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Comparison Between Least Effort and Random Walk in Combined Shipping Service

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Abstract: Now a days, city courier service is very popular, especially in Indonesia. This popularity is also boosted by the rise of online motorcycle taxi service. By using city courier service, local shipment can be delivered faster rather than regular courier service. One problem in this service is the combined shipping method has not implemented yet. So, for customer who sends more than one package to more than one destination, the cost is still calculated in regular price without any reduction. The other problem is even there is more than one shipment, customer has to create order one by one and the packages will be delivered by different driver. So, developing combined shipping system will benefit the customer and the driver. In this research, we propose combined shipping model for city courier service by comparing two methods: least effort and random walk algorithm. In this study, we compare the performance of combined shipping that uses least effort or random walk method and conventional one to one shipping model. In this research, we found that combined shipping that implements least effort algorithm produces the best performance both in non financial aspect and financial aspect. By using least effort algorithm, system generates lowest total driver travel distance and highest average driver's travel distance. The financial consequence is lowest total cost that must be paid by customer and highest average driver's revenue.

Key words: Courier service, least effort, random walk, cost reduction, revenue, produces

INTRODUCTION

Now a days, city courier service is a popular business and it has big opportunity to grow, especially, in Indonesia. Demand in this business is increasing because of two things: e-Commerce and online motorcycle taxi. In Indonesia, many online merchants prefer to use this service to deliver package which their customers are in the same city. This condition is also accelerated by the business to business deal between online motorcycle taxi and e-Commerce companies (Anonymous, 2016a, b). Rather than choosing conventional courier service, city courier service can send package faster. City courier service can deliver package in minutes or hours. So, the package will be delivered to the customer in the same day with the transaction date.

The main provider in city courier service is the online motorcycle taxi company. In Indonesia, the main player is Go-Jek. By having thousand of drivers in one city, Go-Jek utilizes its driver fleet not only transporting people but also delivering packages. This service benefits the driver because it means more revenue opportunity for the driver. While online motorcycle taxi faces resistance from conventional motorcycle taxi and the regulation is still in gray area, courier service faces no resistant (Tang, 2018). Grab as its competitor, recognizes the opportunity too and it also offers the city courier service to its customer by launching GrabExpress (Amirio, 2016). In Go-Jek, the main features that are used in city courier service are Go-Food and Go-Send. In Go-Food, customer can order food to restaurant or food merchant that has collaboration with Go-Jek and after the transaction completion, the Go-Jek driver will deliver the ordered food to the customer. In Go-Send, customer can send package from his location to the destination by using the online taxi driver. Meanwhile, Grab has launched Grab Food as food delivery service in competing with Go-Food (Anonymous, 2016b).

Even many customers enjoy this service, this service still faces problems. One problem is when customer needs to deliver packages to more than one destination. In the existing system, customer has to make order one by one, one order for one destination. It is not efficient, both for the customer and for the driver. So, if there are 50 packages that must be sent to distinct destination, there will be 50 drivers that visit the customer to pick up the package and then deliver it to the destination.

This condition will be better for both customer and driver that can make these multi packages are grouped into blocks and each blocks will be delivered by specified driver. This service is usually called as combined shipping. The process will be simpler. For driver, he can close the daily revenue target faster by delivering more than one packages from one order. For customer, sending packages in block should be rewarded in cost reduction because the total travel distance is getting lower.

The question is how to group the packages from one customer into blocks. In some conditions and it occurs commonly, it is impossible to allocate all packages from one customer to one single driver. A driver still faces limitation in travel time and travel distance. Now a days, it is common that the daily driver's maximum trip is 15 trips. So, if there are 50 packages from single order, at least 4 drivers are needed to deliver the packages so, that, all packages can be delivered in the same day.

When the city is big, such as Jakarta, Bandung or Surabaya, it is impossible for one driver delivers all of the packages because usually the destination location is spread around the city. So, allocating a driver to execute all packages will be very exhausting. So, a block must consist of packages that the number of packages inside it and the distance between packages destination is still tolerable.

So, this research purpose is developing combined shipping method for city courier service. In this research, we propose two models based on two approaches: least effort algorithm and random walk algorithm. Then, we will compare these two methods to observe which method can perform better. This research is the continuation of the previous works that focused on online motorcycle taxi system (Kusuma, 2017a, b). In those works, we explored the online motorcycle taxi system in delivering people. One research focused on the multi agent based model (Kusuma, 2017a) while another focuses on the dispatch system (Kusuma, 2017b). In this current research, we explore the online motorcycle taxi system in its city courier service.

