure that both terminals need improvements in the facility and act of service so that they will gain more customers and the service effectively reducing the queuing time

Keywords: Queuing system, SIT, Duta Bus Station, *M/M/C,* counters, channel, arrival rate, service rate

INTRODUCTION

The two major transport hubs in Kuala Lumpur, Malaysia are Southern Integrated Terminal (SIT) and Duta Bus Station. These terminals serve as the primary entry point for visitors from across the country and offer a range of transport alternatives, including buses, taxis, and trains. The queue system in these terminals has been a major issue because of the large number of passengers and the limited capacity of the transportation services. The only method to solve this issue is to employ multichannel queuing models, so a study utilizing statistical analysis will be conducted to investigate the queuing systems in Southern Integrated Terminal and Duta Bus Station. The data will contain details on arrival times for passengers, the hours of operation for transit, and waiting times for passengers throughout the day. To analyze the data collected for this investigation, only multichannel queuing models will be employed. To mimic the terminal's queuing system, the multichannel queuing model was used in the research. In addition to considering the interactions between various service channels, this model also considers the number of ticket booths or bus platforms. Several scenarios, such expanding the number of service channels or changing the service hours, were simulated using the model to evaluate their impact on passenger queuing behaviour. The objective of this study is to analyse the SIT and Duta Bus Station dataset by using multichannel queuing model to evaluate daily queuing system cost for SIT and Duta Bus Station by referring to queuing theory. Next, to measure the performance of either average service rate is greater than the average arrival rate in SIT and Duta Bus Station.

LITERATURE REVIEW

Queuing Theory

The main outcomes of queuing theory and its applications are found under steady-state settings, and these models may be either deterministic or stochastic. According to studies, waiting times and customer satisfaction are correlated; the longer the wait, the less satisfied the client is. Because of this, it is critical to use queuing theory to resource allocation to meet demand quickly and affordably. Queuing theory research attempts to reduce customer wait times and maximise the use of scarce resources. The predicted length of a business's queue, the frequency that the queue system is states, and the anticipated wait time for customers may all be calculated using the queuing theory [1].

For example, if there are more customers than available facilities can handle, a queue forms, forcing the Air Transport Business Entity to wait in it. One of the statistical techniques that can be applied to solve these issues is queueing theory. The characteristics, models, and performance metrics of airport aircraft queuing systems specifically, the intervals between aircraft arrivals, the duration of aircraft services, and the intervals during which passengers must wait for planes to take off are determined using queueing theory. Applications of queuing theory are anticipated to raise the standard of airport services [2]. Another example is queuing time for customers and popularity vary according to the capacity of the theme park [3].

Queuing also is a sign of civility in a civilised society, indicating that individuals adhere to rules or understandings. According to such rules, one is required to wait for others until they arrive at the destination. Disagreement and conflict must occur if the rules are not sufficiently clear. Standing and waiting are not required for some circumstances, such as visiting the dentist, reserving a tennis court, or reserving a table at a restaurant because these events are carefully planned. Only unscheduled actions, like purchasing cinema tickets or standing in queue to receive assistance at the post office, require standing and waiting in a queue [3].

Single Channel Queuing Model

Research was conducted about single server queuing model application towards construction site. To be exact, there were a usage of model M/G/1 that gave us definition about this model were following Poisson process and the service times follow an exponential distribution or a constant [4]. System performance in steady state is a major topic in queuing theory. In other words, most queuing models assume that the system has been in operation for long enough with the same arrival, service time, and other characteristics that the probability distribution for the queue length and customer delay is independent of time [5].

The service pricing and service effort level influence the client arrival rate and service efficiency, respectively, in a queuing system with a principal and an agent. According to four different scenarios-exogenous centralised decision-making, exogenous decentralised decision-making, endogenous centralised decision-making, and endogenous decentralised decision-making where previous studies have examined the service price and effort decision of the queuing system. This pricing effect is related to the sensitivity of customer delay, according to research on the M/M/1 queuing system with asymmetric information that shows the optimal unknowing price regardless of the arrival rate [6].

