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Online Motorcycle Taxi Simulation by Using Multi Agent System

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Abstract

Motorcycle taxi (ojek) is a popular public transportation in Indonesia for decades. Ojek offers door to door service in cheaper price, especially for single passenger. Nowadays, the online ojek makes this transportation mode becomes more attracting and popular. Because this business is new and the business model is still improved, the simulation of this service is needed to predict the impact of company policy to the driver revenue and the customer satisfaction. In this paper, we propose the simulation that is developed based on multi agent system. There are two types of agent: the driver and the passenger. The novelty of this paper is the usage of some factors in the actor's decision making model. These factors are bravery factor, safety factor, maximum waiting time during finding a driver, maximum number of pickup order trial, driver's maximum distance, and passenger travel distance. Based on the simulation data, some parameters give significant influence in pickup ratio while the others give less significant influence. Parameters that give significant influence are driver inter arrival time, passenger inter arrival time, driver maximum distance, and passenger travel distance. Parameters that give less significant influence are maximum number of pickup order trial, maximum waiting time, safety factor, and bravery factor.

Keywords: Motorcycle taxi, Simulation, Multi agent system, Public transportation

INTRODUCTION

Motorcycle taxi is popular transportation mode for decades in Indonesia. It is known as Ojek. This service gives some advantages. First, this is door to door service so that the passenger will be transported to the end destination. It is different with the fixed route transportation system, such as bus or minibus. This service is similar to the taxi model. Second, the service cost is cheaper than taxi, especially for single passenger. Different with taxi pricing system that grows when the distance is increasing, the ojek gives fix rate and the rate is determined before the service occurs. The service price is determined based on travel distance and is determined based on the negotiation process between the driver and the passenger. It is easy to find ojek, especially at the bus station, railway station, airport, mall, and other public place. Ojek also has function as a feeder so that passenger can be transported from his house to the main street to continue their travel by using bus or other fixed route car based transportation system. Ojek is also easily founded at the crossroad that connects the main street to the residential area. This ojek is usually called pool ojek or traditional ojek.

The mobile and internet utilization, especially smart phone and Google service have changed the situation. Online ojek service disturbs the existence of traditional ojek. Nowadays, there are 40 online ojek companies run in Indonesia [1]. Online ojek makes ojek service become easier to be accessed. The price is lower and more transparent. Many passengers change their preference from traditional ojek to online ojek. It triggers resistance from traditional ojek [2, 3]. In some area, this horizontal conflict is rude [4]. The resistance comes from the car taxi driver too [5]. The online ojek driver is forbidden to pick up customer in some area by the local traditional ojek. This situation makes drivers that stay near the customer should refuse the customer's order so the order is fail. If there is not any drivers have willingness to pick up the passenger, the pickup order then is fail. This situation may reduce the passenger satisfaction.

In some systems, pickup order execution is not mandatory for the driver. The example is Go-Jek which is the largest online ojek service provider in Indonesia. In its system, because of some reasons, driver may refuse the pickup order. In other system, such as Uber, pickup order is mandatory for the nearest available driver. This difference occurs because online ojek is a new business and the system and policy are still improved.

Each system or policy has given impacts for the passenger and the driver. So, it will be good if the policy or system is simulated first before it is implemented. By using simulation, the impact or possible condition can be observed, predicted, and evaluated before being implemented. Unfortunately, there is not any simulation about online ojek service. The closest behavior of the online ojek service is taxi simulation. But, the existing taxi simulation model cannot be used directly to simulate online ojek service.

There are some behaviors that have not been supported by the existing taxi simulation model. Most of taxi simulation models are developed based on conventional taxi. So, the question is what kind of simulation model that can be developed so that the model characteristic is close to and can be used to simulate online ojek service.

In this research, we propose new model in online ojek simulation. This model is developed based on multi agent system. Multi agent system is chosen because in online ojek service where driver may refuse pickup order and passenger may reorder, both drivers and passengers should be seen as autonomous agents.

The structure of this paper is as follows. In the first section, we describe the background of the research, the research question, and the research purpose. In the second section, we review the literature about existing taxi simulation because taxi service behavior is close to online ojek service. In the third section, we explain our finding based on field observation. In the fourth section, we explain the proposed simulation model. In the fifth section, we explain the model implementation to the simulation application. In the sixth section, we discuss the simulation data, research finding, and comparison between our proposed model and the existing model. In the seventh section, we conclude our work and explore the future research potential that is relevant to this research.

EXISTING TAXI SIMULATION MODEL

Taxi simulation or taxi system has been researched for many years. It is because taxi is popular in many countries. Basically, taxi business model is similar. But, the implementation may be various depended on the behavior of the local people in the country or the city. In some researches, the research object is specific, such as New York [6], China [7], Dalian City [8], Mielec [9], Singapore [10,11], Manila [12], and Sioux Fall [13].