MATERIALS AND METHODS

Existing city courier model: Before we discuss about the city courier model, let us discuss the conventional courier service model. In conventional courier service model, beside the customer, at least there are four actors in the company: receiving agent, collecting agent, sorting center and delivery agent. The receiving agent is agent in a local area who receives package from customer. The receiving agent can be the the official agent or partner of the courier company. The collecting agent is the employee of the company that collects packages from receiving agents and then delivers the package to the sorting center. The sorting center is the place where the packages that are collected are sorted and are sent to the destination or other sorting center. The delivery agent deliver package from sorting center to destination. The process is shown in Fig. 1. Based on Fig. 1, actors and their relationship are described in graph. Node represents the actor and link represents the connection. SC1 and SC2 are Sorting Center. One sorting center is for one city. So, suppose that SC1 is in city 1 and SC2 is in city 2. RA is Receiving Agent. RA11-RA13 are Receiving Agents under SC1 coordination. RA21-RA23 are Receiving Agents under SC2 coordination. C is customer who wants to send two packages with different destination. The first package will be sent to Destination D1 and the second package will be sent to Destination D2. D1 is in city 1 and and D2 is in city 2.

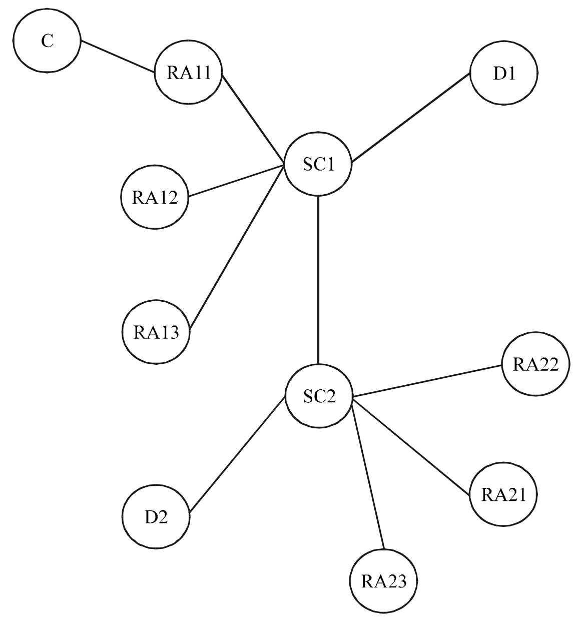

Fig. 1: Conventional courier service model

The first package is shipped locally. It is because the sender (customer) and the destination are in the same city. So, it can be executed by city courier service. But in this case, it will be executed by conventional courier service. In the conventional courier service, customer will go to the RA11 to create shipment order for the first package. Its location may be near the customer's location. Then, a collecting agent under SC1 coordination will go to RA11-RA13 to collect packages that are submitted from these receiving agents. The collected packages then will be delivered to the the SC1 to be sorted and classified. Because the first package is in the SC1 area, then this package will be sent to D1 by SC1's delivery agent.

In the conventional courier service, even the sender and the receiver are in the same city, the package is usually received not in the same day when the package is submitted. It is because the process in the courier service

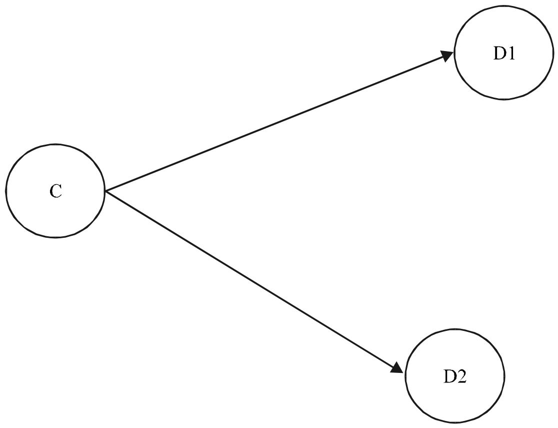

Fig. 2: Online motorcycle taxi based courier service model

has specified schedule. For example, the collecting agent visits the receiving agent at 5 pm. So, the package must be submitted at the receiving agent before 4 pm. Package that is submitted after 4 pm will be collected tomorrow. The collecting agent arrives at sorting center usually at night. The package is then sorted. The sorting process usually finishes at midnight. If the package is in the same city with the sorting center, then the package will be allocated to the available delivery agent to be delivered to the destination next day. If the package destination is different with the sorting center, the package will be deliver to the sorting center is in the same city with the package destination.

Based on this process, if the customer arrives and submits its package in Monday at 3 pm, the package will arrive to destination D1 in Tuesday. If the customer arrives and submits its package in Monday at 6 pm then the package will arrives to destination D1 in Wednesday. The delivery time will be longer if the customer arrives and submits at Saturday. It is because in some courier services, there is no delivery process in Sunday.