Multichannel Queuing Model

In a multiple-channel queuing system, there are two or more servers or channels available to service consumers as they arrive [7]. The M/M/S model is demonstrated between a single straight line, a multi-server, single-phase model, and all servers under the same performance rate assumption. First come, first served (FCFS) models typically support M/M/S models [8]. The M/M/S models are being used to assess the performance measure analysis, which considers the arrival time, waiting time, service time, the priority level for typical consumers, and the number of servers available, based on the earlier study [9]. Multi-server queueing systems are a more complex topic for research because they more accurately describe these systems. Operators in call centres, cashiers in stores, logical information transmission channels obtained from a single physical channel via the use of various multiplexing methods, etc. are just a few examples of real-world systems where the shared restricted resource is split into independent units serving the requests [10].

Other examples, there has been little progress in creating analytical techniques to gauge and forecast truck queue times. To our knowledge, just one researcher has tried to create a model to predict the length of truck lines at marine terminal gates. They created a multi-server queuing model based on the M/M/S and M/E/S formulations in their research. As a result, their queuing model assumed that the distribution of the truck processing time and the truck inter-arrival time are, respectively, exponential. The authors discovered a notable decrease in truck waiting time [11]. Based on previous research that has been done by [12] multichannel queuing model also being used in real life scenario specially in air transportation, which is to be exact, telephone sales manpower planning. As an example, Qantas Airways strives to staff its primary telephone sales reservation office effectively while offering its customers convenient service to lower operating expenses. Traditionally, future phone calls are predicted based on historical business growth to determine personnel needs. The increase in personnel is then estimated using the ratio of the average number of calls an operator can manage to the predicted average increase in phone calls. The additional staff employed does not account for changes in demand during the day because the calculations are based on averages. Customer dissatisfaction and lost revenue have been caused by lengthy wait times for services during busiest business hours. Finding a strategy that balances the needs of the consumer with the quantity of employed operators is the issue at hand.

Prior Researchers offers a two-moment approximation for the queue as well as an asymptotic estimate for the multi-server queue. Based on the listed research that being done by these people in this research which is Zhao, Chaudhry, and Kim, all of them provide precise queue solutions for cases of bulk arrivals with general interarrival time distributions and exponentially distributed service times. By assuming an anticipated renewal mechanism for arriving batches, Hanschke also provides a two-moment approximation for the queue length of multi-server queues with both bulk arrivals and batch service. When the bulk sizes are smaller than the sizes of service batches, this works well. If the bulk sizes are more than the batch sizes, multiple batches immediately join the queue. The arrival times of batches are distributed evenly during the interval between two successive bulk arrivals when the arrival process is modelled for this scenario as a renewal process. As a result, some batch arrivals experience fake delays, and their waiting time is subsequently shortened. An additional term to the queue length is proposed to prepare for the delayed arrivals. This term performs well in single server cases but significantly underestimates the queue length when there are multiple servers because it does not consider the unique dynamics of a multi-server queueing system [13].

Statistical Approach Applied in Queuing Systems

A two-class single transmit queuing model is presented in this study. The model's execution proportions were determined in an ambiguous setting. The primary goal of this investigation is to evaluate the performance of an individual transmit queuing model based on fuzzy queuing theory and intuitionistic fuzzy queuing theory. fuzzy triangle the entry (arrival) and administration (service) rates are described using numbers and triangular intuitionistic fuzzy numbers. The evaluation metrics for the fuzzy queuing theory model are given as a range of values, whereas the intuitionistic fuzzy queuing theory model provides a large range of values. For instance, the fuzzy values are left alone and not converted to crisp values, the methodology can be used to reach scientific findings in a challenging situation. To show that the suggested approach is viable, two numerical problems are addressed. Prototype parts were then subjected to sensitivity studies. When comparing the execution percentage of the two groups, sensitivity testing is performed to identify differences [14].

