LOCKER FACILITY ALLOCATION FOR DELIVERY OF GOODS IN THE E-COMMERCE BUSINESS

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ABSTRACT

In urban logistics, long distance shipments from warehouses to consumer are becoming difficult with continued e-commerce growth. This requires complex planning and scheduling to minimize global travel costs, but often experiences challenges such as lowering the economies of scale in the transportation system, including high levels of load fragmentation and low use of vehicle load compartments. In this study, we propose allocation of locker facilities for delivery point of goods in the e-commerce business. The lockers are spread out at the location determined from the model developed in this study. This locker serves as an effective alternative solution to a gathering point of goods sent by the seller, as well as a gathering point for end customers who take items purchased from e-commerce. We specifically discuss the set covering problem by considering the population density in each region. We attempt to optimize the location facilities by providing several options of the scope to cover the maximum customer. This problem is applied to a 42-node census tract representation of city center of Gresik.

Keywords: Locker allocation, e-commerce, city logistics, set covering problem

1. INTRODUCTION

Direct delivery to end customers is one of the main drivers of heavy commercial vehicle traffic throughout the city. The important role of this business in economic growth in Indonesia, however, is also significantly reducing the function of the economy of scale in the transportation system, including high levels of load fragmentation and the low use of vehicle load compartments. This type of shipping is growing with increasing consumer interest in online shopping. Currently, the biggest mover in the B2C market is e-commerce.

According to the "Global B2C E-commerce Report 2014", B2C e-commerce sales have steadily increased since 2010 as shown in Figure 1.1 and the growth rate has been quite consistent over the past four years with an average value of 23.6% (Nagelvoort et al ., 2014). The development of e-commerce in the B2C market is well represented in various major cities in Indonesia.

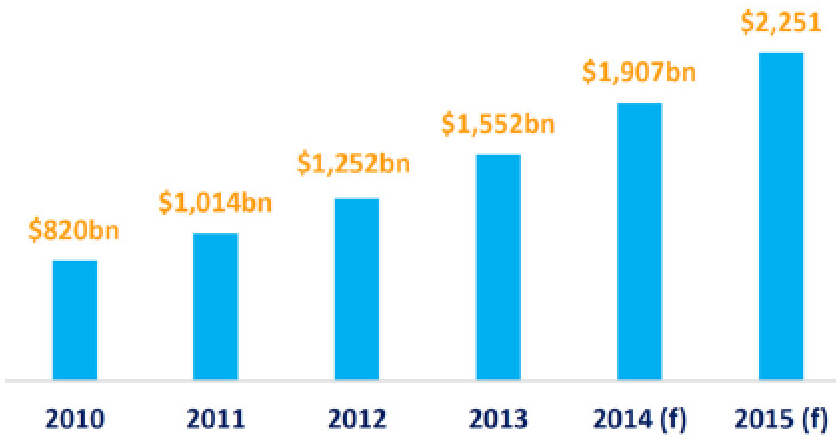

Figure 1. Global B2C e-commerce sales

Last-mile delivery for the e-commerce industry is currently considered the most expensive, most inefficient and polluting part of the entire logistics chain (Gevaers et al., 2014). The fast-growing e-commerce industry has contributed to the expansion of the express shipping market. However, it also presents a big challenge for last-mile delivery. This problem has led to inefficient operations and high shipping costs, especially for online retailers who usually send a large number of shipments to their customers in operations that are carried out every day. This inefficiency in the last mile delivery has contributed enough to hamper the development of an online retail business.

Based on these problems, this study proposes the idea of innovation in the use of an intermediate locker facility or intermediate depot as a medium for collecting goods sent by online sellers and also as a location for taking goods purchased directly by end customers from the e-commerce. Facilities that are suitable for use as an intermediary is to use an automatic locker. This is in addition to its operations that require little human labor, as well as recording the delivery of goods made can be done automatically through an online system.

The distinguishing feature of this parcel locker compared to traditional courier services is a significant reduction in the number of pick up locations of delivery locations required in the entire logistics chain. Parcel lockers are usually placed in public places such as shopping centers, train stations or bus terminals, schools and universities, and others. Because of this, it is possible to receive shipments on time, often when doing other things, such as shopping or refueling a car. By choosing the right location, parcel lockers can not only provide significant economic benefits, but also this can have a positive impact on reducing pollutants emitted into the environment by urban transport and reducing the impact of shipping on traffic problems and congestion in the city area.

