

THE STUDY OF ESTIMATED TIME OF ARRIVAL FOR PUBLIC TRANSPORTATION SYSTEM IN SURANAREE UNIVERSITY OF TECHNOLOGY USING ITS

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Abstract

Number of road traffic accidents on campus increase due to the increasing of personal vehicles. However, internal public transportation system still not meet students' traveling needs. The development of internal public transportation system according to student's needs is main factor. This article presents a model of the estimated time of arrival (ETA) for public mass transit using intelligent transportation system. Simulation processes are created using significant parameters. Delay due to traffic and commute time are presented. The simulation results of each route indicate the estimated time of arrival at each bus stop. Then, the estimated time of arrival are used for bus scheduling timetable developing. Also, the reliability of bus scheduling timetable is the main goal for users' time management. The use of public transportation reduces road accidents on campus in near future. This work introduces quality of services in term of ETA and quality of experiences in term of passengers' satisfaction assessments.

Keywords: Intelligent transport system (ITS), Estimate Time of Arrival (ETA), Smart transit.

Introduction

Mass transportation is an important factor for the livelihood of the population in large urban communities. If the community does not have good public transport systems, it affects the use of large numbers of private vehicles, which increases the chances of road accidents, causing injuries and deaths every year (Ding and Zeng, 2009).

Suranaree University of Technology (SUT) is considered a large community. Located on an area of over 2768.8 Aker, there are buildings scattered throughout the area. each group of buildings has a considerable distance, Especially the student

dormitory building group, and the school building group. However, most students use private vehicles for traveling from the dormitory study group. Because the public transportation system does not meet the needs of students. For this reason, the number of personal vehicles in universities, especially motorcycles, has increased dramatically. Number of accidents increase every year as shown in Figure 1. In 2019, the number of accidents increased dramatically in August. because there are new students entering to SUT.

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Intelligent transportation system adapts communication technology to traditional transportation system. Such as transmitting information from roadside devices to vehicles or transmitting information from vehicles to servers to improve road traffic capability, enhance safety and human comfort by reducing road construction. Sending information from the vehicle to the server, such information can be used to calculate the arrival time at the bus stop. To allow users to plan their trips, it is the introduction of 4G, LTE communication technology to increase efficiency of traditional transportation systems.

Increasing the quality of public transportation services in order to attract more students to use public transportation services, therefore focusing on the accuracy of arrival time (Lam and Leong, 2019). Time that the bus arrives depends on many factors,

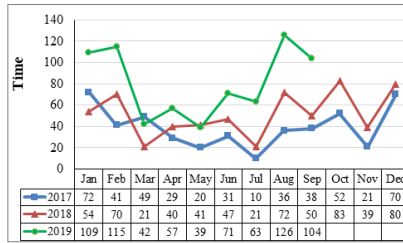


Figure 1. Comparison of Total number of accidents 2017-2019.

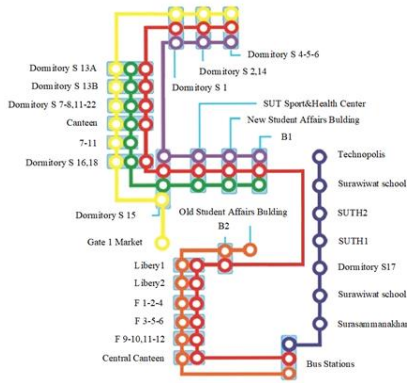


Figure 2. SUT Mass Transit routes and Bus stop in all 6 routes.

Table 1. Simulation parameters.

Parameters	Mean	Value	Unit
v	Average speed of bus	40	km/hr.
S	Distance between bus stop	Depending on Bus stop and GPS positioning system	m
n	Number of intersections	Depend on bus routes	junction
μ	Average service rate of the road	47	veh/min
λ	Average arrival rate of the road	34	veh/min
Queried time	Delays in retrieving data from server.	10	ms

such as traffic congestion, number of passengers, weather, and others. Such factors delay the arrival of the bus stop according to the bus schedule. (Agafonov and Myasnikov, 2015; Jithendra and Naga, 2015; Billones *et al.*, 2018).

This article presents a model for evaluating the arrival time of pauses. The simulation determines the route of the bus. Set a stop sign along the route. And calculate the travel time of the public transportation system on campus, which has travel delays due to traffic. This work introduces quality of services in term of ETA and quality of experiences in term of passengers' satisfaction assessments.

Materials and Methods

Our proposed method starts. First, we design 6 bus route and stop to cover and respond to usage within the university. The path in each path is divided according to color in Figure 2. Next, we explore intersections of the routes of each line. Then, we calculate ETA from parameters as in table 1.

s is distance between bus stops depending on Bus stop GPS positioning system. n depend on bus route. The green line has n 31 junctions. The purple line has n 21 junctions. The orange line has n 37 junctions. The blue line has n 25 junctions. The yellow line has n 42 junctions. The red line has n 71 junctions.