Previous researchers create a fluid model of queue behaviours proactively taking into careful consideration that client arrival is a peak and post-peak period. The rapid queue establishment were observed and optimisation technique for a random service system were used to decrease the total amount of client waiting time. We build two queuing models based on the assumption that there are an equal number of service equipment, one with only common queues and the other with both common and quick queues, and we offer the formulas for computing the sum of the waiting times for the two models. We examine the impact of quick queue on the performance of the service system in the two scenarios of peak and post-peak times. Then this study also demonstrates how to determine how many rapid queues will provide the optimal overall system performance.

Utilising the test for validity of the suggested method using the rapid queue setting and optimisation of the supermarket service system as an example, demonstrating the method's applicability to management practise. The study was conducted by following five special steps to apply the optimisation approach in their research [15].

The primary underlying idea of the multi-channel optimisation method for online marketing is to combine the jump-gradient solution with the two individuals with the least similarity from the global non-dominated solution, and to then exclude the individuals whose distance radius from the combined individual is less than. In the ultimate solution of the global marketing channel optimisation solution, repeat the operation in line with the method until there are no more than two left. After that, by resolving the new solution set, the global marketing channel optimisation solution is updated. The jump-gradient solution combination operation was developed to realise the effective utilisation of the non-dominated solution model [16].

METHODOLOGY

Data Collection

The data were collected from both party which is SIT and Duta Bus Station. Therefore, the raw data that was collected are complete and were used in this study. There are 10 columns of data focusing on arrival of customers in both terminal, number of customer according to each counter (channel), and number of customers waiting to be serviced around 10 days chosen between 24 August 2023 until 2 September 2023.

Model Assumptions

To streamline the analysis and make the model easier to handle, various assumptions are frequently made in a multichannel queuing model. Typical multichannel queuing model assumptions are listed below [19]:

1. Poisson arrival process: A Poisson process is supposed to be followed when clients enter the system. The arrival rate is therefore constant throughout time, and the interarrival periods between consumers have an exponential distribution.
2. Exponential service times: An exponential distribution is seen to be the best fit for the service times needed to serve consumers. This presumption makes the analysis of the queuing model mathematically tractable.
3. Discipline of first-come, first-served (FCFS): It is considered that clients are served according to the order in which they arrive. In the service process, priority or pre-emption are not considered.
4. Independent and identical channels: All service channels have the same service rate distribution, and each channel runs independently. According to this presumption, the service times and charges are dispersed uniformly across all channels.
5. The capacity of the queue, which contains consumers who are waiting, is unlimited. This presumption suggests that clients won't ever be turned away for lack of room in the queue.
6. Homogeneous customer population: It is assumed that all the system's clients are comparable in terms of their personal traits and service needs.
7. The queuing system is thought to be a Markovian process, meaning that future behaviour will only be influenced by the system's current state and not its past.
8. System stability: The assumption that the arrival rate will be lower than the service rate keeps the system steady and prevents an excessive build-up of queues over time.

Although these presumptions might not apply in all real-world situations, it's crucial to keep in mind that they provide a good place to start when examining and comprehending the behaviour of multichannel queuing system.

SIT and Duta Bus Station Layout

There are 1,000 parking spaces, 150 for taxis, and 60 for bus platforms at the terminal before we start gathering data from the two corporate officers. In the bus arrival area, close to the lifts that transport commuters to the arrival hall, are eighteen bays. Built to handle 5,000 bus trips per day at maximum capacity, SIT operated about 1,300 bus travels per day prior to the relocation of northbound bus operations from Pudu Sentral in October 2015. 52,000 passengers a day were accommodated at the terminal as of December 2015. To provide the greatest experience for transport customers, SIT was developed from the ground up. By preserving the "airport experience" paradigm in its daily operations, it aims to produce a sterile, calm, and refreshing environment for travelers to enjoy a comfortable and safe journey. In addition to 41 Centralized Ticketing System (CTS) counters where bus tickets can be purchased, the station offers seven ticket vending machines. The departure hall can accommodate up to 2,000 people, thus it is advised that all ticket holders come there at least 30 minutes before the bus is expected to arrive. There is an additional police checkpoint that must be passed before tickets may be taken from the holders [17].