The condition is different with the city courier service, especially online motorcycle taxi based courier service. Customer makes shipping order through application. The available driver that its location is near the customer will be allocated to execute the order. Then, the allocated driver will visit the customer, collect the package, and deliver it to the destination D1. It means that the collecting and delivery process are handled by single person. The illustration is shown in Fig. 2.

Even the city courier service has advantage in shorter delivery time, there is still problem. For example, if customer sends two packages with different destination as it is shown in Fig. 2. Customer has to create orders one by one. Each order will be executed by single driver. The Go-Jek user interface of this process is shown in Fig. 3.

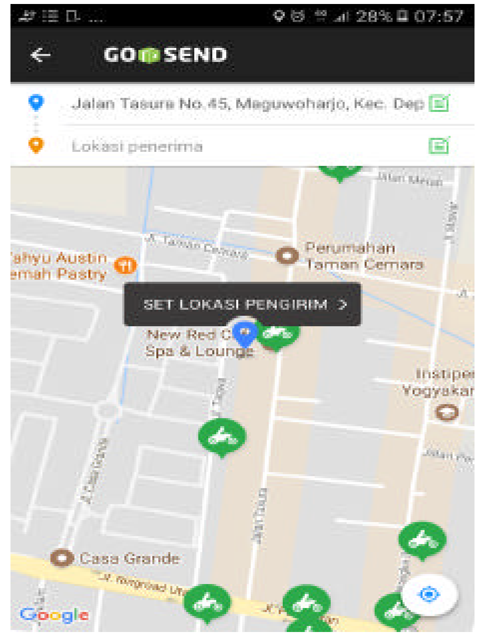

Fig. 3: Go-send user interface

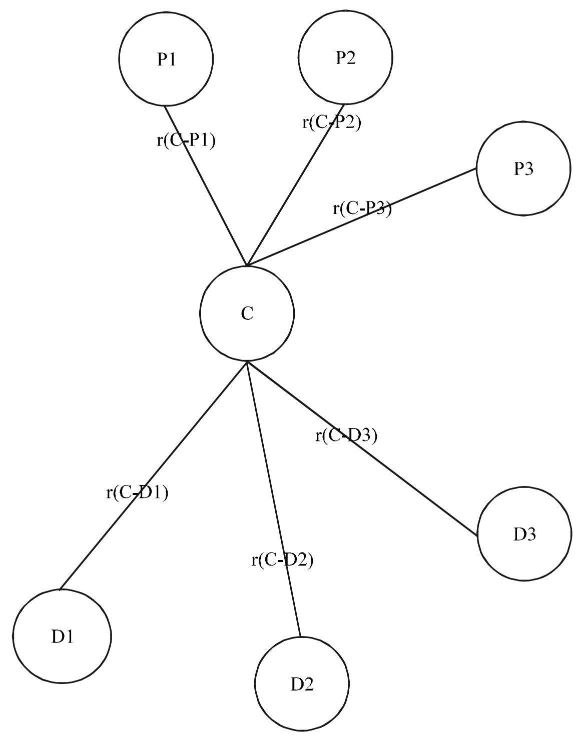

Fig. 4: One to one multi destinations shipping service model

Figure 3 and 4 shows the user interface of Go-Send which is Go-Jek city courier service. The user interface is developed as Android application and it is accessed

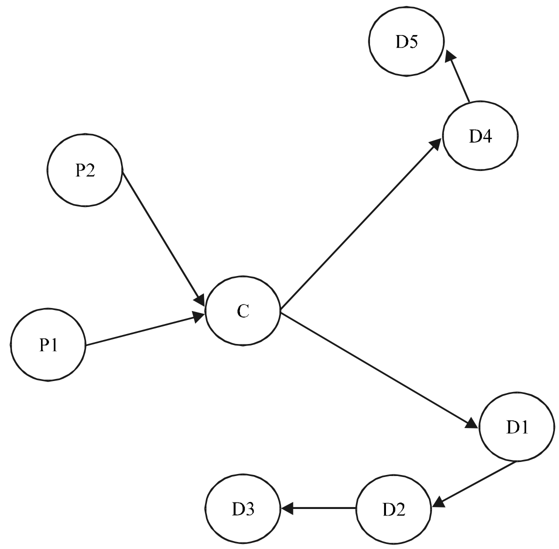

Fig. 5: Combined shipping model

through mobile phone. In this application, it is shown the map and the available drivers near the customer location. In this application, it is shown that customer must fill the sender location and the destination location. In this application, it is also shown that one order is for single sender and single destination. The detailed explanation is shown in Fig. 4.