The taxi business model is also various. In conventional taxi, the service is full private. It means that in one pickup service, driver serves only single passenger or single group of passengers which the members of the group have same pickup location and destination. Nowadays, a new taxi business model, such as ride sharing becomes popular [6]. In the ride sharing model, a driver may serve more than one passenger with different destination but have similar route [6]. This concept is popular in New York [6]. The concept of ride sharing becomes popular because the weakness of conventional taxi service. When the driver serves dedicated service, driver may face empty seat problem. When the car type is sedan, driver can transport until four adult passengers. When the car is multi purposes vehicle (MPV), driver can transport until six adult passengers. So, when the number of passengers that is transported in single time is less than the maximum allocated seats, there will be empty seats. To compensate the empty seat problem, driver charges expensive fee to the passenger because the driver ignores the number of passenger factor. In ride sharing model, to reduce the number of empty seats, driver may pickup more than one passenger when he transports passenger as far as the new passenger has similar route with the existing passenger [6]. Because the number of empty seats may be reduced, the fee that is charged to the passenger is getting lower [6].

Based on the management and ownership of the cars, there are two type of taxi management style. The first type is independent taxi driver. In this type, the car is owned by the driver. The driver's activity is full independent depended on his own target. The competition between drivers is open [7]. In this type, the orientation is self interest [7]. Nevertheless, in some area such as mall, coordination is applied in driver allocation and FIFO model is common [13]. In China, most of taxi is independent taxi [7]. The second type is company managed taxi. In this type, the taxi, especially pickup order allocation is managed by a company. The company also distributes the fleet into certain areas so that the pickup potential is higher. In this model, the owner of the car is the company or the driver. In a city, there may be more than one taxi companies. In this type, beside self interest, the mutual benefit is important too.

There are three methods of passenger catching [7]. The first method is hailing on the street [7]. In this method, the passenger stands beside the street. If there is an empty taxi runs to him, the passenger stops the taxi, negotiates with the driver, and then enters the taxi. There are problems with this method. First, the passenger cannot ensure how long he needs to wait until an empty taxi comes to him. Second, drivers wastes fuel and time by driving empty car in order to find a passenger. Based on the safety aspect, this condition is dangerous because the driver's concentration is divided between driving a car and finding potential passenger [7]. The second method is taxi stand [7]. In this method, there are some taxi cars that stand in some area. This situation is common in bus or railway station, airport, hospital, mall, etc. When there is a passenger, he will come to that area and will be allocated usually to the first taxi. The problem is the passenger needs to walk to the area before getting the taxi. If there is a passenger in a certain distance from that area does not walk to the area, the taxi in this area will not pick up the passenger. It can be an opportunity lost. The third method is pre arranged booking. In this method, a passenger contacts to the taxi company contact center to order a taxi at specific time and location [7]. Then, the company will allocate an available car to the customer based on the order.

In conventional way, passenger contacts the taxi company by using phone call [10,14]. Nowadays, the pickup request can be done by using mobile application. By using the application, passenger does not need to explain the address of the pickup location [10]. The precise pickup location is sent to the server based on the GPS data of the passenger's phone. In this system, operator is not needed to allocate fleet. The car allocation is run automatically and pickup duty is usually instructed to the nearest driver [7]. This system can be implemented because the driver is equipped with GPS embedded phone too so that the system can monitors its fleet. The reason is to minimize the passenger waiting time and pickup fuel cost.

In taxi business, passenger satisfaction and driver's daily revenue [8] are important aspects. These aspects are usually evaluated in many taxi simulations. The factors in passenger satisfaction are waiting time [7], pickup time [7], travel time, and cost. The factors in driver's daily revenue are travel charge, pickup distance, travel distance, fuel cost [7], and idle time. Fuel cost is calculated by multiplying the pickup and travel distance with the average fuel cost per certain distance.

FIELD OBSERVATION

Field observation is done in order to gather the real condition about online motorcycle taxi system. This activity is done by interviewing ojek drivers in Yogyakarta and Bandung. Both cities are in Indonesia. Both cities are big cities with similar characteristics. First, these cities are well known as education city because there are some big national universities in these cities. So, there are a lot of college students in these cities and these students are smart phone users. Many college students in these cities are online ojek customers. Second, beside as education city, these cities are well known tourism destination and some tourists are also online ojek customers too.

Based on the conversation with drivers, there are some reasons why driver chooses not to accept the pickup order. First, some drivers choose to pick up short travel distance only. Second, some drivers avoid a dangerous area, where in this area, conflict may occurs with the traditional driver. Beside these reasons, there are other reasons that driver decides to not accept the pickup order. But, the first and the second reasons are the most significant reasons.

Driver tends to avoid dangerous area. The example is in railway station, airport, or bus station. The other dangerous area is in the entrance gate of some residential area where there are many traditional ojek drivers in there and these traditional ojek drivers are grouped in a strong community. Even this area is dangerous, not all drivers are afraid to pick up the order from this location. Some brave drivers may accept the pickup orders from this dangerous area.