Meanwhile, Near the Tun Razak Hockey Stadium on Jalan Duta lies the Duta Bus Station Bus Terminal. To accommodate buses travelling to northern states, the Duta Bus Terminal is a satellite bus terminal that feeds off the Puduraya Bus Terminal or Pudu Sentral. The bus terminal has parking, snack stands, and restrooms. A coupon system is employed at the 12 boarding platforms, ticket windows, waiting area, and taxi stand. Buses leaving from Duta Bus Station Bus Terminal can easily access the highways going to the northern states of Malaysia, such as Perak, Penang, Kedah, and Perlis, as well as the bordering country Thailand, because to its closeness to the New Klang Valley Motorway (NKVE). Despite being far away, the Duta Bus Station Bus Terminal's location has some advantages. Since most buses that travel between Duta Bus Station and Puduraya Bus Terminal or Pudu Sentral also make stops there, it can be used by passengers who want to avoid the city's traffic as a different point of embarkation or egress [18].

Elements

An analytical-descriptive study and a time-observation study were combined in this investigation. Therefore, the essential variables of arrival time and service time as well as the number of counters that are operational were incorporated in the pre-planned form of a checklist as in the Appendix. The service time (μ) refers to the intervals during which the terminal officer staff provided services to each customer. The arrival time (λ) denotes when a customer entered Southern Integrated Terminal (SIT) and Duta Bus Station. The multichannel queue model approach was used to identify both periods. The following gives a description of the many variables and characteristic models employed in these queuing analyses:

m = number of servers which is defined as both terminal bus officers in the counter.

n = number of customers in a queue either waiting to be served or seeking service.

The queueing analysis may therefore capture several performance measures from the current situation at both terminals, which was determined as follows according to the previous researchers [19]:

1. Mean number of customers in the system (L)
2. Time spent by the customer waiting in the system (W)
3. Length of the wait or the mean number of people in the queue waiting for service (L_q)
4. Average waiting time per customer (W_q)
5. The probability that there are zero customers in the system ($P_o > 0$)
6. Total daily waiting cost ($\lambda W_q \, C_w$)
7. Total daily service cost ($\lambda m C_s$)

Additionally, the researcher can analyse the relevant techniques for improving the terminal buses counter queuing system using the available sources and optimising the number of terminal bus counters based on the analysis of queuing theory using the multichannel method.

Equation

Arrivals are independently and identically distributed and are defined by a continuous density function because of the duration of the intervals. In this study, it is assumed that the inter-arrival periods and service times follow an exponential distribution, or, alternatively, a Poisson distribution for the arrival rate and service rate. The following descriptions of each variable and trait were used:

λ = the arrival rate (customer arrival rate)

μ = the service rate

m = number of servers which is defined as both terminal bus officers in the counter

n = number of customers in a queue either waiting to be served or seeking service

Data gathered are input into the Minitab to do the analysis to figure out the data's statistical distribution. This study uses a multichannel model and includes the following formulae:

Mean number of customers in the system (L)

$$L = \frac{\lambda\mu(\lambda/\mu)^m}{(m-1)!(mu-\lambda)^2} P_o + \frac{\lambda}{\mu} \quad (1)$$

Time spent by the customer waiting in the system

$$W = \frac{L}{\lambda} \quad (2)$$

Length of the wait or the mean number of people in the queue waiting for service (L_q)

$$L_q = L - \frac{\lambda}{\mu} \quad (3)$$

Average waiting time per customer (W_q)

$$W_q = W - \frac{1}{\mu} \quad (4)$$

The probability that there are zero customers in the system (P_o)

$$P_o = \left[\sum_{n=0}^{m-1} \frac{1}{n!}\left(\frac{\mu}{\lambda}\right)^n + \frac{1}{m!}\left(\frac{\lambda}{\mu}\right)^m \frac{m\mu}{m\mu-\lambda}\right]^{-1}, where\ m\mu > \lambda \quad (5)$$

Total daily waiting cost

$$\lambda W_q C_w \quad (6)$$

Total daily service cost

$$\lambda m C_s \quad (7)$$

RESULTS AND DISCUSSION

To fulfil the first objective of the research, we used the data that we got from SIT and Duta Bus Station by finding important value such as λ = the arrival rate (customer arrival rate), μ = the service rate and n = number of customers in a queue either waiting to be served or seeking service

