

SIMULATION OF CITY BUS CIRCULATION PATTERN IN BUS STATION (CASE STUDY: LEUWIPANJANG BUS STATION, BANDUNG, INDONESIA)

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Abstract: Terminal represents location to commutation of mode; where with existence of commutation of mode, hence will generate the existence of a surcharge as so-called cost transit. Rarely the transit expense which must be paid was more than traveling expense as a whole. To overcome the mentioned, hence a good terminal has to be arranged in such a manner to minimize of transit cost in terminal and also in around of terminal.

Considered on important of function of terminal in traveling expense, require to studied one of the especial component which determine performance terminal that is process of circulation of public transport in terminal. In this case taken is perceiving process of circulation public transport departure. And further was conducted by simulation of terminal settlement as according to terminal condition and characteristic. Public transport perceived for case study is city bus in Leuwipanjang bus station which located in Bandung city, West Java, Indonesia.

The purpose of this research is to identify factors of distribution pattern influencing bus departure process, and get a model of process bus departure, and also predict requirement of area for the place of public transport queue in bus station.

From this study obtained that bus arrival pattern follow Poisson's distribution with $\lambda = 0.213$ buses/minute (or 5 minutes/bus). Waiting time pattern in queue follow exponential distribution with mean of waiting time = 12.93 minutes. Bus time service pattern follow normal distribution with mean of time service = 3.956 minutes. While bus departure time pattern follow negative exponential distribution with mean departure = 4.32 minutes/bus. And bus queue area capacities is minimum = 5 buses, availability bus queue area capacities in Leuwipanjang bus station is 10 buses, so that still effective enough.

Result of this research can be used to conduct settlement and management of public transport circulation in bus station.

Key Words: bus station, public transport, distribution pattern, circulation.

1. INTRODUCTION

Terminal represents location to commutation of mode; where with existence of commutation of mode, hence will generate the existence of a surcharge as so-called cost transit. Rarely the transit expense which must be paid was more than traveling expense (cost travel) as a whole.

To overcome the mentioned, hence a good terminal has to be arranged in such a manner to minimize of transit cost in terminal and also in around of terminal.

Especial function of terminal is to provide facility go out and enter from object to be transported, goods or passenger, to and from system. Terminal also frequently represent place where vehicle repaired. In land transportation case, where terminal possible reside in crowded location at the high price of land, facility to maintenance usually located in outside urban area where cheap price of land relative but enough close to terminal.

Considered on important of function of terminal in traveling expense, require to studied one of the especial component which determine performance terminal that is process of circulation movement of public transport in terminal. In this case taken is perceiving process of circulation public transport departure. And further was conducted by simulation settlement of better terminal as according to terminal condition and characteristic.

Public transport perceived for example case is city bus, while terminal taken as case example is Leuwipanjang bus station which located in Bandung city, West Java, Indonesia.

2. SIMULATION'S METHOD

Aim of simulation is be able to model a process and study various occurrences that happened during the process run. For the cases of transportation, occurrence studied usually in the form of vehicle comings and goings, loading and unloading, service time, etc. Important difference found on two simulation type that first is deterministic where all occurrence specified categorically, for example when its occurrence, how long each process will run etc. Secondly is stochastic where there are possibility of existence of variation at various system characteristic which is presented in simulation model, specially modeled characteristic as variable (for example time required for loading and unloading, etc.). The characteristic have probability related to each possible value, where the probability shows the existence of frequency relative from each possible value. In stochastic simulation, possibility the happening of variation of certain characteristic from system follows to be counted. Simulation result shown by a probability which usually follow a certain distribution pattern.

3. PROBABILITY FUNCTION

To present various different systems characteristic used probability density function. The function determines possibility of appearance return characteristic values. Important condition which must fulfill by this function was the amount of probability of possible various values have to equal to one, where a certain value was surely obtained. Some probability density function which usually used is discrete distribution, Poisson's distribution and continue distribution was covering normal distribution, exponential distribution, etc.

4. QUEUE THEORY

In queue theory, there are four queue characteristic which must be determined to forecast variables. First is distribution of arrival headway, second is distribution of service time, third is the amount of lane served and fourth is queue discipline.

