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A design simulation of traffic light intersection using SimEvents MATLAB

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Abstract. The smoothness of traffic flow is one indicators of the excellent management by road managers, especially in the settings of traffic lights on road intersection. The time duration the red and green light must be set precisely according to the traffic density, so that the optimal and fairness queue length and waiting time are obtained for road users in each lane. Some problems at the intersection of the highway are the occurrence of very long queues in one lane, but quite short on the other lane. This happens because the setting is not appropriate on the traffic light time duration. In this article, we propose a model and simulation for intersection with traffic light using MATLAB SimEvents tools. The proposed model is to place an inhibitor module on each path at the intersection, where the entity does not flow for a certain duration of time. Through this simulation, it can be predicted the exact duration time of traffic lights based on the traffic density on each lane.

1. Introduction

The development of cities in the world today shows a significant increase. The City's governments in various countries have begun to develop various infrastructures and technologies to improve people's welfare, one of which is road infrastructure. However, along with the development of road construction, a new problem arose, namely the traffic congestion. Traffic congestion causes many losses in the form of time, costs, waste of fuel, etc., so that optimal traffic control is needed. Congestion problems arise due to the imbalance in the increase in the number of vehicles with highway capacity.

Traffic jam analysis in a road location can be seen as a system of queues of vehicles that come and wait to be served by the system. With this basis, an intersection or other traffic location can be analyzed using a queuing model with a simulation method. The queue model used includes the average rate of arrival of vehicles into the queue at the intersection assumed to follow the Poisson process, and the average rate of vehicle departure from the intersection is assumed to be exponentially distributed [1-5].

In this article, we propose a design for road traffic simulation, specifically for traffic in the intersections with traffic lights. Several researchers have examined this traffic intersection based on several methods such as modeling [6, 7] and fuzzy inference systems [8]. The benefits of this application are for monitoring and predicting congestion at intersections, as well as possible solutions that can be



taken to solve the congestion problems at each of intersection paths. In current time, there are many computer application systems in various fields. Apart from in the field of transportation, computer applications are also used in the field of education, for example the use of Geogebra applications [9, 10] or the implementation of computer-based tests [11].

We propose an application to simulate traffic at intersections so that it can be observed and analyzed. In this simulator, a scenario can be made to determine the exact duration time of the traffic lights in each path, so that the long queues of vehicles that occur can be decomposed. Vehicles can immediately pass through the intersection so that congestion can be avoided. In a previous study, a LINTAS simulator design was developed to simulate the traffic system in Bandung, Indonesia [3, 12].

2. Method

In this article, the design of traffic simulator and its components is created using the SimEvents MATLAB application [13]. SimEvents has been used as a tool to simulate a system in various fields, including Transportation [3, 12] and Internet [14, 15] which involves data flow methods on Content Delivery Networks (CDN) technology and Service-oriented Routers [16-20]. Several methods can be used in vehicle distribution simulations, including load balancing [21] as well as artificial intelligence Bayesian networks [22, 23]. Besides SimEvents, another simulator that is commonly used is NS3 [24]. The components of the simulator system using SimEvents are modules in the form of an entity generator as a medium for generating entity (vehicles), server modules as media services, gate modules as representations of traffic intersections, links as representations of transportation routes, and sink modules for entity disposal.

The data used in creating the application for traffic simulation at this intersection is obtained by the observation method. Data collected includes the duration of the traffic lights shown in table 1.

Table 1. The duration time of traffic light at intersection: Soekarno Hatta – Kiara Condong; Phase number = 4; Cycle time in one phase = 253 Seconds.

Red Light Time	Yellow Light Time	Green Light Time
A = 153 seconds	A = 10 seconds	A = 90 seconds
B = 153 seconds	B = 10 seconds	B = 90 seconds
C = 153 seconds	C = 10 seconds	C = 90 seconds
D = 153 seconds	D = 10 seconds	D = 90 seconds

Source: Department of Perhubungan Bandung City [25].

Other data used in this study is the average rate of arrival of vehicles into the system, and the average rate of departure of vehicles out of the queue system, which is described in table 2.

Table 2. Data for each variable at the intersection of Soekarno-Hatta - Kiara Condong.

Variable	Value	Unit	Information
λ	0.67	Vehicle per seconds	The Average vehicle arrival-rate
μ	3.501	Vehicle per seconds	The average departure-rate of vehicle

The creation and design of the traffic simulation system is carried out through several stages, starting with determining system boundaries and assumptions, vehicle distribution patterns, constructing

conceptual models with diagrams, compiling system model designs with SimEvents software, determining the number of data entities, and running simulations.

3. Simulator design

The design of the simulator system for signalized intersection is shown in Figure 1. This simulator was built using the SimEvents MATLAB application.