The most important factor of the solution efficiency in this study is the exact location of the parcel locker needed in the overall logistics chain of e-commerce. This locker serves as an effective alternative solution to a gathering point of goods sent by the seller, as well as a gathering point for end customers who take items purchased from e-commerce. The allocation problem consists of determining the location of locker facilities that cover minimum distance with limited facilities. We set the covering by considering the population density in each region. We attempt to optimize the location facilities by providing several options of the scope to cover the maximum customer. This problem is applied to a 42-node census tract representation of city center of Gresik. The rest of this paper is organized as follows. Section 2 provides the literature review for set covering problem, p-median and parcel locker in the e-commerce. Section 3 explains the model application and gives run with several options of scope to cover maximum customer. Finally, the conclusion and future research direction are discussed in section 5.

2. LITERATURE REVIEW

2.1 Set Covering Problem

The Set Covering Method is a site allocation optimization method that aims to minimize the number of sites needed to be able to cover other sites. The selected site will be able to cover the demand for other sites, so that it will minimize the number of existing sites and can save costs because the site can cover all requests. According to Daskin (2008), Set Covering is a way to determine the lowest cost of placing a number of facilities where each demand node can be reached by at least one facility. Set Covering is one part of the allocation location problem. The purpose of the allocation location model is to determine the location of facilities that can minimize the cost of assigning facilities to customers with the limitation that each facility is used for a specified number of customers. Service can be performed by the facility if the customer is within the specified distance and the facility is deemed incapable if the distance exceeds the critical value of the distance range (Suharyo, 2015). Based on the conditions contained in Gresik City Center, the Set Covering model can be formulated as follows:

Inputs

$$aij = \begin{cases} 1, if\ candidate\ site\ j\ can\ cover\ demands\ at\ node\ i \\ 0, if\ not \end{cases}$$

Decisions Variables

$$Xj = \begin{cases} 1, if\ we\ locate\ at\ candidate\ site\ j \\ 0, if\ not \end{cases}$$

With this notation, we can formulate the set covering problem as follows:

***Objective function*:**

$$\min = \sum_j f_j X_j \quad \text{……..……………(1)}$$

***Subject to*:**

$$\sum_j a_{ij} X_j \geq 1 \quad \text{…………………….(2)}$$

$$X_j = 0,1 \quad \text{……………………….(3)}$$

The objective function (1) minimizes the total cost of the facilities that are selected. Constraints (2) stipulate the each demand node i must be covered by at least one facility. Note that function (2) gives the number of located facilities that can cover demand node i. Constraints (3) are the integrality constraints.

2.2 P-Median Problem

The P-Median problem is used to find the p facility to minimize the weighted average distance of requests between the requesting node and the closest from the selected facility (Daskin, 2013). The basic p-median problem for determining the location of facilities can be written as follows.

Decision variable

$$W_i = \begin{cases} 1 & \text{1 if node } i \text{ underserved} \\ 0 & \text{0 otherwise} \end{cases}$$

Objective function and constraints

$$\text{Min} \quad \sum_i h_i W_i \qquad (1)$$

$$\sum_j a_{ij} X_j + W_i \geq 1 \qquad \forall i \qquad (2)$$

$$\sum_j X_j \leq P \qquad (3)$$

$$X_j = 0,1 \qquad \forall j \qquad (4)$$

$$W_i \geq 0 \qquad \forall i \qquad (5)$$

This formulation (1) is used in the model to minimize the number of unserved demands. The constraint (2) determines the location of the facility that can serve customer i $(\sum_j a_{ij} X_j \geq 1)$ or customer i not served $(W_i = 1)$. Constraint (3) says that at most P facilities can be used. Constraints (4) and (5) are standard integrality and nonnegativity constraints and that variable coverage (W_i) is a non-negative value.

Previous research that using P-median problem to get parcel locker network facilities was Redi et al (2019). They use p-median to determine the optimal facility location to minimize the cost of transportation.

2.3 Parcel Locker on E-commerce

Parcel lockers offer a response to retail and last mile delivery challenges provoked by the rapid growth of e-commerce worldwide. Retailers, logistics service providers, communities, and other stakeholders now face issues due to increased volumes of goods sold online (Vakulenko, 2017). E-commerce growth rapidly has result on increasing parcel delivery and return volumes which pressure on last mile delivery (Ferrucci & Bock, 2014). According to Vakulenko (2017) that to deal with e-commerce growth, retail dan logistics service providers are implementing innovative tools such as self service technologies (SSTs). In the last mile delivery context SSTs are presented in the form of parcel lockers, or automated lockers, intelligent locker, and self-service delivery lockers. Therefore the performance of parcel locker need to be optimized for the operating strategy.