Queue discipline divided three, that is:

- FIFO (*first in first out*)
- FILO (*first in last out*)
- FVFS (*first vacant first serve*)

Table 1. Relation of Queue at Single Lane Service with Poisson's Arrival and Exponential Service Time

Queue's Model	Model Description
$P(n) = \left(\frac{\lambda}{\mu}\right)^n \left(1 - \frac{\lambda}{\mu}\right) = (\rho^n)(1 - \rho)$	$P(n)$ = possibility of n vehicle in the system
$\bar{n} = \frac{\lambda}{\mu - \lambda} = \frac{\rho}{1 - \rho}$	\bar{n} = amount of vehicle mean in the system
$\text{var}(n) = \frac{\lambda\mu}{(\mu - \lambda)^2} = \frac{\rho}{(1 - \rho)}$	$\text{var}(n)$ = amount of vehicle in the system
$\bar{q} = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{\rho^2}{(1 - \rho)}$	\bar{q} = mean of queue length
$\bar{d} = \frac{1}{\mu - \lambda}$	\bar{d} = mean of using time in the system
$\bar{w} = \frac{\lambda}{\mu(\mu - \lambda)} = \bar{d} - \frac{1}{\mu}$	\bar{w} = mean of waiting time in the system
$p(w \leq t) = 1 - \rho e^{-(1-\rho)\mu t}$	$p(w \leq t)$ = possibility to use waiting time t or less in the queue

Source: Morlok, 1978

Table 2. Relation of Queue at Single Lane Service with Poisson's Arrival and Constant Service Time

Queue's Model	Model Description
$\bar{q} = \frac{2\rho - \rho^2}{2(1 - \rho)}$	\bar{q} = mean of queue length
$\bar{d} = \frac{2 - \rho}{2\mu(1 - \rho)}$	\bar{d} = mean of using time in the system
$\bar{w} = \frac{\rho}{2\mu(1 - \rho)}$	\bar{w} = mean of waiting time in the system

Source: Morlok, 1978

where: λ = mean of arrival level
 μ = mean of service level
 ρ = traffic intensity = λ / μ

For transportation cases, FIFO or FVFS type usually used as queue discipline. **Table 1** above shown relationship between Poisson's arrival distribution with negative exponential service time distribution using unit of service lane. While **Table 2** above represent relationship between Poisson's arrival distribution with constant service time distribution.

5. DATA SUFFICIENCY TEST AND GOODNESS OF FIT

The data sufficient test conducted to know which have been collected its amount have

fulfilled required data minimum boundary. If data have not sufficient, hence require to be done additional survey to obtain enough data. While goodness of fit test conducted to compare between theoretical distributions of data set. The test was conducted using chi square test.

Minimal data required can be calculated by using the following formula:

$$n = \left(\frac{z_{\alpha/2} * \sigma}{E} \right)^2$$

where:

n = minimum data required

σ = standard deviation

E = permitted error

6. DATA COLLECTING

In this study, the require data covering primary and secondary data. The secondary data was needed covering information about services or operational time at bus station and availability of parking facility (wide area for queue). While the primary data, i.e.: bus arrival, bus departure, amount of bus in the queue and bus service time (time of passenger boarding). In the **Table 3** follows was shown data of arrival, departure and queue time bus in the Leuwipanjang bus station.

Table 3. Data of Arrival, Departure and Queue Time of Bus in Leuwipanjang Bus Station

No.	Arrival		Departure		t sistem (min)	t queue (min)	Queue Length (veh)	t service (min)
	Time	Headway (min)	Time	Headway (min)				
1	07.15		08.07		52	52	8	
2	07.49	34	08.11	4	22	18	8	4
3	07.52	3	08.14	3	22	19	7	3
4	07.53	1	08.18	4	25	21	7	4
5	07.54	1	08.22	4	28	24	7	4
6	07.56	2	08.26	4	30	26	8	4
7	07.58	2	08.29	3	31	28	7	3
8	08.00	2	08.34	5	34	29	7	5
9	08.04	4	08.38	4	34	30	6	4
10	08.10	6	08.41	3	31	28	6	3
11	08.16	6	08.44	3	28	25	5	3
12	08.22	6	08.56	12	34	22	8	12
13	08.24	2	09.01	5	37	32	7	5
14	08.26	2	09.06	5	40	35	8	5
15	08.30	4	09.09	3	39	36	8	3
16	08.40	10	09.13	4	33	29	8	4
17	08.45	5	09.17	4	32	28	8	4
18	08.46	1	09.20	3	34	31	7	3
19	08.50	4	09.22	2	32	30	7	2
20	08.53	3	09.25	3	32	29	6	3
21	09.02	9	09.27	2	25	23	5	2
22	09.05	3	09.30	3	25	22	6	3
23	09.07	2	09.34	4	27	23	5	4
24	09.12	5	09.38	4	26	22	5	4
25	09.14	2	09.40	2	26	24	4	2
26	09.21	7	09.44	4	23	19	4	4