Some drivers choose to accept short distance order only. For these drivers, long distance pickup order will be ignored. The reason is the driver may be more productive if they accept short distance order. Even the travel fee is calculated based on distance and progressive, the total revenue may be different. When a driver serves short distance passenger, the probability that the driver can get next order during returning to his home base is high. In the other side, when a driver serve long distance passenger, he may not get next order during returning to his home base. But, some drivers accept long distance passengers.

Sometimes, passenger is easy to find a driver. The other time, finding a driver is very difficult. For example, in the morning, finding a driver is more difficult because many students are needed to be transported to their school. In afternoon, finding a driver is easy because there are many available drivers and the number of available drivers is higher than the number of passengers.

PROPOSED MODEL

In this research, our proposed simulation model is developed based on multi agent system. In this model, there are two types of agent: driver and passenger. Driver role is taking the pickup order, riding to the passenger, and then transporting the passenger from the pickup location to his destination. Passenger role is making pickup order by specifying the pickup location and the destination.

Driver has some specific activities during simulation. First, the driver exists in the simulation. When the driver exists, its status is available. It means that the driver is free and available for picking up the order. When there is a pickup order, it means that there is a passenger stands near the driver then he may execute or refuse the order. If the driver accepts the order then the driver goes to the pickup location and picks up the passenger, and then transports the passenger to his destination. Before completing the order, the driver cannot pick up another order. If the driver chooses to refuse the order, his status is still available. The state diagram of the driver is described in Figure 1.

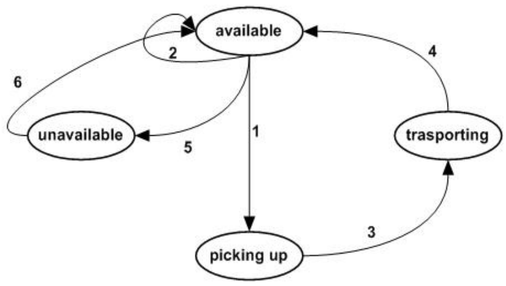

Figure 1: Driver State Diagram

In Figure 1, there are four states in driver model: available, picking up, transporting, and unavailable. When the state is available, driver is not handling passenger and available for pickup order. When the state is picking up, the driver is on the way from his location to the passenger pickup location. When the state is transporting, the driver is transporting the passenger from his pickup location to his destination. When the state is unavailable, the driver cannot execute the pickup order.

In driver state diagram as shown in Figure 1, there are six events that trigger driver's existing state changes to another state. In event one, driver decides to execute the pickup order. In event two, driver decides to refuse the pickup order. In event three, driver has already picked up the passenger and ready to transports him. In event four, the driver has finished transporting the passenger to his destination and ready for next pickup order. In event five, the driver decides to take some break time with certain period. In event six, the driver has finished his break time and ready for next pickup order.

In the other hand, as an agent too, the passenger has some activities during simulation. The activities are creating pickup order, waiting the passenger, and riding to the destination. So, like the driver part, the passenger has several states too. These states are illustrated in Figure 2.

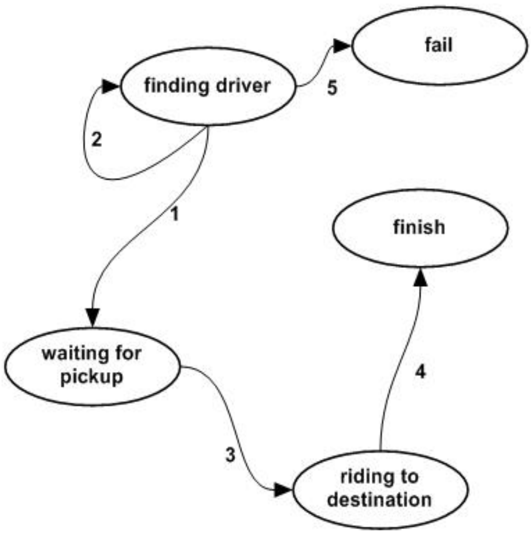

Figure 2: Passenger State Diagram

In Figure 2, there are five states in passenger model. When passenger state is finding driver, the passenger has created the pickup order and is waiting if there is a driver that decides to accept his pickup order. Fail is the state when after several times of pickup order, the passenger is still fail in getting a driver. When the state is waiting for pickup, the passenger is waiting the chosen driver comes to the pickup location. When the state is riding to destination, the passenger is transported to his destination by the chosen driver. When the state is finish or fail, the passenger is removed from the simulation.

Based on Figure 2, there are five events that trigger passenger current state changes to another state. In event one, there is a driver that decides to execute passenger pickup order. In event two, after several periods, there is not any driver that decides to execute the order so that the passenger needs to create pickup order. In event three, the driver has already picked up the passenger at the pickup location and ready to transport the passenger to his destination. In event four, the passenger has successfully transported to his destination. In event five, the number of pickup order actions is reached the maximum value and the passenger is still fail in getting a driver.

