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Research Article

THE PERFORMANCE EVALUATION OF TRAFFIC MANAGEMENT SIMULATION MODEL IN RUSH HOURS FOR PHRANAKHON RAJABHAT UNIVERSITY

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ABSTRACT

This research developed the extended work of a simulation model to estimate the waiting time in the queue at the exit gate of the Phranakhon Rajabhat University, 2 new traffic management models have been created to find the model for decreasing waiting time in queue. The previous models had occupied a special lane for vehicles enter to the rector office, and another had used human control at the exit gate to hold traffic on the main road and let vehicles pass through the exit gate. The results found that waiting times in queue at the exit gate of 2 previous models are not much different due to the natural traffic jam on Chaengwattana road which is the main road where the exit gate is connected to it and only one exit gate to depart from the university. So, this research studied the 2 new models by adding 2nd exit gate to evaluate the waiting time in queue in hoping that waiting time in queue of 1stexit gate is decreased. However, the results show that the waiting time in queue at the 1st exit gate has not much decreased in difference after adding 2nd exit gate due to the majority of vehicles coming to the university to drop off their children and some are vehicles belonging to the officers of the university, those vehicles pass over the junction to use the 2nd exit gate to depart the university. Those vehicles will go through the 1st exit gate and wait in queue to depart the university. Then, the second models created by adding human control at the junction in front of the primary school building to force vehicles to come to the second exit gate at some period then waiting time in queue at the 1st exit gate is decreased and the number of vehicles which get into the Chaengwattana road had increased when compared to the same time at the 2 previous models.

Keywords: MM2, Rush hours, Traffic jam, Waiting Time in Queue.

INTRODUCTION

The traffic is congested during the rush hours (7.00-9.00 AM) due to office hours of the government sector and business sector will start working at 8.30 AM. **Phranakhon Rajabhat University (PNRU)** had located near the government office complex [1]. Many officers or workers took PNRU as the shortcut route to go to their offices and some of them are parents who enter PNRU to send their kids to the school located inside PNRU. [2] had studied 2 simulation traffic management models and one regular model. First is the regular model which imitated the vehicles traveling into the PNRU from 4 entrances as shown in Fig1. The traveling time of each vehicle in the university, the period to hold a break over the speed hump [7], the period to stop and send their kids, and the number of vehicles to leave the exit gate, were collected during the 7.00-9.00 AM working day. The second simulation model had created to study in order to solve the waiting time in queue at the exit gate by applying a special lane to allow vehicles to go directly to the Rector office which is near the exit gate. A third simulation model has been created to improve the waiting time in queue at the exit gate by taking the people (guard) and flag standing at the exit gate to interrupt the vehicle on the Chaengwattana road and lets the vehicle from the gate pass into the Chaengwattana road as shown in fig 3. [2] used EZsim as a tool to develop a simulation model for these 3 models. [2] shown that in the Regular model, the average of each vehicle waiting time at the exit gate to get into Changwatta Road on each working day as Monday is 4.41 minutes. Tuesday, Wednesday, and Thursday are about nearly a minute, only Friday is 6.07 minutes. The second model which applied a special lane to the Rector office had a waiting time at the exit gate to get into Changwatta Road on each working day as Monday is 4.16 minutes. Tuesday, Wednesday, and Thursday are about nearly a minute, only Friday is 5.10 minutes. The last model which applied a guard to halt the car on the main road had a waiting time at the exit gate in order to get into Changwatta Road on each working day as Monday is 4.50 minutes, Tuesday, Wednesday, and Thursday are about nearly a minute, only Friday is 6.10 minutes. The waiting time at the exit gate is high on Monday and Friday due to the natural traffic jam on Chaengwattana Road. These officers who worked at the government center complex or another public state office on Chaengwattana Road need to prepare work and get the job done after the break of working on Saturday and Sunday as same Friday that officers need to clear the work done during the past working day before getting a break on Saturday and Sunday.

