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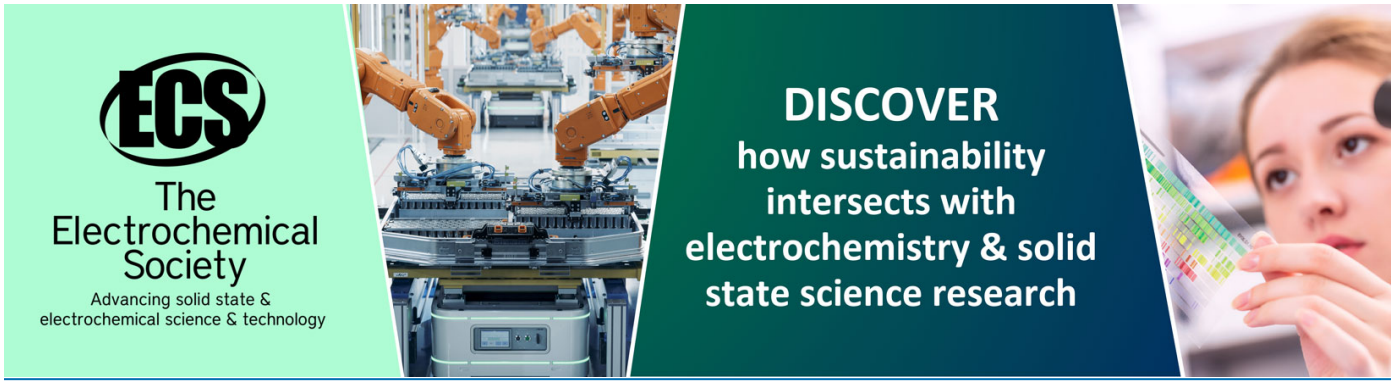

IOP Conf. Series: Materials Science and Engineering **875** (2020) 012027 doi:10.1088/1757-899X/875/1/012027

An Estimation of Origin-Destination Matrices for a Public Transport Network in Makassar using Macrosimulation Visum

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Abstract. The origin-destination (O-D) matrix is fundamental data for transportation planning. It is a primary process for modelling approaches the public transport. Generally, the observation survey of O-D volumes takes much cost, time, and effort. Therefore, establishing an inexpensive and simple observation method is expected to be able to carry out the continuous observation of passengers O-D volumes. Defined that many problems in transport planning and management tasks require an origin-destination (O-D) matrix to represent the travels pattern. The need for low-cost methods to estimate current and future O-D matrix is even more valuable in developing countries because of the rapid changes in population, economic activity, and land use. In this study, the O-D matrix use for modelling trip distribution of passenger in the current and future situation and plotting the model with Visum as a macro simulation program. This study focuses on the O-D volumes on a line of local public transport service. The on-board observation is carrying out, and the frequency of service is observed. Then, the passengers O-D matrix is estimated. These results must be useful to improve the operation of the service of public transport.

1. Introduction

Public transportation plays an important role in urban transportation system. It has a potential to mitigate traffic congestion by reducing private car users. Furthermore, it is necessary to secure urban mobility for citizens in transportation, such as employee, students and others. An effective operation is expected to be carried out based on a fine management. It can be done on condition that the information of passengers demand can be obtained, because it must be fitted to the demand of passengers. So, the effective management of public transport requires the current demand. On the other hand, the demand of passengers of public transportation is changed in the lapse of time. Therefore, not only obtaining the current demand but also must be required to keep the operation be an effective one. Generally, observation survey of O-D volumes take much cost, time and effort. Therefore, establishing an inexpensive and simple observation method is expected to be able to carrying out the continuous observation of passengers O-D volumes.

A high-quality Origin–Destination (OD) matrix is a fundamental prerequisite for any serious transport system analysis. However, it is not always easy to obtain it because OD surveys are expensive and difficult to implement. This is particularly relevant in large cities with congested networks, where detailed zonification and time disaggregation require large sample sizes and complicated survey methods [1].

Furthermore, the researcher explain that models of transport demand have been used for many years to synthesize O-D matrix in study areas. A typical example is the gravity model that had a functional form, plus the appropriate values for the parameter involved, is employed to produce acceptable matrix representing trip making behavior for many trip purpose and time periods. In this study, using gravity model based models for estimating ODM [2].