In passenger model, there are several types of time: total time (t_{tot}), total finding time (t_{totf}), waiting time (t_w), and travel time (t_t). Total time is the time that the passenger spends it from his first booking action until he reaches his destination. Waiting time is the time that passengers need from finding the driver until the driver arrives at the pickup location. Travel time is the time that is spent to transports the passenger from the pickup location to his destination. The total time formula is described in Equation 1.

$$t_{tot} = t_{totf} + t_w + t_t \tag{1}$$

When passenger needs a driver, the passenger will create pickup order. For several times, he waits for driver who will accept his pickup order. Every passenger has his own maximum waiting time during finding a driver. Basically patient passenger has longer maximum waiting time rather than impatient passenger. Let us call the passenger's maximum waiting time during finding a driver is t_{wmax}. But, the maximum waiting time for a driver in one time is not always the same. For example, in one condition, maximum waiting time for a passenger is 30 seconds. In other time, maximum waiting time for this passenger is 32 seconds or 27 seconds. We call this waiting time as passenger's current maximum waiting time during finding a driver (t_{cwmax}). This waiting time is generated randomly when the passenger creates pickup order. When the time he wait reaches his current maximum waiting time and there is not any driver accepts his pickup order then the passenger will recreate pickup order. The passenger will do this action until his maximum number of pickup order trial (n_{maxpo}) is reached. The maximum number of pickup order trial between passengers may be different and this value is generated randomly when the passenger is created. Variable n_{po} is the number of pickup orders that is done by the passenger. So, the total finding driver time is the summation of passenger's finding driver time. This calculation is described in Equation 2. In Equation 2, i is the pickup order index. The $t_{f,i}$ is the passenger's finding time in pickup order at index i. if at time t and we call it t_{acc} there is a driver accepts the pickup order, then the finding driver time at index i is the acceptance time. If at index i there is not any driver accept the pickup order, the finding time is the passenger's current maximum waiting time. It is described in Equation 3. The value of waiting time and travel time are not decided by passenger. These variables are depended on the driver's performance.

$$t_{totf} = \sum_{i=1}^{n_{po}} t_{f,i} \tag{2}$$

$$t_{f,i} = \begin{cases} t_{cw\max}, \mathit{fail} \\ t_{acc}, \mathit{accepted} \end{cases} \tag{3}$$

When a passenger creates a pickup order, this order is broadcasted to drivers that are in the broadcast area. The area is a circle with certain radius (d). The center of the circle is the passenger pickup location. The driver which its location is outside the circle will not receive the pickup order. The goal is to reduce the passenger's waiting time and the driver's pickup distance. The illustration is seen in Figure 3.

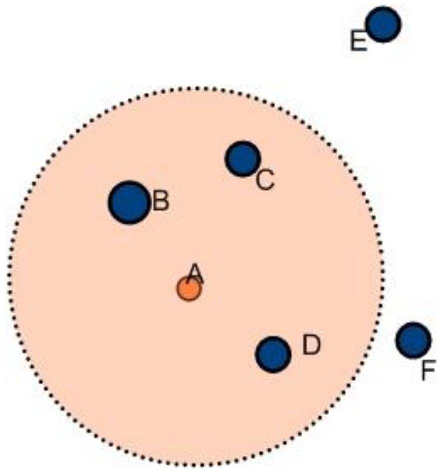

Figure 3: Passenger Broadcast Area

In Figure 3, there are five drivers around the passenger A. There are three drivers that are in the passenger A's broadcast area: driver B, driver C, and driver D. There are two drivers that are outside the passenger A's broadcast area: driver E and driver F. If the passenger A sends pickup order then only driver B, driver C, and driver D that will receive the pickup order. Driver E and driver F will not receive pickup order.

When driver receives the pickup order, he may accept the pickup order or not. In this paper, we propose two aspects which influents the driver's decision making process: the safety aspect and the distance aspect.

In safety aspect, there are two parameters which influents the decision making: driver's bravery and pickup location safety. There are two types of driver: brave driver and not brave driver. There are two types of pickup location: safe location and unsafe location. The decision making process is described in Table 1.

Table 1: Bravery – Safety Matrix Based Action

	Safe	Unsafe
Brave	accept	accept
Not brave	accept	refuse

Based on the distance, the driver may accept or refuse the pickup order. It is depended on the travel distance. Some driver accepts only short distance travel order. While other driver still accepts long distance travel order. So, in this research, we propose maximum travel distance (d_{tmax}) and this value may be different between drivers. If the travel distance prediction that is sent with the pickup order is higher than the driver's maximum travel distance then the driver will refuse the pickup order.