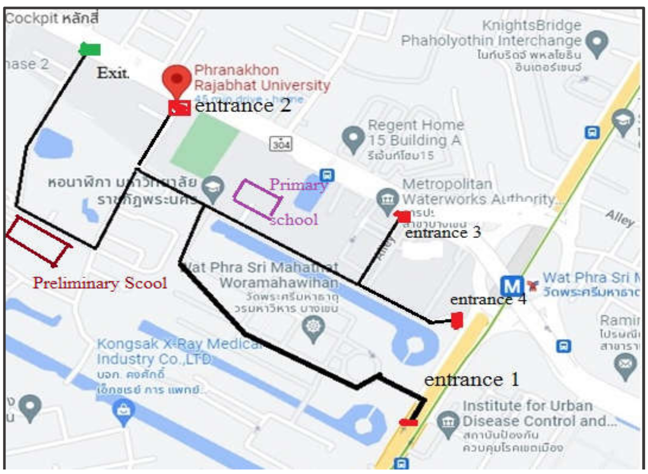

Fig 1. The route for vehicles to travel in the university to exit gate.

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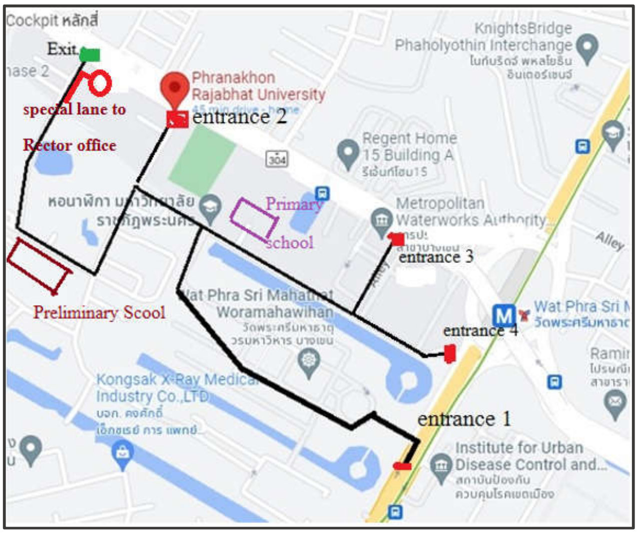

Fig 2. The special lane to allow vehicles to go to Rector office.

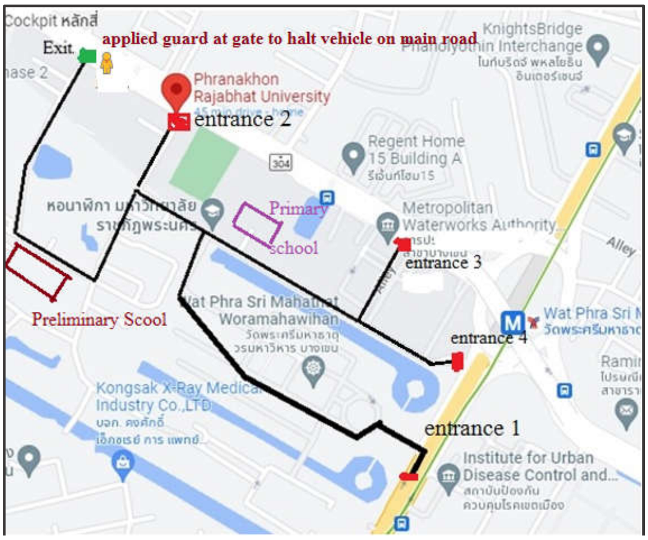

Fig 3. Guard standing at exit gate to let vehicles from the gate enter into main road

SIMULATION MODEL REVIEW

The simulation is modeling to imitate the actual situation of the system that we want to observe and analyzed and then we experiment on that model. Mathematical formulas or programs may use as a tool in order to execute and find the results. However, these results not may be the best answer but they will be the suitable answer (Optimal Solution) to the problem. This result led the whole pieces of the problems to the analyst and bring the guideline to improve the system performance. A discrete event simulation (DES) [8] is taken into consideration on those points in time (events) that are of importance to the simulation. Such events may, for example, each vehicle entering a university, leaving from the entrance, moving on to another route, or stopping by any place. The movements of each event are points of consideration in simulation. Entities and resources will cooperate and change the state in forward. This process needs to put on the model development also the flow of time such as Event where is the instant of time at the state of the system changes, Activity where is a time period of specified length which is known when it begins, Delay is the duration of time of unspecified length, which is not known until it ends and clock where is variable representing simulated time.