3. MODEL APPLICATION

In this section consider the application of the set covering problem (SCP) to find the optimum facilities location. The output of the SCP will be the input of P-median model to an example problem and discussed the implications of the model for parcel locker system. We begin by considering 42-node location representing central city of Gresik, Indonesia at the population density level.

3.1 Node and Population Density

42-node location consists of 2 sub-district (A and B) in central city that have one depot and located in subdistrict A. table 1 show the node and the demand of each node. The demand take 5% of the population.

Table 1. Node and Demand

No	Node	Demand	No	Node	Demand
1	001	84	22	022	414
2	002	148	23	023	121
3	003	591	24	024	147
4	004	134	25	025	101
5	005	246	26	026	84
6	006	258	27	027	25
7	007	109	28	028	55
8	008	114	29	029	295
9	009	91	30	030	505
10	010	286	31	031	480
11	011	263	32	032	207
12	012	188	33	033	128
13	013	158	34	034	147
14	014	157	35	035	202
15	015	111	36	036	207
16	016	108	37	037	151
17	017	91	38	038	159
18	018	67	39	039	486
19	019	226	40	040	286
20	020	333	41	041	791
21	021	385	42	042	294

3.2 Parcel Location Fulfillment

This research solve the covering problem in excel solver. We test in several fulfillment distances (a)7km; (b) 6km; (c) 5km; (d) 3km; (e) 1km.