After the driver accepts the pickup order, then he rides to the pickup location. The pickup distance (d_{pu}) is the real distance between the driver and the pickup location. This distance is usually longer than the direct distance (d_d). So, in this research we propose the distance factor (f_d) that converts the direct distance to the real distance. The distance factor is real number and its value ranges from 1 to 2. The real distance value is calculated by using Equation 4. In this model, the driver's pickup speed (v_p) is needed to calculate the passenger's waiting time. This calculation is described in Equation 5.

$$d_{pu} = f_d \times d_d \quad (4)$$

$$t_w = \frac{d_{pu}}{v_p} \quad (5)$$

After the driver picks up the passenger then the driver transports the passenger to his destination. The driver rides to the destination in certain travel speed (v_t) which is usually under or equal to his pickup speed. So, we use speed factor (f_s) to convert pickup speed into travel speed. The speed factor is real number and its value ranges from 0 to 1. This calculation is described in Equation 6. If the driver's travel speed and the travel distance (d_t) are known then the travel time can be calculated and the calculation is described in Equation 7. The pickup speed and speed factor may be different between drivers.

$$v_t = f_s \times v_p \quad (6)$$

$$t_t = \frac{d_t}{v_t} \quad (7)$$

IMPLEMENTATION

The simulation application is built based on the proposed model. The application is a web based application. The application is set for 25 square kilometers area with 5 km width and 5 km height. This area is presented in 1000 x 1000 pixels area. The visualization of the application can be seen in Figure 4.

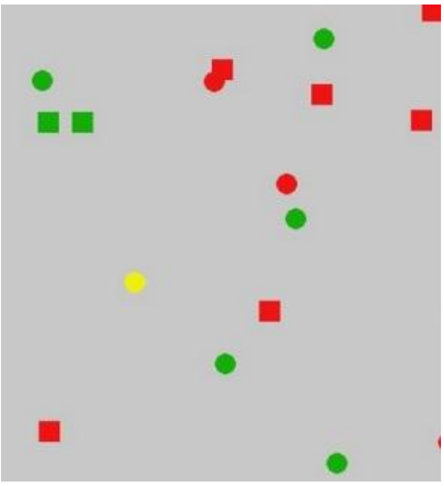

Figure 4: Simulation Visualization

The driver and passenger are represented in certain object and color. Green rectangle represents available driver. Red rectangle represents unavailable driver. Yellow circle represents passenger that is searching the driver. Green circle represents passenger that his pickup order is accepted. Red circle represents passenger that his pickup order is fail.

The simulation is run for certain period. The period is presented in iteration. Each time step or cycle represents one minute is a real world. For example, if the application simulates one hour operation, there are 60 cycles of iterations. The simulation stops after the cycle reaches the end of simulation period.

During the running process, both driver and passenger come into the application one by one with certain gap that is known as inter arrival time. The inter arrival time is set both for passenger (Δt_p) and the driver (Δt_d). In this application, the inter arrival time is generated randomly and follows exponential distribution. It is because theoretically, inter arrival time between events for natural phenomenon follows exponential distribution [16,17]. In the other hand, if the inter arrival time between event follows exponential distribution then the number of events in certain period of time follows Poisson distribution [16,17].

Beside the inter arrival time, some parameters is generated randomly and the value is positive integer. These parameters are maximum waiting time during finding driver, number of maximum pickup order trial, passenger travel distance, driver's maximum travel distance, and driver speed. For these variables, the random numbers that are generated follows Poisson distribution.

DISCUSSION

Based on the proposed model, this model has some similarities with the existing model. In this model, the driver's state is similar with Michal's work [9] where the driver has three states: available, pickup, and and drive. This model is also developed based on agent system and Grau's work is also developed based on agent concept too [13].

Meanwhile, this model has difference with the existing models. In the existing model, the system will allocate the passenger to the nearest driver [7] in order to minimize the passenger waiting time and the driver pickup cost. In this paper, the pickup order will be broadcasted to drivers inside the passenger's broadcast area. Even the passenger is not picked up by his nearest driver, the waiting time is still tolerated. This model also does not implement FIFO concept in allocating driver [13]. In Yao's work, the supply-demand size is used to observe the driver's daily income [8]. In this research, the supply-demand size is used to observe the pickup ratio parameter.

After being implemented into simulation application, the proposed model then is being tested and evaluated. There are several tests in this research. The purpose is to evaluate the relation between the controlled variables and the observed variable. In this paper, the observed variable is pickup ratio. Pickup ratio is the ratio between pickup action and the total passenger. The controlled variables are passenger inter arrival time, driver inter arrival time, maximum number of pickup order trial, maximum waiting time during finding driver, safe area ratio, braveness ratio, driver's maximum travel distance, and passenger's travel distance consecutively. During simulation, there is default value for each controlled variables. This default value is listed in Table 2.

Table 2: Variable Default Value

Variable	Default Value	Units
Δt_d	3	minutes
Δt_p	3	minutes
t_{wmax}	3	minutes
n_{maxpo}	5	trials
f_b	0.5	-
f_s	0.5	-
d_{tmax}	5	Km
d_t	5	Km
v_p	30	km/h

In the first test, the relation between average passenger's inter arrival time and pickup ratio is observed. The value of average passenger's inter arrival time is set from 1 to 10 minutes with the step value is 1 minute. There are 20 running processes in each step. While the passenger's inter arrival time value changes, other controlled variables are set default. The result is described in Table 3.