Table 3. Data of Arrival, Departure and Queue Time of Bus in Leuwipanjang Bus Station (continuation)

No.	Arrival		Departure		t sistem (min)	t queue (min)	Queue Length (veh)	t service (min)
	Time	Headway (min)	Time	Headway (min)				
27	09.28	7	09.49	5	21	16	4	5
28	09.30	2	09.54	5	24	19	5	5
29	09.35	5	09.57	3	22	19	4	3
30	09.44	9	10.02	5	18	13	4	5
31	09.47	3	10.07	5	20	15	5	5
32	09.51	4	10.12	5	21	16	5	5
33	09.54	3	10.17	5	23	18	5	5
34	09.58	4	10.21	4	23	19	4	4
35	10.03	5	10.24	3	21	18	4	3
36	10.07	4	10.29	5	22	17	3	5
37	10.12	5	10.33	4	21	17	2	4
38	10.16	4	10.36	3	20	17	1	3
39	10.23	7	10.40	4	17	13	1	4
40	10.38	15	10.44	4	6	2	1	4
41	10.44	6	10.50	6	6	0	2	6
42	10.45	1	10.54	4	9	5	1	4
43	10.48	3	10.59	5	11	6	4	5
44	10.55	7	11.05	6	10	4	3	6
45	10.56	1	11.09	4	13	9	2	4
46	10.58	2	11.14	5	16	11	2	5
47	10.59	1	11.17	3	18	15	1	3
48	11.10	11	11.22	5	12	7	1	5
49	11.20	10	11.25	3	5	2	1	3
50	11.24	4	11.31	6	7	1	2	6
51	11.27	3	11.34	3	7	4	2	3
52	11.28	1	11.39	5	11	6	2	5
53	11.33	5	11.43	4	10	6	1	4
54	11.38	5	11.47	4	9	5	1	4
55	11.47	9	11.52	5	5	0	2	5
56	11.50	3	11.57	5	7	2	1	5
57	11.52	2	12.02	5	10	5	1	5
58	11.58	6	12.08	6	10	4	1	6
59	12.06	8	12.11	3	5	2	1	3
60	12.09	3	12.16	5	7	2	0	5
61	12.18	7	12.22	6	6	0	1	6
62	12.20	2	12.26	4	6	2	1	4
63	12.25	5	12.29	3	4	1	1	3
64	12.29	4	12.34	5	5	0	1	5
65	12.34	5	12.38	4	4	0	1	4
66	12.35	1	12.41	3	6	3	1	3
67	12.41	6	12.47	6	6	0	1	6
68	12.45	4	12.52	5	7	2	0	5
69	13.00	5	13.01	9	11	0	2	11
70	13.00	0	13.07	6	7	1	1	6
71	13.01	1	13.13	6	12	6	1	6
72	13.13	12	13.15	2	2	0	0	2
73	13.19	6	13.24	5	5	0	0	5
74	13.26	7	13.28	8	2	0	0	2
75	13.30	4	13.34	6	4	0	1	4
76	13.33	3	13.36	2	3	1	1	2
77	13.35	2	13.41	5	6	1	0	5
78	13.43	8	13.46	5	3	0	1	3
79	13.46	3	13.50	4	4	0	0	4
80	13.51	5	13.54	4	3	0	0	3
81	13.57	6	13.58	4	1	0	1	1
82	13.57	0	14.03	5	6	1	0	5
83	14.08	11	14.10	7	3	0	0	3
84	14.20	12	14.22	12	2	0	0	2

Table 3. Data of Arrival, Departure and Queue Time of Bus in Leuwipanjang Bus Station (continuation)

No.	Arrival		Departure		t sistem (min)	t queue (min)	Queue Length (veh)	t service (min)
	Time	Headway (min)	Time	Headway (min)				
85	14.24	4	14.26	4	2	0	0	2
86	14.28	4	14.30	4	2	0	0	2
87	14.32	4	14.34	4	2	0	0	2
88	14.34	2	14.38	4	4	0	0	4
89	14.42	8	14.45	7	3	0	0	3
90	14.47	5	14.50	5	3	0	0	3
91	14.52	5	14.55	5	3	0	0	3

Note: t = time

7. ANALYSIS

7.1. Data Analysis

A. Data Sufficiency

- Data sufficiency test of bus arrival

Obtained data about bus arrival was as follows:

$$\mu = 0.213 \text{ bus/min}$$

$$\sigma = 0.23 \text{ bus/min}$$

Data sufficiency test of bus arrival using $\mu = 0.213$; $\sigma = 0.23$; and level of significant = 1%; also permitted error = 0.1; give result as follows:

$$n = \frac{(2.576)^2 0.23^2}{0.1^2} = 36 \text{ data}$$

So that data which have been collected (91 data), have fulfilled sufficiency of minimum data (36 data).