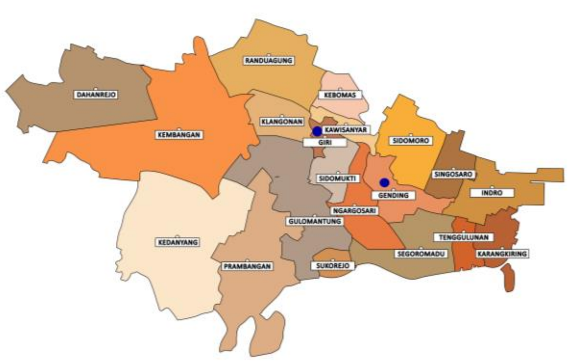

Figure 2a. locker facilities-fulfillment distance 7km

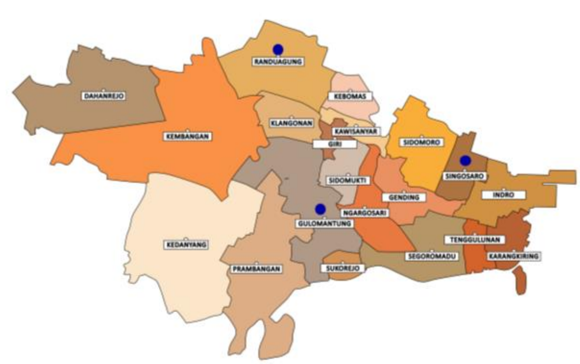

Figure 2b.locker facilities-fulfillment distance 6km

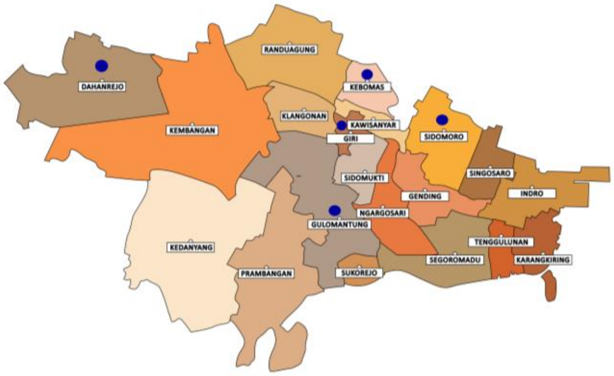

Figure 2c. locker facilities-fulfillment distance 5km

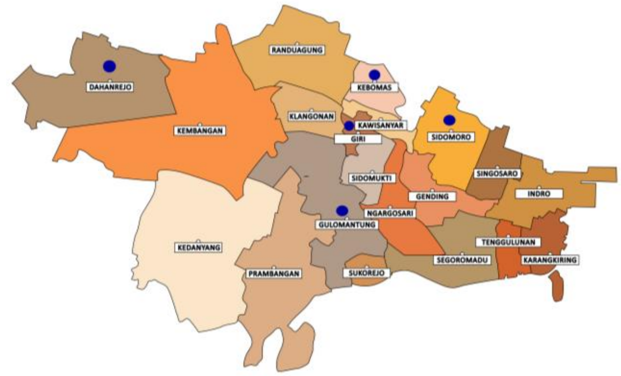

Figure 2d.locker facilities-fulfillment distance 3km

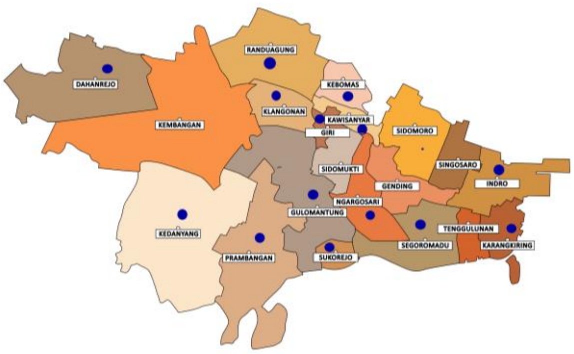

Figure 2e.locker facilities-fulfillment distance 1km

In the figure 2a. the optimal location is 2 facilities and cover around 90% demand. The figure 2b, ther are 3 location that open 3 facilities and 93% of demand fulfillment. Figure 2c, 2d, and 2e order fulfillment can be 100% with 2c will open 4 facilities, 2d will open 6 facilities and 2e will open 26 facilities.

4. CONCLUSSION

This research proposes the locker facility allocation in the e-commerce business. The problem modelled as an integer linier programing. Using set covering problem will generate which node selected to cover all demands. The result of this case study, the most optimal are 5km distance fulfillment. This obtained from p-median which is able to meet the total covering demand on 100%. Further research will focus on vehicle routing problem with pickup and delivery using the output of p-median and adding the two echelon routing in this case.

5. REFERENCES

Daskin, M. S. (2013). Network and Discrete Location: Models, Algorithms, and Applications Second Edition, Wiley.

Daskin, Mark S. (2008). What You Should Know About Location Modelling. Naval Research Logistics 55:283-294

Durand B., Gonzalez-Feliu J., 2012. Urban logistics and e-grocery: Have proximity delivery services a positive impact on shopping trips?. Procedia – Social and Behavioral Sciences. Vol. 39, 510 – 520

Ferrucci, F., & Bock, S. (2014). Real-time control of express pickup and delivery processes in a dynamic environment. Transportation Research Part B: Methodological, 63, 1–14

Gevaers, R., Van de Voorde, E., Vanelslander, T., 2014. Cost modelling and simulation of last-mile characteristics in an innovative B2C supply chain environment with implications on urban areas and cities. Proc. – Soc. Behav. Sci. Vol. 125, 398–411

Iwan, S., Kijewska, K., dan Lemke, J. (2016). Analysis of parcel lockers' efficiency as the last mile delivery solution – the results of the research in Poland, *Transportation Research Procedia* 12, 644 – 655

Lachapellea,U., Burkeb, M., Brothertonb, A., Leungb, A. (2018), Parcel locker systems in a car dominant city: Location, characterisation and potential impacts on city planning and consumer travel access, Journal of Transport Geography, Vol. 71, 1-14

Nagelvoort B., Welie van R., Brink van den P., Weening A, Abraham J., (2014). Global B2C E-commerce Report 2014, Ecommerce Foundation, Amsterdam – Netherlands

Redi, AAN Perwira., Jewpanya, Parida (2019). The Two-Echelon Vehicle Routing Problem With Locker Facilities. Proceedings of The 14th International Congress on Logistics and SCM Systems. 135-139

Suharyo, Sri Okol., Manfaat, Djauhar., Armono, Haryo. (2015). Application of Fuzzy Multi Criteria Decision Making (FMCDM) in modeling determinatio of Naval Vase Development Locations. National Seminar on Applied Science and Technology III. Surabaya: Institut Teknologi Sepuluh November

Toth, P., Vigo, D. (2001), The Vehicle Routing Problem, Siam: United States of America

Wang,Y., Zhang, D., Liu, Q., Shen, F., Lee, L. H. (2016).Towards enhancing the last-mile delivery: An effective crowd-tasking model with scalable solutions. *Transportation Research Part E*. Vol. 93, 279–293

Vakulenko, Yulia., Hellstrom, Daniel., Hjort, Klas (2017). What's in The Parcel Locker? Exploring Customer value in e-commerce Last Mile Delivery. Journal of Business

Zhang, Y., Sun, L., Hu, X., Zhao, C. (2019). Order consolidation for the last-mile split delivery in online retailing. *Transportation Research Part E* Vol. 122, 309–327