Commute time

Travel time refers to the amount of time the car moves from one point to another from the point with the average speed of the car. Which can be calculated from below. (1)

$$D_c = \frac{s}{v} \quad (1)$$

$$D_c = \frac{\text{Distance between bus stop}}{\text{Average speed of bus}} \quad (2)$$

Where; D_c =Commute time.

calculation of distances is calculated by specifying the coordinates on GPS (Yang *et al.*, 2012). SUT speed limit policy set up at 40 km/h in

this simulation. In the future, the real time speed getting from GPS installing inside the bus.

Delays caused by traffic conditions

Traffic congestion is an important factor in determining the arrival of buses for each stop. The M/M/1 queue is used to obtain the closest approximation with meaning arrival rate/service rate/single channel (Zaghal *et al.*, 2017). Arrival is determined by the Poisson process and service is determined by the exponential process. The service rate must be greater than the arrival rate can be calculated from (3).

$$D_T = n \left(\frac{1}{\mu - \lambda} \right) \quad (3)$$

Where; D_T =Delays caused by traffic conditions, n =Number of intersections, μ =Service rate, λ =Arrival rate.

Average delay per person

Passengers or users of the service are another factor that results in a delay in estimated arrival times for a stop. In this section, we calculate the delay time based on the number of passengers boarding and alighting bus at each stop from Equation (4).

$$D_N = N \times d \quad (4)$$

Where; D_N =Delay due to passenger, N =Number of people, d =mean delay per person.

d was collected by passenger counted method. The counter located on the bus. Delays caused by passengers are added to the estimated arrival time to increase accuracy. The number of passengers boarding and alighting will be updated to the server.

Estimate Time of Arrival

ETA is Estimated Time of Arrival. ETA presents in simulation results refer to ETA in each bus stops. Also, total traveling time is the summation of ETA in each bus stops. Bus travels along the road with more obstacles such as traffic situation, number of vehicles on the road. This is the sum of Commute time (D_C), Delays caused by traffic conditions (D_T), Delay due to passenger (D_N) and queried time. ETA calculated from Equations (5) and Equations (6) respectively.

$$ETA = D_C + D_T + D_N + \text{Queried time} \quad (5)$$

$$ETA = \frac{\text{Distance between bus stop}}{\text{Average speed of bus}} + n \left(\frac{1}{\mu - \lambda} \right) \quad (6)$$

Queried time is delays in retrieving data from server.

Results and Discussion

From Figure 3-Figure 8, Bar chart shows the time the buses have travelled between the stop to the stop. From the first stop to the last stop of each route. The green line starts at S13A (male dormitory) and ending at B1 (school building). The purple line starts at S4 (female dormitory) and ending at B1. The orange line starts at B1 and ending at SUT Bus Station. Blue line starts at bus station and ending at SUTH (Suranaree University of Technology Hospital). Yellow line starts at S13A and ending at Gate 1 Market. Red line starts at S13A and ending at the SUT Bus Station, which is the longest route due to Red line is the main route in normal services.

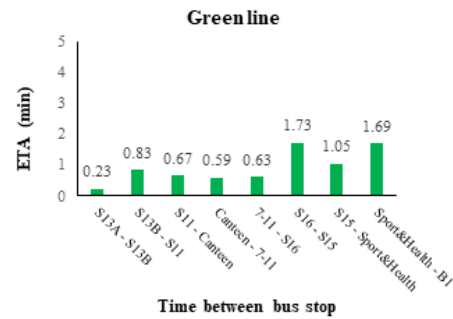


Figure 3. ETA in green route.

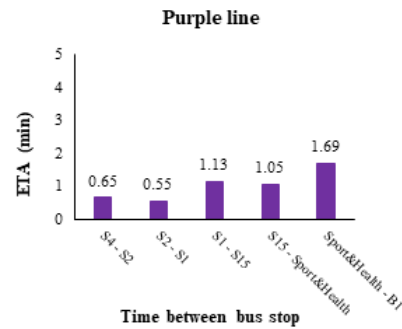


Figure 4. ETA in purple route.

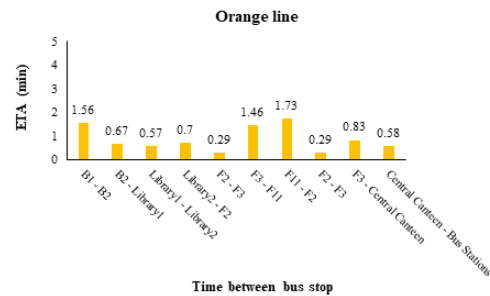


Figure 5. ETA in orange route.

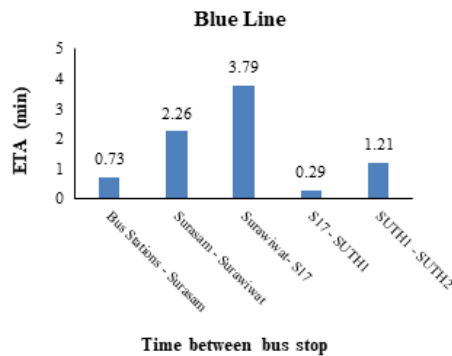


Figure 6. ETA in blue route.