- Data Sufficiency Test of Service Time

Obtained data about bus arrival was as follows:

$$\mu = 3.956 \text{ min/bus}$$

$$\sigma = 1.63 \text{ min/bus}$$

Data sufficiency test of service time using $\mu = 3.956 \text{ min/bus}$; $\sigma = 1.63 \text{ min/bus}$; and level of significant = 1%; also permitted error = 0.5; give result as follows:

$$n = \frac{(2.576)^2 1.63^2}{0.5^2} = 71 \text{ data}$$

So that data which have been collected (91 data), have fulfilled sufficiency of minimum data (71 data).

- Data Sufficiency Test of Time at Queue

$$\mu = 12.93 \text{ min/bus}$$

$$\sigma = 11.90 \text{ min/bus}$$

Data sufficiency test of time at queue using $\mu = 12.93$; $\sigma = 11.90$; and level of significant = 1%; also permitted error = 4; give result as follows:

$$n = \frac{(2.576)^2 11.90^2}{4^2} = 59 \text{ data}$$

So that data which have been collected (91 data), have fulfilled sufficiency of minimum data (59 data).

B. Fitting Distribution

- Fitting distribution of bus arrival
With $\mu = 0.213$ bus/min; and level of significant = 1%; was obtained that bus arrival headway follow Poisson distribution pattern.
- Fitting distribution of service time
With $\mu = 3.956$ min/bus; $\sigma = 1.63$ min/bus; and level of significant = 1%, was obtained that bus service time follow normal distribution.
- Fitting distribution of time at queue
With $\mu = 12.93$ min/bus; and level of significant = 1%, was obtained that waiting time at queue follow negative exponential distribution.

7.2. Simulation Process

A. Existing Departure Process

After fitting distribution step, the next step was developing model base on each distribution type. Using random number (N) can be simulated bus arrival, service time, time at queue for existing condition where just only single lane available.

With mean of bus arrival level = 0.213 bus/min; and follow Poisson distribution was obtained $N = 100e^{-0.213t}$; so can obtained $t = 23.03 - 5 \ln N$ (bus departure headway). Also can be counted estimation of arrival time each bus.

For time at queue follow negative exponential distribution with mean of time at queue = 12.93 minutes, hence by using random number N, time at queue (t) can be counted using $N = 100e^{-t/12.93}$. While for mean of service time = 3.956 min/bus and deviation standard, also can be simulated by using random number. After getting arrival time, time at queue and service time, hence departure time can be counted for each bus. Result of simulation can be shown at **Table 4** as follow.

Table 4. Simulation of Existing Departure Process

No.	Arrival				Time at Queue			Served Time (min to-)	Service Time (min)	Departure Time (min to-)
	N	Ln N	Headway (min)	Arrival Time (min to-)	N	Ln N	Queue Time (min)			
1				0	62	4.13	6	6	2	8
2	60	4.09	3	3	54	3.99	8	11	4	15
3	33	3.50	6	9	54	3.99	8	16	2	18
4	10	2.30	12	21	28	3.33	16	36	6	42
5	47	3.85	4	25	52	3.95	8	42	4	46
6	56	4.03	3	28	54	3.99	8	46	5	51
7	28	3.33	6	34	54	3.99	8	51	6	57
8	15	2.71	9	43	18	2.89	22	64	5	69
9	92	4.52	0	43	20	3.00	21	69	2	71
10	35	3.56	5	48	32	3.47	15	71	6	77
11	66	4.19	2	50	29	3.37	16	77	3	80
12	86	4.45	1	51	57	4.04	7	80	4	84
13	93	4.53	0	51	42	3.74	11	84	4	88
14	47	3.85	4	55	36	3.58	13	88	2	90

Table 4. Simulation of Existing Departure Process (continuation)