Table 3: Relation between Passenger's Inter Arrival Time and Pickup Ratio

Δt_p(minute)	Pickup Ratio (%)		
	Average	Min	Max
1	47.09	34.04	58.14
2	56.50	42.86	65.62
3	60.94	50.00	76.93
4	64.18	42.11	80.77
5	67.63	44.44	83.33
6	71.76	42.85	83.33
7	69.21	53.33	86.67
8	71.44	46.67	90.00
9	68.26	44.44	91.67
10	74.39	42.86	92.31

Based on data in Table 3, it can be seen that higher passenger's inter arrival time makes higher pickup ratio. In the beginning, the pickup ratio increases significantly. Then, the gradient is lower. In the end, the average pickup ratio is stable with the value is close to 75 percents. The range of the minimum pickup ratio is between 34 percents and 53 percents. In the other side, the range of the maximum value of pickup ratio is higher than the minimum value. The range of maximum pickup ratio is between 58 percents and 92 percents. Although the average pickup ratio never reaches 75 percents, the maximum value can get 92 percents.

This condition is reasonable because the increasing of the passenger inter arrival time reduces the number of passengers in a certain period. Meanwhile, the average number of available drivers is constant. So, the opportunity of the successful pickup order is higher. Even that, this condition is not linear because the upper limit of pickup ratio is 100 percents. After certain value of passenger's inter arrival time, the average value of pickup ratio is stable in 70 to 75 percents.

In the second test, the relation between average driver's inter arrival time and pickup ratio is observed. The value of average driver inter arrival time is set from 1 to 10 minutes with the step value is 1 minute. There are 20 running processes in each step. While the driver's inter arrival time value changes, other controlled variables are set default. The result is described in Table 4.

Table 4: Relation between Driver's Inter Arrival Time and Pickup Ratio

Δt_d(minute)	Pickup Ratio (%)		
	Average	Min	Max
1	75.51	56.25	88.46
2	65.79	55.17	78.57
3	65.08	48.27	78.26
4	55.67	42.31	73.91
5	50.34	30.56	62.07
6	46.81	31.03	65.38
7	38.04	20.83	55.56
8	38.11	19.35	62.50
9	34.66	17.24	44.83
10	30.24	15.62	50.00

Based on data in Table 4, it can be seen that higher driver inter arrival time makes lower pickup ratio. When the average driver's inter arrival time is from 1 to 10 minutes, the trend is still linear. The range of minimum pickup ratio is from 56 minutes to 15 minutes. The range of maximum pickup ratio is from 88 minutes to 44 minutes. So, the gradient of the declination of the average, minimum, and maximum values of pickup ratio is similar.

This condition is reasonable because the increasing of the driver inter arrival time reduces the number of available driver in a certain period. Meanwhile, the average number of passenger is constant. So, the opportunity of the successful pickup order is lower. Even the declination trend in Table 4 is linear, after certain value, the declination is stop. It is because the bottom value of pickup ratio is 0, which means there is not any successful pickup order.

In the third test, the relation between average value of the maximum number pickup order trial and pickup ratio is observed. The average value of the maximum pickup order trial is set from 1 to 10 trials with the step value is 1. There are 20 running processes in each step. While the average maximum pickup order trial changes, other controlled variables are set default. The result is described in Table 5.

Based on data in Table 5, it can be seen that higher number of maximum number of pickup order trial makes higher pickup order too. But, the gradient is low. This condition occurs in average, minimum, and maximum value. The average value of pickup ratio is from 56 percents to 64 percents. So, the influence of maximum number of pickup order trials to pickup ratio is not significant.

Table 5: Relation between Maximum Number of Pickup Order Trial and Pickup Ratio

n_{maxpo}	Pickup Ratio (%)		
	Average	Min	Max
1	56.00	38.46	64.28
2	55.92	44.83	70.83
3	58.85	37.50	73.08
4	60.56	36.36	79.31
5	62.44	40.62	79.31
6	64.73	48.27	76.92
7	64.42	48.27	82.61
8	64.88	50.00	85.71
9	59.60	41.18	74.07
10	64.26	50.00	76.92

In the fourth test, the relation between average value of the maximum waiting time during finding the driver and pickup ratio is observed. The average value of the maximum waiting time during finding the driver is set from 1 to 10 minutes with the step value is 1 minute. There are 20 running processes in each step. While the average value of the maximum waiting time during finding the driver changes, other controlled variables are set default. The result is described in Table 6.