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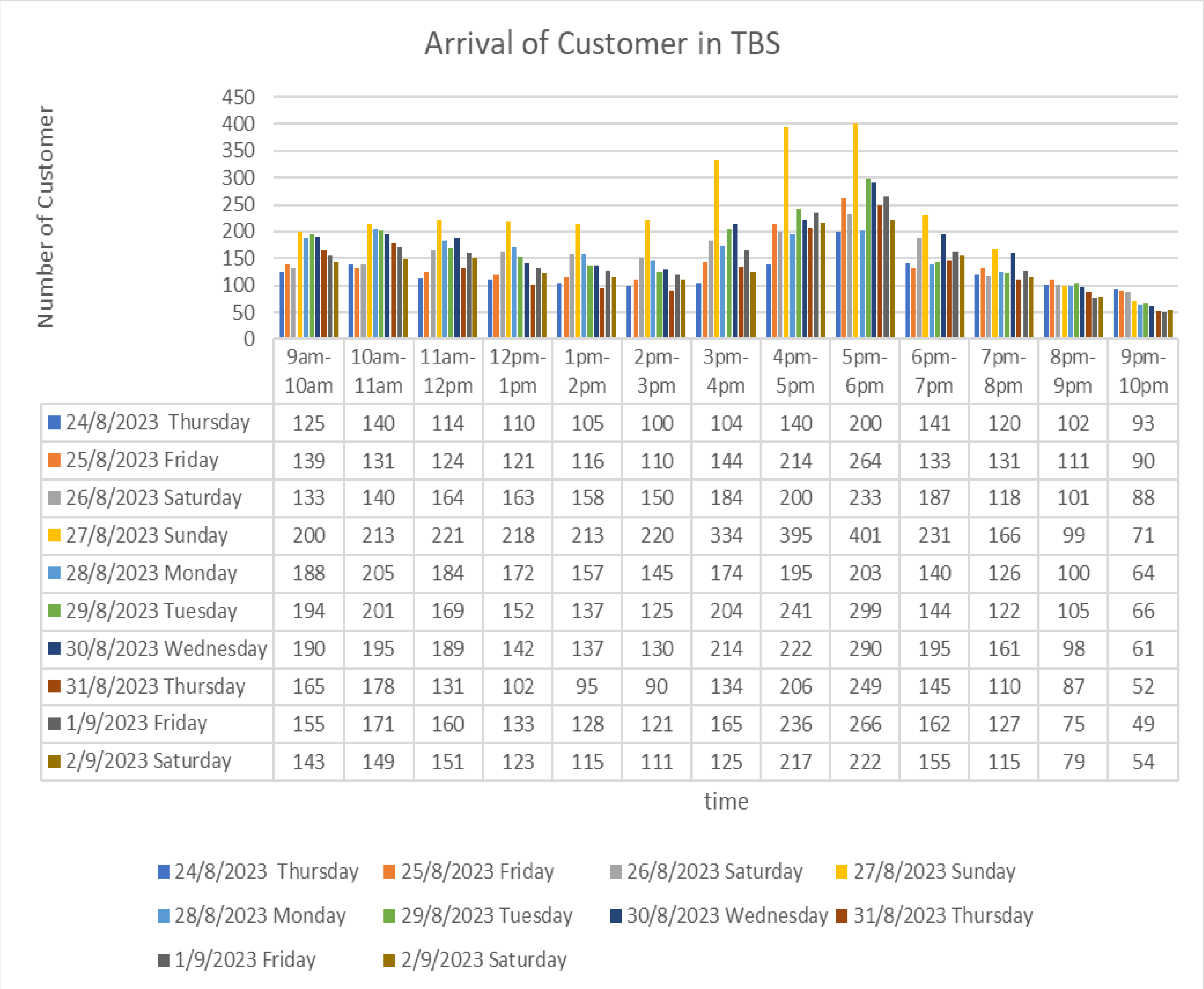
Table 1: Total number of customers that arrived in SIT according to each 10 days.