Suppose that customer will send three packages. Each package will be sent to distinct destination, D1-D3. Because single order is for single destination, so, the customer has to create three shipping orders. Suppose that there are three drivers around the customer: P1-P3. P1 is allocated for D1. P2 is allocated for D2. P3 is allocated to D3. So, the driver travel distance will be r(C-P1)+r(C-D1) for P1, r(C-P2)+r(C-D2) for P2 and r(C-P3)+ r(C-D3) for P3. Total travel distance to send all packages will be r(C-P1)+r(C-D1)+r(C-P2)+r(C-D2)+r(C-P3)+r(C-D3). This calculation of total driver travel distance (r_{tot}) can be formalized in Eq. 1. In Eq. 1, n represents the number of packages with distinct destination:

$$r_{tot} = \sum_{i=1}^{n} \left(r(C-P_i) + r(C-D_i) \right) \quad (1)$$

This condition is not efficient. First, we need n drivers for n packages. Because the drivers are limited, there is condition that there are some packages that cannot be executed because lack of driver. Second, total travel distance is high. Third, total cost is expensive too.

This problem can be solved by combined shipping method. The illustration is shown in Fig. 5. Suppose that there are five packages that must be delivered from one customer to five distinct destinations (D1, D2, ... , D5). By combined shipping, the packages can be clustered into two groups based on their closeness. The first group consists of D1-D3. The second group consists of D4 and D5. In the environment, there are two available drivers that are near the customer: P1 and P2. P1 is allocated for the first group and P2 is allocated for the second group. So, travel distance for P1 is r(P1-C)+r(C-D1)+ r(D1-D2)+r(D2-D3). Travel distance for P2 is r(P2-C)+r (C-D4)+r(D4-D5). The total driver travel distance can be formalized in Eq. 2 until Eq. 4:

$$r_{tot} = \sum_{i=1}^{n_{group}} r_{group,\,1} \quad (2)$$

$$r_{group,\,1} = r(C-P_i) + r(C-D_{i,\,1}) + r_{rest,\,i} \quad (3)$$

$$r_{rest,\,i} = \sum_{i=2}^{m_i} r\left(D_{i,\,j} - D_{i,\,j-1}\right) \quad (4)$$

The explanation of variables that are used is as follows. Variable i is the group index. Variable n_{group} is the number of group. $r_{group,\,i}$ is the driver travel distance in a group. $r_{rest,\,i}$ is the additional distance if there is more than one destination in a group. Variable m is the number of destinations in group.

Proposed model: In this research, we propose two combined shipping models. These models are developed based on different approaches. The first model is developed based on least effort algorithm. The second model is developed based on random walk model. There is travel distance limitation, so that, one driver will not ride too far.

The least effort method is chosen as one of the method candidate because this method has been used in many researches, especially in making efficient action, especially in people movement. Fu *et al*. (2014) uses least effort algorithm in simulating exit selection behavior. Guy *et al*. (2010) uses least effort algorithm in simulating massive crowd behavior. Sarmady *et al*. (2009, 2010) uses least effort algorithm to control pedestrian movement in cellular automata based crowd simulation. Besides, human behavior, least effort algorithm is also used in transmission problem which is done by Monticelli *et al*. (1982) for electric transmission planning in Brazil.

In every method, there are iterations that occur until all packages are grouped. Single iteration represents single group. So, the number of groups can be counted based on the number of the iterations that occurs. In the iteration, there is searching process to find the next package that must be put in a group. The searching

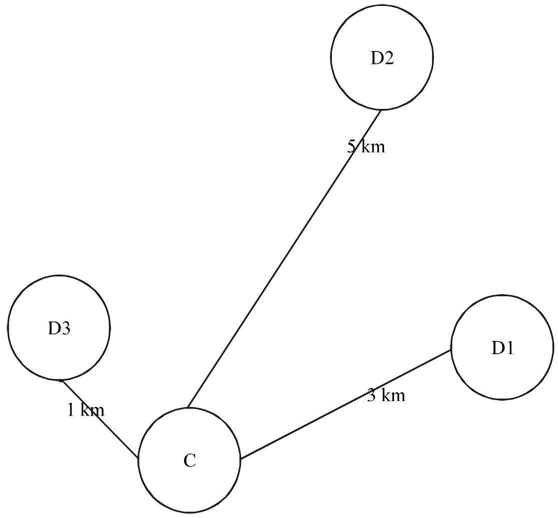

Fig. 6: Least effort algorithm

process will stop if the maximum travel distance is reached or there is not any ungrouped package. The basic algorithm is shown in Fig. 6.

Algorithm1; Basic grouping algorithm:

begin
  $n_{group} \leftarrow 0$
  $n_{exepack} \leftarrow 0$
  while ($n_{exepack} < n_{pack}$)
  begin
    createnewgroup ()
    n_{group}++
    runsearching ()
  end
end

Based on Fig. 6, there are variables and procedures that are used. Variable n_{group} represents the number of groups that are created. Variable $n_{exepack}$ represents the number of packages that has been grouped. Variable n_{pack} represents the total number of packages. Procedure createnewgroup is used to create a new group. Procedure runsearching is used to run the searching process. The detailed process of runsearching procedure is shown in Fig. 7.