Table 6: Relation between Maximum Waiting Time during Finding the Driver and Pickup Ratio

t_{wmax}	Pickup Ratio (%)		
	Average	Min	Max
1	58.52	30.30	80.00
2	62.62	43.33	77.27
3	63.67	46.15	83.33
4	60.65	51.85	72.41
5	64.42	52.38	76.19
6	63.02	48.00	78.57
7	67.18	48.00	87.50
8	64.97	48.39	80.00
9	70.13	54.17	82.76
10	68.92	55.56	86.96

Based on data in Table 6, it can be seen that higher value of the maximum waiting time during finding the driver makes higher pickup ratio. But, as the condition in maximum number of pickup order trial, the increasing gradient is low. So, the influence of the maximum waiting time during finding driver is not significant.

In the fifth test, the relation between average value of the safety factor and pickup ratio is observed. The average value of the safety factor is set from 0.1 to 1 with the step value is 0.1. There are 20 running processes in each step. While the average value of safety factor changes, other controlled variables are set default. The result is described in Table 7.

Table 7: Relation between Safety Factor and Pickup Ratio

f_s	Pickup Ratio (%)		
	Average	Min	Max
0.1	45.27	33.33	62.5
0.2	46.39	23.33	70.96
0.3	54.53	44.83	74.07
0.4	61.41	32.43	79.17
0.5	60.41	48.27	80.00
0.6	65.29	46.15	86.95
0.7	63.63	50.00	73.91
0.8	67.10	46.15	88.23
0.9	67.37	55.17	83.33
1	68.75	48.00	85.00

Based on data in Table 7, it can be seen that higher value of safety factor makes higher pickup ratio. This condition is reasonable because higher number of safe pickup location makes higher number of drivers who have willingness to pick up the passenger. Even that, the gradient is low. The average pickup ratio is from 45 percents to 68 percents. It means that the safety factor does not give significant influence to pickup ratio.

In the sixth test, the relation between average value of the bravery factor and pickup ratio is observed. The average value of the bravery factor is set from 0.1 to 1 with the step value is 0.1. There are 20 running processes in each step. While the average value of bravery factor changes, other controlled variables are set default. The result is described in Table 8.

Table 8: Relation between Bravery Factor and Pickup Ratio

f_b	Pickup Ratio (%)		
	Average	Min	Max
0.1	45.92	53.12	84.62
0.2	53.01	38.46	70.83
0.3	54.03	38.46	74.07
0.4	58.89	42.86	69.56
0.5	59.72	42.85	83.33
0.6	63.00	51.85	79.31
0.7	65.47	46.15	78.94
0.8	69.23	50.00	84.00
0.9	68.38	54.84	85.18
1	70.67	53.12	84.62

Based on data in Table 8, it can be seen that higher bravery factor makes higher pickup ratio. This condition is reasonable because as it mentioned in the proposed model, safety factor affects driver's decision making process. So, higher number of brave driver increases the opportunity of successful pickup. Even that, the influence of bravery factor is not significant too. It can be seen from the low gradient of the average value.

In the seventh test, the relation between average value of driver's maximum distance and pickup ratio is observed. The average value of the driver's maximum distance is set from 1 to 10 kilometers with the step value is 1 kilometer. There are 20 running processes in each step. While the average value of driver's maximum distance changes, other controlled variables are set default. The result is described in Table 9.

Based on data in Table 9, it can be seen that higher driver's maximum distance makes higher pickup ratio. This condition is reasonable because the increasing of driver's maximum distance increases the number of drivers who have willingness to travel long distance. Based on the range of average, minimum, and maximum value, driver's maximum distance gives significant influence to pickup ratio. In the beginning, the gradient is high. The gradient is lower during the increasing value of driver's maximum driver. After certain value, the pickup ratio is stable. The highest average pickup value is 79 percents.

Table 9: Relation between Driver's Maximum Distance and Pickup Ratio

$d_{maxdist}$	Pickup Ratio (%)		
	Average	Min	Max
1	13.58	6.89	26.67
2	26.46	16.13	40.00
3	38.67	17.24	65.38
4	56.64	39.28	79.31
5	59.06	46.67	69.23
6	64.63	44.11	85.18
7	74.65	58.62	92.31
8	72.98	55.17	90.91
9	75.98	60.00	92.00
10	79.42	56.67	92.00

In the eighth test, the relation between average passenger's travel distance and pickup ratio is observed. The average passenger's travel distance is set from 1 to 10 kilometers with the step value is 1 kilometers. There are 20 running processes in each step. While the average passenger travel distance changes, other controlled variables are set default. The result is described in Table 10.

Table 10: Relation between Passenger Travel Distance and Pickup Ratio

d_d	Pickup Ratio (%)		
	Average	Min	Max
1	78.42	65.79	89.28
2	78.87	57.14	96.00
3	71.98	51.72	92.00
4	66.55	45.83	81.81
5	57.63	42.85	69.23
6	53.95	44.00	64.28
7	42.73	31.03	56.52
8	34.56	21.43	47.83
9	29.18	20.00	40.00
10	23.64	5.00	45.16

Based on data in Table 10, it can be seen that higher passenger traveled distance makes lower pickup ratio. This condition is reasonable because higher number of long distance pickup order reduces the number of drivers who have willingness to accept the pickup order. Similar to the driver's maximum distance, the passenger's travel distance gives significant influence to the pickup ratio.