Date	Day	Total
24-Aug	Thursday	1594
25-Aug	Friday	1828
26-Aug	Saturday	2019
27-Aug	Sunday	2982
28-Aug	Monday	2053
29-Aug	Tuesday	2159
30-Aug	Wednesday	2224
31-Aug	Thursday	1744
1-Sep	Friday	1948
2-Sep	Saturday	1759
Total		20310
Average		2031

So, the λ is 2031 peoples arrived in SIT. Meanwhile the number of channels involved, m mentioned in the (1) in data collection section which is m = 10 counters



	9am-10am	10am-11am	11am-12pm	12pm-1pm	1pm-2pm	2pm-3pm	3pm-4pm	4pm-5pm	5pm-6pm	6pm-7pm	7pm-8pm	8pm-9pm	9pm-10pm
24/8/2023 Thursday	125	140	114	110	105	100	104	140	200	141	120	102	93
25/8/2023 Friday	139	131	124	121	116	110	144	214	264	133	131	111	90
26/8/2023 Saturday	133	140	164	163	158	150	184	200	233	187	118	101	88
27/8/2023 Sunday	200	213	221	218	213	220	334	395	401	231	166	99	71
28/8/2023 Monday	188	205	184	172	157	145	174	195	203	140	126	100	64
29/8/2023 Tuesday	194	201	169	152	137	125	204	241	299	144	122	105	66
30/8/2023 Wednesday	190	195	189	142	137	130	214	222	290	195	161	98	61
31/8/2023 Thursday	165	178	131	102	95	90	134	206	249	145	110	87	52
1/9/2023 Friday	155	171	160	133	128	121	165	236	266	162	127	75	49
2/9/2023 Saturday	143	149	151	123	115	111	125	217	222	155	115	79	54

Fig. 1: Arrival of customer in SIT

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Basically, by referring to figure 4.1, we can say that all of customers queuing for one reason which is to buy a ticket to go someplace that be their destiny. Based on the table in the figure 4.1, the largest number of customers arrived on Sunday (27/8/23) with 401 customers queuing on 5pm-6pm. This happened because Malaysia having a public holiday on Thursday (31/8/23) so they tried to get the bus ticket earlier. Second largest number is on 4pm-5pm on the same day which is Sunday (27/8/23) with the total of 395 customers queuing to buy the ticket physically. Meanwhile the lowest number of customers is on Saturday (2/9/23) with the total of 54 customers queuing for the service. The service hours for SIT are starting from 8pm and ended on 10pm. The lowest number that stated before is happening due to SIT will end their shift on 10 pm so that is the reason why number of customers queuing for services is drastically decreasing.

Table 2: Total number of customers that been serviced by each terminal bus counter officers in SIT.

Date	**Day**	**Total**
24-Aug	Thursday	1396
25-Aug	Friday	1477
26-Aug	Saturday	1723
27-Aug	Sunday	2645
28-Aug	Monday	1883
29-Aug	Tuesday	1990
30-Aug	Wednesday	1968
31-Aug	Thursday	1641
1-Sep	Friday	1747
2-Sep	Saturday	1560
Total		18030
Average		1803

So, the μ = 1803 peoples that went be served by the terminal officers. Hence, we calculate total daily waiting cost and service cost by applying all the equation involved in (1) until (9). The same table were created to calculate average waiting time in queue in the research paper and we found out that the time spent by the customers waiting in the system (W) = 39.44 minutes. Thus, we calculate average waiting time per customer (W_q) by following formula in equation (4), we found out the value is same as time spent by the customers waiting in the system(W) = 39.44 minutes. For Duta Bus Station, the data were calculated as Table 4.3.