Fig 4. The M/M/1 simulation model nodes

One Server, Finite Queue (M/M/1/N) the one-server, finite capacity system with exponential inter-arrival and service times. Could be, one exit gate with some vehicles is waiting to enter to the main road. The difference, equilibrium and reduced equations are listed, and the probability on the number of units in the system are developed, along with the performance measures are presented as list below

average number of arrivals per unit of time $= \boldsymbol{\lambda}$

average number of units processed in a unit of time to busy service facility $= \boldsymbol{\mu}$

average time between arrivals: $(\boldsymbol{\tau_a}) = \frac{1}{\lambda}$ (1)

average time to service a unit: $(\boldsymbol{\tau_s}) = \frac{1}{\mu}$ (2)

Utilization of the server: $(P) = \frac{\lambda}{\mu}$ (3)

Average queue length: $(L_q) = \frac{\lambda^2}{\mu(\mu-\lambda)}$ (4)

Average number of units in the system: $(L_s) = \frac{\lambda}{(\mu-\lambda)}$ (5)

Average waiting time in queue: $(W_q) = \frac{\lambda}{\mu(\mu-\lambda)}$ (6)

Average waiting time of an arrival in the system: $(W_s) = \frac{1}{(\mu-\lambda)}$ (7)

PROPOSED MODEL

Fig 5 represents the concept of the simulation model which added a second exit gate into our evaluation. In the past, entrance 2 only allowed vehicles to come into the PNRU. In this study, entrance 2 also allowed vehicles to depart from PNRU at 7.00-9.00 AM. too. The traveling time of each vehicle over the university, the period to hold break over the speed hump, the period to pause and drop off their kids, and the number of vehicles to leave the two exit gates, were collected during the 7.00-9.00 AM working day. The average value of a continuous function on an interval will be used to find the input parameters values to serve as λ and μ for inter-arrival time and service time as well as delay time. Fig 6 represent the simulation model which allowed vehicles to depart the PNRU by using entrance 2 (temporally).