No.	Arrival				Time at Queue			Served Time (min to-)	Service Time (min)	Departure Time (min to-)
	N	Ln N	Headway (min)	Arrival Time (min to-)	N	Ln N	Queue Time (min)			
15	68	4.22	2	57	60	4.09	6	90	5	95
16	76	4.33	1	58	41	3.71	11	95	2	97
17	10	2.30	12	70	29	3.37	16	97	2	99
18	10	2.30	12	82	24	3.18	18	99	3	102
19	13	2.56	10	92	32	3.47	15	106	6	112
20	80	4.38	1	93	52	3.95	8	112	2	114

Note: this simulation only exercise for 20 buses

From simulation's result can be obtained mean of bus departure time = 4.32 minutes, and level of significant = 1%, also can be obtained that bus departure follows negative exponential distribution pattern.

B. Scenario of Departure Process

Some scenario performed to evaluate bus departure process, for example:

- Scenario 1

Scenario 1 conducted by adding lane so that time at queue become to decrease. Addition of such lane was addition of lane for bus departure, so that can departed two buses in one moment, so can decrease time at queue. The conducted change by applying scenario 1 was as follow:

Mean of bus arrival level = 0.213 bus/min

Mean of time at queue decrease become 8 minutes

Mean of service time 3.956 min/bus; with deviation standard = 1.63.

So can be seen departure time and departure distribution for scenario 1 as represented in **Table 5** as follow.

Table 5. Simulation of Departure Process - Scenario 1

No.	Arrival				Time at Queue			Served Time (min to-)	Service Time (min)	Departure Time (min to-)
	N	Ln N	Headway (min)	Arrival Time (min to-)	N	Ln N	Queue Time (min)			
1				0	14	2.64	16	16	2	18
2	60	4.09	3	3	24	3.18	12	18	4	22
3	33	3.50	6	9	68	4.22	3	22	2	24
4	10	2.30	12	21	48	3.87	6	26	6	32
5	47	3.85	4	25	39	3.66	8	32	4	36
6	56	4.03	3	28	62	4.13	4	36	5	41
7	28	3.33	6	34	65	4.17	3	41	6	47
8	15	2.71	9	43	49	3.89	6	48	5	53
9	92	4.52	0	43	66	4.19	3	53	2	55
10	35	3.56	5	48	43	3.76	7	55	6	61
11	66	4.19	2	50	65	4.17	3	61	3	64
12	86	4.45	1	51	69	4.23	3	64	4	68
13	93	4.53	0	51	30	3.40	10	68	4	72
14	47	3.85	4	55	34	3.53	9	72	2	74
15	68	4.22	2	57	47	3.85	6	74	5	79
16	76	4.33	1	58	39	3.66	8	79	2	81
17	10	2.30	12	70	58	4.06	4	81	2	83
18	10	2.30	12	82	17	2.83	14	95	3	98
19	13	2.56	10	92	44	3.78	6	98	6	104
20	80	4.38	1	93	58	4.06	4	102	2	104

▪ Scenario 2

Scenario 2 conducted by increasing amount of bus to serve requirement of demand so that can increased bus departure frequency. Implementation of scenario 2 made as follow:

Mean of departure level increase become 0.3 bus/min

Mean of Time at queue = 12.93 minutes

Mean of service time = 3.956 min/bus; with deviation standard = 1.63.

So can be seen departure time and departure distribution for scenario 2 as represented in **Table 6** below.

Table 6. Simulation of Departure Process - Scenario 2

No.	Arrival				Time at Queue			Served Time (min to-)	Service Time (min)	Departure Time (min to-)
	N	Ln N	Headway (min)	Arrival Time (min to-)	N	Ln N	Queue Time (min)			
1				0	62	4.13	6	6	2	8
2	42	3.74	3	3	54	3.99	8	11	4	15
3	37	3.61	3	6	54	3.99	8	15	2	17
4	60	4.09	2	8	28	3.33	16	24	6	30
5	32	3.47	4	12	52	3.95	8	30	4	34
6	49	3.89	2	14	54	3.99	8	34	5	39
7	53	3.97	2	16	54	3.99	8	39	6	45
8	57	4.04	2	18	18	2.89	22	45	5	50
9	48	3.87	2	20	20	3.00	21	50	2	52
10	49	3.89	2	22	32	3.47	15	52	6	58
11	37	3.61	3	25	29	3.37	16	58	3	61
12	59	4.08	2	27	57	4.04	7	61	4	65
13	7	1.95	9	36	42	3.74	11	65	4	69
14	52	3.95	2	38	36	3.58	13	69	2	71
15	45	3.81	3	41	60	4.09	6	71	5	76
16	7	1.95	9	50	41	3.71	11	76	2	78
17	20	3.00	5	55	29	3.37	16	78	2	80
18	11	2.40	7	62	24	3.18	18	82	3	85
19	5	1.61	10	72	32	3.47	15	89	6	95
20	47	3.85	2	74	52	3.95	8	95	2	97