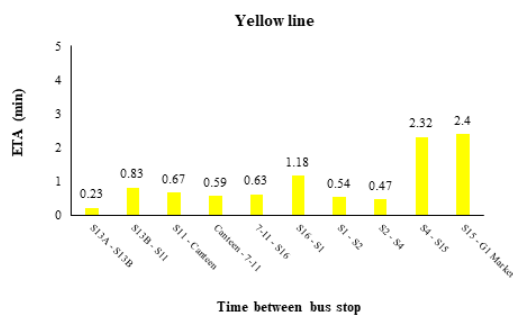


Figure 7. ETA in yellow route.

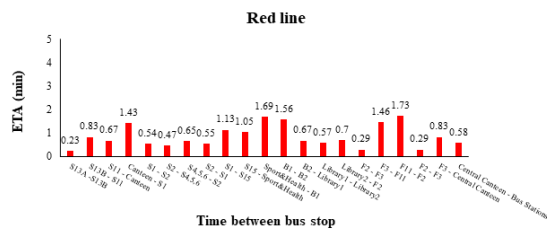


Figure 8. ETA in red route.

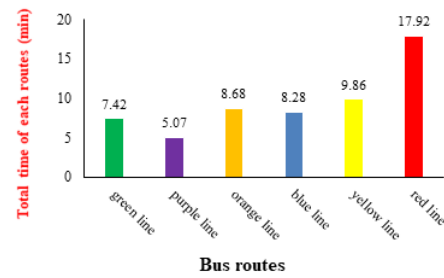


Figure 9. Total ETA in each route.

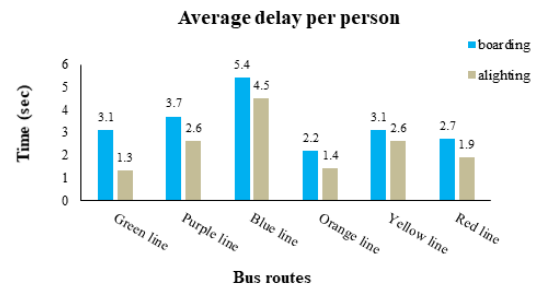


Figure 10. Average time passengers boarding and alighting the bus.

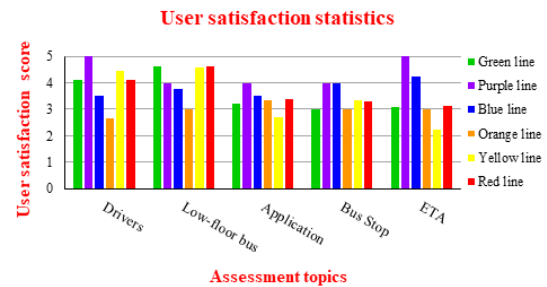


Figure 11. The results of a survey on the satisfaction of SUT Smart Transit users.

From Figure 9, Bar chart shows the time that buses take from the beginning to the end of each route, which shows only the arrivals. Figure 3-9 shows only the sum of travel time and delays caused by traffic. Total trip time are described as follows; Green line takes 7.42 minutes. Purple line takes 5.07 minutes. Orange line takes 8.68 minutes. Blue line takes 8.28 minutes. Yellow line takes 9.86 minutes. Red line takes 17.92 minutes. In Figure 10, Bar chart shows the average time of passengers boarding and alighting from survey. Time taking on the bus is greater than getting off. Because boarding requires touching of the student ID card. Purple line services for female student dormitory. Green line services for male student dormitory. Average delay per person of purple line is greater than green line. Because male students move flexible greater than female students. Average delay per person of Blue line is

the most due to patients taking to SUTH-Hospital. Average delay per person for the orange line is minimal because a low number of users. Yellow line serves both male and female student dormitories, so the average delay per person in the dormitories between the green line and purple line. Average delay per person of Red line is the main value due to normal services. The average delay per person of the red line represents of all routes. Because the red line has the longest routes and operates all day. In Figure 11, Bar chart shows the satisfaction of the passengers. The yellow line operates from male and female student dormitory to SUT market at Gate4. Some students group can walk to Gate4. This reason refers to low users of yellow line. The yellow line operates less frequently, which is 30 minutes per trip. Also, yellow line has low satisfaction scores.

Conclusions

This article presents the simulation results of estimate time of arrival in SUT Mass Transit. Design and set up passenger routes, including all 6 routes, to cover and meet student service needs. Simulation results present how long the bus travels between bus stops, as well as shows the time that bus travelled from the first stop to the last stop. This will be the sum of the travel time and the delay caused by traffic. The results from the field survey were the average time of passengers boarding and alighting bus from six routes, as well as the satisfaction survey of SUT Smart Transit users.

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