Algorithm 2; Runsearching algorithm:

begin
  $r_{trav} \leftarrow 0$
  $p_{now} \leftarrow p(C)$
  while($n_{exepack} < n_{pac}$ and $r_{trav} < r_{max}$)
  begin
    find_next_package ()
    $r_{trav} \leftarrow r_{trav} + r(p_{now} - p_{new})$
    $p_{now} - p_{new}$
    $n_{exepack}$++
  end
end

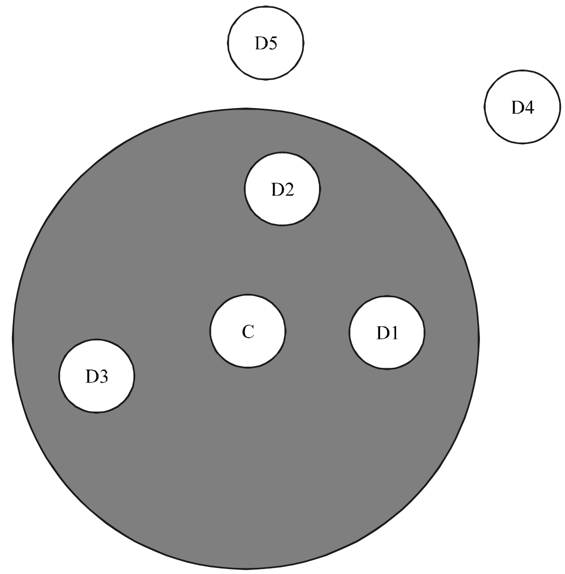

Fig. 7: Random walk algorithm

Based on Fig. 7, some variables and procedure are used in the runsearching algorithm. Variable r_{trav} represents the travel distance of the group. Variable p_{now} represents the current position of the finder. Variable p(C) represents the position of the customer. At the beginning of the searching process, the current position is set at the customer position. Variable r_{max} represents the maximum distance for one group. Variable p_{new} is the position of the next package. After finding new package, the finder position is updated at the new package destination position. The find_next_package procedure is the finding for the next package. The least effort algorithm or random walk algorithm is used in this procedure.

In the least effort algorithm, the finder will choose the package that the destination is closest to its current position as its next package that must be executed. In this method, even the destination is far as long as this package is the closest destination from its current location, so, this package will be the next package. Based on this explanation, the least effort algorithm uses deterministic approach. The illustration is shown in algoritm 1. The least effort formula is described in Eq. 5 and 6.

The illustration of least effort algorithm is as follows: Suppose that the current finder position is at C. There are three destinations that their package has not been grouped yet: D1-D3. The distance between them and the current finder position is 3, 5 and 1 km consecutively. Based on the formulae that are described in Eq. 5 and 6, the next selected destination is D3 because its location is the closest to the finder current position. s(g) will be 0 if this package has not been grouped and 1 if the package has been grouped:

$$G = \forall(g)|s(g) = 0 \quad (5)$$

$$g_{\downarrow sel} = g|\min(r(p_{\downarrow now} - p(g))) \wedge \in G \quad (6)$$

The second method is based on random walk approach. In some research, random walk is used as stochastic approach in finding efficient solution possibility. Random walk has been used in many research areas. Goswami *et al*. (2004) explains that random walk method achieves better solution in solving traveling salesman problem. Li (2011) proposed reinforced random walk to solve shortest path in electric network. Rego *et al*. (2011) uses random walk to explain process in traveling salesman problem.

In this method, observation range (r_{ob}) is used as driver limitation. So, the driver's next destination will not be too far. The next package that is chosen must be in the current finder observation range. If there is more than one destination in the observation range, then the next selected package will be chosen randomly. The illustration is shown in algoritm 2. If there is not any destination in the observation range, the searching process is stop. If there is still any package that has not been executed, then new group will be created. The formulae is described in Eq. 7.

Algoritm 2, it is shown that there are five packages that must be chosen as the next selected package: D1, D2, , ..., D5. The current finder position is at C. The packages that their destination is in the observation range are D1-D3. The packages that their destination is out the observation range are D4 and D5. So, D4 and D5 are not included as candidate of the next selected package. The next selected package is chosen randomly between D1-D3. In this research, the random process follows uniform distribution so, that, every candidate has equal opportunity to be selected:

$$G = \forall(g)|s(g) = 0 \wedge r(p_{\downarrow now} - p(g) < r_{\downarrow ob} \quad (7)$$

$$g_{\downarrow sel} = g|\text{random}(1, n(G)) \quad (8)$$

Based on Eq. 7, different with Eq. 5, the member of set G is not also the package that has not been grouped yet, but also the distance between its location and the current finder location is under the observation range. In Eq. 8, it can be seen that the next selected package