This study focuses on the O-D volumes on a line of local transport service. Local transport is one of a public transportation similar as a bus service called *local transport*. Its vehicle size is small and the capacity of the vehicle is around 10 people. It is served on pre-determined route and passengers can get on and off at any place on the line. Instead of using a general O-D observation, passengers O-D estimation method using simple onboard observation is established. In the onboard observation, only the number of getting on and off passengers at every stopping point. These data would recorded in every stopping point and tracking the location by GPS. The counted numbers are aggregated by unit of pre-determined road sections ("zones" thereafter). Then, zone to zone passengers O-D volumes are estimated by estimation method of gravity model and plotting the zone of catching area of passenger with *Visum* program. Finally, the whole passengers O-D volumes are estimated by expanding the obtained O-D considering the sampling rate of onboard observation.

The proposed estimation method is applied to a local transport line served in Makassar, Indonesia. The onboard observation is carrying out and the frequency of local transport service is observed. Then, the passengers O-D matrix are estimated. These results must be useful to improve the operation of local transport service.

2. The study Methods

The study implement of priority policy to develop public transport in many countries, the public transport has become the major way for the passenger transport in city. Especially about the location of the origin-destination, the influence of the bus station on the urban transport is very important, which has become the bottleneck section in urban transport [3].

On the other hand, for the developing countries, the local transports that doesn't have bus station are existed. These situation increase the likelihood of the bottleneck, the public transport can stop in everywhere and time to boarding and alighting the passengers. Thus, better understanding of the origin-destination of public transport based on demand. This study conducted with observation survey by boarding and alighting (on-off) passengers in Makassar. The data of passengers took in holiday and workday on totally 60 samples of public transport through B1 line (Hasanuddin University-Cenderawasih). The estimation of O-D matrix would be established using the *G*ravity model with the production-attraction-constraint (PACGR). Generally, observation survey of O-D volumes takes much cost, time and effort. In this study, the passengers of O-D volumes carrying out by a simple observation. The simple observation is inexpensive in terms of man power, low cost, organizational and management requirements, in which it can be collected without disrupting travelers. In this study, proposed an inexpensive and simple observation method is expected to be able to carrying out the O-D passengers volumes.

The OD research defined that the synthesis model famous and commonly is gravity (GR), because it simple and easy to understand [4, 5]. This method using the gravity concept whereas the production and attractive trips have the relationship to origin zones, such us population and the value of O-D matrix relate to accessibility (constraint) as a distance, time, also cost function [6].

Eventually, for transportation purpose, the gravity (GR) stated as:

$$T_{ij} \approx O_i \cdot D_j \cdot f_{ij} \tag{1}$$

where:

Tij = the trips between origin (*i*) to destination (*d*)
Oi and *Dj* = quadratic distance between two zones
f_{ij} = deterrence function

Oi and *Dj* stated the total trips origin from zone *i* and ends in the zone *j*, f_{ij} here is the deterrence function. Therefore, the sum of O-D matrix cell based on 'row' produce the total trips from each zone, whereas the sum based on a column produces total trips towards each zone [7]. The new equation become as follows:

$$T_{ij} \approx A_i \cdot O_i \cdot B_j \cdot D_j \cdot f_{ij} \tag{2}$$

This equation *Ai* and *Bj* are getting by iteration and with simply checked for *Tij* in the equation (1) already fulfill the constrained, which then the value has to use again to count the *Ai*. This process had been iterating until the value of *Ai* and *Bj* generating a certain value (converge). Some sample probably has different iteration depend on the value of *Oi* and *Dj* [8]. Then finally converge value would use for counting each value of O-D and established the matrix. Generally define the value of *Ai* and *Bj* will be calculated iteratively. This calculation can be started by assuming the value of *Ai* or *Bj*. In order to starting the iteration for the calculation the value of *Ai* will be assumed as one for all zones (*Ai* =1). The first value of *Ai* could be assumed any numbers bigger than zero. This assumption value just affect to the number of iteration to achieve the converge value. The bigger difference between the first and last number make more iteration required to achieve the converge value. The same way also applied in case the iteration started by *Bj* value. Bellows is an example to get the converge value of *Ai* and *Bj* on morning sample for more specific value in each cell matrix. The first step is determining the value of Ai as one in the first iteration. Then, this value will be used to calculate the value of B_j.

The O-D matrix is required for directional traffic assignment. In this matrix, the rows and columns represent the origin and destination zone respectively (Table 1). The converge value with getting *Ai* and *Bj* for every i and j, also for deterrence function, then all of matrix cell of sample one as the example bellows.

$$t_{11} = A_1 \cdot O_1 \cdot B_1 \cdot D_1 \cdot C_{ij} - \alpha$$

.