▪ Scenario 3

Scenario 3 conducted by applying combination of scenario 1 and scenario 2. Implementation of scenario 3 made as follow:

Mean of bus departure level increase become 0.3 bus/min

Mean of time at queue decrease become 8 minutes

Mean of service time = 3.956 min/bus; with deviation standard = 1.63.

So can be seen departure time and departure distribution for scenario 3 as represented in **Table 7** below.

Table 7. Simulation of Departure Process - Scenario 3

No.	Arrival				Time at Queue			Served Time (min to-)	Service Time (min)	Departure Time (min to-)
	N	Ln N	Headway (min)	Arrival Time (min to-)	N	Ln N	Queue Time (min)			
1				0	14	2.64	16	16	2	18
2	42	3.74	3	3	24	3.18	12	18	4	22
3	37	3.61	3	6	68	4.22	3	22	2	24
4	60	4.09	2	8	48	3.87	6	24	6	30
5	32	3.47	4	12	39	3.66	8	30	4	34
6	49	3.89	2	14	62	4.13	4	34	5	39
7	53	3.97	2	16	65	4.17	3	39	6	45

Table 7. Simulation of Departure Process - Scenario 3 (continuation)

No.	Arrival				Time at Queue			Served Time (min to-)	Service Time (min)	Departure Time (min to-)
	N	Ln N	Headway (min)	Arrival Time (min to-)	N	Ln N	Queue Time (min)			
8	57	4.04	2	18	49	3.89	6	45	5	50
9	48	3.87	2	20	66	4.19	3	50	2	52
10	49	3.89	2	22	43	3.76	7	52	6	58
11	37	3.61	3	25	65	4.17	3	58	3	61
12	59	4.08	2	27	69	4.23	3	61	4	65
13	7	1.95	9	36	30	3.40	10	65	4	69
14	52	3.95	2	38	34	3.53	9	69	2	71
15	45	3.81	3	41	47	3.85	6	71	5	76
16	7	1.95	9	50	39	3.66	8	76	2	78
17	20	3.00	5	55	58	4.06	4	78	2	80
18	11	2.40	7	62	17	2.83	14	80	3	83
19	5	1.61	10	72	44	3.78	6	83	6	89
20	47	3.85	2	74	58	4.06	4	89	2	91

C. Calculation of Queue and Efficiency Capacities of Bus Queue Area

Calculation of queue conducted at existing condition where the data were bus departure level (λ)= 0.213 bus/min; and service time = 3.956 min/bus. By using the data can be conducted the following calculation:

- Mean of service level $\mu = \frac{1}{3.956} = 0.253 \text{ bus / min}$
- Usage factor $\rho = \frac{\lambda}{\mu} = \frac{0.213}{0.253} = 0.84$
- Mean of amount of vehicle in the system $\bar{n} = \frac{0.84}{(1-0.84)} = 5.25 (\approx 6 \text{ buses})$
- Mean of queue length $\bar{q} = \frac{0.84^2}{(1-0.84)} = 4.41 (\approx 5 \text{ buses})$
- Mean of time in the system $\bar{d} = \frac{1}{0.253 - 0.213} = 0.04 \text{ min}$

There can be concluded that from bus queue area capacities side is minimum equal to 5 buses, in this case availability bus queue area capacities in Leuwipanjang bus station is 10 buses, so that still effective enough.

8. CONCLUSION

From result of analysis obtained that especial parameter which influence bus departure process are bus arrival time, waiting time in queue and service time. From this study obtained that bus arrival pattern follow Poisson’s distribution pattern with $\lambda = 0.213$ buses/minute (or 5 minutes/bus). Waiting time pattern in queue follow exponential distribution pattern with mean of waiting time = 12.93 minutes. Bus time service pattern follow normal distribution pattern with mean of service time = 3.956 minutes. While bus departure time pattern follow negative exponential distribution pattern with mean of departure 4.32 minutes/bus.

Besides that also can be concluded that from bus queue area capacities side is minimum equal to 5 buses, in this case availability bus queue area capacities in Leuwipanjang bus station is

10 buses, so that still effective enough.

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