Table 1: Non financial performance for least effort algorithm (n_{pack})

n_{pack}	Average r_{trav}(km)	Total r_{trav}(km)	n_{group}
5	33.00	33.00	1
10	49.13	49.13	1
15	29.78	59.56	2
20	36.32	72.64	2
25	30.25	90.75	3
30	29.56	88.69	3

Table 2: Financial performance for least effort algorithm (n_{pack})

n_{pack}	Average driver revenue (rupiah)	Total cost (rupiah)
5	65,200	65,200
10	97,600	97,600
15	58,400	116,800
20	71,400	142,800
25	59,466	178,400
30	58,133	174,400

Table 3: Non financial performance for random walk algorithm (n_{pack})

n_{pack}	Average r_{trav}(km)	Total r_{trav} (km)	n_{group}
5	12.99	45.74	3.6
10	13.14	61.82	4.8
15	19.03	83.92	4.4
20	25.10	100.39	4.0
25	21.84	124.63	5.8
30	24.86	138.51	5.6

Table 4: Financial performance for random walk algorithm (n_{pack})

n_{pack}	Average driver revenue (rupiah)	Total cost (rupiah)
5	25,227	88,800
10	25,440	119,600
15	37,180	164,000
20	49,200	196,800
25	43,062	245,600
30	48,649	271,200

Table 5: Non financial performance conventional shipping model (n_{pack})

n_{pack}	Average r_{trav} (km)	Total r_{trav} (km)
5	8.28	41.42
10	7.20	71.96
15	8.83	132.47
20	9.63	192.64
25	8.61	215.19
30	8.25	247.54

shown that when the number of packages increases, the total travel distance increases too. This is normal. But the average driver's travel distance fluctuates. The maximum average driver's travel distance is 49.13 km when the number of packages is 10 units. The minimum average driver's travel distance is 29.56 when the number of packages is 30 units. This condition is the consequence of the increasing of the number of the group.

Based on data in Table 2, it is shown that when the number of packages increases, the total cost that must be paid by the customer increases too. This is normal. In the other hand, the average driver's revenue fluctuates. The maximum average driver's revenue is 97, 600 rupiah when the number of packages is 10 units. The minimum average driver's revenue is 58,133 rupiah when the number of packages is 30 units. Based on data in Table 3, it is shown

Table 6: Financial performance conventional shipping model (n_{pack})

n_{pack}	Average driver revenue (rupiah)	Total cost (rupiah)
5	19,760	98,800
10	17,760	177,600
15	20,506	307,600
20	22,720	454,400
25	20,832	520,800
30	19,893	596,800

that when the number of packages increases, the total driver's travel distance increases too. On the other hand, the average driver's travel distance tends to grow with fluctuation. The maximum average driver's travel distance is 25.10 km when the number of packages is 20 units. The minimum average driver's travel distance is 12.99 when the number of packages is 5 units. This condition is the consequence of the increasing of the number of groups.

Based on data in Table 4, it is shown that when the number of packages increases, the total cost that must be paid by the customer increases too. Meanwhile, the average driver's revenue tends to grow with fluctuation. This condition follows the average driver's travel distance.

Based on data in Table 5, it is shown that in conventional one to one shipping model when the number of packages increases, the total driver's travel distance increases too. Meanwhile this condition does not affect to the average driver's travel distance.

Based on data in Table 6, it is shown that in the conventional one to one shipping model when the number of packages increases, the total cost that must be paid by the customer increases too. Meanwhile, similar to the non financial performance, the increasing of the number of packages does not affect to the average driver's revenue.

By comparing Table 1, 3 and 5, it can be seen that least effort method gives best non financial performance rather than random walk method or conventional one to one shipping model. With the same number of packages by using least effort algorithm, system generates lowest total driver's travel distance and highest average driver's travel distance. So, this method gives most efficient process in minimizing total driver's travel distance in one side and maximizing average driver's travel distance in another side. This condition is different with the conventional one to one shipping model that produces lowest efficient in non financial aspect. This model produces highest total driver's travel distance and lowest average driver's travel distance. The non financial performance of the random walk method is in the middle position.

This condition affects to the financial performance. By comparing the financial performance, least effort algorithm gives best performance by generating lowest cost that must be paid by the customer and highest average driver's revenue. So, least effort is successful in minimizing total cost in one side and maximizing driver's revenue in another side. The conventional one to one shipping produces the worst financial performance. This model produces highest total cost that must be paid by customer and lowest average driver's revenue. The financial performance of random walk method is in the middle position.