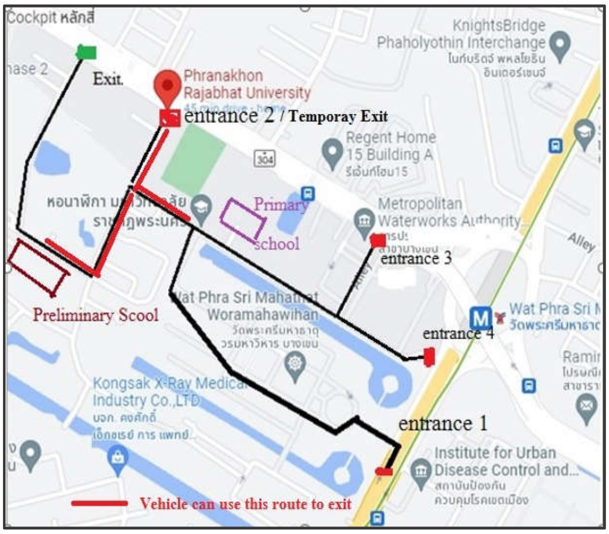

Fig 5. The Proposed model which adding other exit gates

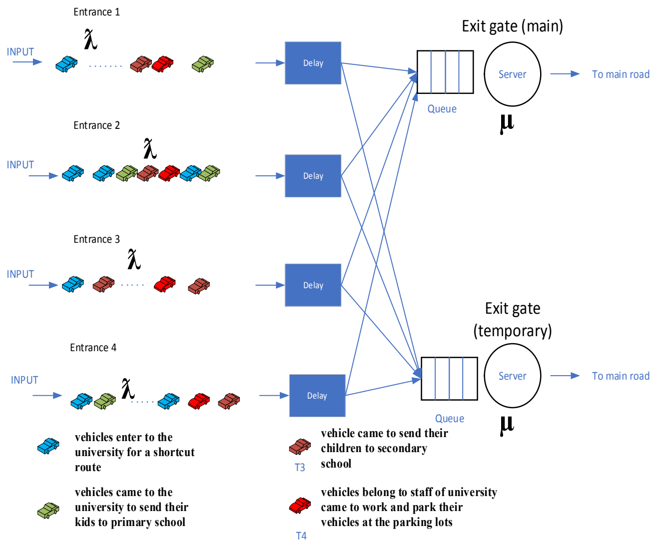

Fig 6. Simulation model for adding second exit gate

The figure 7 shown the concept of the simulation model which imitated of adding human to control the traffic flow at the junction in front of primary school building where is the destination of most vehicle which came into the PNRU. Human (Guard) will force the vehicles to second exit gate (Entrance 2) when his WALKIE-TALKIE RADIOS informed to let some vehicles to go to exit date due to many vehicles waiting queue to depart at 1st exit gate. The traveling time of each vehicles over the university, period of time to hold break over the speed hump, the period of time to stop and send their kids, and number of vehicles to leave the 2 exit gates, were collected during the 7.00-9.00 AM on working day. The average value of a continuous function on an interval will be used to find the input parameters values to serve as λ and μ for inter-arrival time and service time as well as delay time.

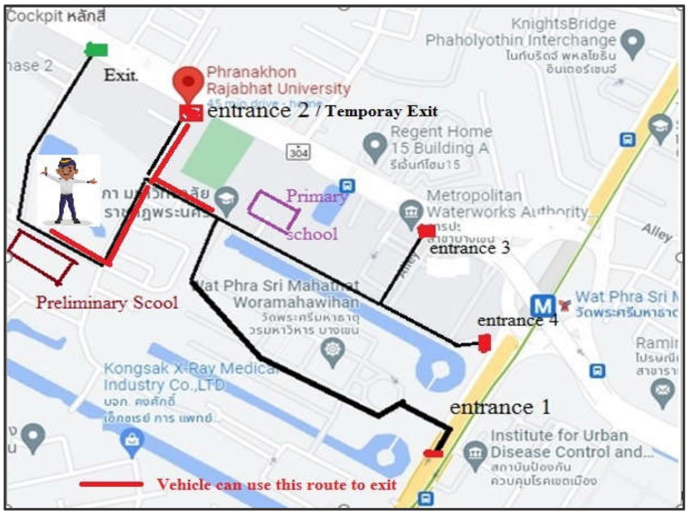

Fig 7. Proposed model which adding human to forced vehicles to other exit gates

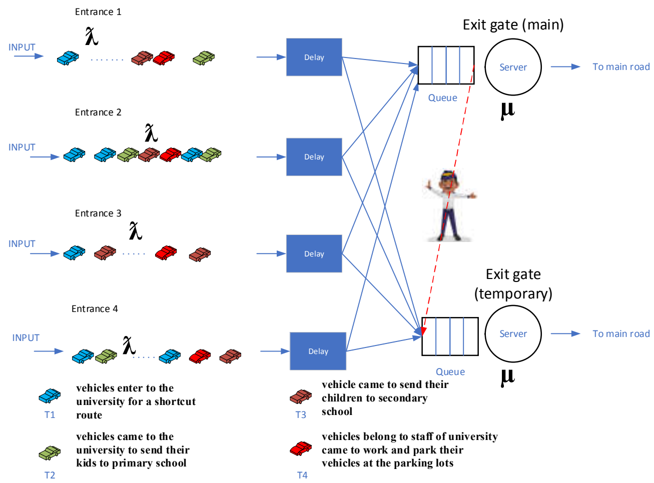

Fig 8. Simulation model for adding human to force vehicles to second exit gate

Delay time

The vehicles which enter into the university can be classified into 4 group types. First (T1) is the vehicles came in the university for a shortcut route to exit to Changwattana Road, second (T2) is the vehicles came in the university to send their kids to primary school, third (T3) is vehicle came in university to send their children to secondary school, and last (T4) is the vehicles belong to university's staff who came to work and park their vehicles at the parking lots [3],[5]. The vehicle's travelling time over the university has calculated based on each group type which are collected from 7.00-9.00 am in3 months period time with Linear Statistical Models [12]. The average value of a continuous function to be performed in order to obtain the average delay time based on each vehicle group type versus each working day where is shown in table 1.

Table 1. The average delay time for each vehicles type.