Table 3: Total number of customers arrived in Duta Bus Station according to each 10 days

Date	**Day**	**Total**
24-Aug	Thursday	974
25-Aug	Friday	1075
26-Aug	Saturday	1047
27-Aug	Sunday	1219
28-Aug	Monday	1195
29-Aug	Tuesday	1354
30-Aug	Wednesday	1121
31-Aug	Thursday	1033
1-Sep	Friday	2169
2-Sep	Saturday	2369
Total		13556
Average		1355.6

The value of λ is 1356 peoples arrived in Duta Bus Station. Meanwhile the number of channels involved, m mentioned in the 3.1 in data collection section which is m = 10 counters

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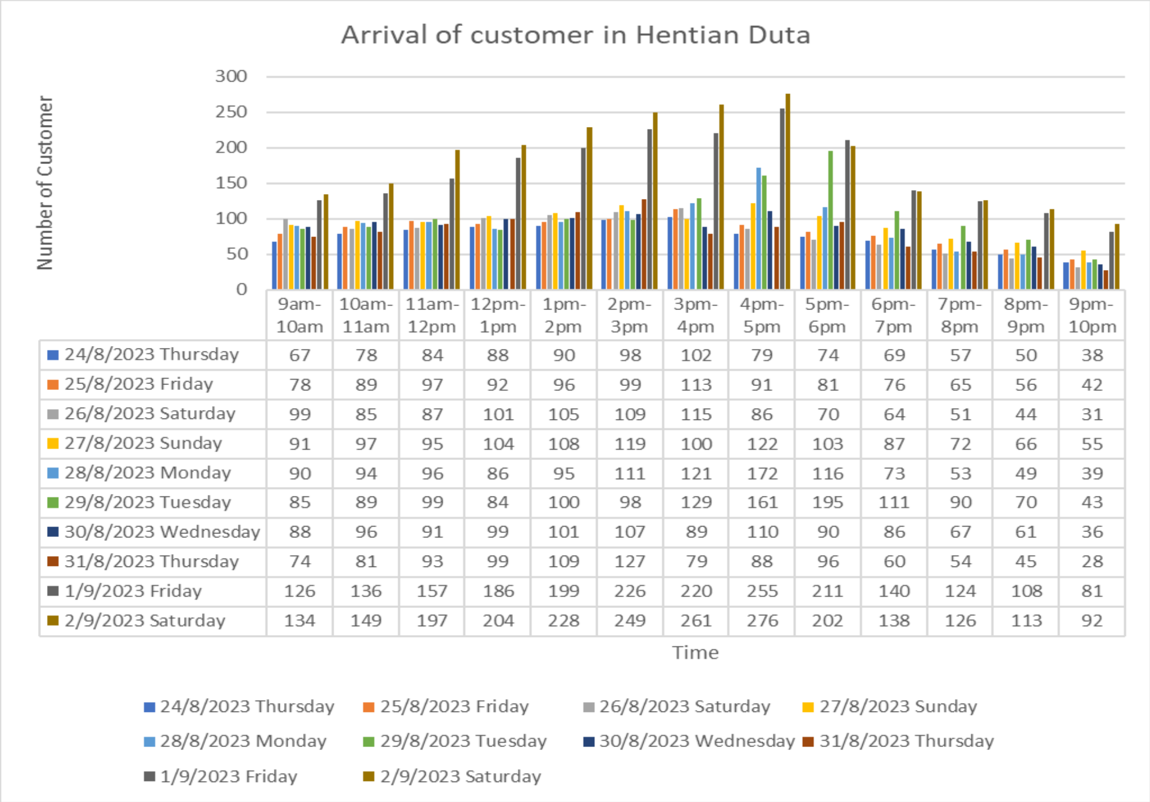

	9am-10am	10am-11am	11am-12pm	12pm-1pm	1pm-2pm	2pm-3pm	3pm-4pm	4pm-5pm	5pm-6pm	6pm-7pm	7pm-8pm	8pm-9pm	9pm-10pm
24/8/2023 Thursday	67	78	84	88	90	98	102	79	74	69	57	50	38
25/8/2023 Friday	78	89	97	92	96	99	113	91	81	76	65	56	42
26/8/2023 Saturday	99	85	87	101	105	109	115	86	70	64	51	44	31
27/8/2023 Sunday	91	97	95	104	108	119	100	122	103	87	72	66	55
28/8/2023 Monday	90	94	96	86	95	111	121	172	116	73	53	49	39
29/8/2023 Tuesday	85	89	99	84	100	98	129	161	195	111	90	70	43
30/8/2023 Wednesday	88	96	91	99	101	107	89	110	90	86	67	61	36
31/8/2023 Thursday	74	81	93	99	109	127	79	88	96	60	54	45	28
1/9/2023 Friday	126	136	157	186	199	226	220	255	211	140	124	108	81
2/9/2023 Saturday	134	149	197	204	228	249	261	276	202	138	126	113	92