Table 7: Non financial performance for least effort algorithm (r_{max})

r_{max}	Average r_{trav}(km)	Total r_{trav} (km)	n_{group}
40	30.53	72.95	2.4
50	34.76	69.51	2.0
60	33.95	67.91	2.0
70	34.09	68.17	2.0
80	33.96	67.93	2.0

Table 8: Financial performance for least effort algorithm (r_{max})

r_{max}	Average driver revenue (rupiah)	Total cost (rupiah)
40	60,200	144,000
50	68,200	136,400
60	66,600	133,200
70	67,200	134,400
80	66,800	133,600

Table 9: Non financial performance for random walk algorithm (r_{max})

r_{max}	Average r_{trav} (km)	Total r_{trav} (km)	n_{group}
40	18.01	101.18	5.6
50	20.37	97.56	4.8
60	21.66	94.60	4.8
70	20.23	94.64	4.8
80	21.57	91.91	4.4

The second test is to observe the performance for different maximum travel distance value. The maximum travel distance value ranges from 40-80 km. The average number of packages is 20 units. The maximum number of packages in a group is 10. The result is shown in Table 7 and 8 for least effort algorithm and in Table 9 and 10 for random walk algorithm.

Based on data in Table 7, it is shown that the in the least effort algorithm, the increasing of maximum travel distance does not affect to the total driver's travel distance or the average driver's travel distance. Even there is a tendency that the total travel distance decreases, the decreasing is not significant and fluctuating. It also can be seen that the number of group does not change.

Based on data in Table 8, it is shown that when system implements least effort algorithm when the maximum travel distance increases, the influence to the financial performance is not significant. Even there is tendency in decreasing in total cost and increasing in average driver's revenue, the change is not significant and is fluctuating.

Based on data in Table 9, it is shown that when system implements random walk method when the maximum travel distance increases, the total driver travel

Table 10: Financial performance for random walk algorithm (r_{max})

r_{max}	Average driver revenue (rupiah)	Total cost (rupiah)
40	35,112	197,200
50	39,800	190,800
60	42,187	184,000
70	39,460	184,400
80	42,160	179,600

Table 11: Non financial performance for least effort algorithm (n_{max})

n_{max}	Average r_{trav} (km)	Total r_{trav} (km)	n_{group}
8	26.22	78.66	3
9	25.56	76.68	3
10	34.04	68.09	2
11	35.92	71.85	2
12	38.48	76.97	2

Table 12: Financial performance for least effort algorithm (n_{max})

n_{max}	Average driver revenue (rupiah)	Total cost (rupiah)
8	51,600	154,800
9	50,000	150,000
10	67,200	134,400
11	71,000	142,000
12	75,800	151,600

Table 13: Non financial performance for random walk algorithm (n_{max})

n_{max}	Average r_{trav} (km)	Total r_{trav} (km)	n_{group}
8	18.69	93.43	5.0
9	19.05	93.62	5.0
10	22.27	98.22	4.6
11	23.51	106.15	4.8
12	19.25	94.80	5.0

distance decreases. The average number of groups decreases too. In the other side, the average driver distance increases but not significant and fluctuating.

Based on data in Table 10, it is shown that when system implements random walk method when the maximum travel distance increases, the total cost that must be paid by the customer decreases. Meanwhile the average driver's revenue increases but not significant and fluctuating.

When the maximum travel distance changes, the least effort algorithm still performs better than the random walk method. By comparing data in Table 7 and 9 in non financial aspect by using least effort algorithm, the total driver's travel distance is lower while the average driver's travel distance is lower than by using random walk method. By comparing data in Table 8 and 10 in financial aspect by using least effort algorithm, the total cost that must be paid by the customer is lower while the average driver's revenue is higher than by using random walk method.

The third test is to observe the performance for different maximum number of packages in a group value. The maximum number of packages in a group ranges from 8-12. The average number of packages is 20 units. The maximum travel distance is 60 km. The result is shown in Table 11 and 12 for least effort algorithm and in Table 13 and 14 for random walk algorithm. Based on data in Table 11, it is shown that when system implements least effort algorithm, the change in maximum number of packages does not affect the total driver travel distance. In the other hand, the increasing of the maximum number of packages makes the average driver's travel distance increase. Meanwhile increasing of maximum number of packages makes the number of groups tends to decrease.

Table 14: Financial performance for random walk algorithm (n_{max})

n_{max}	Average driver revenue (rupiah)	Total cost (rupiah)
8	36,480	182,400
9	37,100	182,400
10	43,867	193,600
11	45,990	207,600
12	37,613	185,200

Based on data in Table 12, it is shown that when using least effort algorithm, the change in maximum number of packages in group does not affect the total cost that must be paid by the customer. Meanwhile when the maximum number of packages in a group increases, the average driver revenue increases.