.

$$t_{n-n}$$

In the on-off data, total passengers from origin and destination input is create on the following table

Table 1. The trips from origin and destination zone

Zone		Destination							Sum
		1	…	…	j	…	…	n	O_i
Origin	1	t_{1-1}	…	…	t_{1-j}	…	…	t_{1-n}	O_1
	:	:			:				
	:	:			:				
	i	t_{i-1}	…	…	t_{i-j}	…	…	t_{i-1}	O_i
	:	:			:				
	:	:			:				
	n	t_{n-1}	…	…	t_{n-1}	…	…	t_{n-n}	O_n
Sum D_j		D_1	…	…	D_j	…	…	D_n	T

3. Result and Discussion

3.1. The Onboard Observation Data

The onboard observation bring out the public transport travel time and the number of passengers of pete-pete sampling. Every sample has departure and arrived time when started and finished one destination A – B and B – A. The pete-pete sample are classified in interval times. For the total travel time and sample of pete-pete are shown in table bellows.

Table 2. Travel time of samples

Workday	Line A-B Departure	Line A-B Arrived	Line B-A Departure	Line B-A Arrived
Morning	6:30	7:41	7:48	8:34
	6:35	7:29	7:29	8:29
	6:44	7:40	7:40	8:35
	6:30	7:38	7:43	8:34
	6:31	7:26	7:34	8:26
	6:32	7:26	7:28	8:22
	8:40	9:27	7:54	10:42
	8:42	9:42	9:42	10:42
	8:36	9:43	9:45	10:42
	8:44	10:17	10:18	11:05
	8:41	9:36	9:37	10:35
	8:28	9:32	9:33	10:27
Noon	11:42	12:46	12:48	13:47
	11:49	12:49	12:49	13:51
	11:44	13:01	13:03	14:27
	11:08	12:07	12:10	13:01
	11:48	12:51	12:53	13:51
	11:28	12:32	12:33	13:27
	14:40	15:25	15:26	17:05
	14:10	15:15	15:15	16:20
	14:34	15:54	15:54	17:04
	14:12	15:26	15:27	16:20
	14:06	15:08	15:09	16:09
	14:09	15:18	15:20	16:25
Afrer-noon	17:18	18:55	18:57	20:05
	17:24	18:39	18:40	19:59
	17:05	18:25	18:26	19:38
	17:01	18:00	18:03	19:36
	16:19	18:00	18:00	19:08
	17:27	19:01	19:01	20:17

Holiday	Line A-B Departure	Line A-B Arrived	Line B-A Departure	Line B-A Arrived
Morning	6:46	7:34	7:35	8:25
	6:45	7:33	7:34	8:25
	6:36	7:30	7:34	8:22
	6:50	7:31	7:35	8:25
	6:36	7:15	7:16	8:12
	6:54	8:24	8:28	9:06
	8:39	9:11	9:18	10:06
	8:28	9:21	9:21	10:14
	8:22	8:58	8:58	10:51
	8:42	9:25	9:25	9:58
	8:36	9:34	9:34	10:36
	9:08	10:20	10:20	11:10
Noon	11:35	12:12	12:18	12:55
	11:26	12:19	12:19	13:13
	10:52	11:42	11:44	12:30
	11:08	11:49	11:56	12:37
	10:37	11:24	11:31	12:17
	11:12	12:06	12:08	12:54
	13:21	14:13	14:21	14:54
	14:20	15:10	15:10	16:09
	14:10	14:47	14:47	15:36
	14:17	15:07	15:13	16:06
	14:17	15:06	15:03	15:50
	12:56	15:03	15:03	15:58
After-noon	16:17	17:09	17:13	18:01
	16:13	17:04	17:05	18:01
	17:10	17:47	17:47	18:36
	16:10	16:49	16:53	18:33
	16:59	17:50	17:50	18:47
	16:01	17:42	17:43	18:42

The tables are the data result from passenger record and marking by GPS for totally samples. The tables record the passengers and stopping point are analyzed to determine the position of each passengers of sampling in line. These created by Visum software to read the GPS track and waypoint. The total passengers separately more details in zones. Established the number of passengers based on marking stopping point based on zone is illustrated in figures below.