Day	Vehicle group type			
	T1	T2	T3	T4
Moday	345 second	645 second	765 second	489 second
Tuesday	298 second	603 second	742 second	456 second
Wednesday	303 second	584 second	762 second	412 second
Thursday	278 second	498 second	701 second	403 second
Friday	324 second	635 second	759 second	465 second

Input

The Figure 8 shown the time period versus the summation of vehicles which get into PNRU from 4 entrances at 3 months period time [6]. The formula (6) is applied to find the inter-arrival time for that period of time (7.00-9.00). The average value of a continuous function on an interval will be applied at this period time (3 months), the average inter-arrival time (λ) for the vehicle type 1 (T1) based on each working day as follow; Monday is 61.08 second, Tuesday is 65.93 second, Wednesday is 72.03 second, Thursday is 134.72 second and Friday is 124.80 second. Vehicle type 2 (T2) has inter-arrival time as follow; Monday is 68.41 second, Tuesday is 73.85 second, Wednesday is 80.67 second, Thursday is 109.20 second and Friday is 99.96 second. Vehicle type 3(T3) has inter-arrival time as follow; Monday is 114.01 second, Tuesday is 123.08 second, Wednesday is 134.45 second, Thursday is 97.50 second and Friday is 89.25 second. The last (T4) has inter-arrival time as follow; Monday is 53.44 second, Tuesday is 57.69 second, Wednesday is 63.03 second, Thursday is 58.50 second and Friday is 53.55 second.

Average = $1/n * \sum_{i=1}^{n}((\mathrm{Ei} + \mathrm{Ei} + 1)/2 * (\mathrm{Ti} + 1 - \mathrm{Ti}))$(6)

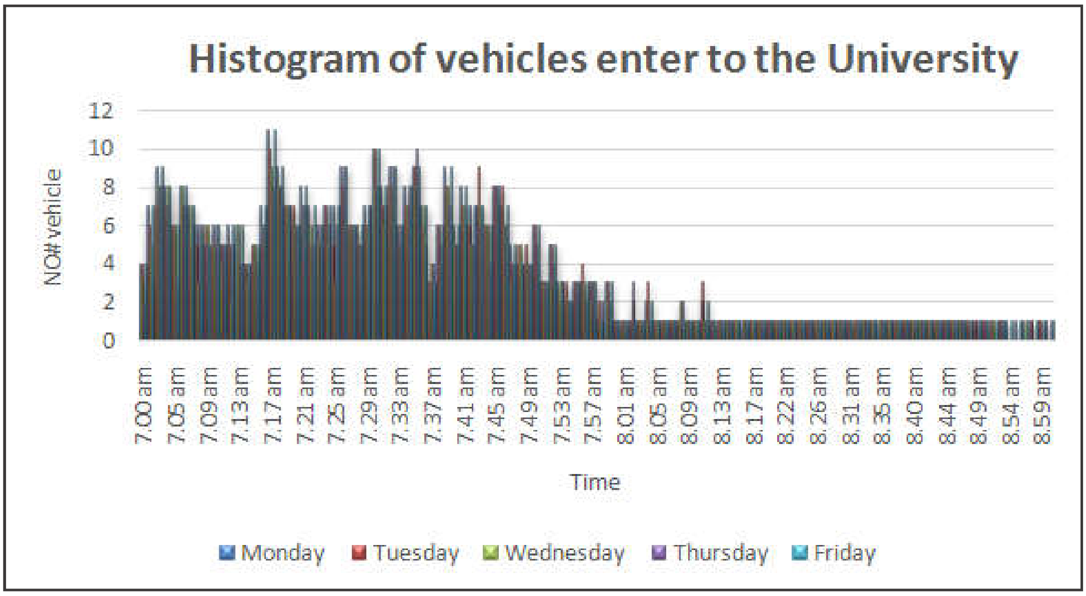

Figure 8. Number of Vehicle's histogram enter to the University

Service time

At the exits gate [4], only 1 way to depart the PNRU. [2] was shown that many vehicles got strict at this exit gate due to the Chaengwattana road had faced of heavy traffic jam. So that, few vehicles which be able to get into the Chaengwattana road. The number of vehicles which can get into Chaengwattana road are collected as shown on figure 9. The data of number of vehicles which be able to get into Chaengwattana road versus period of time (7.00-9.00 am) had been used and the average value of a continuous function to be performed on this data in order to find the average service time of vehicle which are departed from the exits gate to get into Chaengwattana road. The average service time (μ) for Monday is 32.29 second, Tuesday is 38.71 second, Wednesday is 41.86 second, Thursday is 44.72 second and Friday is 37.89 second.