CONCLUSION AND FUTURE WORK

Based on the explanation above, the online motorcycle taxi simulation model that is explained in this paper has been able to simulate the online motorcycle taxi condition. Based on field observation, some parameters have been added in the decision making model. The driver's parameters are maximum distance and bravery factor. The passenger's parameters are maximum number of pickup order trial during finding the driver, maximum waiting time during finding the driver, safety factor, and travel distance. Meanwhile, the system parameters are passenger inter arrival time, driver inter arrival time, driver location, passenger pickup location, and the broadcast area.

Based on the simulation data, some parameters give significant influence in pickup ratio while the others give less significant influence. The parameters that give significant influence are driver inter arrival time, passenger inter arrival time, driver maximum distance, and passenger travel distance. Parameters that give less significant influence are maximum number of pickup order trial, maximum waiting time, safety factor, and bravery factor.

There are many research potentials in online motorcycle taxi online simulation. It is because there are various fleet management systems. Because online motorcycle taxi is new business and the system is still developed then creating simulation model with different management system is still challenging. The most important goal is creating mutual benefit between the stakeholders: driver, passenger, and company.

REFRENCES

[1] H. Asprihanto, N. Owen, "Smell Test for Indonesia's Motorcycle Taxi Candidates", Reuters, January 11, 2016, http://www. reuters.com/article/us-indonesia-transportation-idUSKCN0UP0JM20160111.

[2] I. Budiari, "Go-Jek Drivers Fearing Violent Resistance from Traditional Ojek", The Jakarta Post, June 11, 2015, http:// www. thejakartapost.com/news/2015/06/11/go-jek-drivers-fearing-violent-resistance-traditional-ojek.html.

[3] N. Freischlad, "Why Motorcycle Taxi Drivers are Ganging Up Against on Demand Ride Apps in Indonesia", Techinasia, July 15, 2015, https://www.techinasia.com/startups-in-indonesia-indonesia-motorcycle-hailing-taxi-apps-jakarta-gojek.

[4] N. Freischlad, "Drive-by Attack on Go_jek Office as Discontent Simmers Inside and Out (Update: CEO Responds)", Techinasia, November 4, 2015, https://www.techinasia.com/gojeks-driveby-shooting-anger-coming-company.

[5] A. Harvey, "Jakarta's Taxi Industry Battles Against App-Based Motorcycle Service GoJek", ABC, April 7, 2016, http:// www.abc.net.au/news/2016-04-02/ jakarta-embraces-app-based-transport/7291518.

[6] M. Ota, H. Vo, C. Silva, J. Freire, "A Scalable Approach for Data-Driven Ride-Sharing Simulation", Proceeding of the 2015 IEEE International Conference on Big Data, 2015, October 29, Santa Clara, pp.888-897.

[7] R. Bai, J. Li, J.A.D. Atkin, G. Kendall, "A Novel Approach to Independent Taxi Scheduling Problem Based on Stable Matching", Journal of The Operational Research Society, vol 65(10), 2014, pp.1501-1510.

[8] B. Yao, L. Yin, Q. Cao, J. Gao, M. Zhang, "Fleet Size and Fare Optimization for Taxi under Dynamic Demand", Journal of Transport Literature, vol 10(4), 2016.

[9] M. Maciejewski, K. Nagel, "Simulation and Dynamic Optimization of Taxi Services in MATSim", unpublished.

[10] K.T. Voon, K.C. Yow, "GSM Positioning-Based Taxi Booking and Dispatch System", Proceeding of the 10th WSEAS International Conference on Applied Informatics and Communications, Taipei, August 20, 2010.

[11] C. Wang, W.K. Ng, H. Chen, "From Data to Knowledge to Action: A Taxi Business Intelligence System", Proceeding of the 15th International Conference on Information Fusion, July 9, 2012, Singapore.

[12] A.G.A Paronda, J.S.F. Regidor, S.G. Napalang, "Comparative Analysis of Transportation Network Companies (TNCs) and Conventional Taxi Services in Metro Manila", Proceeding of 23th Annual Conference of The Transportation Science Society of The Philippines, Quezon City, August 8, 2016.

[13] J.M.S. Grau, M.A.E. Romeu, "Agent Based Modelling for Simulating Taxi Services", Procedia Computer Science, vol (52), 2015, pp.902-907.

[14] Y. Cheng, "Singapore's Satellite-Based Taxi Tracking and Booking System", unpublished.

[15] P.D. Kusuma, "Fibrous Root Model in Batik Pattern Generation", Journal of Theoretical and Applied Information Technology, vol. 24(6), 2017, in press.

[16] ___, "Modeling Arrival Time: The Poisson Distribution", 2007, unpublished.

[17] J. Virtano, "Queueing Theory/Poisson Process", unpublished.