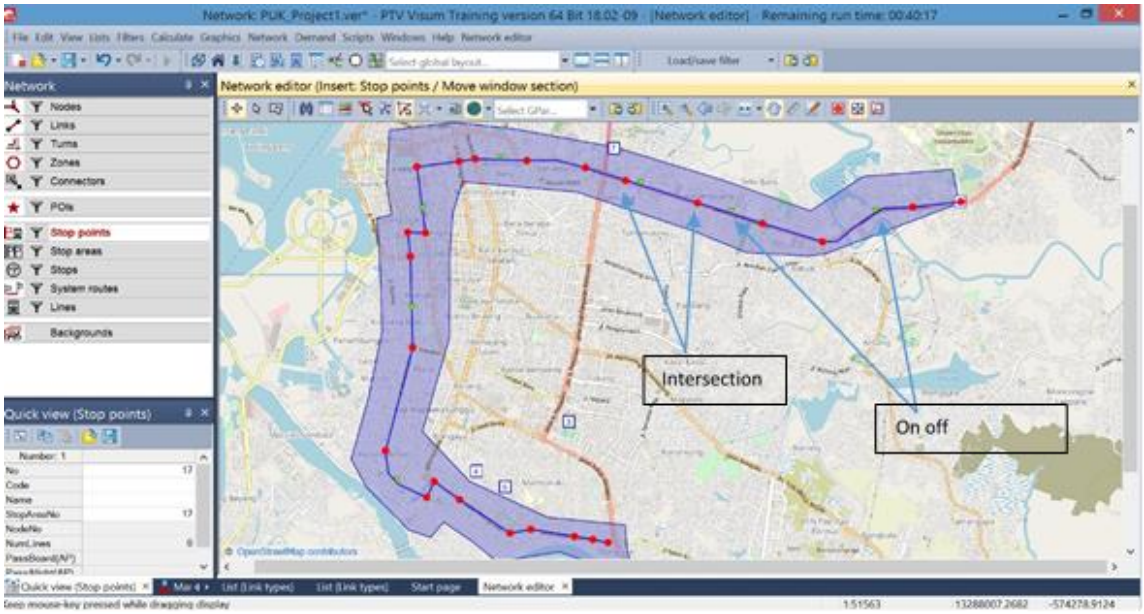

Figure 1. The figure of catchment area of passengers' by Visum

3.2. The Traffic Counts

According to counts data, the total operating pete-pete of B1 line are obtained. In the table bellows show the total vehicles by time interval.

Table 3. Pete-pete counts

Time	Vehicles Zone (A-B)	Vehicles Zone (B-A)
06:00 – 07:00	45	22
07:01 – 08:00	45	68
08:01 – 09:00	58	40
09:01 – 10:00	51	45
10:01 – 11:00	42	44
11:01 – 12:00	51	35
12:01 – 13:00	39	38
13:01 – 14:00	39	41
14:01 – 15:00	36	56
15:01 – 16:00	48	42
16:01 – 17:00	44	37
17:01 – 18:00	47	45
a. workday		

Time	Vehicles Zone (A-B)	Vehicles Zone (B-A)
06:00 – 07:00	13	16
07:01 – 08:00	42	34
08:01 – 09:00	41	35
09:01 – 10:00	39	40
10:01 – 11:00	44	37
11:01 – 12:00	31	37
12:01 – 13:00	37	33
13:01 – 14:00	33	32
13:01 – 14:00	38	31
15:01 – 16:00	32	28
16:01 – 17:00	39	28
17:01 – 18:00	38	45
b. holiday		

The pete-pete passing through observation area has counted. For total unit that registered administratively of B1 Line (sample observed) is 146 units.

3.3. The O-D Passengers Volume

The O-D matrix have been established for all sample in morning, noon, and afternoon. Onboard data observation produces the cell value for *Oi* and *Dj*. Then, using gravity model method to represent the O-D matrix. The total value in cell not only give information about the O-D volume of passenger but also the total passengers each zone for totally sample.The result of estimation shows the highest O-D

volumes as the pattern according to zone for totally sample in interval time, morning, noon, and afternoon that shown on the following figures. The total passenger each zone would be one of figure to evaluate the service of pete-pete and realize the fine management of public transport in Makassar. The histogram bellows explain information for total passenger on zone of B1 line.