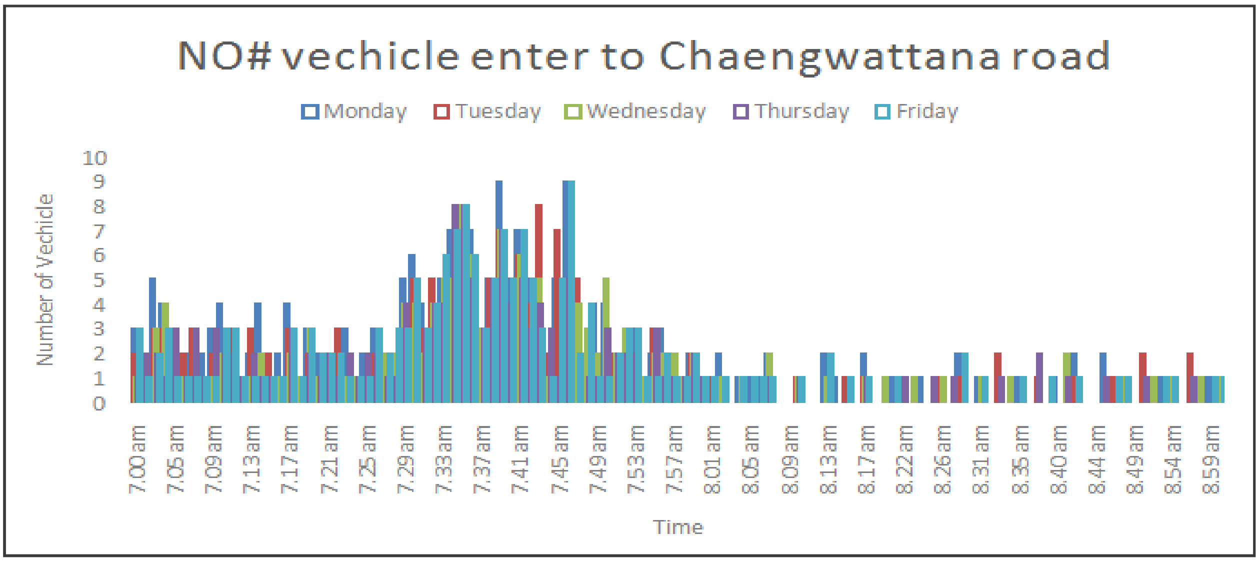

Figure 9. Number of vehicle's histogram can get into Chaengwattana road

As Fig 7, The 2nd exit gate is set up for this study, it located near to the 1st exits gate that about 300 meters far away. This gate functions as entrance for the vehicles to get into university at present. For this study, we set hypothesis that it can allow vehicles to depart the university. And we have known the number of vehicles that used this entrance with an average 38% of vehicles that came into the university from the observing data. So that the possibility of chance for vehicles depart the university is greater than the 1st exits gate because when one vehicle turned left and pass through the 2nd exit gate, other vehicles inside university can pass through the 2nd exit gate and get into Chaengwattana road. We applied linear statistical models to the average service time of vehicle from first exit gate, and find the average service time of vehicle at 2nd exit gate, the results (μ)on Monday is 19.38 second, Tuesday is 24 second, Wednesday is 25.95 second, Thursday is 27.72 second and Friday is 23.49second

SIMULATION CONFIGURATION AND PARAMETER

The EZsim is used to develop the simulation model [9]. The first proposed model was developed from regular model which has only one exit gate plus special lane to rector office from [2] and plus with 2nd exit gate as represented on Fig 6, we have known the number of vehicles that came to the rector office from [2] are as follows, Monday is 29 vehicles, Tuesday is 20 vehicles, Wednesday is 21 vehicles, Thursday is 22 vehicles and Friday is 35 vehicles. The first proposed model was modified form first proposed model in [2] for proving our hypothesis, then at the queue of server, the number of vehicles will drop of from the queue before serviced is equal to 13% on Monday, 11.3% on Thursday, 11.6 % on Wednesday, 13.6% on Thursday and 18.42% on Friday. Then, the we add the 2nd exit gate to the model in order to find the Mean Queue Length Mean Waiting Time in Queue, Mean traveling time in the university, Minimum traveling time in the university, and Maximum traveling time in the university, to compare these parameters with [2]results.