Based on data in Table 13, it is shown that when using random walk method, the change in maximum number of packages does not affect in non financial performance. All non financial performances includes: total driver travel distance, average driver's travel distance and number of groups tends to fluctuate.

The fluctuating performance in non financial performance affects the financial performance. Based on data in Table 14, it is shown that when using random walk method, the change in maximum number of packages does not affect the total cost that must be paid by customer and average driver's revenue.

Based on the explanation above, the maximum number of packages that can be carried in single group does not affect the performance. This condition occurs both when system using least effort algorithm or random walk method. This condition also occurs in non financial performance or financial performance. The exception is in average driver's revenue when the system implements least effort algorithm.

CONCLUSION

Based on the explanation above, the proposed model has been implemented into the city courier service simulation to simulate combined shipping process. The simulation has shown that by using combined shipping model, better performance is achieved rather than by using conventional one to one shipping model.

This condition occurs both when system using least effort algorithm or random walk method. But the least effort algorithm performs better than random walk method.

This better performance occurs in both financial aspect and non financial aspect. In non financial aspect, least effort algorithm produces lower total driver travel distance and higher average driver's travel distance rather than random walk method. As consequence, in financial aspect, least effort algorithm performs better than random walk method. Least effort algorithm generates lower total cost that must be paid by customer and higher average driver's revenue.

In this study, it is shown that some parameters give significant affect while other parameters give less significant affect. The combined shipping model performs more efficiently rather than conventional one to one shipping model when the number of packages increases. In the other side when they are applied independently, the maximum number of packages and the maximum driver travel distance in single group gives less significant influence to system performance.

This research is part of study in city courier business that now a days is emerging by the rise of online taxi business. Many research opportunities are in this field. Many new shipping models can be proposed such as scheduled shipping and etc.

REFERENCES

Amirio, D., 2016. Grab vies for 50 percent of Online Ojek Market. Jakarta Post, Jakarta, Indonesia.

Anonymous, 2016a. Bukalapak, Go-Jek collaborate on delivery service. The Jakarta Post, Jakarta, Indonesia.

Anonymous, 2016b. Grab hits the road with GrabFood food delivery service. The Jakarta Post, Jakarta, Indonesia.ttp://www.thejakartapost.com/news/2016/05/02/grab-hits-the-road-with-grabfood-food-delivery-service.html

Fu, L., W. Song, W. Lv and S. Lo, 2014. Simulation of exit selection behavior using least effort algorithm. Trans. Res. Procedia, 2: 533-540.

Goswami, D., H. Karnick, P. Jain and H.K. Maji, 2004. Towards efficiently solving quantum traveling salesman problem. Quant. Phys., 1: 1-8.

Guy, S.J., J. Chhugani, S. Curtis, P. Dubey and M. Lin *et al*., 2010. Pledestrians: A least-effort approach to crowd simulation. Proceedings of the 2010 ACM SIGGRAPH/Eurographics Symposium on Computer Animation, July 2-4, 2010, ACM, Madrid, Spain, pp: 119-128.

Kusuma, P.D., 2017a. Nearest driver-FIFO combination model in online motorcycle taxi dispatch system. J. Theor. Appl. Inf. Technol., 95: 6236-6247.

Kusuma, P.D., 2017b. Online motorcycle taxi simulation by using multi agent system. Intl. J. Appl. Eng. Res., 12: 9199-9208.

Li, D., 2011. Shortest paths through a reinforced random walk. Master Thesis, Uppsala Universitet, Uppsala, Sweden.

Monticelli, A., A. Santos, M.V.F. Pereira, S.H. Cunha and B.J. Parker *et al*., 1982. Interactive transmission network planning using a least-effort criterion. IEEE. Trans. Power Apparatus Syst., 10: 3919-3925.

Rego, C., D. Gamboa, F. Glover and C. Osterman, 2011. Traveling salesman problem heuristics: Leading methods, implementations and latest advances. Eur. J. Oper. Res., 211: 427-441.

Sarmady, S., F. Haron and A.Z. Talib, 2010. Simulating crowd movements using fine grid cellular automata. Proceedings of the 2010 12th International Conference on Computer Modelling and Simulation (UKSim), March 24-26, 2010, IEEE, Cambridge, UK., ISBN:978-1-4244-6614-6, pp: 428-433.

Sarmady, S., F. Haron and A.Z.H. Talib, 2009. Modeling groups of pedestrians in least effort crowd movements using cellular automata. Proceedings of the 2009 3rd Asia International Conference on Modelling and Simulation, May 25-29, 2009, IEEE, Bandung, Bali, Indonesia, ISBN:978-0-7695-3648-4, pp: 520-525.

Tang, W., 2018. Go-food gets warm welcome despite weighty scheme. Jakarta Post, Jakarta, Indonesia.