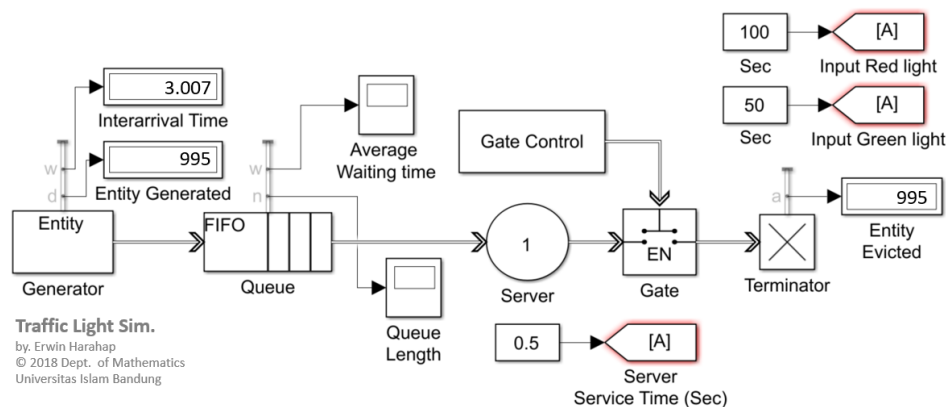


Figure 1. Design of a traffic light intersection simulator using SimEvents.

Next, we will discuss how the simulator system shown in Figure 1 works. The process of arrival is assumed to be Poisson with the average arrival rate λ , managed in the "Generator" module with the principle of the M/M/1 queue. Then the vehicle enters the intersection, and is assumed to stop because red light and queueing. The process of waiting in the queue is managed in the "Queue" module.

The duration of the red light and green light is managed on the "Gate Control" module with the path opening and closing mechanism managed in the "Gate" module. When the green light is on, the Gate module will open and the vehicle moves to leave the intersection. The average speed of the vehicle moving out leaving the intersection is μ , where the value of μ is entered in "Server's service time". The output of the simulation results is Queue-length and Average Waiting time of the vehicle in the queue. Queue-length can be obtained in the "Queue-length" module, and the average waiting time in the queue can be obtained in the "Average waiting time" module.

4. Results and discussion

At this stage, the results of the simulation will be discussed using SimEvents as shown in Figure 1. After the simulator is run, it will produce the average waiting time of the vehicle in the queue, and the queue length based on the simulation time. Data is then used as described in Table 1, which is about the duration of traffic lights for red and green lights. and Table 2, namely data on average vehicle arrival rates and average departure rates. The duration of the simulation time is 1500 seconds. Based on the simulation process, the simulation results of the queue length are shown in Figure 2.

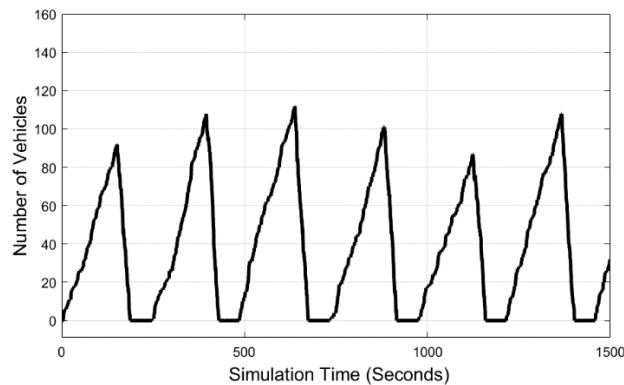


Figure 2. The Queue-length of the vehicle based on the simulation time.

As shown in Figure 2, the average vehicle arrival rate is 0.67 vehicles per second (about 40 vehicles per minute) that enters the intersection. The average rate of vehicles leaving the intersection is 3,501 vehicles per second (about 210 vehicles per minute). This is possible because at the intersection there are three lanes of vehicles and move together leaving the intersection when the green light is on. Based on Figure 1, the average queue length of vehicles that occur is 97 vehicles per unit of cycle, and the queue runs out when the green light, so it does not result in an increase in the queue at each traffic light cycle.

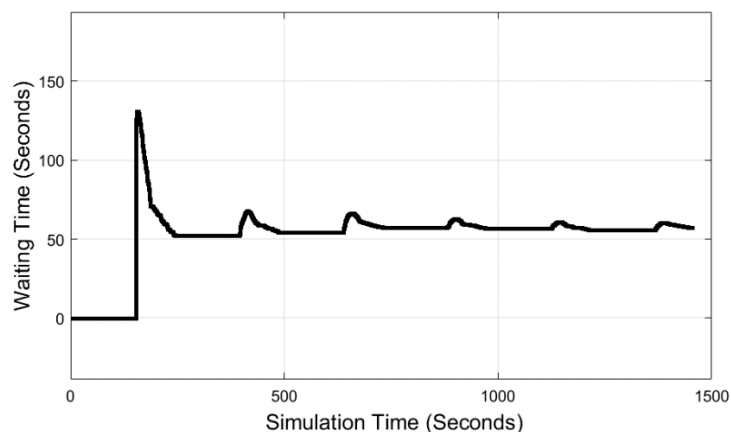


Figure 3. The Average Queue waiting time at the traffic lights intersection.

Furthermore, Figure 3 shows the results of the simulation in the form of an average waiting time for each vehicle in the queue at the intersection. By using the parameters of the duration of the traffic light in table 1 and the rate of arrival and departure in table 2, the average waiting time is 55 seconds. Further research is needed regarding to the queue waiting time so that it can be compared with the stress threshold.

5. Conclusion

The conclusion that can be obtained in this study is that the traffic light intersection simulator works well with input the duration of the traffic light, the average rate of vehicle's arrival entering the intersection, and the average vehicle leaving the intersection. To obtain optimal results, it is necessary to set the correct traffic time, where the ideal situation is that all vehicles that stop and enter the queue when the red light can leave the queue when the green light, so that no vehicle is left behind. To realize this, further research is needed by comparing simulation data with data in the real situation.

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