For the second proposed model, the people (guard) has applied at gate and hold flag to interrupt vehicle flow on main road [11]. We used conclusion from hypothesis that wrote on [13] which is proved and noted that the waiting time for the driver allow another drivers who can jostle and aggressively put its nose into the constriction to pass through is algebraic decay with an exponent of 1.5 and 2.5 unit of vehicles where it collected from two cities of India at traffic intersection [10]. We applied this value to this proposed model by allow guard to lets two vehicles consecutive pass through the gate and get into the Changwattana road per one interruption. Moreover, the 2nd exit gate as represented on Fig 8 is applied to this model.

Table 2 Parameters for regular model and proposed models

			1st exit gate	2nd exit gate	
	Vehicle group type	**Inter-arrival time (second)**	**Service time (second)**	**Service time (second)**	**Travelling time on the University (second)**
Monday	T1	61.08	32.29	19.47	345.00
	T2	68.41			645.00
	T3	114.01			765.00
	T4	53.44	None	None	489.00
Tuesday	T1	65.93	38.71	25.26	298.00
	T2	73.85			603.00
	T3	123.08			742.00
	T4	57.69	None	None	456.00
Wednesday	T1	72.03	41.86	27.2	303.00
	T2	80.67			584.00
	T3	134.45			762.00
	T4	63.03	None	None	412.00
Thursday	T1	134.72	44.72	29.8	278.00
	T2	109.20			498.00
	T3	97.50			701.00
	T4	58.50	None	None	403.00
Friday	T1	124.80	37.89	23.45	324.00
	T2	99.96			635.00
	T3	89.25			759.00
	T4	53.55	None	None	465.00

RESULT AND DISCUSSION

Table 3 indicated that 1st new proposed model by adding 2nd exit gate to the previous model which added a special lane to the rector office model has a waiting time in queue decreased by nearly doubled. All through, 2nd new proposed model by adding 2nd exit gate to the previous model with a guard to force vehicle flow on the junction to travel to 2nd exit gate when a long queue exits at 1st exit gate. However, the results show that the waiting time in queue at the 1st new proposed model has a different from 2nd new proposed model exit gate due to the guard will force the vehicles to travel to 2nd exit gate when the long queue exiting on the 1st exit gate, in contrast, the vehicles from the primary school will decide on their own to go to 1st exit gate or 2nd exit gate, by then a lot of vehicles go to the 1st exit gate due to their habitually travel in the university [14].

Table 3 Results of 2 previous simulation models with 2 new proposed models.

			Unit in (Second)				
			Mon	Tues	Wed	Thurs	Fri
Model from [2] as Basement to compare	Adding Special lane to rector office model *	Mean Queue Length	14.21	2.6	1.5	2.3	22.46
		Mean Waiting Time in Queue	249.9	32.52	15.28	16.49	299.5
		Mean traveling time in the university	834	511	489	426	959
		Minimum traveling time in the university	391	289	299	261	341
		Maximum traveling time in the university	1250	853	827	798	1630
	Adding guard to interrupt vehicle flow on main road*	Mean Queue Length	13.75	1.9	1.1	1.7	20.75
		Mean Waiting Time in Queue	270.53	29.12	14.23	16.34	342.1
		Mean traveling time in the university	825	512	489	456	920
		Minimum traveling time in the university	381	284	291	210	318
		Maximum traveling time in the university	1250	853	827	798	1630
1st Proposed Model	Adding Special lane to rector office model + 2nd Gate	Mean Queue Length 1st exit gate	11.25	1.4	1.25	1.52	18.12
		Mean Queue Length 2nd exit gate	5.6	1.1	12.81	11.12	14.1
		Mean Waiting Time in Queue for 1st exit gate	201.53	25.17	0.9	1.54	269.51
		Mean Waiting Time in Queue for 2nd exit gate	124.12	18.12	10.42	9.45	163.12
		Mean traveling time in the university	812	504	456	389	911
		Minimum traveling time in the university	312	248	254	221	305
		Maximum traveling time in the university	1198	812	791	735	1542
2nd Proposed Model	Adding guard to force vehicle flow on junction + 2nd Gate	Mean Queue Length 1st exit gate	10.55	1.1	1.1	0.9	18.75
		Mean Queue Length 2nd exit gate	7.6	1.2	1.1	9.34	13.2
		Mean Waiting Time in Queue for 1st exit gate	183.42	8.23	8.43	0.8	190.12
		Mean Waiting Time in Queue for 2nd exit gate	98.21	10.25	8.13	8.46	118.59
		Mean traveling time in the university	789	504	425	412	845
		Minimum traveling time in the university	298	248	243	189	287
		Maximum traveling time in the university	1108	812	792	756	1587