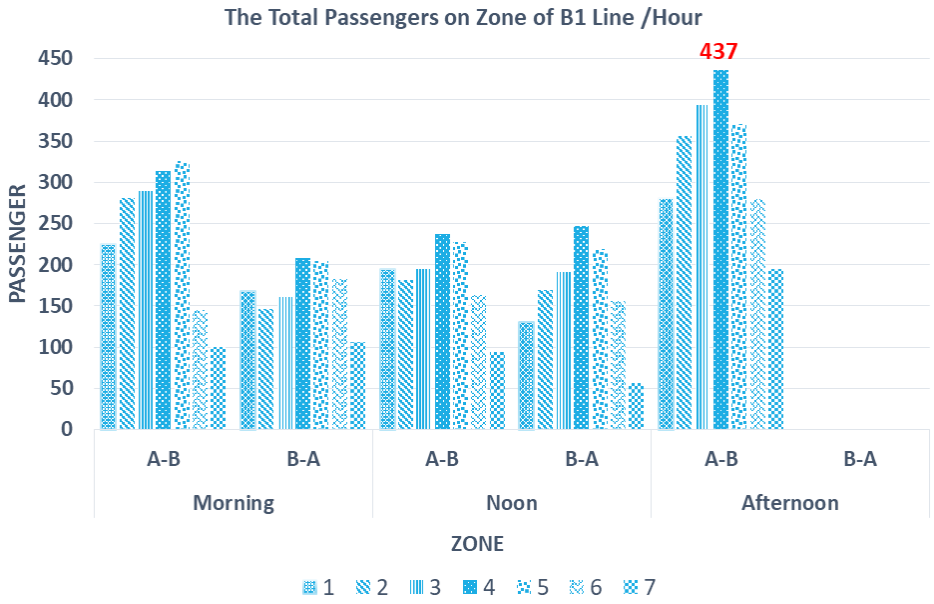

Figure 2. The total passenger on zone of B1 line (A-B) and (B-A) on workday

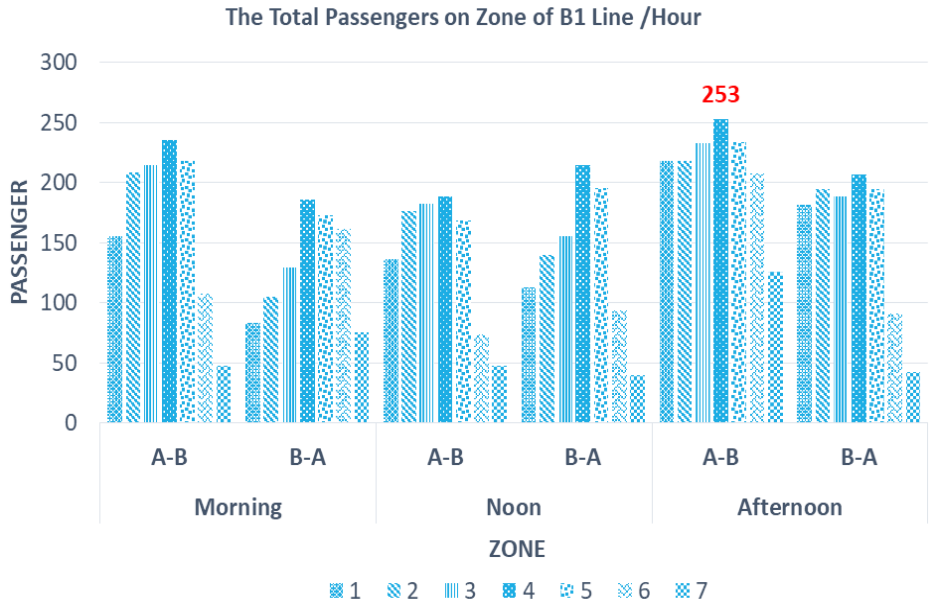

Figure 3. The total passenger on zone of B1 line (A-B) and (B-A) on holiday

4. Conclusion

In this study, the O-D matrix of Makassar has estimated in a couple of days represented in workday and holiday at morning, noon, afternoon. As the result we can see the O-D passenger's volumes of sampling tend to the OD general of B1 line. Both of OD passengers' volumes sampling and general have similarly trend to values as follows:

- OD Passengers Volume Pattern (workday): in the morning, the OD pattern on zone 1-5 and return direction on zone 7-1, in the noon, the OD pattern on zone 1-7 and return direction on zone 6-1, in the afternoon, the OD pattern on zone 1-7. The highest passengers is 437 / hour. The demand of pete-pete is around 45 units.
- The OD Passengers Volume Pattern (holiday): in the morning, the O-D pattern on zone 1-5 and return direction on zone 7-1, in the noon, the O-D pattern on zone 1-5 and return direction on zone 5-1, in the afternoon, the OD pattern on zone 1-7 and return direction on zone 5-1. The highest passengers is 253 / hour. The demand of pete-pete is around 26 units.

Compare to general O-D survey that need more time, effort, and resource such us observer was identify an origin and destination location of each passenger. The simple observation in this study just use general equipment such GPS with marking the stopping point of passengers and determined the location in zones compare with pete-pete counting was give same result about the total O-D of public transportation and total passengers in observation line..

Acknowledgments
Authors wishing to acknowledge assistance or encouragement from Faculty of Engineering Universitas Hasanuddin especially for Laboratory Based Education (LBE) Research Grant for funding and also for Civil Engineering Department, Faculty of Engineering that support and contribute in the research.

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