Fig. 2: Arrival of customers in Duta Bus Station

Basically, by referring to figure 4.2, we can say that not all of the customers were using Duta Bus Station as their main transportation hub. This is because Duta Bus Station is a transit for people who were going to North of Malaysia such as Perak, Kedah, and Perlis. Based on the table in the figure 4.2, the largest number of customers arrived on Saturday (2/9/23) with 276 customers queuing on 4pm-5pm. This happened since Malaysia having a public holiday on Thursday (31/8/23) so they tried to get the bus ticket on a one or two days later. Second largest number is on 3pm-4pm on the same day which is Saturday (2/9/23) with the total of 261 customers queuing to buy the ticket physically. Meanwhile the lowest number of customers is on Saturday (31/8/23) with the total of 28 customers queuing for the service. The service hours for Duta Bus Station are starting from 8pm and ended on 10pm. The lowest number that stated before is happening due to Duta Bus Station will end their shift on 10 pm so that is the reason why number of customers queuing for services is drastically decreasing.

Table 4: Total number of customers that been serviced by each terminal bus counter officers in Duta Bus Station

Date	Day	Total
24-Aug	Thursday	849
25-Aug	Friday	897
26-Aug	Saturday	1060
27-Aug	Sunday	1072
28-Aug	Monday	1063
29-Aug	Tuesday	1229
30-Aug	Wednesday	998
31-Aug	Thursday	953
1-Sep	Friday	2034
2-Sep	Saturday	2250
Total		12405
Average		1240.5

So, the μ = 1241 peoples that went be served by the terminal officers. Hence, we calculate total daily waiting cost and service cost by applying all the equation involved in 3.1 until 3.9. The same table were created to calculate average waiting time in queue in the research paper and we found out that the time spent by the customers waiting in the system(W) = 41.25 minutes. Thus, we calculate average waiting time per customer (W_q) by following formula in equation 3.4, we found out the value is same as time spent by the customers waiting in the system(W) = 41.25 minutes.

To fulfil second objective is by calculating total daily service cost and waiting cost for both terminals. For SIT, after calculation and researched, our waiting cost is RM30, and service cost is RM14. Meanwhile for Duta Bus Station, the waiting cost is RM25, and service cost is RM15. Hence, the table below shows the comparison of total daily service cost and waiting cost for both terminals.

Table 5: Total daily service cost and waiting cost for both terminals.

Terminal	Daily Waiting Cost	Daily Service Cost
SIT	RM 2,133, 309.60	RM252,420
Duta Bus Station	RM1,279,781.25	RM186,150

Based on the result above, we know that Duta Bus Station has the greater daily service cost and daily waiting cost compared to SIT. This happened due to customers arrival rate are the factor that leading to this result for both terminals.

The fulfilment of last objective is by calculating the performance of both terminals which one has the greater average service rate compared to average arrival rate.

Tabe 6: Performance validation of comparison between average service rate and average arrival rate for both terminals

Terminal	Average Arrival Rate	Average Service Rate	Difference
SIT	2031	1803	228
Duta Bus Station	1356	1241	115

Based on these result shows in table 4.6 that the SIT has greater average service rate and average arrival rate compared to Duta Bus Station. Therefore, the performance of SIT is greater than Duta Bus Station which gave us meaning that the effectiveness in reduce customer waiting time because the not yet arrive, but the service is done completely.

CONCLUSION

Basically, we learn that both terminals need to improve in their facility and include the service they offered to the customer so that they will gain a lot of customers and thus can reduce the queueing time to make the whole terminals operation much better. Perhaps with technology nowadays, self-service in the terminals is much more needed with the addition of self-service ticket buying machines. The result of this research is to learn a better understanding of queuing theory models using multichannel queuing models in both transportation hubs.

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