* the result from [2] where only one exit gate applied

CONCLUSION

The 2 new proposed models have indicated after 2nd exit gate had been added, waiting time in queue decreased by nearly doubled. The driver can reduce stress and release tension for reaching the working place on time. However, the university needs to provide two guards to conduct 2nd new proposed model which costs university expenses. In contrast, 1st new proposed models do not need guards to conduct, but the waiting time queue is not much different. This result implied that the simulation model can explore 'what if' questions and scenarios without having to experiment on the real system itself. Simulation helped to point out the pro and cons in each scenario for testing each hypothesis. It provides us with data and output without cost before deploying on a real system.

FUTURE WORK

After 2 new proposed models were developed, 2 traffic management models have created to study and tested in order to find the solution to decrease the waiting time in queue at the exit gates. As the 2nd new proposed model required 2 guards to conduct the model, and it required a budget from the university to hire them. So, we have an idea to build a smart sign to inform the drivers at each junction to decide whether to go left or right by the amount of time to reach the university exit gates in a unit of seconds. To this idea, only one time spend on the smart sign is better than a monthly expenditure for 2 guards.

REFERENCES

[1] Al Shdifat. M. Traffic Capacity at Parking lots' and University Entrance and exits in Jordan. Master Thesis. Civil Engineering Department, Jordan University of Science and Technology (2016).

[2] SuraseePrhmkaew, The simulation model for vehicles to quick exit of the university in rush hours, The 4th International conference on Multidisciplinary and Current Education research (ICMCER 2023), Bangkok Thailand, April 11-12, 2023, Proceeding, pp 31-38 (2023)

[3] Australia/New Zealand standard. Parking facilities part 1: off-street car-parking (2004).

[4] Crommelin, R. W. Entrance-exit design and control for major parking facilities. Paper presented to Los Angeles parking association (1972).

[5] Ellson, P. B. Parking: Dynamic Capacities of Car Parks. Report LR221. Crowthorne, Berkshire. Transportation Road Research Laboratory (1969).

[6] Frantzeskakis, J. M. Traffic Flow Analysis for Dimensioning Entrances -- Exits and Reservoir Space for OffStreet Parking. ITE Journal. pp 16-24 (1981).

[7] Al-Omari, B., Al-Masaeid, H. Effect of Speed Humps on Traffic Delay in Jordan., Road and Transport Research Journal, Volume. 11. pp. 49-55 (2002).

[8] Pappu SK (1997). Simulating computer systems. IEEE Potentials 16 (1): 16–18.

[9] Mala and S.P. Varma (2016), Minimization of Traffic Congestion by Using Queuing Theory, IOSR Journal of Mathematics (IOSR-JM), Volume 12, Issue 1 Ver. II (Jan. - Feb. 2016), PP 116-122.

[10] Martin Anokye, A.R. Abdul-Aziz, etl, (2013), Application of Queuing Theory toVehicular Traffic at Signalized Intersection in Kumasi-Ashanti Region, Ghana, American International Journal of Contemporary Research, Vol. 3 No. 7

[11] Shuguo Yang and Xiaoyan Yang (2014), The Application of the Queuing Theory in the Traffic Flow of Intersection, World Academy of Science, Engineering and Technology International Journal of Mathematical and Computational Sciences Vol:8, No:6.

[12] Neter, John, and William Wasserman. Applied Linear Statistical Models. Homewood, Ill. R.D. Irwin, 1974.

[13] Dasgupta, Subinay, 2021.How long does one wait at a traffic congestion?, Physica A: Statistical Mechanics and its Applications, Elsevier, vol. 574(C).

[14] Sokoloski JA. Simulation: models that vary overtime. In Principles of Modeling and Simulation : A Multidisciplinary Approach, Sokolowski JA Banks CM, Eds. Hoboken, NJ: Wiley, 2009, pp.47-69.

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